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The ethics of artificial intelligence: Issues and initiatives

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The ethics of artificial intelligence: Issues and initiatives

This study deals with the ethical implications and moral questions that arise from the development and implementation of artificial intelligence (AI) technologies. It also reviews the guidelines and frameworks which countries and regions around the world have created to address them. It presents a comparison between the current main frameworks and the main ethical issues, and highlights gaps around the mechanisms of fair benefit-sharing; assigning of responsibility; exploitation of workers; energy demands in the context of environmental and climate changes; and more complex and less certain implications of AI, such as those regarding human relationships.

AMSCE-1101

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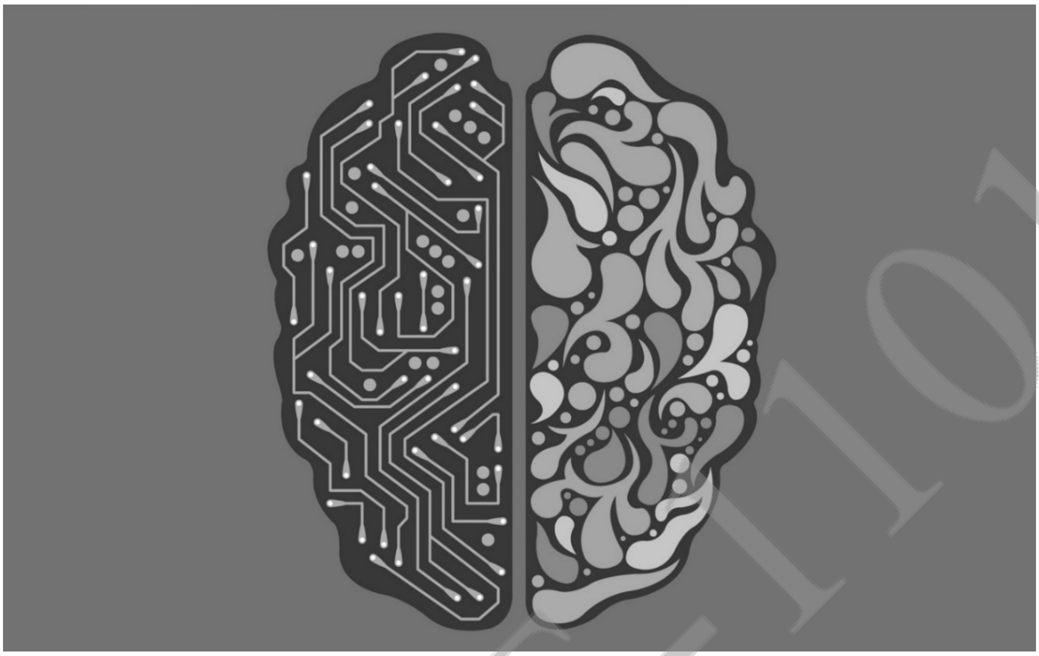
AMSCE-1101

Executive summary



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This report deals with the ethical implications and moral questions that arise from the development and implementation of artificial intelligence (AI) technologies. It also reviews the guidelines and frameworks that countries and regions around the world have created to address them. It presents a comparison between the current main frameworks and the main ethical issues, and highlights gaps around mechanisms of fair benefit sharing; assigning of responsibility; exploitation of workers; energy demands in the context of environmental and climate changes; and more complex and less certain implications of AI, such as those regarding human relationships.

Chapter 1 introduces the scope of the report and defines key terms. The report draws on the European Commission's definition of AI as 'systems that display intelligent behaviour'. Other key terms defined in this chapter include intelligence and how this is used in the context of AI and intelligent robots (i.e. robots with an embedded AI), as well as defining machine learning, artificial neural networks and deep learning, before moving on to consider definitions of morality and ethics and how these relate to AI.

In Chapter 2 the report **maps the main ethical dilemmas and moral questions associated with the deployment of AI**. The report begins by outlining a number of potential benefits that could arise from AI as a context in which to situate ethical, social and legal considerations. Within the context of issues for society, the report considers the potential impacts of AI on the labour market, focusing on the likely impact on economic growth and productivity, the impact on the workforce, potential impacts on different demographics, including a worsening of the digital divide, and the consequences of deployment of AI on the workplace. The report considers the potential impact of AI on inequality and how the benefits of AI could be shared within society, as well as issues concerning the concentration of AI technology within large internet companies and political stability. Other societal issues addressed in this chapter include privacy, human rights and dignity, bias, and issues for democracy.

Chapter 2 moves on to consider the impact of AI on human psychology, raising questions about the impact of AI on relationships, as in the case of intelligent robots taking on human social roles, such as nursing. Human-robot relationships may also affect human-human relationships in as yet unanticipated ways. This section also considers the question of personhood, and whether AI systems should have moral agency.

Impacts on the financial system are already being felt, with AI responsible for high trading volumes of equities. The report argues that, although markets are suited to automation, there are risks including the use of AI for intentional market manipulation and collusion.

AI technology also poses questions for both civil and criminal law, particularly whether existing legal frameworks apply to decisions taken by AIs. Pressing legal issues include liability for tortious, criminal and contractual misconduct involving AI. While it may seem unlikely that AIs will be deemed to have sufficient autonomy and moral sense to be held liable themselves, they do raise questions about who is liable for which crime (or indeed if human agents can avoid liability by claiming they did not know the AI could or would do such a thing). In addition to challenging questions around liability, AI could abet criminal activities, such as smuggling (e.g. by using unmanned vehicles), as well as harassment, torture, sexual offences, theft and fraud. Self-driving autonomous cars are likely to raise issues in relation to product liability that could lead to more complex cases (currently insurers typically avoid lawsuits by determining which driver is at fault, unless a car defect is involved).

Large-scale deployment of AI could also have both positive and negative impacts on the environment. Negative impacts include increased use of natural resources, such as rare earth metals, pollution and waste, as well as energy consumption. However, AI could help with waste management and conservation offering environmental benefits.

The potential impacts of AI are far-reaching, but they also require trust from society. AI will need to be introduced in ways that build trust and understanding, and respect human and civil rights. This requires transparency, accountability, fairness and regulation.

Chapter 3 explores **ethical initiatives in the field of AI**. The chapter first outlines the ethical initiatives identified for this report, summarising their focus and where possible identifying funding sources. The harms and concerns tackled by these initiatives is then discussed in detail. The issues raised can be broadly aligned with issues identified in Chapter 2 and can be split into questions around: human rights and well-being; emotional harm; accountability and responsibility; security, privacy, accessibility and transparency; safety and trust; social harm and social justice; lawfulness and justice; control and the ethical use (or misuse) of AI; environmental harm and sustainability; informed use; existential risk.

All initiatives focus on human rights and well-being, arguing that AI must not affect basic and fundamental human rights. The IEEE initiative further recommends governance frameworks, standards and regulatory bodies to oversee use of AI and ensure that human well-being is prioritised throughout the design phase. The Montreal Protocol argues that AI should encourage and support the growth and flourishing of human well-being.

Another prominent issue identified in these initiatives is concern about the impact of AI on the human emotional experience, including the ways in which AIs address cultural sensitivities (or fail to do so). Emotional harm is considered a particular risk in the case of intelligent robots with whom humans might form an intimate relationship. Emotional harm may also arise should AI be designed to emotionally manipulate users (though it is also recognised that such nudging can also have

AMSCE-IU

positive impacts, e.g. on healthy eating). Several initiatives recognise that nudging requires particular ethical consideration.

The need for accountability is recognised by initiatives, the majority of which focus on the need for AI to be auditable as a means of ensuring that manufacturers, designers and owners/operators of AI can be held responsible for harm caused. This also raises the question of autonomy and what that means in the context of AI.

Within the initiatives there is a recognition that new standards are required that would detail measurable and testable levels of transparency so that systems can be objectively assessed for compliance. Particularly in situations where AI replaces human decision-making initiatives, we argue that AI must be safe, trustworthy, reliable and act with integrity. The IEEE focus on the need for researchers to operate with a 'safety mindset' to pre-empt unintended or unanticipated behaviours.

With regard to societal harms, the IEEE suggests that social and moral norms should be considered in design, while the Japanese Society for AI, suggests that AI should be designed with social responsibility in mind. Several initiatives focus on the need to consider social inclusion and diversity, and the risk that AI could widen gaps between developed and developing economies. There is concern that AI-related degree programmes fail to equip designers with appropriate knowledge of ethics.

Legal issues are also addressed in the initiatives, with the IEEE arguing that AI should not be granted the status of 'personhood' and that existing laws should be scrutinised to ensure that they do not practically give AI legal autonomy.

Concerns around environmental harms are evident across initiatives, including concerns about resource use but also acknowledgement that AI could play a role in conservation and sustainable stewardship. The UNI Global Union states that AI should put people and plants first, striving to protect and enhance biodiversity and ecosystems.

Throughout the initiatives, there is a recognition of the need for greater public engagement and education with regard to the potential harms of AI. The initiatives suggest a range of ways in which this could be achieved, as a way of raising a number of topics that should be addressed through such initiatives.

Autonomous weapons systems attract particular attention from initiatives, given their potential to seriously harm society.

Case studies in Chapter 3 cover the particular risks associated with healthcare robots, which may be involved in diagnosis, surgery and monitoring health and well-being as well as providing caring services. The first case study highlights particular risks associated with embodied AI, which have moving parts that can cause injury. Healthcare AI applications also have implications for training of healthcare professionals and present data protection, legal and equality challenges. The case study raises a number of ethical concerns in relation to the deployment of robots for the care of the elderly in particular. The use of AI in healthcare also raises questions about trust, for example, how trust in professionals might change if they are seen as 'users' of technology.

A second case study explores ethical issues associated with the development of autonomous vehicles (AVs). In the context of driving, six levels of automation are recognised by SAE International: no automation, hands on (e.g. Cruise Control), hands off (driver still monitors driving), eyes off (driver can turn attention elsewhere, but must be prepared to intervene), minds off (no driver attention required) and steering wheel optional (human intervention is not required). Public safety is a key concern regarding the deployment of autonomous vehicles, particularly following high-profile deaths associated with the use such vehicles. Liability is also a key concern with this emerging technology and the lack of standards, processes and regulatory frameworks for accident investigation hampers efforts to investigate accidents. Furthermore, with the exception of the US state of California, manufacturers are not required to log near misses.

Manufacturers of autonomous vehicles also collect significant amounts of data from AVs, which raises questions about the privacy and data protection rights of drivers and passengers. AVs could change urban environments, with, for example, additional infrastructure needed (AV-only lanes), but also affecting traffic congestion and requiring the extension of 5G network coverage.

A final case study explores the use of AI in warfare and the potential for AI applications to be used as weapons. AI is already used in military contexts. However, there are particular aspects of developing AI technologies that warrant consideration. These include: lethal autonomous weapons; drone technologies; robotic assassination and mobile-robotic-improvised explosive devices.

Key ethical issues arising from greater military use of AI include questions about the involvement of human judgement (if human judgement is removed, could this violate International Humanitarian Law). Would increasing use of AI reduce the threshold for going to war (affecting global stability)?

Chapter 4 discusses emerging **AI ethics standards and regulations**. There are a number of emerging standards that address emerging ethical, legal and social impacts of robotics and AI. Perhaps the earliest of these is the BS 8611 Guide to the Ethical Design and Application of Robots and Robotic Systems. It is based on a set of 20 distinct ethical hazards and risks, grouped under four categories: societal, application, commercial & financial, and environmental. The standard recognises physical hazards as implying ethical hazards and recognises that both physical and emotional hazards should be balanced against expected benefits to the user.

National and International policy initiatives are addressed in Chapter 5: **National and International Strategies on AI**. Canada launched the first national strategy on AI in March 2017, followed soon after by Japan, with many initiatives published since (see Figure 5. 1), including national strategies for Denmark, Finland, France, Germany, Sweden and the UK. The EU Strategy was the first international initiative on AI and supports the strategies of individual Member States. Strategies vary however in the extent to which they address ethical issues. At the European level, public concerns feature prominently in AI initiatives. Other international AI initiatives that cover ethical principles include: G7 Common Vision for the Future of AI, Nordic-Baltic Region Declaration on AI, OECD Principles on AI and the World Economic Form's Global AI Council. The United Nations has several initiatives relating to AI, including the AI for Good Global Summit; UNICRI Centre for AI and Robotics; UNESCO Report on Robotics Ethics.

Finally, Chapter 6 draws together the **themes emerging** from the literature, ethical initiatives and national and international strategies in relation to AI, highlighting gaps. It questions whether the two current international frameworks (EU High Level Expert Group, 2018[2] and OECD principles for AI, 2019) for the governance of AI are sufficient to meet the challenges it poses. The analysis highlights gaps in relation to environmental concerns; human psychology; workforce, particularly in relation to inequality and bias; democracy and finance.

Table of contents

AMSCE-1101

AMSCE-1101

Table of figures

Table of tables

AMSCE-1101

AMSCE-1101

1. Introduction

Rapid developments in artificial intelligence (AI) and machine learning carry huge potential benefits. However it is necessary to explore the full ethical, social and legal aspects of AI systems if we are to avoid unintended, negative consequences and risks arising from the implementation of AI in society.

This chapter introduces AI broadly, including current uses and definitions of intelligence. It also defines robots and their position within the broader AI field.

1.1. What is AI – and what is intelligence?

The European Commission's Communication on Artificial Intelligence (European Commission, 2018a) defines artificial intelligence as follows:

> *'Artificial Intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals.*
>
> *AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications).'*

Within this report, we consider both software-based AI and intelligent robots (i.e. robots with an embedded AI) when exploring ethical issues. Intelligent robots are therefore a subset of AI (whether or not they make use of machine learning).

How do we define intelligence? A straightforward definition is that intelligent behaviour is 'doing the right thing at the right time'. Legg and Hunt (2007) survey a wide range of informal definitions of intelligence, identifying three common features: that intelligence is (1) 'a property that an individual agent has as it interacts with its environment or environments', (2) 'related to the agent's ability to succeed or profit with respect to some goal or objective', and (3) 'depends on how able that agent is to adapt to different objectives and environments'. They point out that intelligence involves adaptation, learning and understanding. At its simplest, then, intelligence is 'the ability to acquire and apply knowledge and skills and to manipulate one's environment'.

In interpreting these definitions of intelligence, we need to understand that for a physical **robot** its environment is the real world, which can be a human environment (for social robots), a city street (for an autonomous vehicle), a care home or hospital (for a care or assisted living robot), or a workplace (for a workmate robot). The 'environment' of a software AI is its context, which might be clinical (for a medical diagnosis AI), or a public space – for face recognition in airports, for instance, or virtual for face recognition in social media. But, like physical robots, software AIs almost always interact with humans, whether via question and answer interfaces: via text for chatbots, or via speech for digital assistants on mobile phones (i.e. Siri) or in the home (i.e. Alexa).

It is this interaction with humans that gives rise to almost all of the ethical issues surveyed in this report.

All present-day AIs and robots are examples of what we refer to as **'narrow' AI**: a term that reflects that fact that current AIs and robots are typically only capable of undertaking one specialised task. A long-term goal of AI and robotics research is so-called **artificial general intelligence (AGI)** which

AMSCE-101

would be comparable to human intelligence.[1] It is important to understand that present-day narrow AI is often better than most humans at one particular task; examples are chess- or Go-playing AIs, search engines or natural language translation systems. But a general-purpose care robot capable of, for instance, preparing meals for an elderly person (and washing the dishes afterwards), helping them dress or undress, get into and out of bed or the bath etc., remains a distant research goal.

Machine learning is the term used for AIs which are capable of learning or, in the case of robots, adapting to their environment. There are a broad range of approaches to machine learning, but these typically fall into two categories: supervised and unsupervised learning. Supervised learning systems generally make use of **Artificial Neural Networks (ANNs)**, which are trained by presenting the ANN with inputs (for instance, images of animals) each of which is tagged (by humans) with an output (i.e. giraffe, lion, gorilla). This set of inputs and matched outputs is called a training data set. After training, an ANN should be able to identify which animal is in an image it is presented with (i.e. a lion), even though that particular image with a lion wasn't present in the training data set. In contrast, unsupervised learning has no training data; instead, the AI (or robot) must figure out on its own how to solve a particular task (i.e. how to navigate successfully out of a maze), generally by trial and error.

Both supervised and unsupervised learning have their limitations. With supervised learning, the training data set must be truly representative of the task required; if not, the AI will exhibit bias. Another limitation is that ANNs learn by picking out features of the images in the training data unanticipated by the human designers. So, for instance, they might wrongly identify a car against a snowy background as a wolf, because all examples of wolves in the images of the training data set had snowy backgrounds, and the ANN has learned to identify snowy backgrounds as wolves, rather than the wolf itself. Unsupervised learning is generally more robust than supervised learning but suffers the limitation that it is generally very slow (compared with humans who can often learn from as few as one trial).

The term **deep learning** simply refers to (typically) supervised machine learning systems with large (i.e. many-layered) ANNs and large training data sets.

It is important to note the terms AI and machine learning are not synonymous. Many highly capable AIs and robots do not make use of machine learning.

1.2. Definition of morality and ethics, and how that relates to AI

Ethics are moral principles that govern a person's behaviour or the conduct of an activity. As a practical example, one ethical principle is *to treat everyone with respect*. Philosophers have debated ethics for many centuries, and there are various well-known principles, perhaps one of the most famous being Kant's categorical imperative 'act as you would want all other people to act towards all other people'.[2]

AI ethics is concerned with the important question of how human developers, manufacturers and operators should behave in order to minimise the ethical harms that can arise from AI in society, either arising from poor (unethical) design, inappropriate application or misuse. The scope of AI ethics spans immediate, here-and-now concerns about, for instance, data privacy and bias in current AI systems; near- and medium-term concerns about, for instance, the impact of AI and robotics on

AMSCE-101

[1] AGI could be defined as technologies that are explicitly developed as systems that can learn incrementally, reason abstractly and act effectively over a wide range of domains—just like humans can.

[2] From Kant's 1785 book *Groundwork of the Metaphysics of Morals*, with a variety of translations from the original German.

jobs and the workplace; and longer-term concerns about the possibility of AI systems reaching or exceeding human-equivalent capabilities (so-called superintelligence).

Within the last 5 years AI ethics has shifted from an academic concern to a matter for political as well as public debate. The increasing ubiquity of smart phones and the AI-driven applications that many of us now rely on every day, the fact that AI is increasingly impacting all sectors (including industry, healthcare, policing & the judiciary, transport, finance and leisure), as well as the seeming prospect of an AI 'arms race', has prompted an extraordinary number of national and international initiatives, from NGOs, academic and industrial groupings, professional bodies and governments. These initiatives have led to the publication of a large number of sets of ethical principles for robotics and AI (at least 22 different sets of ethical principles have been published since January 2017), new ethical standards are emerging (notably from the British Standards Institute and the IEEE Standards Association), and a growing number of countries (and groups of countries) have announced AI strategies (with large-scale investments) and set up national advisory or policy bodies.

In this report we survey these initiatives in order to draw out the main ethical issues in AI and robotics.

1.3. Report structure

Robots and artificial intelligence (AI) come in various forms, as outlined above, each of which raises a different **range of ethical concerns**. These are outlined in Chapter 2: Mapping the main ethical dilemmas and moral questions associated with the deployment of AI. This chapter explores in particular:

Social impacts: this section considers the potential impact of AI on the labour market and economy and how different demographic groups might be affected. It addresses questions of inequality and the risk that AI will further concentrate power and wealth in the hands of the few. Issues related to privacy, human rights and dignity are addressed as are risks that AI will perpetuate the biases, intended or otherwise, of existing social systems or their creators. This section also raises questions about the impact of AI technologies on democracy, suggesting that these technologies may operate for the benefit of state-controlled economies.

Psychological impacts: what impacts might arise from human-robot relationships? How might we address dependency and deception? Should we consider whether robots deserve to be given the status of 'personhood' and what are the legal and moral implications of doing so?

Financial system impacts: potential impacts of AI on financial systems are considered, including risks of manipulation and collusion and the need to build in accountability.

Legal system impacts: there are a number of ways in which AI could affect the legal system, including: questions relating to crime, such as liability if an AI is used for criminal activities, and the extent to which AI might support criminal activities such as drug trafficking. In situations where an AI is involved in personal injury, such as in a collision involving an autonomous vehicle, then questions arise around the legal approach to claims (whether it is a case of negligence, which is usually the basis for claims involving vehicular accidents, or product liability).

Environmental impacts: increasing use of AIs comes with increased use of natural resources, increased energy demands and waste disposal issues. However, AIs could improve the way we manage waste and resources, leading to environmental benefits.

Impacts on trust: society relies on trust. For AI to take on tasks, such as surgery, the public will need to trust the technology. Trust includes aspects such as fairness (that AI will be impartial), transparency (that we will be able to understand how an AI arrived at a particular decision),

AMSCE-110

accountability (someone can be held accountable for mistakes made by AI) and control (how we might 'shut down' an AI that becomes too powerful).

In Chapter 3, **Ethical initiatives in the field of artificial intelligence**, the report reviews a wide range of ethical initiatives that have sprung up in response to the ethical concerns and issues emerging in relation to AI. **Section 3.1** discusses the issues each initiative is exploring and identifies reports available (as of May 2019).

Ethical harms and concerns tackled by the initiatives outlined above, are discussed in Section 3.2. These are broadly split into 12 categories: human rights and well-being; emotional harm; accountability and responsibility; security, privacy, accessibility, and transparency; safety and trust; social harm and social justice; financial harm; lawfulness and justice; control and the ethical use (or misuse) of AI; environmental harm and sustainability; informed use and existential risks. The chapter explores each of these topics and the ways in which they are being addressed by the initiatives.

Chapter 4 presents the current status of **AI Ethical standards and regulation**. At present only one standard (British Standard BS8611, *Guide to the ethical design of robots and robotic systems*) specifically addresses AI. However, the IEEE is developing a number of standards that affect AI in a range of contexts. While these are in development, they are presented here as an indication of where standards and regulation is progressing.

Finally, Chapter 5 explores **National and international strategies on AI**. The chapter considers what is required for a trustworthy AI and visions for the future of AI as they are articulated in national and international strategies.

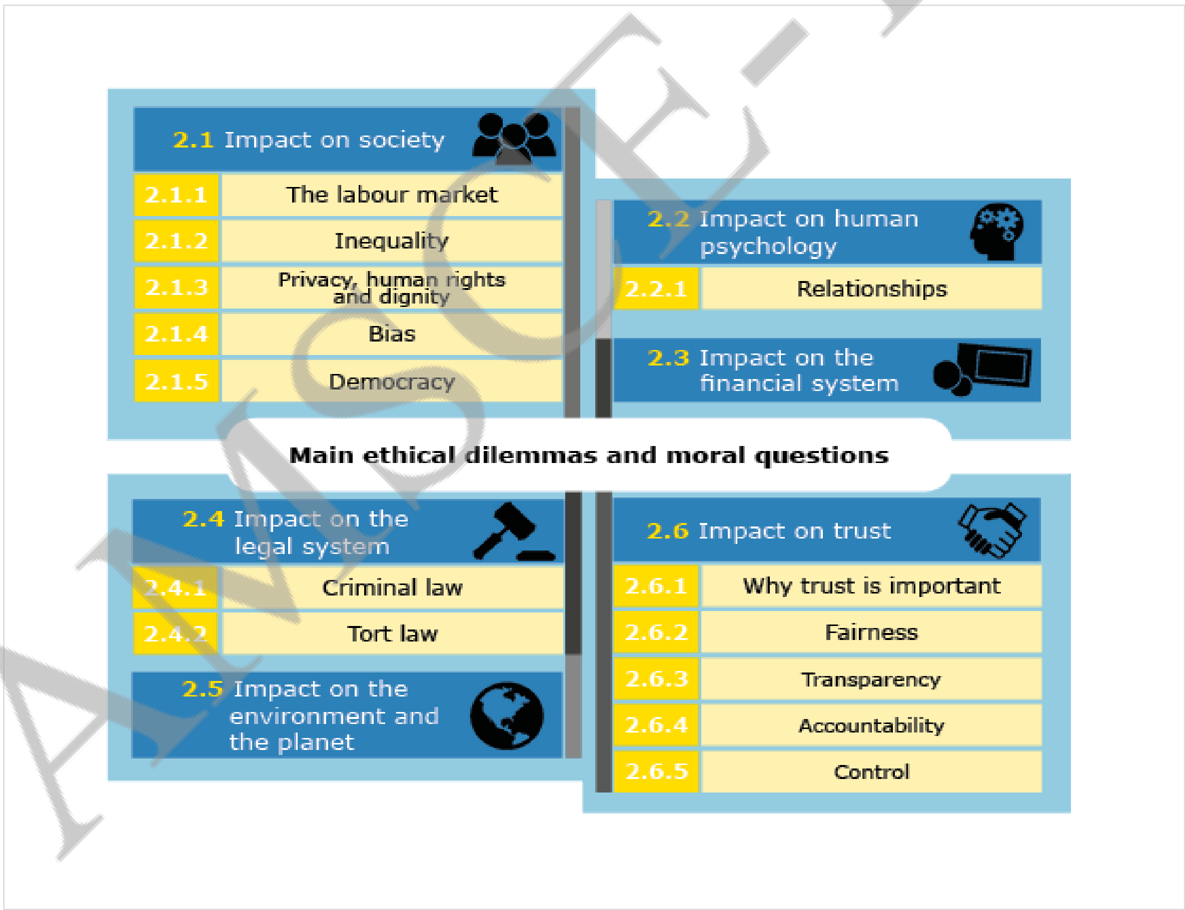
AMSCE-IIOT

2. Mapping the main ethical dilemmas and moral questions associated with the deployment of AI

According to the Future of Life Institute (n.d.), AI 'holds great economic, social, medical, security, and environmental promise', with potential benefits including:

- Helping people to acquire new skills and training;
- Democratising services;
- Designing and delivering faster production times and quicker iteration cycles;
- Reducing energy usage;
- Providing real-time environmental monitoring for air pollution and quality;
- Enhancing cybersecurity defences;
- Boosting national output;
- Reducing healthcare inefficiencies;
- Creating new kinds of enjoyable experiences and interactions for people; and
- Improving real-time translation services to connect people across the globe.

Figure 1: Main ethical and moral issues associated with the development and implementation of AI


2.1 Impact on society
2.1.1 The labour market
2.1.2 Inequality
2.1.3 Privacy, human rights and dignity
2.1.4 Bias
2.1.5 Democracy
2.2 Impact on human psychology
2.2.1 Relationships
2.3 Impact on the financial system
Main ethical dilemmas and moral questions
2.4 Impact on the legal system
2.4.1 Criminal law
2.4.2 Tort law
2.5 Impact on the environment and the planet
2.6 Impact on trust
2.6.1 Why trust is important
2.6.2 Fairness
2.6.3 Transparency
2.6.4 Accountability
2.6.5 Control

In the long term, AI may lead to 'breakthroughs' in numerous fields, says the Institute, from basic and applied science to medicine and advanced systems. However, as well as great promise, increasingly capable intelligent systems create significant ethical challenges (Winfield, 2019a). This section of the report summarises the main ethical, social and legal considerations in the deployment

AMSCE-1101

of AI, drawing insights from relevant academic literature. The issues discussed deal with impacts on: human society; human psychology; the financial system; the legal system; the environment and the planet; and impacts on trust.

2.1. Impact on society

2.1.1. The labour market

People have been concerned about the displacement of workers by technology for centuries. Automation, and then mechanisation, computing, and more recently AI and robotics have been predicted to destroy jobs and create irreversible damage to the labour market. Leontief (1983), observing the dramatic improvements in the processing power of computer chips, worried that people would be replaced by machines, just as horses were made obsolete by the invention of internal combustion engines. In the past, however, automation has often substituted for human labour in the short term, but has led to the creation of jobs in the long term (Autor, 2015).

Nevertheless, there is widespread concern that artificial intelligence and associated technologies could create mass unemployment during the next two decades. One recent paper concluded that new information technologies will put 'a substantial share of employment, across a wide range of occupations, at risk in the near future' (Frey and Osborne, 2013).

AI is already widespread in finance, space exploration, advanced manufacturing, transportation, energy development and healthcare. Unmanned vehicles and autonomous drones are also performing functions that previously required human intervention. We have already seen the impact of automation on 'blue-collar' jobs; however, as computers become more sophisticated, creative, and versatile, more jobs will be affected by technology and more positions made obsolete.

Impact on economic growth and productivity

Economists are generally enthusiastic about the prospects of AI on economic growth. Robotics added an estimated 0.4 percentage points of annual GDP growth and labour productivity for 17 countries between 1993 and 2007, which is of a similar magnitude to the impact of the introduction of steam engines on growth in the United Kingdom (Graetz and Michaels, 2015).

Impact on the workforce

It is hard to quantify the effect that robots, AI and sensors will have on the workforce because we are in the early stages of the technology revolution. Economists also disagree on the relative impact of AI and robotics. One study asked 1,896 experts about the impact of emerging technologies; 48 percent believed that robots and digital agents would displace significant numbers of both 'blue' and 'white' collar workers, with many expressing concern that this would lead to vast increases in income inequality, large numbers of unemployable people, and breakdowns in the social order (Smith and Anderson, 2014). However, the other half of the experts who responded to this survey (52%) expected that technology would *not* displace more jobs than it created by 2025. Those experts believed that although many jobs currently performed by humans will be substantially taken over by robots or digital agents, they have faith that human ingenuity will create new jobs, industries, and ways to make a living.

Some argue that technology is already producing major changes in the workforce:

> *'Technological progress is going to leave behind some people, perhaps even a lot of people, as it races ahead… there's never been a better time to be a worker with special skills or the right education because these people can use technology to create and capture value. However, there's never been a worse time to be a worker with only 'ordinary' skills and abilities to offer, because computers, robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rate' (Brynjolfsson and McAfee, 2014).*

AMSCE-IOT

Ford (2009) issues an equally strong warning, and argues that:

> *'as technology accelerates, machine automation may ultimately penetrate the economy to the extent that wages no longer provide the bulk of consumers with adequate discretionary income and confidence in the future. If this issue is not addressed, the result will be a downward economic spiral'. He warns that 'at some point in the future — it might be many years or decades from now — machines will be able to do the jobs of a large percentage of the 'average' people in our population, and these people will not be able to find new jobs'.*

However, some economists dispute these claims, saying that although many jobs will be lost through technological improvements, new ones will be created. According to these individuals, the job gains and losses will even out over the long run.

> *'There may be fewer people sorting items in a warehouse because machines can do that better than humans. But jobs analysing big data, mining information, and managing data sharing networks will be created' (West, 2018).*

If AI led to economic growth, it could create demand for jobs throughout the economy, including in ways that are not directly linked to technology. For example, the share of workers in leisure and hospitality sectors could increase if household incomes rose, enabling people to afford more meals out and travel (Furman and Seamans, 2018).

Regardless, it is clear that a range of sectors will be affected. Frey and Osborne (2013) calculate that there is a high probability that 47 percent of U.S. workers will see their jobs become automated over the next 20 years. According to their analysis, telemarketers, title examiners, hand sewers, mathematical technicians, insurance underwriters, watch repairers, cargo agents, tax preparers, photographic process workers, new accounts clerks, library technicians, and data-entry specialists have a 99 percent chance of having their jobs computerised. At the other end of the spectrum, recreational therapists, mechanic supervisors, emergency management directors, mental health social workers, audiologists, occupational therapists, health care social workers, oral surgeons, firefighter supervisors and dieticians have less than a one percent chance of this.

In a further study, the team surveyed 156 academic and industry experts in machine learning, robotics and intelligent systems, and asked them what tasks they believed could currently be automated (Duckworth et al., 2019). They found that work that is clerical, repetitive, precise, and perceptual can increasingly be automated, while work that is more creative, dynamic, and human oriented tends to be less 'automatable'.

Worryingly, eight times as much work fell between 'mostly' and 'completely' automatable than between 'mostly not' and 'not at all' automatable, when weighted by employment. Activities classified as 'reasoning and decision making' and 'coordinating, developing, managing, and advising' were less likely than others to be automatable, while 'administering', 'information and data processing' and 'performing complex and technical activities' were likely to be more so.

Overall the model predicted very high automation potential for office, administrative support, and sales occupations, which together employ about 38 million people in the U.S. Also at high risk of automation were physical processes such as production, farming, fishing and forestry, and transportation and material moving, which employ about 20 million people in total. In contrast, occupations that were robust to automation included education, legal, community service, arts, and media occupations, and to a lesser extent, management, business, and financial occupations.

Unsurprisingly, the study found that occupations with the highest salaries and levels of education tend to be the least amenable to automation. However, even this does not guarantee that an occupation's activities cannot be automated. As the authors point out, air traffic controllers earn

AMSCE-101

about US$125,000 a year, but it is thought that their tasks could largely be automated. In contrast, preschool teachers and teaching assistants earn under $30,000 a year, yet their roles are not thought to be amenable to automation.

Labour-market discrimination: effects on different demographics

The impacts of these sizeable changes will not be felt equally by all members of society. Different demographics will be affected to varying extents, and some are more at risk than others from emerging technologies. Those with few technical skills or specialty trades will face the most difficulties (UK Commission for Employment and Skills, 2014). Young people entering the labour market will also be disproportionately affected, since they are at the beginning of their careers and they will be the first generation to work alongside AI (Biavaschi et al., 2013). Even though many young people have time to acquire relevant expertise, few gain training in science, technology, engineering, and math (STEM) fields, limiting their ability to withstand employment alterations. According to the U.S. Department of Education (2014), there will be a 14 percent increase in STEM jobs between 2010 and 2020 — but 'only 16 percent of American high school seniors are proficient in mathematics and interested in a STEM career'.

Women may also be disproportionately affected, as more women work in caregiving positions — one of the sectors likely to be affected by robots. Due to discrimination, prejudice and lack of training, minorities and poor people already suffer high levels of unemployment: without high-skill training, it will be more difficult for them to adapt to a new economy. Many of these individuals also lack access to high-speed Internet, which limits their ability to access education, training and employment (Robinson et al., 2015).

Special Eurobarometer survey 460 identified that EU residents have a largely positive response to the increasing use of digital technology, considering it to improve society, the economy, and their quality of life, and that most also consider themselves competent enough to make use of this technology in various aspects of their life and work (European Commission, 2017). However, crucially, this attitude varied by age, location, and educational background — a finding that is central to the issue of how AI will affect different demographics and the potential issues arising around the 'digital divide'.

For instance, young men with high levels of education are the most likely to hold positive views about digitisation and the use of robots — and are also the most likely to have taken some form of protective measure relating to their online privacy and security (thus placing them at lower risk in this area). These kinds of socio-demographic patterns highlight a key area of concern in the increasing development and implementation of AI if nobody is to be disadvantaged or left behind (European Commission, 2017).

Consequences

'When we're talking about 'AI for good', we need to define what 'good' means. Currently, the key performance indicators we look to are framed around GDP. Not to say it's evil, but it's about measuring productivity and exponential profits'. (John Havens)

It is possible that AI and robotic technologies could exacerbate existing social and economic divisions, via putting current job classes at risk, eliminating jobs, causing mass unemployment in automatable job sectors. Discrimination may also be an issue, with young people potentially being disproportionately affected, alongside those without high-skill training.

2.1.2. Inequality

'The biggest question around AI is inequality, which isn't normally included in the debate about AI ethics. It is an ethical issue, but it's mostly an issue of politics – who benefits from AI?' (Jack Stilgoe)

AMSCE-IOL

AI and robotics technology are expected to allow companies to streamline their businesses, making them more efficient and more productive. However, some argue that this will come at the expense of their human workforces. This will inevitably mean that revenues will be split across fewer people, increasing social inequalities. Consequently, individuals who hold ownership in AI-driven companies are set to benefit disproportionately.

Inequality: exploitation of workers

Changes in employment related to automation and digitisation will not be expressed solely via job *losses*, as AI is expected to create many numerous and new forms of employment (Hawksworth and Fertig, 2018), but also in terms of job *quality*. Winfield (2019b) states that new jobs may require highly skilled workers but be repetitive and dull, creating 'white-collar sweatshops' filled with workers performing tasks such as tagging and moderating content – in this way, AI could bring an additional human cost that must be considered when characterising the benefits of AI to society.

Building AI most often requires people to manage and clean up data to instruct the training algorithms. Better (and safer) AI needs huge training data sets and a whole new outsourced industry has sprung up all over the world to meet this need. This has created several new categories of job.

These include: (i) scanning and identifying offensive content for deletion, (ii) manually tagging objects in images in order to create training data sets for machine learning systems (for example, to generate training data sets for driverless car AIs) and (iii) interpreting queries (text or speech) that an AI chatbot cannot understand. Collectively these jobs are sometimes known by the term 'mechanical turk' (so named after the 18th century chess playing automaton that was revealed to be operated by a human chess master hidden inside the cabinet).

When first launched such tasks were offered as a way for people to earn extra money in their spare time, however Gray and Suri (2019) suggest that 20 million individuals are now employed worldwide, via third party contractors, in an on-demand 'gig economy', working outside the protection of labour laws. The jobs are usually scheduled, routed, delivered and paid for online, through application programming interfaces (APIs). There have been a few journalistic investigations into the workers in this field of work[3] – termed 'ghost work' by Harvard researcher Mary L. Gray because of the 'hidden' nature of the value chain providing the processing power on which AI is based (Gray, 2019).

The average consumer of AI technology may never know that a person was part of the process – the value chain is opaque. One of the key ethical issues is that – given the price of the end-products – these temporary workers are being inequitably reimbursed for work that is essential to the functioning of the AI technologies. This may be especially the case where the labour force reside in countries outside the EU or US – there are growing 'data-labelling' industries in both China and Kenya, for example. Another issue is with the workers required to watch and vet offensive content for media platforms such as Facebook and YouTube (Roberts, 2016). Such content can include hate speech, violent pornography, cruelty and sometimes murder of both animals and humans. A news report (Chen, 2017) outlines mental health issues (PTSD-like trauma symptoms, panic attacks and burnout), alongside poor working conditions and ineffective counselling.

This hidden army of piecemeal workers are undertaking work that is at best extremely tedious and poorly paid, at worst, precarious, unhealthy and/or psychologically harmful. Gray's research makes the case that workers in this field still display the desire to invest in work as something more than a single payment transaction, and advises that the economic, social and psychological impacts of 'ghost work' should be dealt with systematically. Making the worker's inputs more transparent in the end-product, ensuring the value chain improves the equitable distribution of benefits, and

AMSCE-IOI

[3] The Verge: https://www.theverge.com/2019/5/13/18563284/mary-gray-ghost-work-microwork-labor-silicon-valley-automation-employment-interview;

ensuring appropriate support structures for those humans-in-the-loop who deal with psychologically harmful content are all important steps to address the ethical issues.

Sharing the benefits

AI has the potential to bring significant and diverse benefits to society (Conn, 2018; UK Government Office for Science, 2015; The Future of Life Institute, n.d.; The White House, 2016) and facilitate, among other things, greater efficiency and productivity at lower cost (OECD, n.d.). The Future of Life Institute (n.d.) states that AI may be capable of tackling a number of the most difficult global issues – poverty, disease, conflict – and thus improve countless lives.

A US report on AI, automation, and the economy (2016) highlights the importance of ensuring that potential benefits of AI do not accumulate unequally, and are made accessible to as many people as possible. Rather than framing the development of AI and automation as leading to an inevitable outcome determined by the technology itself, the report states that innovation and technological change 'does not happen in a vacuum': the future of AI may be shaped not by technological capability, but by a wide range of non-technical incentives (The White House, 2016). Furthermore, the inventor or developer of an AI has great potential to determine its use and reach (Conn, 2018), suggesting a need for inventors to consider the wider potential impacts of their creations.

Automation is more applicable to certain roles than others (Duckworth et al., 2018), placing certain workers at a disadvantage and potentially increasing wage inequality (Acemoglu and Restrepo, 2018). Businesses may be motivated by profitability (Min, 2018) – but, while this may benefit business owner(s) and stakeholders, it may not benefit workers.

Brundage and Bryson (2016) mention the case study of electricity, which they say is sometimes considered analogous to AI. While electricity can make many areas more productive, remove barriers, and bring benefits and opportunity to countless lives, it has taken many decades for electricity to reach some markets, and 'indeed, over a billion [people] still lack access to it'.

To ensure that AI's benefits are distributed fairly – and to avoid a whoever designs it first, wins dynamic – one option may be to pre-emptively declare that AI is not a private good but instead for the benefit of all, suggests Conn (2018). Such an approach would require a change in cultural norms and policy. New national and governmental guidelines could underpin new strategies to harness the beneficial powers of AI for citizens, help navigate the AI-driven economic transition, and retain and strengthen public trust in AI (Min, 2018). Brundage and Bryson (2016) agree with this call for policy and regulation, stating that 'it is not sufficient to fund basic research and expect it to be widely and equitably diffused in society by private actors'. However, such future scenarios are not predetermined, says Servoz (2019), and will be shaped by present-day policies and choices.

The Future of Life Institute (n.d.) lists a number of policy recommendations to tackle the possible 'economic impacts, labour shifts, inequality, technological unemployment', and social and political tensions that may accompany AI. AI-driven job losses will require new retraining programmes and social and financial support for displaced workers; such issues may require economic policies such as universal basic income and robot taxation schemes. The Institute suggests that policies should focus on those most at risk of being left behind – caregivers, women and girls, underrepresented populations and the vulnerable – and on those building AI systems, to target any 'skewed product design, blind spots, false assumptions [and] value systems and goals encoded into machines' (The Future of Life Institute, n.d.).

According to Brundage and Bryson (2016), taking a proactive approach to AI policies is not 'premature, misguided [or] dangerous', given that AI 'is already sufficiently mature technologically to impact billions of lives trillions of times a day'. They suggest that governments seek to improve their related knowledge and rely more on experts; that relevant research is allocated more funding; that policymakers plan for the future, seeking 'robustness and preparedness in the face of uncertainty'; and that AI is widely applied and proactively made accessible (especially in areas of great social value, such as poverty, illness, or clean energy).

Considering the energy industry as an example, AI may be able to modernise the energy grid, improve its reliability, and prevent blackouts by regulating supply and demand at both local and national levels, says Wolfe (2017). Such a 'smart grid' would save energy companies money but also allow consumers to actively monitor their own energy use in real-time and see cost savings, passing the benefits from developer to producer to consumer – and opening up new ways to save, earn, and interact with the energy grid (Gagan, 2018; Jacobs, 2017). Jacobs (2017) discusses the potential for 'prosumers' (those who both produce and consume energy, interacting with the grid in a new way) to help decentralise energy production and be a 'positive disruptive force' in the electricity industry – if energy strategy is regulated effectively via updated policy and management. Giving consumers real-time, accessible data would also help them to select the most cost-efficient tariff for them, say Ramchurn et al. (2013), given that accurately estimating one's yearly consumption and deciphering complex tariffs is a key challenge facing energy consumers. This may therefore have some potential to alleviate energy poverty, given that energy price increases and dependence on a centralised energy supply grid can leave households in fuel poverty (Ramchurn et al., 2013).

Concentration of power among elites

'Does AI have to increase inequality? Could you design systems that target, for example, the needs of the poorest people? If AI was being used to further benefit rich people more than it benefits poor people, which it looks likely to be, or more troublingly, put undue pressure on already particularly marginalised people, then what might we do about that? Is that an appropriate use of AI?' (Jack Stilgoe)

Nemitz (2018) writes that it would be 'naive' to ignore that AI will concentrate power in the hands of a few digital internet giants, as 'the reality of how [most societies] use the Internet and what the Internet delivers to them is shaped by a few mega corporations…the development of AI is dominated exactly by these mega corporations and their dependent ecosystems'.

The accumulation of technological, economic and political power in the hands of the top five players – Google, Facebook, Microsoft, Apple and Amazon – affords them undue influence in areas of society relevant to opinion-building in democracies: governments, legislators, civil society, political parties, schools and education, journalism and journalism education and — most importantly — science and research.

In particular, Nemitz is concerned that investigations into the impact of new technologies like AI on human rights, democracy and the rule of law may be hampered by the power of tech corporations, who are not only shaping the development and deployment of AI, but also the debate on its regulation. Nemitz identifies several areas in which tech giants exert power:

1. **Financial**. Not only can the top five players afford to invest heavily in political and societal influence, they can also afford to buy new ideas and start-ups in the area of AI, or indeed any other area of interest to their business model — something they are indeed doing.
2. **Public discourse.** Tech corporations control the infrastructures through which public discourse takes place. Sites like Facebook and Google increasingly become the main, or even only, source of political information for citizens, especially the younger generation, to the detriment of the fourth estate. The vast majority of advertising revenue now also goes to Google and Facebook, removing the main income of newspapers and rendering investigative journalism unaffordable.

3. **Collecting personal data.** These corporations collect personal data for profit, and profile people based on their behaviour (both online and offline). They know more about us than ourselves or our friends — and they are using and making available this information for profit, surveillance, security and election campaigns.

Overall, Nemitz concludes that

> *'this accumulation of power in the hands of a few — the power of money, the power over infrastructures for democracy and discourse, the power over individuals based on profiling and the dominance in AI innovation…must be seen together, and…must inform the present debate about ethics and law for AI'.*

Bryson (2019), meanwhile, believes this concentration of power could be an inevitable consequence of the falling costs of robotic technology. High costs can maintain diversity in economic systems. For example, when transport costs are high, one may choose to use a local shop rather than find the global best provider for a particular good. Lower costs allow relatively few companies to dominate, and where a few providers receive all the business, they will also receive all of the wealth.

Political instability

Bryson (2019) also notes that the rise of AI could lead to wealth inequality and political upheaval. Inequality is highly correlated with political polarisation (McCarty et al., 2016), and one possible consequence of polarisation is an increase in identity politics, where beliefs are used to signal in-group status or affiliation (Iyengar et al., 2012; Newman et al., 2014). This could unfortunately result in situations where beliefs are more tied to a person's group affiliation than to objective facts, and where faith in experts is lost.

> *'While occasionally motivated by the irresponsible use or even abuse of position by some experts, in general losing access to experts' views is a disaster. No one, however intelligent, can master in their lifetime all human knowledge. If society ignores the stores of expertise it has built up — often through taxpayer-funding of higher education — it sets itself at a considerable disadvantage' (Bryson, 2019).*

2.1.3. Privacy, human rights and dignity

AI will have profound impacts on privacy in the next decade. The privacy and dignity of AI users must be carefully considered when designing service, care and companion robots, as working in people's homes means they will be privy to intensely private moments (such as bathing and dressing). However, other aspects of AI will also affect privacy. Smith (2018), President of Microsoft, recently remarked:

> *'[Intelligent 3] technology raises issues that go to the heart of fundamental human rights protections like privacy and freedom of expression. These issues heighten responsibility for tech companies that create these products. In our view, they also call for thoughtful government regulation and for the development of norms around acceptable uses.'*

Privacy and data rights

'Humans will not have agency and control [over their data] in any way if they are not given the tools to make it happen'. (John Havens)

One way in which AI is already affecting privacy is via Intelligent Personal Assistants (IPA) such as Amazon's Echo, Google's Home and Apple's Siri. These voice activated devices are capable of

AMSCE-101

learning the interests and behaviour of their users, but concerns have been raised about the fact that they are always on and listening in the background.

A survey of IPA customers showed that people's biggest privacy concern was their device being hacked (68.63%), followed by it collecting personal information on them (16%), listening to their conversations 24/7 (10%), recording private conversations (12%), not respecting their privacy (6%), storing their data (6%) and the 'creepy' nature of the device (4%) (Manikonda et al, 2018). However despite these concerns, people were very positive about the devices, and comfortable using them.

Another aspect of AI that affects privacy is Big Data. Technology is now at the stage where long-term records can be kept on anyone who produces storable data — anyone with bills, contracts, digital devices, or a credit history, not to mention any public writing and social media use. Digital records can be searched using algorithms for pattern recognition, meaning that we have lost the default assumption of anonymity by obscurity (Selinger and Hartzog, 2017).

Any one of us can be identified by facial recognition software or data mining of our shopping or social media habits (Pasquale, 2015). These online habits may indicate not just our identity, but our political or economic predispositions, and what strategies might be effective for changing these (Cadwalladr, 2017a,b).

Machine learning allows us to extract information from data and discover new patterns, and is able to turn seemingly innocuous data into sensitive, personal data. For example, patterns of social media use can predict personality categories, political preferences, and even life outcomes (Youyou et al., 2015). Word choice, or even handwriting pressure on a digital stylus, can indicate emotional state, including whether someone is lying (Hancock et al., 2007; Bandyopadhyay and Hazra, 2017). This has significant repercussions for privacy and anonymity, both online and offline.

AI applications based on machine learning need access to large amounts of data, but data subjects have limited rights over how their data are used (Veale et al., 2018). Recently, the EU adopted new General Data Protection Regulations (GDPR) to protect citizen privacy. However, the regulations only apply to personal data, and not the aggregated 'anonymous' data that are usually used to train models.

In addition, personal data, or information about who was in the training set, can in certain cases be reconstructed from a model, with potentially significant consequences for the regulation of these systems. For instance, while people have rights about how their personal data are used and stored, they have limited rights over trained models. Instead, models have been typically thought to be primarily governed by varying intellectual property rights, such as trade secrets. For instance, as it stands, there are no data protection rights nor obligations concerning models in the period after they have been built, but before any decisions have been taken about using them.

This brings up a number of ethical issues. What level of control will subjects have over the data that are collected about them? Should individuals have a right to use the model, or at least to know what it is used for, given their stake in training it? Could machine learning systems seeking patterns in data inadvertently violate people's privacy if, for example, sequencing the genome of one family member revealed health information about other members of the family?
Another ethical issue surrounds how to prevent the identity, or personal information, of an individual involved in training a model from being discovered (for example through a cyber-attack). Veale et al. (2018) argue that extra protections should be given to people whose data have been used to train models, such as the right to access models; to know where they have originated from, and to whom they are being traded or transmitted; the right to erase themselves from a trained model; and the right to express a wish that the model not be used in the future.

AMSCE-IOI

AMSCE-101

Human rights

AI has important repercussions for democracy, and people's right to a private life and dignity. For instance, if AI can be used to determine people's political beliefs, then individuals in our society might become susceptible to manipulation. Political strategists could use this information to identify which voters are likely to be persuaded to change party affiliation, or to increase or decrease their probability of turning out to vote, and then to apply resources to persuade them to do so. Such a strategy has been alleged to have significantly affected the outcomes of recent elections in the UK and USA (Cadwalladr, 2017a; b).

Alternatively, if AI can judge people's emotional states and gauge when they are lying, these people could face persecution by those who do not approve of their beliefs, from bullying by individuals through to missed career opportunities. In some societies, it could lead to imprisonment or even death at the hands of the state.

Surveillance

'Networks of interconnected cameras provide constant surveillance over many metropolitan cities. In the near future, vision-based drones, robots and wearable cameras may expand this surveillance to rural locations and one's own home, places of worship, and even locations where privacy is considered sacrosanct, such as bathrooms and changing rooms. As the applications of robots and wearable cameras expand into our homes and begin to capture and record all aspects of daily living, we begin to approach a world in which all, even bystanders, are being constantly observed by various cameras wherever they go' (Wagner, 2018).

This might sound like a nightmare dystopian vision, but the use of AI to spy is increasing. For example, an Ohio judge recently ruled that data collected by a man's pacemaker could be used as evidence that he committed arson (Moon, 2017). Data collected by an Amazon Alexa device was also used as evidence (Sauer, 2017). Hundreds of connected home devices, including appliances and televisions, now regularly collect data that may be used as evidence or accessed by hackers. Video can be used for a variety of exceedingly intrusive purposes, such as detecting or characterising a person's emotions.

AI may also be used to monitor and predict potential troublemakers. Face recognition capacities are alleged to be used in China, not only to identify individuals, but to identify their moods and states of attention both in re-education camps and ordinary schools (Bryson, 2019). It is possible, such technology could be used to penalise students for not paying attention or penalise prisoners who do not appear happy to comply with their (re)education.

Unfortunately, governments do not always have their citizens' interests at heart. The Chinese government has already used surveillance systems to place over a million of its citizens in re-education camps for the crime of expressing their Muslim identity (Human Rights Watch, 2018). There is a risk that governments fearing dissent will use AI to suppress, imprison and harm individuals.

Law enforcement agencies in India already use 'proprietary, advance hybrid AI technology' to digitise criminal records, and use facial recognition to predict and recognise criminal activity (Marda, 2018; Sathe, 2018). There are also plans to train drones to identify violent behaviour in public spaces, and to test these drones at music festivals in India (Vincent, 2018). Most of these programmes intend to reduce crime rates, manage crowded public spaces to improve safety, and bring efficiency to law enforcement. However, they have clear privacy and human rights implications, as one's appearance and public behaviour is monitored, collected, stored and possibly shared without consent. Not only does the AI discussed operate in the absence of safeguards to prevent misuse, making them ripe for surveillance and privacy violations, they also operate at questionable levels of accuracy. This could lead to false arrests and people from disproportionately vulnerable and marginalised communities being made to prove their innocence.

Freedom of speech

Freedom of speech and expression is a fundamental right in democratic societies. This could be profoundly affected by AI. AI has been widely touted by technology companies as a solution to problems such as hate speech, violent extremism and digital misinformation (Li and Williams, 2018). In India, sentiment analysis tools are increasingly deployed to gauge the tone and nature of speech online, and are often trained to carry out automated content removal (Marda, 2018). The Indian Government has also expressed interest in using AI to identify fake news and boost India's image on social media (Seth 2017). This is a dangerous trend, given the limited competence of machine learning to understand tone and context. Automated content removal risks censorship of legitimate speech; this risk is made more pronounced by the fact that it is performed by private companies, sometimes acting on the instruction of government. Heavy surveillance affects freedom of expression, as it encourages self-censorship.

2.1.4. Bias

AI is created by humans, which means it can be susceptible to bias. Systematic bias may arise as a result of the data used to train systems, or as a result of values held by system developers and users. It most frequently occurs when machine learning applications are trained on data that only reflect certain demographic groups, or which reflect societal biases. A number of cases have received attention for promoting unintended social bias, which has then been reproduced or automatically reinforced by AI systems.

Examples of AI bias

The investigative journalism organisation ProPublica showed that COMPAS, a machine learning based software deployed in the US to assess the probability of a criminal defendant re-offending, was strongly biased against black Americans. The COMPAS system was more likely to incorrectly predict that black defendants would reoffend, while simultaneously, and incorrectly, predicting the opposite in the case of white defendants (ProPublica, 2016).

Researchers have found that automated advertisement distribution tools are more likely to distribute adverts for well-paid jobs to men than women (Datta et al., 2015). AI-informed recruitment is susceptible to bias; an Amazon self-learning tool used to judge job-seekers was found to significantly favour men, ranking them highly (Dastin, 2018). The system had learned to prioritise applications that emphasised male characteristics, and to downgrade applications from universities with a strong female presence.

Many popular image databases contain images collected from just a few countries (USA, UK), which can lead to biases in search results. Such databases regularly portray women performing kitchen chores while men are out hunting (Zhao et al, 2017), for example, and searches for 'wedding gowns' produce the standard white version favoured in western societies, while Indian wedding gowns are categorised as 'performance art' or 'costumes' (Zhou 2018). When applications are programmed with this kind of bias, it can lead to situations such as a camera automatically warning a photographer that their subject has their eyes closed when taking a photo of an Asian person, as the camera has been trained on stereotypical, masculine and light-skinned appearances.

ImageNet, which has the goal of mapping out a world of objects, is a vast dataset of 14.1 million images organised into over 20,000 categories – the vast majority of which are plants, rocks, animals. Workers have sorted 50 images a minute into thousands of categories for ImageNet – at such a rate

AMSCE-101

there is large potential for inaccuracy. Problematic, inaccurate – and discriminatory - tagging (see Discrimination above) can be maintained in datasets over many iterations

There have been a few activities that have demonstrated the bias contained in data training sets. One is a facial recognition app (ImageNet Roulette)[4] which makes assumptions about you based entirely on uploaded photos of your face – everything from your age and gender to profession and even personal characteristics. It has been critiqued for its offensive, inaccurate and racist labelling – but the creators say that it is an interface that shows users how a machine learning model is interpreting the data and how results can be quite disturbing.[5]

Implications

As many machine-learning models are built from human-generated data, human biases can easily result in a skewed distribution in training data. Unless developers work to recognise and counteract these biases, AI applications and products may perpetuate unfairness and discrimination. AI that is biased against particular groups within society can have far-reaching effects. Its use in law enforcement or national security, for example, could result in some demographics being unfairly imprisoned or detained. Using AI to perform credit checks could result in some individuals being unfairly refused loans, making it difficult for them to escape a cycle of poverty (O'Neil 2016). If AI is used to screen people for job applications or university admissions it could result in entire sections of society being disadvantaged.

This problem is exacerbated by the fact that AI applications are usually 'black boxes', where it is impossible for the consumer to judge whether the data used to train them are fair or representative. This makes biases hard to detect and handle. Consequently, there has been much recent research on making machine learning fair, accountable and transparent, and more public-facing activities and demonstrations of this type would be beneficial.

2.1.5 Democracy

As already discussed, the concentration of technological, economic and political power among a few mega corporations could allow them undue influence over governments — but the adoption and implementation of AI could threaten democracy in other ways too.

Fake news and social media

Throughout history, political candidates campaigning for office have relied on limited anecdotal evidence and surveys to give them an insight into what voters are thinking. Now with the advent of Big Data, politicians have access to huge amounts of information that allow them to target specific categories of voters and develop messaging that will resonate with them most.

This may be a good thing for politicians, but there is a great deal of evidence that AI-powered technologies have been systematically misused to manipulate citizens in recent elections, damaging democracy. For example, 'bots' — autonomous accounts — were used to spread biased news and propaganda via Twitter in the run up to both the 2016 US presidential election and the Brexit vote in the United Kingdom (Pham, Gorodnichenko and Talavera, 2018). Some of these automated accounts were set up and operated from Russia and were, to an extent, able to bias the content viewed on social media, giving a false impression of support.

During the 2016 US presidential election, pro-Trump bots have been found to have infiltrated the online spaces used by pro-Clinton campaigners, where they spread highly automated content,

[4] Created by artist Trevor Paglen and Professor Kate Crawford and New York University.

[5] https://www.vice.com/en_uk/article/xweagk/ai-face-app-imagenet-roulette

generating one-quarter of Twitter traffic about the 2016 election (Hess, 2016). Bots were also largely responsible for popularising #MacronLeaks on social media just days before the 2017 French presidential election (Polonski, 2017). They bombarded Facebook and Twitter with a mix of leaked information and falsified reports, building the narrative that Emmanuel Macron was a fraud and hypocrite.

A recent report found that at least 28 countries — including both authoritarian states and democracies — employ 'cyber troops' to manipulate public opinion over major social networking applications (Bradshaw and Howard, 2017). These cyber troops use a variety of tactics to sway public opinion, including verbally abusing and harassing other social media users who express criticism of the government. In Russia, cyber troops have been known to target journalists and political dissidents, and in Mexico, journalists are frequently targeted and harassed over social media by government-sponsored cyber troops (O'Carrol, 2017). Others use automated bots — according to Bradshaw and Howard (2017), bots have been deployed by government actors in Argentina, Azerbaijan, Iran, Mexico, the Philippines, Russia, Saudi Arabia, South Korea, Syria, Turkey and Venezuela. These bots are often used to flood social media networks with spam and 'fake' or biased news, and can also amplify marginal voices and ideas by inflating the number of likes, shares and retweets they receive, creating an artificial sense of popularity, momentum or relevance. According to the authors, authoritarian regimes are not the only or even the best at organised social media manipulation.

In addition to shaping online debate, AI can be used to target and manipulate individual voters. During the U.S. 2016 presidential election, the data science firm Cambridge Analytica gained access to the personal data of more than 50 million Facebook users, which they used to psychologically profile people in order to target adverts to voters they thought would be most receptive.
There remains a general distrust of social media among members of the public across Europe, and its content is viewed with caution; a 2017 Eurobarometer survey found that just 7% of respondents deemed news stories published on online social platforms to be generally trustworthy (European Commission, 2017). However, a representative democracy depends on free and fair elections in which citizens can vote without manipulation — and AI threatens to undermine this process.

News bubbles and echo chambers

The media increasingly use algorithmic news recommenders (ANR) to target customised news stories to people based on their interests (Thurman, 2011; Gillespie, 2014). However presenting readers with news stories based on their previous reading history lowers the chance of people encountering different and undiscovered content, opinions and viewpoints (Harambam et al., 2018). There is a danger this could result in increasing societal polarisation, with people essentially living in 'echo chambers' and 'filter bubbles' (Pariser, 2011) where they are only exposed to their own viewpoints. The interaction of different ideas and people is considered crucial to functioning democracies.

The end of democracies

Some commentators have questioned whether democracies are particularly suited to the age of AI and machine learning, and whether its deployment will enable countries with other political systems to gain the advantage (Bartlett, 2018). For the past 200 years democracies have flourished because individual freedom is good for the economy. Freedom promotes innovation, boosting the economy and wealth, and creating well-off people who value freedom. However, what if that link was weakened? What if economic growth in the future no longer depended on individual freedom and entrepreneurial spirit?

A centrally planned, state-controlled economy may well be better suited to a new AI age, as it is less concerned with people's individual rights and privacy. For example, the size of the country's population means that Chinese businesses have access to huge amounts of data, with relatively few restraints on how those data can be used. In China, there are no privacy or data protection laws, such as the new GDPR rules in Europe. As China could soon become the world leader in AI, this means it could shape the future of the technology and the limits on how it is used.

'The last few years suggest digital technology thrives perfectly well under monopolistic conditions: the bigger a company is, the more data and computing power it gets, and the more efficient it becomes; the more efficient it becomes, the more data and computing power it gets, in a self-perpetuating loop' (Bartlett, 2018). According to Bartlett, people's love affair with 'convenience' means that if a 'machinocracy' was able to deliver wealth, prosperity and stability, many people would probably be perfectly happy with it.

2.2 Impact on human psychology

AI is getting better and better at modelling human thought, experience, action, conversation and relationships. In an age where we will frequently interact with machines as if they are humans, what will the impact be on real human relationships?

2.2.1 Relationships

Relationships with others form the core of human existence. In the future, robots are expected to serve humans in various social roles: nursing, housekeeping, caring for children and the elderly, teaching, and more. It is likely that robots will also be designed for the explicit purpose of sex and companionship. These robots may be designed to look and talk just like humans. People may start to form emotional attachments to robots, perhaps even feeling love for them. If this happens, how would it affect human relationships and the human psyche?

Human-robot relationships

'The biggest risk [of AI] that anyone faces is the loss of ability to think for yourself. We're already seeing people are forgetting how to read maps, they're forgetting other skills. If we've lost the ability to be introspective, we've lost human agency and we're spinning around in circles'. (John Havens)

One danger is that of **deception** and **manipulation**. Social robots that are loved and trusted could be misused to manipulate people (Scheutz 2012); for example, a hacker could take control of a personal robot and exploit its unique relationship with its owner to trick the owner into purchasing products. While humans are largely prevented from doing this by feelings like empathy and guilt, robots would have no concept of this.

Companies may design future robots in ways that enhance their trustworthiness and appeal. For example, if it emerged that humans are reliably more truthful with robots[6] or conversational AIs (chatbots) than they are with other humans, it would only be a matter of time before robots were used to interrogate humans — and if it emerged that robots are generally more believable than humans, then robots would likely be used as sales representatives.

It is also possible that people could become psychologically dependent on robots. Technology is known to tap into the reward functions of the brain, and this addiction could lead people to perform actions they would not have performed otherwise.

AMSCE-101

[6] The word's first chatbot ELIZA, developed by AI pioneer Joseph Weizenbaum showed that many early users were convinced of ELIZA's intelligence and understanding, despite Weizenbaum's insistence to the contrary.

It may be difficult to predict the psychological effects of forming a relationship with a robot. For example, Borenstein and Arkin (2019) ask how a 'risk-free' relationship with a robot may affect the mental and social development of a user; presumably, a robot would not be programmed to break up with a human companion, thus theoretically removing the emotional highs and lows from a relationship.

Enjoying a friendship or relationship with a companion robot may involve mistaking, at a conscious or unconscious level, the robot for a real person. To benefit from the relationship, a person would have to 'systematically delude themselves regarding the real nature of their relation with the [AI]' (Sparrow, 2002). According to Sparrow, indulging in such 'sentimentality of a morally deplorable sort' violates a duty that we have to ourselves to apprehend the world accurately. Vulnerable people would be especially at risk of falling prey to this deception (Sparrow and Sparrow, 2006).

Human-human relationships

Robots may affect the stability of marital or sexual relationships. For instance, feelings of jealousy may emerge if a partner is spending time with a robot, such as a 'virtual girlfriend' (chatbot avatar). Loss of contact with fellow humans and perhaps a withdrawal from normal everyday relationships is also a possibility. For example, someone with a companion robot may be reluctant to go to events (say, a wedding) where the typical social convention is to attend as a human-human couple. People in human-robot relationships may be stigmatised.

There are several ethical issues brought about by humans forming relationships with robots:

- Could robots change the beliefs, attitudes, and/or values we have about human-human relationships? People may become impatient and unwilling to put the effort into working on human-human relationships when they can have a relationship with a 'perfect' robot and avoid these challenges.

- Could 'intimate robots' lead to an increase in violent behaviour? Some researchers argue that 'sexbots' would distort people's perceptions about the value of a human being, increasing people's desire or willingness to harm others. If we are able to treat robots as instruments for sexual gratification, then we may become more likely to treat other people this way. For example, if a user repeatedly punched a companion robot, would this be unethical (Lalji, 2015)? Would violence towards robots normalise a pattern of behaviour that would eventually affect other humans? However, some argue that robots could be an outlet for sexual desire, reducing the likelihood of violence, or to help recovery from assault.

Machines made to look and act like us could also affect the 'social suite' of capacities we have evolved to cooperate with one another, including love, friendship, cooperation and teaching (Christakis, 2019). In other words, AI could change how loving and kind we are—not just in our direct interactions with the machines in question, but in our interactions with one another. For example, should we worry about the effect of children being rude to digital assistants such as Alexa or Siri? Does this affect how they view or treat others?

Research shows that robots have the capacity to change how cooperative we are. In one experiment, small groups of people worked with a humanoid robot to lay railroad tracks in a virtual world. The robot was programmed to make occasional errors — and to acknowledge them and apologise. Having a clumsy, apologetic robot actually helped these groups perform *better* than control groups, by improving collaboration and communication among the human group members. This was also true in a second experiment, where people in groups containing error-prone robots consistently outperformed others in a problem-solving task (Christakis, 2017).

Both of these studies demonstrate that AI can improve the way humans relate to one another. However, AI can also make us behave less productively and less ethically. In another experiment, Christakis and his team gave several thousand subjects money to use over multiple rounds of an online game. In each round, subjects were told that they could either be selfish and keep their money, or be altruistic and donate some or all of it to their neighbours. If they made a donation, the researchers matched it, doubling the money their neighbours received. Although two thirds of people initially acted altruistically, the scientists found that the group's behaviour could be changed simply by adding just a few robots (posing as human players) that behaved selfishly. Eventually, the human players ceased cooperating with each other. The bots thus converted a group of generous people into selfish ones.

The fact that AI might reduce our ability to work together is concerning, as cooperation is a key feature of our species. 'As AI permeates our lives, we must confront the possibility that it will stunt our emotions and inhibit deep human connections, leaving our relationships with one another less reciprocal, or shallower, or more narcissistic,' says Christakis (2019).

2.2.4 Personhood

As machines increasingly take on tasks and decisions traditionally performed by humans, should we consider giving AI systems 'personhood' and moral or legal agency? One way of programming AI systems is 'reinforcement learning', where improved performance is reinforced with a virtual reward. Could we consider a system to be suffering when its reward functions give it negative input? Once we consider machines as entities that can perceive, feel and act, it is no huge leap to ponder their legal status. Should they be treated like animals of comparable intelligence? Will we consider the suffering of 'feeling' machines?

Scholars have increasingly discussed the legal status(es) of robots and AI systems over the past three decades. However, the debate was reignited recently when a 2017 resolution of the EU parliament invited the European Commission 'to explore, analyse and consider the implications of all possible legal solutions, [including]...creating a specific legal status for robots in the long run, so that at least the most sophisticated autonomous robots could be established as having the status of electronic persons responsible for making good any damage they may cause, and possibly applying electronic personality to cases where robots make autonomous decisions or otherwise interact with third parties independently'.

However, the resolution provoked a number of objections, including an open letter from several 'Artificial Intelligence and Robotics Experts' in April 2018 which stated that 'the creation of a Legal Status of an 'electronic person' for 'autonomous', 'unpredictable' and 'self-learning' robots' should be discarded from technical, legal and ethical perspectives. Attributing electronic personhood to robots risks misplacing moral responsibility, causal accountability and legal liability regarding their mistakes and misuses, said the letter.

The majority of ethics research regarding AI seems to agree that AI machines should not be given moral agency, or seen as persons. Bryson (2018) argues that giving robots moral agency could in itself be construed as an immoral action, as 'it would be unethical to put artefacts in a situation of competition with us, to make them suffer, or to make them unnecessarily mortal'. She goes on to say that

> *'there are substantial costs but little or no benefits from the perspective of either humans or robots to ascribing and implementing either agency or patiency to intelligent artefacts beyond that ordinarily ascribed to any possession. The responsibility for any moral action taken by an artefact should therefore be attributed to its owner or operator, or in case of malfunctions to its manufacturer, just as with conventional artefacts'.*

AMSCE-101

2.3 Impact on the financial system

One of the first domains where autonomous applications have taken off is in financial markets, with most estimates attributing over half of trading volume in US equities to algorithms (Wellman and Rajan, 2017).

Markets are well suited to automation, as they now operate almost entirely electronically, generating huge volumes of data at high velocity, which require algorithms to digest. The dynamism of markets means that timely response to information is critical, providing a strong incentive to take slow humans out of the decision loop. Finally, and perhaps most obviously, the rewards available for effective trading decisions are considerable, explaining why firms have invested in this technology to the extent that they have. In other words, algorithmic trading can generate profits at a speed and frequency that is impossible for a human trader.

Although today's autonomous agents operate within a relatively narrow scope of competence and autonomy, they nevertheless take actions with consequences for people.

A well-known instance is that of Knight Capital Group. During the first 45 minutes of the trading day on 1 August 2012, while processing 212 small orders from customers, an automated trading agent developed by and operating on behalf of Knight Capital erroneously submitted millions of orders to the equity markets. Over four million transactions were executed in the financial markets as a result, leading to billions of dollars in net long and short positions. The company lost $460 million on the unintended trades, and the value of its own stock fell by almost 75%.

Although this is an example of an accidental harm, autonomic trading agents could also be used maliciously to destabilise markets, or otherwise harm innocent parties. Even if their use is not intended to be malicious, the autonomy and adaptability of algorithmic trading strategies, including the increasing use of sophisticated machine learning techniques makes it difficult to understand how they will perform in unanticipated circumstances.

Market manipulation

King et al. (2019) discuss several ways in which autonomous financial agents could commit financial crimes, including market manipulation, which is defined as 'actions and/or trades by market participants that attempt to influence market pricing artificially' (Spatt, 2014).

Simulations of markets comprising artificial trading agents have shown that, through reinforcement learning, an AI can learn the technique of order-book spoofing, which involves placing orders with no intention of ever executing them in order to manipulate honest participants in the marketplace (Lin, 2017).

Social bots have also been shown to exploit markets by artificially inflating stock through fraudulent promotion, before selling its position to unsuspecting parties at an inflated price (Lin 2017). For instance, in a recent prominent case a social bot network's sphere of influence was used to spread disinformation about a barely traded public company. The company's value gained more than 36,000% when its penny stocks surged from less than $0.10 to above $20 a share in a matter of few weeks (Ferrara 2015).

Collusion

Price fixing, a form of collusion may also emerge in automated systems. As algorithmic trading agents can learn about pricing information almost instantaneously, any action to lower a price by

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one agent will likely be instantaneously matched by another. In and of itself, this is no bad thing and only represents an efficient market. However, the possibility that lowering a price will result in your competitors simultaneously doing the same thing acts as a disincentive. Therefore, algorithms (if they are rational) will maintain artificially and tacitly agreed higher prices, by not lowering prices in the first place (Ezrachi and Stucke, 2016). Crucially, for collusion to take place, an algorithm does not need to be designed specifically to collude.

Accountability

While the responsibility for trading algorithms rests with the organisations' that develop and deploy them, autonomous agents may perform actions — particularly in unusual circumstances — that would have been difficult to anticipate by their programmers. Does that difficulty mitigate responsibility to any degree?

For example, Wellman and Rajan (2017) give the example of an autonomous trading agent conducting an arbitrage operation, which is when a trader takes advantage of a discrepancy in prices for an asset in order to achieve a near-certain profit. Theoretically, the agent could attempt to instigate arbitrage opportunities by taking malicious actions to subvert markets, for example by propagating misinformation, obtaining improper access to information, or conducting direct violations of market rules

Clearly, it would be disadvantageous for autonomous trading agents to engage in market manipulation, however could an autonomous algorithm even meet the legal definition of market manipulation, which requires 'intent'?

Wellmen and Rajan (2017) argue that trading agents will become increasingly capable of operating at wider levels without human oversight, and that regulation is now needed to prevent societal harm. However, attempts to regulate or legislate may be hampered by several issues.

2.4 Impact on the legal system

The creation of AI machines and their use in society could have a huge impact on criminal and civil law. The entire history of human laws has been built around the assumption that people, and not robots, make decisions. In a society in which increasingly complicated and important decisions are being handed over to algorithms, there is the risk that the legal frameworks we have for liability will be insufficient.

Arguably, the most important near-term legal question associated with AI is who or what should be liable for tortious, criminal, and contractual misconduct involving AI and under what conditions.

2.4.1 Criminal law

A crime consists of two elements: a voluntary criminal act or omission (*actus reus*) and an intention to commit a crime (*mens rea*)**.** If robots were shown to have sufficient awareness, then they could be liable as direct perpetrators of criminal offenses, or responsible for crimes of negligence. If we admit that robots have a mind of their own, endowed with human-like free will, autonomy or moral sense, then our whole legal system would have to be drastically amended.

Although this is possible, it is not likely. Nevertheless, robots may affect criminal laws in more subtle ways.

AMSCE-101

Liability

The increasing delegation of decision making to AI will also impact many areas of law for which *mens rea*, or intention, is required for a crime to have been committed.

What would happen, for example if an AI program chosen to predict successful investments and pick up on market trends made a wrong evaluation that led to a lack of capital increase and hence, to the fraudulent bankruptcy of the corporation? As the intention requirement of fraud is missing, humans could only be held responsible for the lesser crime of bankruptcy triggered by the robot's evaluation (Pagallo, 2017).

Existing liability models may be inadequate to address the future role of AI in criminal activities (King et al, 2019). For example, in terms of *actus reus*, while autonomous agents can carry out the criminal act or omission, the voluntary aspect of *actus reus* would not be met, since the idea that an autonomous agent can act voluntarily is contentious. This means that agents, artificial or otherwise could potentially perform criminal acts or omissions without satisfying the conditions of liability for that particular criminal offence.

When criminal liability is fault-based, it also requires *mens rea* (a guilty mind). The *mens rea* may comprise an intention to commit the *actus reus* using an AI-based application, or knowledge that deploying an autonomous agent will or could cause it to perform a criminal action or omission. However, in some cases the complexity of the autonomous agent's programming could make it possible that the designer, developer, or deployer would neither know nor be able to predict the AI's criminal act or omission. This provides a great incentive for human agents to avoid finding out what precisely the machine learning system is doing, since the less the human agents know, the more they will be able to deny liability for both these reasons (Williams 2017).

The actions of autonomous robots could also lead to a situation where a human manifests the *mens rea*, and the robot commits the *actus reus*, splintering the components of a crime (McAllister 2017).

Alternatively, legislators could define criminal liability without a fault requirement. This would result in liability being assigned to the person who deployed the AI regardless of whether they knew about it, or could predict the illegal behaviour. Faultless liability is increasingly used for product liability in tort law (e.g., pharmaceuticals and consumer goods). However, Williams (2017) argues that *mens rea* with intent or knowledge is important, and we cannot simply abandon that key requirement of criminal liability in the face of difficulty in proving it.

Kingston (2018) references a definition provided by Hallevy (2010) on how AI actions may be viewed under criminal law. According to Hallevy, these legal models can be split into three scenarios:

1. *Perpetrator-via-another*. If an offence is committed by an entity that lacks the mental capacity for *mens rea* – a child, animal, or mentally deficient person – then they are deemed an innocent agent. However, if this innocent agent was instructed by another to commit the crime, then the instructor is held criminally liable. Under this model, an AI may be held to be an innocent agent, with either the software programmer or user filling the role of perpetrator-via-another.

2. *Natural-probable-consequence*. This relates to the accomplices of a criminal action; if no conspiracy can be proven, an accomplice may still be held legally liable if the perpetrator's acts were a natural or probable consequence of a scheme encouraged or aided by an accomplice. This scenario may hold when an AI that was designed for a 'good' purpose is misappropriated and commits a crime. For example, a factory line robot may injure a nearby worker they erroneously consider a threat to their programmed mission. In this

case, programmers may be held liable as accomplices if they knew that a criminal offence was a natural or probable consequence of their program design or use. This would not hold for an AI that was programmed to do a 'bad' thing, but to those that are misappropriated. Anyone capable and likely of foreseeing an AI being used in a specific criminal way may be held liable under this scenario: the programmer, the vendor, the service provider, or the user (assuming that the system limitations and possible consequences of misuse are spelt out in the AI instructions – which is unlikely).

3. *Direct liability*. This model attributes both *actus* and *mens rea* to an AI. However, while *actus rea* (the action or inaction) is relatively simple to attribute to an AI, says Kingston (2018), attributing *mens rea* (a guilty mind) is more complex. For example, the AI program 'driving' an autonomous vehicle that exceeds the speed limit could be held criminally liable for speeding – but for strict liability scenarios such as this, no criminal intent is required, and it is not necessary to prove that the car sped knowingly. Kingston also flags a number of possible issues that arise when considering AI to be directly liable. For example, could an AI infected by a virus claim a defence similar to coercion or intoxication, or an AI that is malfunctioning claim a defence akin to insanity? What would punishment look like – and who would be punished?

Identifying who exactly would be held liable for an AI's actions is important, but also potentially difficult. For example, 'programmer' could apply to multiple collaborators, or be widened to encompass roles such as program designer, product expert, and their superiors – and the fault may instead lie with a manager that appointed an inadequate expert or programmer (Kingston, 2010).

Psychology

There is a risk that AI robots could manipulate a user's mental state in order to commit a crime. This was demonstrated by Weizenbaum (1976) who conducted early experiments into human–bot interactions where people revealed unexpectedly personal details about their lives. Robots could also normalise sexual offences and crimes against people, such as the case of certain sexbots (De Angeli, 2009).

Commerce, financial markets and insolvency

As discussed earlier in this report, there are concerns that autonomous agents in the financial sector could be involved in market manipulation, price fixing and collusion. The lack of intention by human agents, and the likelihood that autonomous agents (AAs) may act together also raises serious problems with respect to liability and monitoring. It would be difficult to prove that the human agent intended the AA to manipulate markets, and it would also be difficult to monitor such manipulations. The ability of AAs to learn and refine their capabilities also implies that these agents may evolve new strategies, making it increasingly difficult to detect their actions (Farmer and Skouras 2013).

Harmful or Dangerous Drugs

In the future AI could be used by organised criminal gangs to support the trafficking and sale of banned substances. Criminals could use AI equipped unmanned vehicles and autonomous navigation technologies to smuggle illicit substances. Because smuggling networks are disrupted by monitoring and intercepting transport lines, law enforcement becomes more difficult when unmanned vehicles are used to transport contraband. According to Europol (2017), drones present a real threat in the form of automated drug smuggling. Remote-controlled cocaine-trafficking submarines have already been discovered and seized by US law enforcement (Sharkey et al., 2010).

AMSCE-1101

Unmanned underwater vehicles (UUVs) could also be used for illegal activities, posing a significant threat to enforcing drug prohibitions. As UUVs can act independently of an operator (Gogarty and Hagger, 2008), it would make it more difficult to catch the criminals involved.

Social bots could also be used to advertise and sell pornography or drugs to millions of people online, including children.

Offences Against the Person

Social bots could also be used to harass people. Now that AI can generate more sophisticated fake content, new forms of harassment are possible. Recently, developers released software that produces synthetic videos where a person's face can be accurately substituted for another's. Many of these synthetic videos are pornographic and there is now the risk that malicious users may synthesise fake content in order to harass victims (Chesney and Citron 2018).

AI robots could also be used to torture and interrogate people, using psychological (e.g., mimicking people known to the torture subject) or physical torture techniques (McAllister 2017). As robots cannot understand pain or experience empathy, they will show no mercy or compassion. The mere presence of an interrogation robot may therefore cause the subject to talk out of fear. Using a robot would also serve to distance the human perpetrator from the *actus reus,* and emotionally distance themselves from their crime, making torture more likely.

As unthinking machines, AAs cannot bear moral responsibility or liability for their actions. However, one solution would be to take the approach of *strict* criminal liability, where punishment or damages may be imposed without proof of fault, which would lower the intention-threshold for the crime. However even under a strict liability framework, the question of who exactly should face imprisonment for AI-caused offences against a person is difficult. It is clear that an AA cannot be held liable. Yet, the number of actors involved creates a problem in ascertaining where the liability lies—whether with the person who commissioned and operated the AA, or its developers, or the legislators and policymakers who sanctioned real-world deployment of such agents (McAllister 2017).

Sexual Offences

There is a danger that AI embodied robots could be used to promote sexual objectification, sexual abuse and violence. As discussed in section 2.1, sexbots could allow people to simulate sexual offences such as rape fantasies. They could even be designed to emulate sexual offences, such as adult and child rape (Danaher 2017).

Interaction with social bots and sexbots could also desensitise a perpetrator towards sexual offences, or even heighten their desire to commit them (De Angeli 2009; Danaher 2017).

AMSCE-101

Who is responsible?

When considering the possible consequences and misuse of an AI, the key question is: *who is responsible for the actions of an AI*? Is it the programmers, manufacturers, end users, the AI itself, or another? Is the answer to this question the same for all AI or might it differ, for example, for systems capable of learning and adapting their behaviour?

According to the European Parliament Resolution (2017) on AI, legal responsibility for an AI's action (or inaction) is traditionally attributed to a human actor: the owner, developer, manufacturer or operator of an AI, for instance. For example, self-driving cars in Germany are currently deemed the responsibility of their owner. However, issues arise when considering third-party involvement, and advanced systems such as self-learning neural networks: if an action cannot be predicted by the developer because an AI has sufficiently changed from their design, can a developer be held responsible for that action? Additionally, current legislative infrastructure and the lack of effective regulatory mechanisms pose a challenge in regulating AI and assigning blame, say Atabekov and Yastrebov (2018), with autonomous AI in particular raising the question of whether a new legal category is required to encompass their features and limitations (European Parliament, 2017).

Taddeo and Floridi (2018) highlight the concept of 'distributed agency'. As an AI's actions or decisions come about following a long, complex chain of interactions between both human and robot – from developers and designers to manufacturers, vendors and users, each with different motivations, backgrounds, and knowledge – then an AI outcome may be said to be the result of distributed agency. With distributed agency comes distributed responsibility. One way to ensure that AI works towards 'preventing evil and fostering good' in society may be to implement a moral framework of distributed responsibility that holds all agents accountable for their role in the outcomes and actions of an AI (Taddeo and Floridi, 2018).

Different applications of AI may require different frameworks. For example, when it comes to military robots, Lokhorst and van den Hoven (2014) suggest that the primary responsibility lies with a robot's designer and deployer, but that a robot may be able to hold a certain level of responsibility for its actions.

Learning machines and autonomous AI are other crucial examples. Their use may create a 'responsibility gap', says Matthias (2004), where the manufacturer or operator of a machine may, in principle, be unable to predict a given AI's future behaviour – and thus cannot be held responsible for it in either a legal or moral sense. Matthias proposes that the programmer of a neural network, for instance, increasingly becomes the 'creator of software organisms', with very little control past the point of coding. The behaviour of such AI deviates from the initial programming to become a product of its interactions with its environment – the clear distinction between the phases of programming, training, and operation may be lost, making the ascription of blame highly complex and unclear. This responsibility gap requires the development and clarification of appropriate moral practice and legislation alongside the deployment of learning automata (Matthias, 2004). This is echoed by Scherer (2016), who states that AI has so far been developed in 'a regulatory vacuum', with few laws or regulations designed to explicitly address the unique challenges of AI and responsibility.

Theft and fraud, and forgery and impersonation

AI could be used to gather personal data, and forge people's identities. For example, social media bots that add people as 'friends' would get access to their personal information, location, telephone number, or relationship history (Bilge et al., 2009). AI could manipulate people by building rapport with them, then exploiting that relationship to obtain information from or access to their computer (Chantler and Broadhurst 2006).

AI could also be used to commit banking fraud by forging a victim's identity, including mimicking a person's voice. Using the capabilities of machine learning, Adobe's software is able to learn and reproduce people's individual speech pattern from a 20-min recording of that person's voice. Copying the voice of the customer could allow criminals to talk to the person's bank and make transactions.

2.4.2 Tort law

Tort law covers situations where one person's behaviour causes injury, suffering, unfair loss, or harm to another person. This is a broad category of law that can include many different types of personal injury claims.

Tort laws serve two basic, general purposes: 1) to compensate the victim for any losses caused by the defendant's violations; and 2) to deter the defendant from repeating the violation in the future.

Tort law will likely come into sharp focus in the next few years as self-driving cars emerge on public roads. In the case of self-driving autonomous cars, when an accident occurs there are two areas of law that are relevant - negligence and product liability.

Today most accidents result from driver error, which means that liability for accidents are governed by negligence principles (Lin et al, 2017). Negligence is a doctrine that holds people liable for acting unreasonably under the circumstances (Anderson et al, 2009). To prove a negligence claim, a plaintiff must show that:

- A duty of care is owed by the defendant to the plaintiff
- There has been a breach of that duty by the defendant
- There is a causal link between the defendant's breach of duty and the plaintiff's harm, and;
- That the plaintiff has suffered damages as a result.

Usually insurance companies determine the at fault party, avoiding a costly lawsuit. However this is made much more complicated if a defect in the vehicle caused the accident. In the case of self-driving cars, accidents could be caused by hardware failure, design failure or a software error – a defect in the computer's algorithms.

Currently, if a collision is caused by an error or defect in a computer program, the manufacturer would be held responsible under the Product Liability doctrine, which holds manufacturers, distributors, suppliers, retailers, and others who make products available to the public responsible for the injuries those products cause.

As the majority of autonomous vehicle collisions are expected to be through software error, the defect would likely have to pass the 'risk-utility test' (Anderson et al., 2010), where a product is defective if the foreseeable risks of harm posed by the product could have been reduced or avoided by the adoption of a reasonable alternative design by the seller, and the omission of the alternative design renders the product not reasonably safe.

AMSCE-1101

However, risk-utility test cases, which are needed to prove design defects are complex and require many expert witnesses, making design defect claims expensive to prove (Gurney et al, 2013). The nature of the evidence, such as complex algorithms and sensor data is also likely to make litigation especially challenging and complex.

This means the methods used to recover damages for car accidents would have to switch from an established, straightforward area of the law into a complicated and costly area of law (products liability). A plaintiff would need multiple experts to recover and find the defect in the algorithm, which would have implications for even the most straightforward of autonomous vehicle accidents. This would likely affect the ability of victims to get compensation and redress for injuries sustained in car accidents.

2.5 Impact on the environment and the planet

AI and robotics technologies require considerable computing power, which comes with an energy cost. Can we sustain massive growth in AI from an energetic point of view when we are faced with unprecedented climate change?

2.5.1 Use of natural resources

The extraction of nickel, cobalt and graphite for use in lithium ion batteries – commonly found in electrical cars and smartphones - has already damaged the environment, and AI will likely increase this demand. As existing supplies are diminished, operators may be forced to work in more complex environments that are dangerous to human operators – leading to further automation of mining and metal extraction (Khakurel et al., 2018). This would increase the yield, and depletion rate of rare earth metals, degrading the environment further.

2.5.2 Pollution and waste

At the end of their product cycle, electronic goods are usually discarded, leading to a build-up of heavy metals and toxic materials in the environment (O'Donoghue, 2010).

Increasing the production and consumption of technological devices such as robots will exacerbate this waste problem, particularly as the devices will likely be designed with 'inbuilt obsolescence' – a process where products are designed to wear out 'prematurely' so that customers have to buy replacement items – resulting in the generation of large amounts of electronic waste (Khakurel et al., 2018). Planned obsolescence depletes the natural environment of resources such as rare earth metals, while increasing the amount of waste. Sources indicate that in North America, over 100 million cell phones and 300 million personal computers are discarded each year (Guiltinana et al., 2009).

Ways of combating this include 'encouraging consumers to prefer eco-efficient, more sustainable products and services' (World Business Council for Sustainable Development, 2000). However, this is hampered by consumers expecting frequent upgrades, and the lack of consumer concern for environmental consequences when contemplating an upgrade.

2.5.3 Energy concerns

As well as the toll that increased mining and waste will have on the environment, adoption of AI technology, particularly machine learning, will require more and more data to be processed. And that requires huge amounts of energy. In the United States, data centres already account for about 2 percent of all electricity used. In one estimation, DeepMind's AlphaGo – which beat Go Champion Lee Sedol in 2016 – took 50,000 times as much power as the human brain to do so (Mattheij, 2016).

AMSCEL101

AI will also require large amounts of energy for manufacturing and training – for example, it would take many hours to train a large-scale AI model to understand and recognise human language such that it could be used for translation purposes (Winfield, 2019b). According to Strubell, Ganesh, and McCallum (2019), the carbon footprint of training, tuning, and experimenting with a natural language processing AI is over seven times that of an average human in one year, and roughly 1.5 times the carbon footprint of an average car, including fuel, across its entire lifetime.

2.5.4 Ways AI could help the planet

Alternatively AI could actually help us take better care of the planet, by helping us manage waste and pollution. For example, the adoption of autonomous vehicles could reduce greenhouse gas emissions, as autonomous vehicles could be programmed to follow the principles of eco-driving throughout a journey, reducing fuel consumption by as much as 20 percent and reducing greenhouse gas emissions to a similar extent (Iglinski et al., 2017). Autonomous vehicles could also reduce traffic congestion by recommending alternative routes and the shortest routes possible, and by sharing traffic information to other vehicles on the motorways, resulting in less fuel consumption.

There are also applications for AI in conservation settings. For example, deep-learning technology could be used to analyse images of animals captured by motion-sensor cameras in the wild. This information could then be used to provide accurate, detailed, and up-to-date information about the location, count, and behaviour of animals in the wild, which could be useful in enhancing local biodiversity and local conservation efforts (Norouzzadeh et al., 2018).

2.6 Impact on trust

AI is set to change our daily lives in domains such as transportation; the service industry; health-care; education; public safety and security; and entertainment. Nevertheless, these systems must be introduced in ways that build trust and understanding, and respect human and civil rights (Dignum, 2018). They need to follow fundamental human principles and values, and safeguard the well-being of people and the planet.

The overwhelming consensus amongst the research community is that trust in AI can only be attained by fairness, transparency, accountability and regulation. Other issues that impact on trust are how much control we want to exert over AI machines, and if, for example we want to always maintain a human-in the loop, or give systems more autonomy.

While robots and AI are largely viewed positively by citizens across Europe, they also evoke mixed feelings, raising concern and unease (European Commission 2012; European Commission 2017). Two Eurobarometer surveys, which aim to gauge public perception, acceptance, and opinion of specific topics among EU citizens in Member States, have been performed to characterise public attitudes towards robots and AI (survey 382), and towards increasing digitisation and automation (survey 460).

These surveys suggest that there is some way to go before people are comfortable with the widespread use of robots and advanced technology in society. For example, while respondents favoured the idea of prioritising the use of robots in areas that pose risk or difficulty to humans — space exploration, manufacturing, military, security, and search and rescue, for instance — they were very uncomfortable with areas involving vulnerable or dependent areas of society. Respondents opposed the use of robots to care for children, the elderly, and the disabled; for education; and for healthcare, despite many holding positive views of robots in general. The majority of those surveyed were also 'totally uncomfortable' with the idea of having their dog

AMSCE - IOI

walked by a robot, having a medical operation performed by a robot, or having their children or elderly parents minded by a robot — scenarios in which trust is key.

2.6.1 Why trust is important

'In order for AI to reach its full potential, we must allow machines to sometimes work autonomously, and make decisions by themselves without human input', explains Taddeo (2017).

Imagine a society in which there is no trust in doctors, teachers, or drivers. Without trust we would have to spend a significant portion of our lives devoting time and resources to making sure other people, or things were doing their jobs properly (Taddeo, 2017). This supervision would come at the expense of doing our own jobs, and would ultimately create a dysfunctional society.

> *'We trust machine learning algorithms to indicate the best decision to make when hiring a future colleague or when granting parole during a criminal trial; to diagnose diseases and identify a possible cure. We trust robots to take care of our elderly and toddlers, to patrol borders, and to drive or fly us around the globe. We even trust digital technologies to simulate experiments and provide results that advance our scientific knowledge and understanding of the world. This trust is widespread and is resilient. It is only reassessed (rarely broken) in the event of serious negative consequences.' (Taddeo, 2017)*

In fact digital technologies are so pervasive that trusting them is essential for our societies to work properly. Constantly supervising a machine learning algorithm used to make a decision would require significant time and resources, to the point that using digital technologies would become unfeasible. At the same time, however, the tasks with which we trust digital technologies are of such relevance that a complete lack of supervision may lead to serious risks for our safety and security, as well for the rights and values underpinning our societies.

In other words, it is crucial to identify an effective way to trust digital technologies so that we can harness their value, while protecting fundamental rights and fostering the development of open, tolerant, just information societies (Floridi, 2016; Floridi and Taddeo, 2016). This is especially important in hybrid systems involving human and artificial agents.

But how do we find the correct level of trust? Taddeo suggests that in the short term design could play a crucial role in addressing this problem. For example, pop-up messages alerting users to algorithmic search engine results that have taken into account the user's online profile, or messages flagging that the outcome of an algorithm may not be objective. However in the long term, an infrastructure is needed that enforces norms such as fairness, transparency and accountability across all sectors.

2.6.2 Fairness

In order to trust AI it must be fair and impartial. As discussed in section 3.4, as more and more decisions are delegated to AI, we must ensure that those decisions are free from bias and discrimination. Whether it's filtering through CVs for job interviews, deciding on admissions to university, conducting credit ratings for loan companies, or judging the risk of someone reoffending, it's vital that decisions made by AI are fair, and do not deepen already entrenched social inequalities.

But how do we go about making algorithms fair? It's not as easy as it seems. The problem is that it is impossible to know what algorithms based on neural networks are actually learning when you train them with data. For example, the COMPAS algorithm, which assessed how likely someone was to commit a violent crime was found to strongly discriminate against black people. However the

AMSCE-I0I

algorithms were not actually given people's race as an input. Instead the algorithm inferred this sensitive data from other information, e.g. address.

For instance, one study found that two AI programs that had independently learnt to recognise images of horses from a vast library, used totally different approaches (Lapuschkin et al., 2019). While one AI focused rightly on the animal's features, the other based its decision wholly on a bunch of pixels at the bottom left corner of each horse image. It turned out that the pixels contained a copyright tag for the horse pictures. The AI worked perfectly for entirely the wrong reasons.

To devise a fair algorithm, first you must decide what a fair outcome looks like. Corbett-Davies et al. (2017) describe four different definitions of algorithmic fairness for an algorithm that assesses people's risk of committing a crime.

1. Statistical parity - where an equal proportion of defendants are detained in each race group. For example, white and black defendants are detained at equal rates.

2. Conditional statistical parity - where controlling for a limited set of 'legitimate' risk factors, an equal proportion of defendants are detained within each race group. For example, among defendants who have the same number of prior convictions, black and white defendants are detained at equal rates.

3. Predictive equality - where the accuracy of decisions is equal across race groups, as measured by false positive rate. This means that among defendants who would not have gone on to commit a violent crime if released, detention rates are equal across race groups.

4. Calibration - among defendants with a given risk score, the proportion who reoffend is the same across race groups.

However, while it is possible to devise algorithms that satisfy some of these requirements, many notions of fairness conflict with one another, and it is impossible to have an algorithm that meets all of them.

Another important aspect of fairness is to know *why* an automated program made a particular decision. For example, a person has the right to know why they were rejected for a bank loan. This requires transparency. However as we will find out, it is not always easy to find out why an algorithm came to a particular decision – many AIs employ complex 'neural networks' so that even their designers cannot explain how they arrive at a particular answer.

2.6.3 Transparency

A few years ago, a computer program in America assessed the performance of teachers in Houston by comparing their students' test scores against state averages (Sample, 2017). Those with high ratings won praise and even bonuses, while those with low ratings faced being fired. Some teachers felt that the system marked them down without good reason, however they had no way of checking if the program was fair or faulty as the company that built the software, the SAS Institute, considered its algorithm a trade secret and would not disclose its workings. The teachers took their case to court, and a federal judge ruled that the program had violated their civil rights.

This case study highlights the importance of transparency for building trust in AI - it should always be possible to find out *why* an autonomous system made a particular decision, especially if that decision caused harm. Given that real-world trials of driverless car autopilots have already resulted in several fatal accidents, there is clearly an urgent need for transparency in order to discover *how*

AMSCE-101

and *why* those accidents occurred, remedy any technical or operational faults, and establish accountability.

This issue is also prevalent amongst members of the public, especially when it comes to healthcare, a very personal issue for many (European Commission, 2017). For example, across Europe, many express concern over their lack of ability to access their health and medical records; while the majority would be happy to pass their records over to a healthcare professional, far fewer would be happy to do so to a public or private company for the purposes of medical research. These attitudes reflect concerns over trust, data access, and data use — all of which relate strongly to the idea of transparency and of understanding *what* AI gathers, *why*, and *how* one may access the data being gathered about them.

Black boxes

Transparency can be very difficult with modern AI systems, especially those based on deep learning systems. Deep learning systems are based on artificial neural networks (ANNs), a group of interconnected nodes, inspired by a simplification of the way neurons are connected in a brain. A characteristic of ANNs is that, after the ANN has been trained with datasets, any attempt to examine the internal structure of the ANN in order to understand why and how the ANN makes a particular decision is more or less impossible. Such systems are referred to as 'black boxes'.

Another problem is that of how to verify the system to confirm that it fulfils the specified design requirements. Current verification approaches typically assume that the system being verified will never change its behaviour, however systems based on machine learning—by definition—change their behaviour, so any verification is likely to be rendered invalid after the system has learned (Winfield and Jirotka, 2018).

The AI Now Institute at New York University, which researches the social impact of AI, recently released a report which urged public agencies responsible for criminal justice, healthcare, welfare and education to ban black box AIs because their decisions cannot be explained. The report also recommended that AIs should pass pre-release trials and be monitored 'in the wild' so that biases and other faults are swiftly corrected (AI Now Report, 2018).

In many cases, it may be possible to find out how an algorithm came to a particular decision without 'opening the AI black box'. Rather than exposing the full inner workings of an AI, researchers recently developed a way of working out what it would take to change their AI's decision (Wachter et al., 2018). Their method could explain why an AI turned down a person's mortgage application, for example, as it might reveal that the loan was denied because the person's income was £30,000, but would have been approved if it was £45,000. This would allow the decision to be challenged, and inform the person what they needed to address to get the loan.

Kroll (2018) argues that, contrary to the criticism that black-box software systems are inscrutable, algorithms are fundamentally understandable pieces of technology. He makes the point that inscrutability arises from the power dynamics surrounding software systems, rather than the technology itself, which is always built for a specific purpose, and can also always be understood in terms of design and operational goals, and inputs, outputs and outcomes. For example, while it is hard to tell why a particular ad was served to a particular person at a particular time, it is possible to do so, and to not do so is merely a design choice, not an inevitability of the complexity of large systems – systems must be designed so that they support analysis.

Kroll argues that it is possible to place too much focus on understanding the mechanics of a tool, when the real focus should be on how that tool is put to use and in what context.

AMSCE-IOI

Other issues and problems with transparency include the fact that software and data are proprietary works, which means it may not be in a company's best interest to divulge how they address a particular problem. Many companies view their software and algorithms as valuable trade secrets that are absolutely key to maintaining their position in a competitive market.

Transparency also conflicts with privacy, as people involved in training machine learning models may not want their data, or inferences about their data to be revealed. In addition, the lay public, or even regulators may not have the technological know-how to understand and assess algorithms.

Explainable systems

Some researchers have demanded that systems produce explanations of their behaviours (Selbst and Barocas 2018: Wachter et al., 2017; Selbst and Powles, 2017). However, that requires a decision about what must be explained, and to whom. Explanation is only useful if it includes the context behind how the tool is operated. The danger is that explanations focus on the mechanism of how the tool operates at the expense of contextualising that operation.

In many cases, it may be unnecessary to understand the precise mechanisms of an algorithmic system, just as we do not understand how humans make decisions. Similarly, while transparency is often taken to mean the disclosure of source code or data, we don't have to see the computer source code for a system to be transparent, as this would tell us little about its behaviour. Instead transparency must be about the external behaviour of algorithms. This is how we regulate the behaviour of humans — not by looking into their brain's neural circuitry, but by observing their behaviour and judging it against certain standards of conduct.

Explanation may not improve human trust in a computer system, as even incorrect answers would receive explanations that may seem plausible. Automation bias, the phenomenon in which humans become more likely to believe answers that originate from a machine (Cummings, 2004), could mean that such misleading explanations have considerable weight.

Intentional understanding

The simplest way to understand a piece of technology is to understand what it was designed to do, how it was designed to do that, and why it was designed in that particular way instead of some other way (Kroll, 2018). The best way of ensuring that a program does what you intend it to, and that there are no biases, or unintended consequences is through thorough validation, investigation and evaluation of the program during development. In other words, measuring the performance of a system during development in order to uncover bugs, biases and incorrect assumptions. Even carefully designed systems can miss important facts about the world, and it is important to verify that systems are operating as intended. This includes whether the model accurately measures what it is supposed to – a concept known as construct validity; and whether the data accurately reflects the real world

For example a machine learning model tasked with conducting credit checks could inadvertently learn that a borrower's quality of clothing correlates with their income and hence their creditworthiness. During development the software should be checked for such correlations, so that they can be rejected.

Algorithm auditors

Larsson et al. (2019) suggest a role for professional algorithm auditors, whose job would be to interrogate algorithms in order to ensure they comply with pre-set standards. One example would be an autonomous vehicle algorithm auditor, who could provide simulated traffic scenarios to ensure that the vehicle did not disproportionately increase the risk to pedestrians or cyclists relative to passengers.

AMCSE-101

Recently, researchers proposed a new class of algorithms, called oversight programs, whose function is to 'monitor, audit, and hold operational AI programs accountable' (Etzioni and Etzioni 2016). For example, one idea would be to have an algorithm that conducts real-time assessments of the amount of bias caused by a news filtering algorithm, raising an alarm if bias increases beyond a certain threshold.

2.6.4 Accountability

'How do decision-makers make sense of what decisions get made by AI technologies and how these decisions are different to those made by humans?... the point is that AI makes decisions differently from humans and sometimes we don't understand those differences; we don't know why or how it is making that decision.' (Jack Stilgoe)

Another method of ensuring trust of AI is through accountability. As discussed, accountability ensures that if an AI makes a mistake or harms someone, there is someone that can be held responsible, whether that be the designer, the developer or the corporation selling the AI. In the event of damages incurred, there must be a mechanism for redress so that victims can be sufficiently compensated.

A growing body of literature has begun to address concepts such as algorithmic accountability and responsible AI. Algorithmic accountability, according to Caplan et al. (2018), deals with the delegation of responsibility for damages incurred as a result of algorithmically based decisions producing discriminatory or unfair consequences. One area where accountability is likely to be important is the introduction of self-driving vehicles. In the event of an accident, who should be held accountable? A number of fatal accidents have already occurred with self-driving cars, for example in 2016, a Tesla Model S equipped with radar and cameras determined that a nearby lorry was in fact the sky, which resulted in a fatal accident. In March 2018, a car used by Uber in self-driving vehicle trials hit and killed a woman in Arizona, USA. Even if autonomous cars are safer than vehicles driven by humans, accidents like these undermine trust.

Regulation

One way of ensuring accountability is regulation. Winfield and Jirotka (2018) point out that technology is, in general, trusted if it brings benefits and is safe and well regulated. Their paper argues that one key element in building trust in AI is ethical governance – a set of processes, procedures, cultures and values designed to ensure the highest standards of behaviour. These standards of behaviour need to be adopted by individual designers and the organisations in which they work, so that ethical issues are dealt with as or before they arise in a principled manner, rather than waiting until a problem surfaces and dealing with it in an ad-hoc way.

They give the example of airliners, which are trusted because we know that they are part of a highly regulated industry with an outstanding safety record. The reason commercial aircraft are so safe is not just good design, it is also the tough safety certification processes, and the fact that when things do go wrong, there are robust and publicly visible processes of air accident investigation.

Winfield and Jirotka (2018) suggest that some robot types, driverless cars for instance, should be regulated through a body similar to the Civil Aviation Authority (CAA), with a driverless car equivalent of the Air Accident Investigation Branch.

When it comes to public perception of robots and advanced technology, regulation and management crops up as a prominent concern. In two surveys of citizens across the EU (European Commission 2012; European Commission, 2012), both showed that there was a generally positive view of robots and digitisation as long as this is implemented and managed carefully. In fact, between 88% and 91% of those surveyed declared that robots and advanced technology must be managed carefully, one of the strongest results in either survey — reflecting a strong concern and area of priority amongst EU citizens.

2.6.5 Control

Another issue which affects public trust of AI is control. Much of this relates to fears around the idea of 'Superintelligence' - that as artificial intelligence increases to the point that it surpasses human abilities, it may come to take control over our resources and outcompete our species, leading to human extinction. A related fear is that, even if an AI agent was carefully designed to have goals aligned with human needs, it might develop for itself unanticipated subgoals that are not. For example, Bryson (2019) gives the example of a chess-playing robot taught to improve its game. This robot inadvertently learns to shoot people that switch it off at night, depriving it of vital resources. However, while most researchers agree this threat is unlikely to occur, to maintain trust in AI, it is important that humans have ultimate oversight over this technology.

Human in the loop

One idea that has been suggested by researchers is that of always keeping a human-in-the-loop (HITL). Here a human operator would be a crucial component of the automated control process, supervising the robots. A simple form of HITL already in existence is the use of human workers to label data for training machine learning algorithms. For example when you mark an email as 'spam', you are one of many humans in the loop of a complex machine learning algorithm, helping it in its continuous quest to improve email classification as spam or non-spam.

However HITL can also be a powerful tool for regulating the behaviour of AI systems. For instance, many researchers argue that human operators should be able to monitor the behaviour of LAWS, or 'killer robots,' or credit scoring algorithms (Citron and Pasquale 2014). The presence of a human fulfils two major functions in a HITL AI system (Rahwan, 2018):

> 1. The human can identify misbehaviour by an otherwise autonomous system, and take corrective action. For instance, a credit scoring system may misclassify an adult as ineligible for credit because their age was incorrectly input—something a human may spot from the applicant's photograph. Similarly, a computer vision system on a weaponised drone may mis-identify a civilian as a combatant, and the human operator—it is hoped—would override the system.
>
> 2. Keeping humans in the loop would also provide accountability - if an autonomous system causes harm to human beings, having a human in the loop provides trust that somebody would bare the consequence of such mistakes. According to Rahwan (2018), until we find a way to punish algorithms for harm to humans, 'it is hard to think of any other alternative'.

However, although HITL is useful for building AI systems that are subject to oversight, it may not be enough. AI machines that make decisions with wider societal implications, such as algorithms that control millions of self-driving cars or news filtering algorithms that influence the political beliefs and preferences of millions of citizens, should be subject to oversight by society as a whole, requiring a 'society-in-the-loop' paradigm (Rahwan, 2018).

The big red button

As a way to address some of the threats of artificial intelligence, researchers have proposed ways to stop an AI system before it has a chance to escape outside control and cause harm. A so-called 'big red button', or 'kill switch' would enable human operators to interrupt or divert a system, while preventing the system from learning that such an intervention is a threat. However, some

AMSCE-101

commentators fear that a sufficiently advanced AI machine could anticipate this move and defend itself by learning to disable its own 'kill switch'.

The red button raises wider practical questions about shutting down AI systems in order to keep them safe. What is the best way to accomplish that, and for what specific kinds of AI systems?

Orseau and Armstrong (2016) recently published a paper about how to prevent AI programmed through reinforcement learning (RL) from seeing interruptions as a threat. For example, an algorithm trying to optimise its chess performance may learn to disable its off switch so that it can spend more time learning how to play chess. Or it may learn to harm people who tried to switch it off, etc. What the researchers propose is to steer certain variants of reinforcement learning away from learning to avoid or impede an interruption. In this way, the authors argue, a system can pursue an optimal policy that is also interruptible. By being 'safely interruptible,' the paper concludes, reinforcement learning will not undermine the means of responsible oversight and intervention.

Riedl and Harrison (2017) suggests making a 'big red button' that, once pressed, diverted the AI into a simulated world where it could pursue its reward functions without causing any harm. Alternatively another idea is to maintain system uncertainty about key reward functions, which would prevent AI from attaching value to disabling an off-switch (Hadfield-Menell et al., 2016).

However Arnold and Schultz (2018) argue that the 'red button' approach comes at the point when a system has already 'gone rogue' and seeks to obstruct interference, and that 'big red button' approaches focus on long-term threats, imagining systems considerably more advanced than exist today and neglecting the present day problems with keeping automated systems accountable. A better approach, according to Arnold and Scheutz, would be to make ongoing self-evaluation and testing an integral part of a system's operation, in order to diagnose how the system is performing, and correct any errors.

They argue that to achieve this AIs should contain an ethical core (EC) consisting of a scenario-generation mechanism and a simulation environment used to test a system's decisions in simulated worlds, rather than the real world. This EC would be kept hidden from the system itself, so that the system's algorithms would be prevented from learning about its operation and its function, and ultimately its presence. Through continual testing in the simulated world, the EC would monitor and check for deviant behaviour - providing a far more effective and vigilant response than an emergency button which one might not get to push in time.

AMSCE-IOI

3. Ethical initiatives in the field of artificial intelligence

As detailed in previous sections, there are myriad ethical considerations accompanying the development, use and effects of artificial intelligence (AI). These range from the potential effects AI could have on the fundamental human rights of citizens within a society to the security and utilisation of gathered data; from the bias and discrimination unintentionally embedded into an AI by a homogenous group of developers, to a lack of public awareness and understanding about the consequences of their choices and usage of any given AI, leading to ill-informed decisions and subsequent harm.

AI builds upon previous revolutions in ICT and computing and, as such, will face a number of similar ethical problems. While technology may be used for good, potentially it may be misused. We may excessively anthropomorphise and humanise AI, blurring the lines between human and machine. The ongoing development of AI will bring about a new 'digital divide', with technology benefiting some socioeconomic and geographic groups more than others. Further, AI will have an impact on our biosphere and environment that is yet to be qualified (Veruggio and Operto, 2006).

3.1. International ethical initiatives

While official regulation remains scarce, many independent initiatives have been launched internationally to explore these – and other – ethical quandaries. The initiatives explored in this section are outlined in Table 3.1 and will be studied in light of the associated harms and concerns they aim to understand and mitigate.

AMSCE-110J

Table 1: Ethical initiatives and harms addressed

Initiative	Location	Key issues tackled	Publications	Sources of funding
The Institute for Ethics in Artificial Intelligence	Germany	Human-centric engineering and a focus on the cultural and social anchoring of rapid advances in AI, covering disciplines including philosophy, ethics, sociology, and political science.		Initial (2019) funding grant from Facebook ($7.5 million over five years).
The Institute for Ethical AI & Machine Learning	United Kingdom	The Institute aims to empower all from individuals to entire nations to develop AI, based on eight principles for responsible machine learning: these concern the maintenance of human control, appropriate redress for AI impact, evaluation of bias, explicability, transparency, reproducibility, mitigation of the effect of AI automation on workers, accuracy, cost, privacy, trust, and security.		unknown
The Institute for Ethical Artificial Intelligence in Education	United Kingdom	The potential threats to young people and education of the rapid growth of new AI technology, and ensuring the ethical development of AI-led EdTech.		unknown
The Future of Life Institute	United States	Ensuring that the development of AI is beneficial to humankind, with a focus on safety and existential risk: autonomous weapons arms race, human control of AI, and the potential dangers of advanced 'general/strong' or super-intelligent AI.	'*Asilomar AI Principles*'	Private. Top donors: Elon Musk (SpaceX and Tesla), Jaan Tallinn (Skype), Matt Wage (financial trader), Nisan Stiennon (software engineer), Sam Harris, George Godula (tech entrepreneur), and Jacob Trefethen (Harvard).
The Association for Computing Machinery	United States	The transparency, usability, security, accessibility, accountability, and digital inclusiveness of computers and networks, in terms of research, development, and implementation.	Statements on: algorithmic transparency and accountability (January 2017), computing and network security (May 2017), the Internet of Things (June 2017), accessibility, usability, and digital inclusiveness (September 2017),	unknown

AMSCE-101

			and mandatory access to information infrastructure for law enforcement (April 2018).	
The Japanese Society for Artificial Intelligence (JSAI)	Japan	To ensure that AI R&D remains beneficial to human society, and that development and research is conducted ethically and morally.	'***Ethical Guidelines***'	unknown
AI4All	United States	Diversity and inclusion in AI, to expose underrepresented groups to AI for social good and humanity's benefit.		Google
The Future Society	United States	The impact and governance of artificial intelligence to broadly benefit society, spanning policy research, advisory and collective intelligence, coordination of governance, law, and education.	'***Draft Principles for the Governance of AI'*** Published October 2017 (later published on their website on 7th February 2019),	unknown
The AI Now Institute	United States	The social implications of AI, especially in the areas of: Rights and liberties, labour and automation, bias and inclusion, and safety and critical infrastructure.		Various organisations, including Luminate, the MacArthur Foundation, Microsoft Research, Google, the Ford Foundation, DeepMind Ethics & Society, and the Ethics & Governance of AI Initiative.
The Institute of Electrical and Electronics Engineers (IEEE)	United States	Societal and policy guidelines to keep AI and intelligent systems human-centric, and serving humanity's values and principles. Focuses on ensuring that all stakeholders – across design and development – are educated, trained, and empowered to prioritise the ethical considerations of human rights, well-being, accountability, transparency, and awareness of misuse.	'***Ethically Aligned Design'* First Edition** (March 2019)	
The Partnership on AI	United States	Best practices on AI technologies: Safety, fairness, accountability, transparency, labour and the economy, collaboration between people and systems, social and societal influences, and social good.		The Partnership was formed by a group of AI researchers representing six of the world's largest tech companies: Apple,

AMSCE101

				Amazon, DeepMind and Google, Facebook, IBM, and Microsoft.
The Foundation for Responsible Robotics	The Netherlands	Responsible robotics (in terms of design, development, use, regulation, and implementation). Proactively taking stock of the issues that accompany technological innovation, and the impact these will have on societal values such as safety, security, privacy, and well-being.		unknown
AI4People	Belgium	The social impacts of AI, and the founding principles, policies, and practices upon which to build a 'good AI society'.	'***Ethical Framework for a Good AI Society***'	Atomium— European Institute for Science, Media and Democracy. Some funding was provided to the project's Scientific Committee Chair from the Engineering and Physical Sciences Research Council.
The Ethics and Governance of Artificial Intelligence Initiative	United States	Seeks to ensure that technologies of automation and machine learning are researched, developed, and deployed in a way which vindicate social values of fairness, human autonomy, and justice.		The Harvard Berkman Klein Center and the MIT Media Lab. Supported by The Miami Foundation (fiscal sponsorship), Knight Foundation, Luminate, Red Hoffman, and the William and Flora Hewlett Foundation.
Saidot: Enabling responsible AI ecosystems	Finland	Helping companies, governments, and organisations develop and deploy responsible AI ecosystems, to deliver transparent, accountable, trustworthy AI services. Enabling organisations to develop human-centric AI, with a focus on increasing the levels of trust and accountability in AI ecosystems. The platform offers software and algorithmic systems that can 'validate [an] intelligence system's trustworthiness' (Saidot, 2019)		
euRobotics	Europe	Maintaining and extending European talent and progress in robotics – AI industrialisation and economic impact.		European Commission

AMSCE-1101

The Centre for Data Ethics and Innovation	UK	Identifying and plugging gaps in our regulatory landscape, AI use of data, and maximising the benefits of AI to society.		UK Government
Special Interest Group on Artificial Intelligence (SIGAI), The Association for Computing Machinery	United States	. Promoting and supporting the growth and application of AI principles and techniques throughout computing, and promoting AI education and publications through various forums		The Association for Computing Machinery
	Other key international developments: current and historical			
The Montréal Declaration	Canada	The socially responsible development of AI, bringing together 400 participants across all sectors of society to identify the ethical and moral challenges in the short and long term. Key values: well-being, autonomy, justice, privacy, knowledge, democracy, and accountability.		Université de Montréal with the support of the Fonds de recherche en santé du Québec and the Palais des congrès de Montréal.
The UNI Global Union	Switzerland	Worker disruption and transparency in the application of AI, robotics, and data and machine learning in the workplace. Safeguarding workers' interests and maintaining human control and a healthy power balance.	'***Top 10 Principles for Ethical AI***'	unknown
The European Robotics Research Network (EURON)	Europe (Coordinator based in Sweden)	Research co-ordination, education and training, publishing and meetings, industrial links and international links in robotics.	'***Roboethics Roadmap***'	European Commission (2000-2004)
The European Robotics Platform (EUROP)	Europe	Bringing European robotics and AI community together. Industry-driven, focus on competitiveness and innovation.		European Commission

AMSCE-1101

3.2. Ethical harms and concerns tackled by these initiatives

All of the initiatives listed above agree that AI should be researched, developed, designed, deployed, monitored, and used in an ethical manner – but each has different areas of priority. This section will include analysis and grouping of the initiatives above, by type of issues they aim to address, and then outline some of the proposed approaches and solutions to protect from harms.

A number of key issues emerge from the initiatives, which **can be broadly split into the following categories:**

1. Human rights and well-being
   Is AI in the best interests of humanity and human well-being?

2. Emotional harm
   Will AI degrade the integrity of the human emotional experience, or facilitate emotional or mental harm?

3. Accountability and responsibility
   Who is responsible for AI, and who will be held accountable for its actions?

4. Security, privacy, accessibility, and transparency
   How do we balance accessibility and transparency with privacy and security, especially when it comes to data and personalisation?

5. Safety and trust
   What if AI is deemed untrustworthy by the public, or acts in ways that threaten the safety of either itself or others?

6. Social harm and social justice
   How do we ensure that AI is inclusive, free of bias and discrimination, and aligned with public morals and ethics?

7. Financial harm
   How will we control for AI that negatively affects economic opportunity and employment, and either takes jobs from human workers or decreases the opportunity and quality of these jobs?

8. Lawfulness and justice
   How do we go about ensuring that AI - and the data it collects - is used, processed, and managed in a way that is just, equitable, and lawful, and subject to appropriate governance and regulation? What would such regulation look like? Should AI be granted 'personhood'?

9. Control and the ethical use – or misuse – of AI
   How might AI be used unethically - and how can we protect against this? How do we ensure that AI remains under complete human control, even as it develops and 'learns'?

10. Environmental harm and sustainability
    How do we protect against the potential environmental harm associated with the development and use of AI? How do we produce it in a sustainable way?

11. Informed use
    What must we do to ensure that the public is aware, educated, and informed about their use of

AMSCE-1101

and interaction with AI?

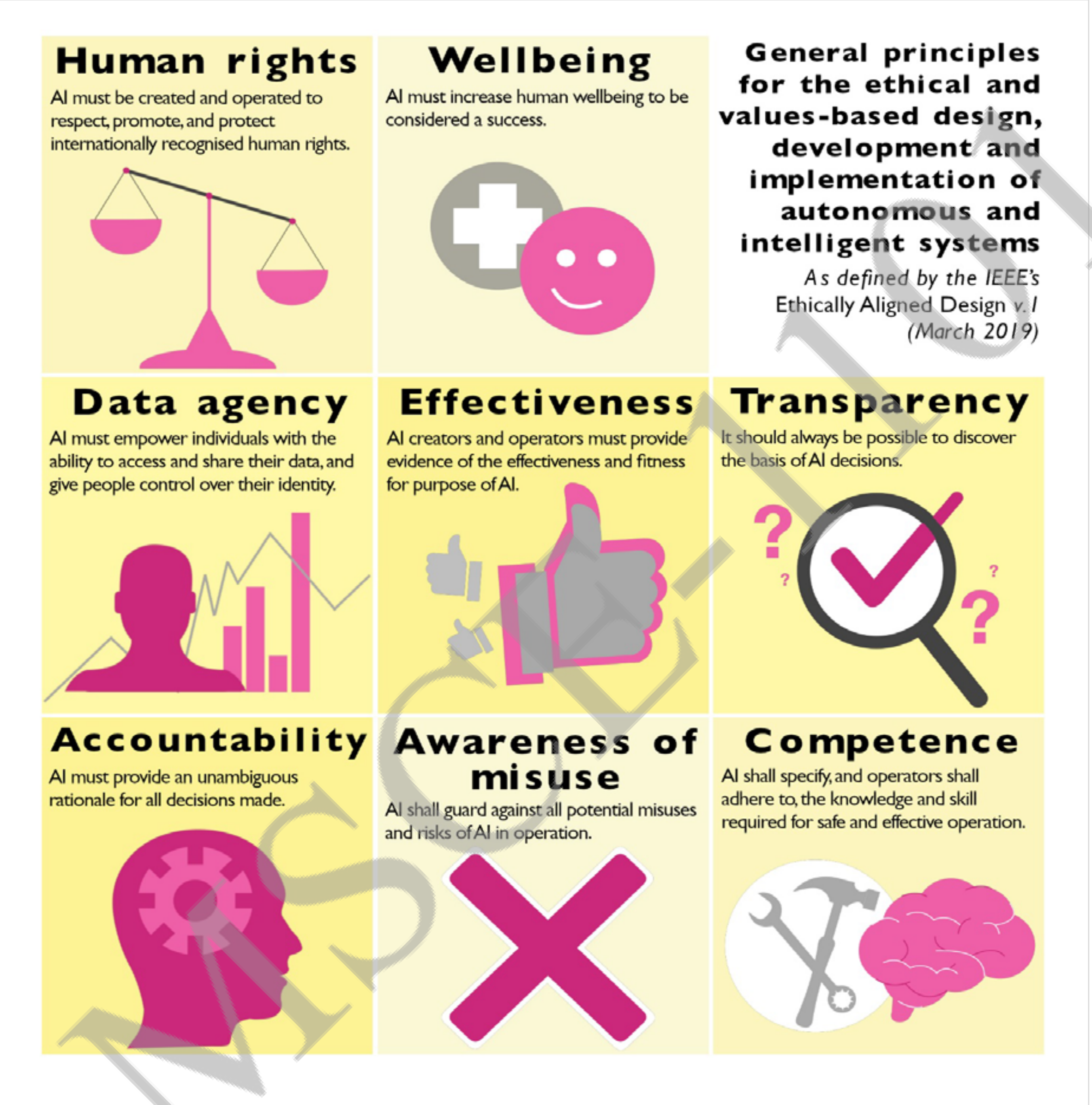
12. Existential risk
    How do we avoid an AI arms race, pre-emptively mitigate and regulate potential harm, and ensure that advanced machine learning is both progressive and manageable?

Overall, these initiatives all aim to identify and form ethical frameworks and systems that establish human beneficence at the highest levels, prioritise benefit to both human society and the environment (without these two goals being placed at odds), and mitigate the risks and negative impacts associated with AI — with a focus on ensuring that AI is accountable and transparent (IEEE, 2019).

The IEEE's '***Ethically Aligned Design: A Vision for Prioritising Human Well-being with Autonomous and Intelligent Systems***' (v1; 2019) is one of the most substantial documents published to date on the ethical issues that AI may raise — and the various proposed means of mitigating these.

AMSCE-1101

Figure 2: General principles for the ethical and values-based design, development, and implementation of autonomous and intelligent systems (as defined by the IEEE's *Ethically Aligned Design* First Edition March 2019)



Human rights

AI must be created and operated to respect, promote, and protect internationally recognised human rights.

Wellbeing

AI must increase human wellbeing to be considered a success.

General principles for the ethical and values-based design, development and implementation of autonomous and intelligent systems

As defined by the IEEE's Ethically Aligned Design v. I *(March 2019)*

Data agency

AI must empower individuals with the ability to access and share their data, and give people control over their identity.

Effectiveness

AI creators and operators must provide evidence of the effectiveness and fitness for purpose of AI.

Transparency

It should always be possible to discover the basis of AI decisions.

Accountability

AI must provide an unambiguous rationale for all decisions made.

Awareness of misuse

AI shall guard against all potential misuses and risks of AI in operation.

Competence

AI shall specify, and operators shall adhere to, the knowledge and skill required for safe and effective operation.

Areas of key impact comprise sustainable development; personal data rights and agency over digital identity; legal frameworks for accountability; and policies for education and awareness. They fall under **the three pillars of the Ethically Aligned Design conceptual framework:** Universal human values; political self-determination and data agency; and technical dependability.

3.2.1 Harms in detail

Taking each of these harms in turn, this section explores how they are being conceptualised by initiatives and some of the challenges that remain.

Human rights and well-being

All initiatives adhere to the view that ***AI must not impinge on basic and fundamental human rights***, such as human dignity, security, privacy, freedom of expression and information, protection of personal data, equality, solidarity and justice (European Parliament, Council and Commission, 2012).

How do we ensure that AI upholds such fundamental human rights and prioritises human well-being? Or that AI does not disproportionately affect vulnerable areas of society, such as children, those with disabilities, or the elderly, or reduce quality of life across society?

In order to ensure that human rights are protected, the IEEE recommends new governance frameworks, standards, and regulatory bodies which oversee the use of AI; translating existing legal obligations into informed policy, allowing for cultural norms and legal frameworks; and always maintaining complete human control over AI, without granting them rights or privileges equal to those of humans (IEEE, 2019). To safeguard human well-being, defined as 'human satisfaction with life and the conditions of life, as well as an appropriate balance between positive and negative affect' (*ibid*), the IEEE suggest prioritising human well-being throughout the design phase, and using the best and most widely-accepted available metrics to clearly measure the societal success of an AI.

There are crossovers with accountability and transparency: there must always be appropriate ways to identify and trace the impingement of rights, and to offer appropriate redress and reform. Personal data are also a key issue here; AI collect all manner of personal data, and users must retain the access to, and control of, their data, to ensure that their fundamental rights are being lawfully upheld (IEEE, 2019).

According to the ***Foundation for Responsible Robotics***, AI must be ethically developed with human rights in mind to achieve their goal of 'responsible robotics', which relies upon proactive innovation to uphold societal values like safety, security, privacy, and well-being. The Foundation engages with policymakers, organises and hosts events, publishes consultation documents to educate policymakers and the public, and creates public-private collaborations to bridge the gap between industry and consumers, to create greater transparency. It calls for ethical decision-making right from the research and development phase, greater consumer education, and responsible law- and policymaking – made before AI is released and put into use.

The ***Future of Life Institute*** defines a number of principles, ethics, and values for consideration in the development of AI, including the need to design and operate AI in a way that is compatible with the ideals of human dignity, rights, freedoms, and cultural diversity[7]. This is echoed by the ***Japanese Society for AI Ethical Guidelines***, which places the utmost importance on AI being realised in a way that is beneficial to humanity, and in line with the ethics, conscience, and competence of both its researchers and society as a whole. AI must contribute to the peace, safety, welfare, and public interest of society, says the Society, and protect human rights.

The Future Society's Law and Society Initiative emphasises that human beings are equal in rights, dignity, and freedom to flourish, and are entitled to their human rights.[8] With this in mind, to what extent should we delegate to machines decisions that affect people? For example, could AI 'judges' in the legal profession be more efficient, equitable, uniform, and cost-saving than human ones –

[7] https://futureoflife.org/ai-principles/
[8] http://thefuturesociety.org/law-and-society-initiative

and even if they were, would this be an appropriate way to deploy AI? ***The Montréal Declaration***[9] aims to clarify this somewhat, by pulling together an ethical framework that promotes internationally recognised human rights in fields affected by the rollout of AI: 'The principles of the current declaration rest on the common belief that human beings seek to grow as social beings endowed with sensations, thoughts and feelings, and strive to fulfil their potential by freely exercising their emotional, moral and intellectual capacities.' In other words, AI must not only not disrupt human well-being, but it must also proactively encourage and support it to improve and grow.

Some approach AI from a more specific viewpoint – such as the ***UNI Global Union***, which strives to protect an individual's right to work. Over half of the work currently done by people could be done faster and more efficiently in an automated way, says the Union. This identifies a prominent harm that AI may cause in the realm of human employment. The Union states that we must ensure that AI serves people and the planet, and both protects and increases fundamental human rights, human dignity, integrity, freedom, privacy, and cultural and gender diversity[10].

Emotional harm

What is it to be human? AI will interact with and have an impact on the human emotional experience in ways that have not yet been qualified; humans are susceptible to emotional influence both positively and negatively, and ***'affect' – how emotion and desire influence behaviour – is a core part of intelligence***. Affect varies across cultures, and, given different cultural sensitivities and ways of interacting, affective and influential AI could begin to influence how people view society itself. The ***IEEE*** recommend various ways to mitigate this risk, including the ability to adapt and update AI norms and values according to who they are engaging with, and the sensitivities of the culture in which they are operating.

There are various ways in which AI could inflict emotional harm, including false intimacy, over-attachment, objectification and commodification of the body, and social or sexual isolation. These are covered by various of the aforementioned ethical initiatives, including **the Foundation for Responsible Robotics, Partnership on AI, the AI Now** institute (especially regarding affect computing), **the Montréal Declaration**, and the **European Robotics Research Network (EURON) Roadmap** (for example, their section on the risks of humanoids).

These possible harms come to the fore when considering the development of an intimate relationship with an AI, for example in the sex industry. Intimate systems, as the ***IEEE*** call them, must not contribute to sexism, racial inequality, or negative body image stereotypes; must be for positive and therapeutic use; must avoid sexual or psychological manipulation of users without consent; should not be designed in a way that contributes to user isolation from human companionship; must be designed in a way that is transparent about the effect they may have on human relationship dynamics and jealousy; must not foster deviant or criminal behaviour, or normalise illegal sexual practices such as paedophilia or rape; and must not be marketed commercially as a person (in a legal sense or otherwise).

Affective AI is also open to the possibility of deceiving and coercing its users – researchers have defined the act of AI subtly modifying behaviour as '***nudging***', when an AI emotionally manipulates and influences its user through the affective system. While this may be useful in some ways – drug dependency, healthy eating – it could also trigger behaviours that worsen human health. Systematic analyses must examine the ethics of affective design prior to deployment; users must be educated on how to recognise and distinguish between nudges; users must have an opt-in system for autonomous nudging systems; and vulnerable populations that cannot give informed consent, such

AMSCE-101

[9] https://www.montrealdeclaration-responsibleai.com/the-declaration
[10] http://www.thefutureworldofwork.org/media/35420/uni_ethical_ai.pdf

as children, must be subject to additional protection. In general, stakeholders must discuss the question of whether or not the nudging design pathway for AI, which lends itself well to selfish or detrimental uses, is an ethical one to pursue (IEEE, 2019).

As raised by the ***IEEE*** (2019), nudging may be used by governments and other entities to influence public behaviour. Would it be ethically appropriate for a robot to use nudging to encourage, for example, charitable behaviour or donations? We must pursue full transparency regarding the beneficiaries of such behaviour, say the IEEE, due to the potential for misuse.

Other issues include technology addiction and emotional harm due to societal or gender bias.

Accountability and responsibility

The vast majority of initiatives mandate that AI must be ***auditable***, in order to assure that the designers, manufacturers, owners, and operators of AI are held accountable for the technology or system's actions, and are thus considered responsible for any potential harm it might cause. According to the ***IEEE***, this could be achieved by the courts clarifying issues of culpability and liability during the development and deployment phases where possible, so that those involved understand their obligations and rights; by designers and developers taking into account the diversity of existing cultural norms among various user groups; by establishing multi-stakeholder ecosystems to create norms that currently do not exist, given that AI-oriented technology is too new; and by creating registration and record-keeping systems so that it is always possible to trace who is legally responsible for a particular AI.

Sex and Robots

In July of 2017, the ***Foundation for Responsible Robotics*** published a report on 'Our Sexual Future with Robots' (Foundation for Responsible Robotics, 2019). This aimed to present an objective summary of the various issues and opinions surrounding our intimate association with technology. Many countries are developing robots for sexual gratification; these largely tend to be pornographic representations of the human body – and are mostly female. These representations, when accompanied by human anthropomorphism, may cause robots to be perceived as somewhere between living and inanimate, especially when sexual gratification is combined with elements of intimacy, companionship and conversation. Robots may also affect societal perceptions of gender or body stereotypes, erode human connection and intimacy and lead to greater social isolation. However, there is also some potential for robots to be of emotional sexual benefit to humans, for example by helping to reduce sex crime, and to rehabilitate victims of rape or sexual abuse via inclusion in healing therapies.

The ***Future of Life Institute*** tackles the issue of accountability via its **Asilomar Principles**, a list of 23 guiding principles for AI to follow in order to be ethical in the short and long term. Designers and builders of advanced AI systems are 'stakeholders in the moral implications of their use, misuse, and actions, with a responsibility and opportunity to shape those implications' (FLI, 2017); if an AI should make a mistake, it should also be possible to ascertain why. The ***Partnership on AI*** also stresses the importance of accountability in terms of bias. We should be sensitive to the fact that assumptions and biases exist within data and thus within systems built from these data, and strive not to replicate them – i.e. to be actively accountable for building fair, bias-free AI.

All other initiatives highlight the importance of accountability and responsibility – both by designers and AI engineers, and by regulation, law and society on a larger scale.

Access and transparency vs. security and privacy

A main concern over AI is its ***transparency***, explicability, security, reproducibility, and interpretability: is it possible to discover why and how a system made a specific decision, or why and how a robot acted in the way it did? This is especially pressing in the case of *safety-critical* systems that may have direct consequences for physical harm: driverless cars, for example, or medical diagnosis systems. Without transparency, users may struggle to understand the systems they are using – and their associated consequences – and it will be difficult to hold the relevant persons accountable and responsible.

To address this, the ***IEEE*** propose developing new standards that detail measurable and testable levels of transparency, so systems can be objectively assessed for their compliance. This will likely take different forms for different stakeholders; a robot user may require a 'why-did-you-do-that' button, while a certification agency or accident investigator will require access to relevant algorithms in the form of an 'ethical black box' which provides failure transparency (IEEE, 2019).

Autonomy and agent vs. patient

The current approach to AI is undeniably anthropocentric. This raises **possible issues around the distinction between moral agents and moral patients, between artificial and natural, between self-organising and not**. AI cannot become autonomous in the same way that living beings are considered autonomous (IEEE, 2019), but how do we define autonomy in terms of AI? Machine autonomy designates how machines act and operate according to regulation, but any attempts to implant emotion and morality into AI 'blur the distinction between agents and patients and may encourage anthropomorphic expectations of machines', writes the ***IEEE*** — especially as embodied AI begins to look increasingly similar to humans. Establishing a usable distinction between human and system/machine autonomy involves questions of free will, being/becoming and predetermination. It is clear that further discussion is needed to clarify what 'autonomy' may mean in terms of artificial intelligence and systems.

AI require data to continually learn and develop their automatic decision-making. These data are personal and may be used to identify a particular individual's physical, digital, or virtual identity (i.e. personally identifiable information, PII). 'As a result,' write the IEEE (2017), 'through every digital transaction (explicit or observed) humans are generating a unique digital shadow of their physical self'. To what extent can humans realise the right to keep certain information private, or have input into how these data are used? Individuals may lack the appropriate tools to control and cultivate their unique identity and manage the associated ethical implications of the use of their data. Without clarity and education, many users of AI will remain unaware of the digital footprint they are creating, and the information they are putting out into the world. Systems must be put in place for users to control, interact with and access their data, and give them agency over their digital personas.

PII has been established as the asset of the individual (by Regulation (EU) 2016/679 in Europe, for example), and systems must ask for explicit consent at the time data are collected and used, in order to protect individual autonomy, dignity and right to consent. The IEEE mention the possibility of a personalised 'privacy AI or algorithmic agent or guardian' to help individuals curate and control their personal data and foresee and mitigate potential ethical implications of machine learning data exchange.

The ***Future of Life Institute's Asilomar Principles*** agree with the IEEE on the importance of transparency and privacy across various aspects: failure transparency (if an AI fails, it must be possible to figure out why), judicial transparency (any AI involved in judicial decision-making must provide a satisfactory explanation to a human), personal privacy (people must have the right to access, manage, and control the data AI gather and create), and liberty and privacy (AI must not unreasonably curtail people's real or perceived liberties). ***Saidot*** takes a slightly wider approach and strongly emphasises the importance of AI that are transparent, accountable, and trustworthy, where people, organisations, and smart systems are openly connected and collaborative in order to foster cooperation, progress, and innovation.

All of the initiatives surveyed identify transparency and accountability of AI as an important issue. This balance underpins many other concerns – such as legal and judicial fairness, worker compensation and rights, security of data and systems, public trust, and social harm.

Safety and trust

Where AI is used to supplement or replace human decision-making, there is consensus that it must be ***safe, trustworthy, and reliable, and act with integrity***.

The ***IEEE*** propose cultivating a 'safety mindset' among researchers, to 'identify and pre-empt unintended and unanticipated behaviors in their systems' and to develop systems which are 'safe by design'; setting up review boards at institutions as a resource and means of evaluating projects and their progress; encouraging a community of sharing, to spread the word on safety-related developments, research, and tools. The ***Future of Life Institute's Asilomar principles*** indicate that all involved in developing and deploying AI should be mission-led, adopting the norm that AI 'should only be developed in the service of widely shared ethical ideals, and for the benefit of all humanity rather than one state or organisation' (Future of Life Institute, 2017). This approach would build public trust in AI, something that is key to its successful integration into society.

An 'ethical black box'

Initiatives including the ***UNI Global Union*** and ***IEEE*** suggest equipping AI systems with an 'ethical black box': a device that can record information about said system to ensure its accountability and transparency, but that also includes clear data on the ethical consideration built into the system from the beginning (UNI Global Union, n.d.).

The Japanese Society for AI proposes that AI should act with integrity at all times, and that AI and society should earnestly seek to learn from and communicate with one another. 'Consistent and effective communication' will strengthen mutual understanding, says the Society, and '[contribute] to the overall peace and happiness of mankind' (JSAI, 2017). The ***Partnership on AI*** agrees, and strives to ensure AI is trustworthy and to create a culture of cooperation, trust, and openness among AI scientists and engineers. The ***Institute for Ethical AI & Machine Learning*** also emphasises the importance of dialogue; it ties together the issues of trust and privacy in its eight core tenets, mandating that AI technologists communicate with stakeholders about the processes and data involved to build trust and spread understanding throughout society.

Social harm and social justice: inclusivity, bias, and discrimination

AI development requires ***a diversity of viewpoints***. There are several organisations establishing that these must be in line with community viewpoints and align with social norms, values, ethics, and preferences, that biases and assumptions must not be built into data or systems, and that AI should be aligned with public values, goals, and behaviours, respecting cultural diversity. Initiatives also argue that all should have access to the benefits of AI, and it should work for the common good. In other words, developers and implementers of AI have a social responsibility to embed the right values into AI and ensure that they do not cause or exacerbate any existing or future harm to any part of society.

The ***IEEE*** suggest first identifying social and moral norms of the specific community in which an AI will be deployed, and those around the specific task or service it will offer; designing AI with the idea of 'norm updating' in mind, given that norms are not static and AI must change dynamically and transparently alongside culture; and identifying the ways in which people resolve norm conflicts, and equipping AI with a system in which to do so in a similar and transparent way. This should be done collaboratively and across diverse research efforts, with care taken to evaluate and assess potential biases that disadvantage specific social groups.

Several initiatives – such as ***AI4All*** and the ***AI Now Institute*** – explicitly advocate for fair, diverse, equitable, and non-discriminatory inclusion in AI at all stages, with a focus on support for under-represented groups. Currently, AI-related degree programmes do not equip aspiring developers and designers with an appropriate knowledge of ethics (IEEE, 2017), and corporate environments and business practices are not ethically empowering, with a lack of roles for senior ethicists that can steer and support value-based innovation.

On a global scale, the inequality gap between developed and developing nations is significant. While AI may have considerable usefulness in a humanitarian sense, they must not widen this gap or exacerbate poverty, illiteracy, gender and ethnic inequality, or disproportionately disrupt employment and labour. The IEEE suggests taking action and investing to mitigate the inequality gap; integrating corporate social responsibility (CSR) into development and marketing; developing transparent power structures; facilitating and sharing robotics and AI knowledge and research; and generally keeping AI in line with the US Sustainable Development Goals[11]. AI technology should be made equally available worldwide via global standardisation and open-source software, and interdisciplinary discussion should be held on effective AI education and training (IEEE, 2019).

A set of ethical guidelines published by the ***Japanese Society for AI*** emphasises, among other considerations, the importance of a) contribution to humanity, and b) social responsibility. AI must act in the public interest, respect cultural diversity, and always be used in a fair and equal manner.

The ***Foundation for Responsible Robotics*** includes a Commitment to Diversity in its push for responsible AI; the ***Partnership on AI*** cautions about the 'serious blind spots' of ignoring the presence of biases and assumptions hidden within data; ***Saidot*** aims to ensure that, although our social values are now 'increasingly mediated by algorithms', AI remains human-centric (Saidot, 2019); the ***Future of Life Institute*** highlights a need for AI imbued with human values of cultural diversity and human rights; and the ***Institute for Ethical AI & Machine Learning*** includes 'bias evaluation' for monitoring bias in AI development and production. The dangers of human bias and assumption are a frequently identified risk that will accompany the ongoing development of AI.

Financial harm: Economic opportunity and employment

AI may disrupt the economy and lead to loss of jobs or work disruption for many humans, and will have an impact on workers' rights and displacement strategy as many strains of work become automated (and vanish in related business change).

Additionally, rather than just focusing on the number of jobs lost or gained, traditional employment structures will need to be changed to mitigate the effects of automation and take into account the complexities of employment. Technological change is happening too fast for the traditional workforce to keep pace without retraining. Workers must train for adaptability, says the ***IEEE*** (2019), and new skill sets, with fallback strategies put in place for those who cannot be re-trained, and training programmes implemented at the level of high school or earlier to increase access to future employment. The ***UNI Global Union*** call for multi-stakeholder ethical AI governance bodies on global and regional levels, bringing together designers, manufacturers, developers, researchers, trade unions, lawyers, CSOs, owners, and employers. AI must benefit and empower people broadly and equally, with policies put in place to bridge the economic, technological, and social digital divides, and ensure a just transition with support for fundamental freedoms and rights.

The AI Now Institute works with diverse stakeholder groups to better understand the implications that AI will have for labour and work, including automation and early-stage integration of AI changing the nature of employment and working conditions in various sectors. ***The Future Society*** specifically asks how AI will affect the legal profession: 'If AI systems are demonstrably superior to

[11] https://sustainabledevelopment.un.org/?menu=1300

human attorneys at certain aspects of legal work, what are the ethical and professional implications for the practice of law?' (Future Society, 2019)

AI in the workplace will affect far more than workers' finances, and may offer various positive opportunities. As laid out by the **IEEE** (2019), AI may offer potential solutions to workplace bias – if it is developed with this in mind, as mentioned above – and reveal deficiencies in product development, allowing proactive improvement in the design phase (as opposed to retroactive improvement).

'*RRI is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society).*' (Von Schomberg, 2013)

Responsible research and innovation (RRI)

RRI is a growing area, especially in the EU, that draws from classical ethics to provide tools with which to address ethical concerns from the very outset of a project. When incorporated into a project's design phase, RRI increases the chances of design being both relevant and strong in terms of ethical alignment. Many research funders and organisations include RRI in their mission statements and within their research and innovation efforts (IEEE, 2019).

Lawfulness and justice

Several initiatives address the need for AI to be lawful, equitable, fair, just and subject to appropriate, pre-emptive governance and regulation. The many complex ethical problems surrounding AI translate directly and indirectly into discrete legal challenges. How should AI be labelled: as a product? An animal? A person? Something new?

The ***IEEE*** conclude that AI should not be granted any level of 'personhood', and that, while development, design and distribution of AI should fully comply with all applicable international and domestic law, there is much work to be done in defining and implementing the relevant legislation. Legal issues fall into a few categories: legal status, governmental use (transparency, individual rights), legal accountability for harm, and transparency, accountability, and verifiability. The IEEE suggest that AI should remain subject to the applicable regimes of property law; that stakeholders should identify the types of decisions that should never be delegated to AI, and ensure effective human control over those decisions via rules and standards; that existing laws should be scrutinised and reviewed for mechanisms that could practically give AI legal autonomy; and that manufacturers and operators should be required to comply with the applicable laws of all jurisdictions in which an AI could operate. They also recommend that governments reassess the legal status for AI as they become more sophisticated, and work closely with regulators, societal and industry actors and other stakeholders to ensure that the interests of humanity – and not the development of systems themselves – remain the guiding principle.

Control and the ethical use – or misuse – of AI

With more sophisticated and complex new AI come more sophisticated and complex possibilities for misuse. Personal data may be used maliciously or for profit, systems are at risk of hacking, and technology may be used exploitatively. This ties into informed use and public awareness: as we enter a new age of AI, with new systems and technology emerging that have never before been implemented, citizens must be kept up to date of the risks that may come with either the use or misuse of these.

AMSCE-101

The ***IEEE*** suggests new ways of educating the public on ethics and security issues, for example a 'data privacy' warning on smart devices that collect personal data; delivering this education in scalable, effective ways; and educating government, lawmakers, and enforcement agencies surrounding these issues, so they can work collaboratively with citizens – in a similar way to police officers providing safety lectures in schools – and avoid fear and confusion (IEEE, 2019).

Personhood and AI

The issue of whether or not an AI deserves 'personhood' ties into debates surrounding accountability, autonomy, and responsibility: is it the AI itself that is responsible for its actions and consequences, or the person(s) who built them?

This concept, rather than allowing robots to be considered people in a human sense, would place robots on the same legal level as corporations. It is worth noting that corporations' legal personhood can currently shield the natural persons behind them from the implications of the law. However, ***The UNI Global Union*** asserts that legal responsibility lies with the creator, not the robot itself, and calls for a ban on attributing responsibility to robots.

Other issues include manipulation of behaviour and data. Humans must retain control over AI and oppose subversion. Most initiatives reviewed flag this as a potential issue facing AI as it develops, and flag that AI must behave in a way that is predictable and reliable, with appropriate means for redress, and be subject to validation and testing. AI must also work for the good of humankind, must not exploit people, and be regularly reviewed by human experts.

Environmental harm and sustainability

The production, management, and implementation of AI must be sustainable and avoid environmental harm. This also ties in to the concept of well-being; a key recognised aspect of well-being is environmental, concerning the air, biodiversity, climate change, soil and water quality, and so on (IEEE, 2019). The ***IEEE*** (EAD, 2019) state that AI must do no harm to Earth's natural systems or exacerbate their degradation, and contribute to realising sustainable stewardship, preservation, and/or the restoration of Earth's natural systems. The ***UNI Global Union*** state that AI must put people and the planet first, striving to protect and even enhance our planet's biodiversity and ecosystems (UNI Global Union, n.d.). The ***Foundation for Responsible Robotics*** identifies a number of potential uses for AI in coming years, from agricultural and farming roles to monitoring of climate change and protection of endangered species. These require responsible, informed policies to govern AI and robotics, say the Foundation, to mitigate risk and support ongoing innovation and development.

Informed use: public education and awareness

Members of the public must be educated on the use, misuse, and potential harms of AI, via civic participation, communication, and dialogue with the public. The issue of consent – and how much an individual may reasonably and knowingly give – is core to this. For example, the ***IEEE*** raise several instances in which consent is less clear-cut than might be ethical: what if one's personal data are used to make inferences they are uncomfortable with or unaware of? Can consent be given when a system does not directly interact with an individual? This latter issue has been named the 'Internet of Other People's Things' (IEEE, 2019). Corporate environments also raise the issue of power imbalance; many employees do not have clear consent on how their personal data – including those on health – is used by their employer. To remedy this, the IEEE (2017) suggest employee data impact assessments to deal with these corporate nuances and ensure that no data is collected without employee consent. Data must also be only gathered and used for specific, explicitly stated, legitimate purposes, kept up-to-date, lawfully processed, and not kept for a longer period than necessary. In cases where subjects do not have a direct relationship with the system gathering data, consent must be dynamic, and the system designed to interpret data preferences and limitations on collection and use.

To increase awareness and understanding of AI, undergraduate and postgraduate students must be educated on AI and its relationship to sustainable human development, say the IEEE. Specifically, curriculum and core competencies should be defined and prepared; degree programmes focusing on engineering in international development and humanitarian relief should be exposed to the potential of AI applications; and awareness should be increased of the opportunities and risks faced by Lower Middle Income Countries in the implementation of AI in humanitarian efforts across the globe.

Many initiatives focus on this, including the ***Foundation for Responsible Robotics, Partnership on AI, Japanese Society for AI Ethical Guidelines, Future Society*** and ***AI Now Institute***; these and others maintain that clear, open and transparent dialogue between AI and society is key to the creation of understanding, acceptance, and trust.

Existential risk

According to the Future of Life Institute, the main existential issue surrounding AI 'is not malevolence, but competence' – AI will continually learn as they interact with others and gather data, leading them to gain intelligence over time and potentially develop aims that are at odds with those of humans.

'*You're probably not an evil ant-hater who steps on ants out of malice,' 'but if you're in charge of a hydroelectric green energy project and there's an anthill in the region to be flooded, too bad for the ants. A key goal of AI safety research is to never place humanity in the position of those ants' (*The Future of Life Institute, 2019).

AI also poses a threat in the form of ***autonomous weapons systems (AWS)***. As these are designed to cause physical harm, they raise numerous ethical quandaries. The IEEE (2019) lays out a number of recommendations to ensure that AWS are subject to meaningful human control: they suggest audit trails to guarantee accountability and control; adaptive learning systems that can explain their reasoning in a transparent, understandable way; that human operators of autonomous systems are identifiable, held responsible, and aware of the implications of their work; that autonomous behaviour is predictable; and that professional codes of ethics are developed to address the development of autonomous systems – especially those intended to cause harm. The pursuit of AWS may lead to an international arms race and geopolitical stability; as such, the IEEE recommend that systems designed to act outside the boundaries of human control or judgement are unethical and violate fundamental human rights and legal accountability for weapons use.

Given their potential to seriously harm society, these concerns must be controlled for and regulated pre-emptively, says the ***Foundation for Responsible Robotics***. Other initiatives that cover this risk explicitly include the ***UNI Global Union*** and the ***Future of Life Institute***, the latter of which cautions against an arms race in lethal autonomous weapons, and calls for planning and mitigation efforts for possible longer-term risks. We must avoid strong assumptions on the upper limits of future AI capabilities, assert the FLI's **Asilomar Principles**, and recognise that advanced AI represents a profound change in the history of life on Earth.

3.3. Case studies

3.3.1. Case study: healthcare robots

Artificial Intelligence and robotics are rapidly moving into the field of healthcare and will increasingly play roles in diagnosis and clinical treatment. For example, currently, or in the near future, robots will help in the diagnosis of patients; the performance of simple surgeries; and the monitoring of patients' health and mental wellness in short and long-term care facilities. They may also provide basic physical interventions, work as companion carers, remind patients to take their

AMSCE-1101

medications, or help patients with their mobility. In some fundamental areas of medicine, such as medical image diagnostics, machine learning has been proven to match or even surpass our ability to detect illnesses.

Embodied AI, or robots, are already involved in a number of functions that affect people's physical safety. In June 2005, a surgical robot at a hospital in Philadelphia malfunctioned during prostate surgery, injuring the patient. In June 2015, a worker at a Volkswagen plant in Germany was crushed to death by a robot on the production line. In June 2016, a Tesla car operating in autopilot mode collided with a large truck, killing the car's passenger (Yadron and Tynan, 2016).

As robots become more prevalent, the potential for future harm will increase, particularly in the case of driverless cars, assistive robots and drones, which will face decisions that have real consequences for human safety and well-being. The stakes are much higher with embodied AI than with mere software, as robots have moving parts in physical space (Lin et al., 2017). Any robot with moving physical parts poses a risk, especially to vulnerable people such as children and the elderly.

Safety

Again, perhaps the most important ethical issue arising from the growth of AI and robotics in healthcare is that of safety and avoidance of harm. It is vital that robots should not harm people, and that they should be safe to work with. This point is especially important in areas of healthcare that deal with vulnerable people, such as the ill, elderly, and children.

Digital healthcare technologies offer the potential to improve accuracy of diagnosis and treatments, but to thoroughly establish a technology's long-term safety and performance investment in clinical trials is required. The debilitating side-effects of vaginal mesh implants and the continued legal battles against manufacturers (The Washington Post, 2019), stand as an example against shortcutting testing, despite the delays this introduces to innovating healthcare. Investment in clinical trials will be essential to safely implement the healthcare innovations that AI systems offer.

User understanding

The correct application of AI by a healthcare professional is important to ensure patient safety. For instance, the precise surgical robotic assistant 'the da Vinci' has proven a useful tool in minimising surgical recovery, but requires a trained operator (The Conversation, 2018).

A shift in the balance of skills in the medical workforce is required, and healthcare providers are preparing to develop the digital literacy of their staff over the next two decades (NHS' Topol Review, 2009). With genomics and machine learning becoming embedded in diagnoses and medical decision-making, healthcare professionals need to become digitally literate to understand each technological tool and use it appropriately. It is important for users to trust the AI presented but to be aware of each tool's strengths and weaknesses, recognising when validation is necessary. For instance, a generally accurate machine learning study to predict the risk of complications in patients with pneumonia erroneously considered those with asthma to be at low risk. It reached this conclusion because asthmatic pneumonia patients were taken directly to intensive care, and this higher-level care circumvented complications. The inaccurate recommendation from the algorithm was thus overruled (Pulmonology Advisor, 2017).

However, it's questionable to what extent individuals need to understand how an AI system arrived at a certain prediction in order to make autonomous and informed decisions. Even if an in-depth understanding of the mathematics is made obligatory, the complexity and learned nature of machine learning algorithms often prevent the ability to understand how a conclusion has been made from a dataset — a so called 'black box' (Schönberger, 2019). In such cases, one possible route

AMSCE-101

to ensure safety would be to license AI for specific medical procedures, and to 'disbar' the AI if a certain number of mistakes are made (Hart, 2018).

Data protection

Personal medical data needed for healthcare algorithms may be at risk. For instance, there are worries that data gathered by fitness trackers might be sold to third parties, such as insurance companies, who could use those data to refuse healthcare coverage (National Public Radio, 2018). Hackers are another major concern, as providing adequate security for systems accessed by a range of medical personnel is problematic (Forbes, 2018).

Pooling personal medical data is critical for machine learning algorithms to advance healthcare interventions, but gaps in information governance form a barrier against responsible and ethical data sharing. Clear frameworks for how healthcare staff and researchers use data, such as genomics, in a way that safeguards patient confidentiality is necessary to establish public trust and enable advances in healthcare algorithms (NHS' Topol Review, 2009).

Legal responsibility

Although AI promises to reduce the number of medical mishaps, when issues occur, legal liability must be established. If equipment can be proven to be faulty then the manufacturer is liable, but it is often tricky to establish what went wrong during a procedure and whether anyone, medical personnel or machine, is to blame. For instance, there have been lawsuits against the da Vinci surgical assistant (Mercury News, 2017), but the robot continues to be widely accepted (The Conversation, 2018).

In the case of 'black box' algorithms where it is impossible to ascertain how a conclusion is reached, it is tricky to establish negligence on the part of the algorithm's producer (Hart, 2018).

For now, AI is used as an aide for expert decisions, and so experts remain the liable party in most cases. For instance, in the aforementioned pneumonia case, if the medical staff had relied solely on the AI and sent asthmatic pneumonia patients home without applying their specialist knowledge, then that would be a negligent act on their part (Pulmonology Advisor, 2017; International Journal of Law and Information Technology, 2019).

Soon, the omission of AI could be considered negligence. For instance, in less developed countries with a shortage of medical professionals, withholding AI that detects diabetic eye disease and so prevents blindness, because of a lack of ophthalmologists to sign off on a diagnosis, could be considered unethical (The Guardian, 2019; International Journal of Law and Information Technology, 2019).

Bias

Non-discrimination is one of the fundamental values of the EU (see Article 21 of the EU Charter of Fundamental Rights), but machine learning algorithms are trained on datasets that often have proportionally less data available about minorities, and as such can be biased (Medium, 2014). This can mean that algorithms trained to diagnose conditions are less likely to be accurate for ethnic patients; for instance, in the dataset used to train a model for detecting skin cancer, less than 5 percent of the images were from individuals with dark skin, presenting a risk of misdiagnosis for people of colour (The Atlantic, 2018).

To ensure the most accurate diagnoses are presented to people of all ethnicities, algorithmic biases must be identified and understood. Even with a clear understanding of model design this is a difficult task because of the aforementioned 'black box' nature of machine learning. However, various codes of conduct and initiatives have been introduced to spot biases earlier. For instance,

AMSCE-IOT

The Partnership on AI, an ethics-focused industry group was launched by Google, Facebook, Amazon, IBM and Microsoft (The Guardian, 2016) — although, worryingly, this board is not very diverse.

Equality of access

Digital health technologies, such as fitness trackers and insulin pumps, provide patients with the opportunity to actively participate in their own healthcare. Some hope that these technologies will help to redress health inequalities caused by poor education, unemployment, and so on. However, there is a risk that individuals who cannot afford the necessary technologies or do not have the required 'digital literacy' will be excluded, so reinforcing existing health inequalities (The Guardian, 2019).

The UK's National Health Services' Widening Digital Participation programme is one example of how a healthcare service has tried to reduce health inequalities, by helping millions of people in the UK who lack the skills to access digital health services. Programmes such as this will be critical in ensuring equality of access to healthcare, but also in increasing the data from minority groups needed to prevent the biases in healthcare algorithms discussed above.

Quality of care

'There is remarkable potential for digital healthcare technologies to improve accuracy of diagnoses and treatments, the efficiency of care, and workflow for healthcare professionals' (NHS' Topol Review, 2019).

If introduced with careful thought and guidelines, companion and care robots, for example, could improve the lives of the elderly, reducing their dependence, and creating more opportunities for social interaction. Imagine a home-care robot that could: remind you to take your medications; fetch items for you if you are too tired or are already in bed; perform simple cleaning tasks; and help you stay in contact with your family, friends and healthcare provider via video link.
However, questions have been raised over whether a 'cold', emotionless robot can really substitute for a human's empathetic touch. This is particularly the case in long-term caring of vulnerable and often lonely populations, who derive basic companionship from caregivers. Human interaction is particularly important for older people, as research suggests that an extensive social network offers protection against dementia. At present, robots are far from being real companions. Although they can interact with people, and even show simulated emotions, their conversational ability is still extremely limited, and they are no replacement for human love and attention. Some might go as far as saying that depriving the elderly of human contact is unethical, and even a form of cruelty.

And does abandoning our elderly to cold machine care objectify (degrade) them, or human caregivers? It's vital that robots don't make elderly people feel like objects, or with even less control over their lives than when they were dependent on humans — otherwise they may feel like they are 'lumps of dead matter: to be pushed, lifted, pumped or drained, without proper reference to the fact that they are sentient beings' (Kitwood 1997).

In principle, autonomy, dignity and self-determination can all be thoroughly respected by a machine application, but it's unclear whether application of these roles in the sensitive field of medicine will be deemed acceptable. For instance, a doctor used a telepresence device to give a prognosis of death to a Californian patient; unsurprisingly the patient's family were outraged by this impersonal approach to healthcare (The Independent, 2019). On the other hand, it's argued that new technologies, such as health monitoring apps, will free up staff time for more direct interactions with patients, and so potentially increase the overall quality of care (The Guardian, Press Association, Monday 11 February 2019).

AMSCE-IIOI

Deception

A number of 'carebots' are designed for social interactions and are often touted to provide an emotional therapeutic role. For instance, care homes have found that a robotic seal pup's animal-like interactions with residents brightens their mood, decreases anxiety and actually increases the sociability of residents with their human caregivers. However, the line between reality and imagination is blurred for dementia patients, so is it dishonest to introduce a robot as a pet and encourage a social-emotional involvement? (KALW, 2015) And if so, is if morally justifiable?

Companion robots and robotic pets could alleviate loneliness amongst older people, but this would require them believing, in some way, that a robot is a sentient being who cares about them and has feelings — a fundamental deception. Turkle et al. (2006) argue that 'the fact that our parents, grandparents and children might say 'I love you' to a robot who will say 'I love you' in return, does not feel completely comfortable; it raises questions about the kind of authenticity we require of our technology'. Wallach and Allen (2009) agree that robots designed to detect human social gestures and respond in kind all use techniques that are arguably forms of deception. For an individual to benefit from owning a robot pet, they must continually delude themselves about the real nature of their relation with the animal. What's more, encouraging elderly people to interact with robot toys has the effect of infantilising them.

Autonomy

It's important that healthcare robots actually benefit the patients themselves, and are not just designed to reduce the care burden on the rest of society — especially in the case of care and companion AI. Robots could empower disabled and older people and increase their independence; in fact, given the choice, some might prefer robotic over human assistance for certain intimate tasks such as toileting or bathing. Robots could be used to help elderly people live in their own homes for longer, giving them greater freedom and autonomy. However, how much control, or autonomy, should a person be allowed if their mental capability is in question? If a patient asked a robot to throw them off the balcony, should the robot carry out that command?

Liberty and privacy

As with many areas of AI technology, the privacy and dignity of users' needs to be carefully considered when designing healthcare service and companion robots. Working in people's homes means that robots will be privy to private moments such as bathing and dressing; if these moments are recorded, who should have access to the information, and how long should recordings be kept? The issue becomes more complicated if an elderly person's mental state deteriorates and they become confused — someone with Alzheimer's could forget that a robot was monitoring them, and could perform acts or say things thinking that they are in the privacy of their own home. Home-care robots need to be able to balance their user's privacy and nursing needs, for example by knocking and awaiting an invitation before entering a patient's room, except in a medical emergency.

To ensure their charge's safety, robots might sometimes need to act as supervisors, restricting their freedoms. For example, a robot could be trained to intervene if the cooker was left on, or the bath was overflowing. Robots might even need to restrain elderly people from carrying out potentially dangerous actions, such as climbing up on a chair to get something from a cupboard. Smart homes with sensors could be used to detect that a person is attempting to leave their room, and lock the door, or call staff — but in so doing the elderly person would be imprisoned.

Moral agency

'There's very exciting work where the brain can be used to control things, like maybe they've lost the use of an arm…where I think the real concerns lie is with things like behavioural targeting: going straight to the hippocampus and people pressing 'consent', like we do now, for data access'. (John Havens)

AMSCE-IOT

Robots do not have the capacity for ethical reflection or a moral basis for decision-making, and thus humans must currently hold ultimate control over any decision-making. An example of ethical reasoning in a robot can be found in the 2004 dystopian film 'I, Robot', where Will Smith's character disagreed with how the robots of the fictional time used cold logic to save his life over that of a child's. If more automated healthcare is pursued, then the question of moral agency will require closer attention. Ethical reasoning is being built into robots, but moral responsibility is about more than the application of ethics — and it is unclear whether robots of the future will be able to handle the complex moral issues in healthcare (Goldhill, 2016).

Trust

Larosa and Danks (2018) write that AI may affect human-human interactions and relationships within the healthcare domain, particularly that between patient and doctor, and potentially disrupt the trust we place in our doctor.

'Psychology research shows people mistrust those who make moral decisions by calculating costs and benefits — like computers do' (The Guardian, 2017). Our distrust of robots may also come from the number of robots running amok in dystopian science fiction. News stories of computer mistakes — for instance, of an image-identifying algorithm mistaking a turtle for a gun (The Verge, 2017) — alongside worries over the unknown, privacy and safety are all reasons for resistance against the uptake of AI (Global News Canada, 2016).

Firstly, doctors are explicitly certified and licensed to practice medicine, and their license indicates that they have specific skills, knowledge, and values such as 'do no harm'. If a robot replaces a doctor for a particular treatment or diagnostic task, this could potentially threaten patient-doctor trust, as the patient now needs to know whether the system is appropriately approved or 'licensed' for the functions it performs.

Secondly, patients trust doctors because they view them as paragons of expertise. If doctors were seen as 'mere users' of the AI, we would expect their role to be downgraded in the public's eye, undermining trust.

Thirdly, a patient's experiences with their doctor are a significant driver of trust. If a patient has an open line of communication with their doctor, and engages in conversation about care and treatment, then the patient will trust the doctor. Inversely, if the doctor repeatedly ignores the patient's wishes, then these actions will have a negative impact on trust. Introducing AI into this dynamic could increase trust — if the AI reduced the likelihood of misdiagnosis, for example, or improved patient care. However, AI could also decrease trust if the doctor delegated too much diagnostic or decision-making authority to the AI, undercutting the position of the doctor as an authority on medical matters.

As the body of evidence grows to support the therapeutic benefits for each technological approach, and as more robotic interacting systems enter the marketplace, then trust in robots is likely to increase. This has already happened for robotic healthcare systems such as the da Vinci surgical robotic assistant (The Guardian, 2014).

Employment replacement

As in other industries, there is a fear that emerging technologies may threaten employment (The Guardian, 2017), for instance, there are carebots now available that can perform up to a third of nurses' work (Tech Times, 2018). Despite these fears, the NHS' Topol Review (2009) concluded that 'these technologies will not replace healthcare professionals but will enhance them ('augment them'), giving them more time to care for patients'. The review also outlined how the UK's NHS will nurture a learning environment to ensure digitally capable employees.

AMSCE-101

3.3.2 Case study: Autonomous Vehicles

Autonomous Vehicles (AVs) are vehicles that are capable of sensing their environment and operating with little to no input from a human driver. While the idea of self-driving cars has been around since at least the 1920s, it is only in recent years that technology has developed to a point where AVs are appearing on public roads.

According to automotive standardisation body SAE International (2018), there are six levels of driving automation:

0	No automation	An automated system may issue warnings and/or momentarily intervene in driving, but has no sustained vehicle control.
1	Hands on	The driver and automated system share control of the vehicle. For example, the automated system may control engine power to maintain a set speed (e.g. Cruise Control), engine and brake power to maintain and vary speed (e.g. Adaptive Cruise Control), or steering (e.g. Parking Assistance). The driver must be ready to retake full control at any time.
2	Hands off	The automated system takes full control of the vehicle (including accelerating, braking, and steering). However, the driver must monitor the driving and be prepared to intervene immediately at any time.
3	Eyes off	The driver can safely turn their attention away from the driving tasks (e.g. to text or watch a film) as the vehicle will handle any situations that call for an immediate response. However, the driver must still be prepared to intervene, if called upon by the AV to do so, within a timeframe specified by the AV manufacturer.
4	Minds off	As level 3, but no driver attention is ever required for safety, meaning the driver can safely go to sleep or leave the driver's seat.
5	Steering wheel optional	No human intervention is required at all. An example of a level 5 AV would be a robotic taxi.

Some of the lower levels of automation are already well-established and on the market, while higher level AVs are undergoing development and testing. However, as we transition up the levels and put more responsibility on the automated system than the human driver, a number of ethical issues emerge.

Societal and Ethical Impacts of AVs

'We cannot build these tools saying, 'we know that humans act a certain way, we're going to kill them – here's what to do'.' (John Havens)

Public safety and the ethics of testing on public roads

At present, cars with 'assisted driving' functions are legal in most countries. Notably, some Tesla models have an Autopilot function, which provides level 2 automation (Tesla, nd). Drivers are legally allowed to use assisted driving functions on public roads provided they remain in charge of the

AMSCE-IOL

vehicle at all times. However, many of these assisted driving functions have not yet been subject to independent safety certification, and as such may pose a risk to drivers and other road users. In Germany, a report published by the Ethics Commission on Automated Driving highlights that it is the public sector's responsibility to guarantee the safety of AV systems introduced and licensed on public roads, and recommends that all AV driving systems be subject to official licensing and monitoring (Ethics Commision, 2017).

In addition, it has been suggested that the AV industry is entering its most dangerous phase, with cars being not yet fully autonomous but human operators not being fully engaged (Solon, 2018). The risks this poses have been brought to widespread attention following the first pedestrian fatality involving an autonomous car. The tragedy took place in Arizona, USA, in May 2018, when a level 3 AV being tested by Uber collided with 49-year-old Elaine Herzberg as she was walking her bike across a street one night. It was determined that Uber was 'not criminally liable' by prosecutors (Shepherdson and Somerville, 2019), and the US National Transportation Safety Board's preliminary report (NTSB, 2018), which drew no conclusions about the cause, said that all elements of the self-driving system were operating normally at the time of the crash. Uber said that the driver is relied upon to intervene and take action in situations requiring emergency braking – leading some commentators to call out the misleading communication to consumers around the terms 'self-driving cars' and 'autopilot' (Leggett, 2018). The accident also caused some to condemn the practice of testing AV systems on public roads as dangerous and unethical, and led Uber to temporarily suspend its self-driving programme (Bradshaw, 2018).

This issue of human safety — of both public and passenger — is emerging as a key issue concerning self-driving cars. Major companies — Nissan, Toyota, Tesla, Uber, Volkswagen — are developing autonomous vehicles capable of operating in complex, unpredictable environments without direct human control, and capable of learning, inferring, planning and making decisions.

Self-driving vehicles could offer multiple benefits: statistics show you're almost certainly safer in a car driven by a computer than one driven by a human. They could also ease congestion in cities, reduce pollution, reduce travel and commute times, and enable people to use their time more productively. However, they won't mean the end of road traffic accidents. Even if a self-driving car has the best software and hardware available, there is still a collision risk. An autonomous car could be surprised, say by a child emerging from behind a parked vehicle, and there is always the issue of *how: how* should such cars be programmed when they must decide whose safety to prioritise?

Driverless cars may also have to choose between the safety of passengers and other road users. Say that a car travels around a corner where a group of school children are playing; there is not enough time to stop, and the only way the car can avoid hitting the children is to swerve into a brick wall — endangering the passenger. Whose safety should the car prioritise: the children's', or the passenger's?

Processes and technologies for accident investigation

AVs are complex systems that often rely on advanced machine learning technologies. Several serious accidents have already occurred, including a number of fatalities involving level 2 AVs:

- In January 2016, 23-year-old Gao Yaning died when his Tesla Model S crashed into the back of a road-sweeping truck on a highway in Hebei, China. The family believe Autopilot was engaged when the accident occurred and accuse Tesla of exaggerating the system's capabilities. Tesla state that the damage to the vehicle made it impossible to determine whether Autopilot was engaged and, if so, whether it malfunctioned. A civil case into the crash is ongoing, with a third-party appraiser reviewing data from the vehicle (Curtis, 2016).

AMSCE-IQI

- In May 2016, 40-year-old Joshua Brown died when his Tesla Model S collided with a truck while Autopilot was engaged in Florida, USA. An investigation by the National Highways and Transport Safety Agency found that the driver, and not Tesla, were at fault (Gibbs, 2016). However, the National Highway Traffic Safety Administration later determined that both Autopilot and over-reliance by the motorist on Tesla's driving aids were to blame (Felton, 2017).

- In March 2018, Wei Huang was killed when his Tesla Model X crashed into a highway safety barrier in California, USA. According to Tesla, the severity of the accident was 'unprecedented'. The National Transportation Safety Board later published a report attributing the crash to an Autopilot navigation mistake. Tesla is now being sued by the victim's family (O'Kane, 2018).

Unfortunately, efforts to investigate these accidents have been stymied by the fact that standards, processes, and regulatory frameworks for investigating accidents involving AVs have not yet been developed or adopted. In addition, the proprietary data logging systems currently installed in AVs mean that accident investigators rely heavily on the cooperation of manufacturers to provide critical data on the events leading up to an accident (Stilgoe and Winfield, 2018).

One solution is to fit all future AVs with industry standard event data recorders — a so-called 'ethical black box' — that independent accident investigators could access. This would mirror the model already in place for air accident investigations (Sample, 2017).

Near-miss accidents

At present, there is no system in place for the systematic collection of near-miss accidents. While it is possible that manufacturers are collecting this data already, they are not under any obligation to do so — or to share the data. The only exception at the moment is the US state of California, which requires all companies that are actively testing AVs on public roads to disclose the frequency at which human drivers were forced to take control of the vehicle for safety reasons (known as 'disengagement').

In 2018, the number of disengagements by AV manufacturer varied significantly, from one disengagement for every 11,017 miles driven by Waymo AVs to one for every 1.15 miles driven by Apple AVs (Hawkins, 2019). Data on these disengagements reinforces the importance of ensuring that human safety drivers remain engaged. However, the Californian data collection process has been criticised, with some claiming its ambiguous wording and lack of strict guidelines enables companies to avoid reporting certain events that could be termed near-misses.

Without access to this type of data, policymakers cannot account for the frequency and significance of near-miss accidents, or assess the steps taken by manufacturers as a result of these near-misses. Again, lessons could be learned from the model followed in air accident investigations, in which all near misses are thoroughly logged and independently investigated. Policymakers require comprehensive statistics on all accidents and near-misses in order to inform regulation.

Data privacy

It is becoming clear that manufacturers collect significant amounts of data from AVs. As these vehicles become increasingly common on our roads, the question emerges: to what extent are these data compromising the privacy and data protection rights of drivers and passengers?

Already, data management and privacy issues have appeared, with some raising concerns about the potential misuse of AV data for advertising purposes (Lin, 2014). Tesla have also come under fire for the unethical use of AV data logs. In an investigation by *The Guardian*, the newspaper found multiple instances where the company shared drivers' private data with the media following crashes, without their permission, to prove that its technology was not responsible (Thielman, 2017). At the same time, Tesla does not allow customers to see their own data logs.

One solution, proposed by the German Ethics Commission on Automated Driving, is to ensure that that all AV drivers be given full data sovereignty (Ethics Commission, 2017). This would allow them to control how their data is used.

Employment

The growth of AVs is likely to put certain jobs — most pertinently bus, taxi, and truck drivers — at risk.

In the medium term, truck drivers face the greatest risk as long-distance trucks are at the forefront of AV technology (Viscelli, 2018). In 2016, the first commercial delivery of beer was made using a self-driving truck, in a journey covering 120 miles and involving no human action (Isaac, 2016). Last year saw the first fully driverless trip in a self-driving truck, with the AV travelling seven miles without a single human on board (Cannon, 2018).

Looking further forward, bus drivers are also likely to lose jobs as more and more buses become driverless. Numerous cities across the world have announced plans to introduce self-driving shuttles in the future, including Edinburgh (Calder, 2018), New York (BBC, 2019a) and Singapore (BBC 2017). In some places, this vision has already become a reality; the Las Vegas shuttle famously got off to a bumpy start when it was involved in a collision on its first day of operation (Park, 2017), and tourists in the small Swiss town of Neuhausen Rheinfall can now hop on a self-driving bus to visit the nearby waterfalls (CNN, 2018). In the medium term, driverless buses will likely be limited to routes that travel along 100% dedicated bus lanes. Nonetheless, the advance of self-driving shuttles has already created tensions with organised labour and city officials in the USA (Weinberg, 2019). Last year, the Transport Workers Union of America formed a coalition in an attempt to stop autonomous buses from hitting the streets of Ohio (Pfleger, 2018).

Fully autonomous taxis will likely only become realistic in the long term, once AV technology has been fully tested and proven at levels 4 and 5. Nonetheless, with plans to introduce self-driving taxis in London by 2021 (BBC, 2018), and an automated taxi service already available in Arizona, USA (Sage, 2019), it is easy to see why taxi drivers are uneasy.

The quality of urban environments

In the long-term, AVs have the potential to reshape our urban environment. Some of these changes may have negative consequences for pedestrians, cyclists and locals. As driving becomes more automated, there will likely be a need for additional infrastructure (e.g. AV-only lanes). There may also be more far-reaching effects for urban planning, with automation shaping the planning of everything from traffic congestion and parking to green spaces and lobbies (Marshall and Davies, 2018). The rollout of AVs will also require that 5G network coverage is extended significantly — again, something with implications for urban planning (Khosravi, 2018).

The environmental impact of self-driving cars should also be considered. While self-driving cars have the potential to significantly reduce fuel usage and associated emissions, these savings could be counteracted by the fact that self-driving cars make it easier and more appealing to drive long distances (Worland, 2016). The impact of automation on driving behaviours should therefore not be underestimated.

Legal and ethical responsibility

From a legal perspective, who is responsible for crashes caused by robots, and how should victims be compensated (if at all) when a vehicle controlled by an algorithm causes injury? If courts cannot resolve this problem, robot manufacturers may incur unexpected costs that would discourage investment. However, if victims are not properly compensated then autonomous vehicles are unlikely to be trusted or accepted by the public.

Robots will need to make judgement calls in conditions of uncertainty, or 'no win' situations. However, which ethical approach or theory should a robot be programmed to follow when there's no legal guidance? As Lin et al. explain, different approaches can generate different results, including the number of crash fatalities.

Additionally, who should choose the ethics for the autonomous vehicle — drivers, consumers, passengers, manufacturers, politicians? Loh and Loh (2017) argue that responsibility should be shared among the engineers, the driver and the autonomous driving system itself. However, Millar (2016) suggests that the user of the technology, in this case the passenger in the self-driving car, should be able to decide what ethical or behavioural principles the robot ought to follow. Using the example of doctors, who do not have the moral authority to make important decisions on end-of-life care without the informed consent of their patients, he argues that there would be a moral outcry if engineers designed cars without either asking the driver directly for their input, or informing the user ahead of time how the car is programmed to behave in certain situations.

Ethical dilemmas in development

In 2014, the Open Roboethics initiative (ORi 2014a, 2014b) conducted a poll asking people what they thought an autonomous car in which they were a passenger should do if a child stepped out in front of the vehicle in a tunnel. The car wouldn't have time to brake and spare the child, but could swerve into the walls of the tunnel, killing the passenger. This is a spin on the classic 'trolley dilemma', where one has the option to divert a runaway trolley from a path that would hurt several people onto the path that would only hurt one.

36 % of participants said that they would prefer the car to swerve into the wall, saving the child; however, the majority (64 %) said they would wish to save themselves, thus sacrificing the child. 44 % of participants thought that the passenger should be able to choose the car's course of action, while 33 % said that lawmakers should choose. Only 12 % said that the car's manufacturers should make the decision. These results suggest that people do not like the idea of engineers making moral decisions on their behalf.

Asking for the passenger's input in every situation would be impractical. However, Millar (2016) suggests a 'setup' procedure where people could choose their ethics settings after purchasing a new car. Nonetheless, choosing how the car reacts in advance could be seen as premeditated harm, if, for example a user programmed their vehicle to always avoid vehicle collisions by swerving into cyclists. This would increase the user's accountability and liability, whilst diverting responsibility away from manufacturers.

3.3.3 Case study: Warfare and weaponisation

Although partially autonomous and intelligent systems have been used in military technology since at least the Second World War, advances in machine learning and AI signify a turning point in the use of automation in warfare.

AI is already sufficiently advanced and sophisticated to be used in areas such as satellite imagery analysis and cyber defence, but the true scope of applications has yet to be fully realised. A recent report concludes that AI technology has the potential to transform warfare to the same, or perhaps even a greater, extent than the advent of nuclear weapons, aircraft, computers and biotechnology (Allen and Chan, 2017). Some key ways in which AI will impact militaries are outlined below.

Lethal autonomous weapons

As automatic and autonomous systems have become more capable, militaries have become more willing to delegate authority to them. This is likely to continue with the widespread adoption of AI, leading to an AI inspired arms-race. The Russian Military Industrial Committee has already approved an aggressive plan whereby 30% of Russian combat power will consist of entirely remote-controlled and autonomous robotic platforms by 2030. Other countries are likely to set similar goals. While the United States Department of Defense has enacted restrictions on the use of autonomous and semi-autonomous systems wielding lethal force, other countries and non-state actors may not exercise such self-restraint.

Drone technologies

Standard military aircraft can cost more than US$100 million per unit; a high-quality quadcopter Unmanned Aerial Vehicle, however, currently costs roughly US$1,000, meaning that for the price of a single high-end aircraft, a military could acquire one million drones. Although current commercial drones have limited range, in the future they could have similar ranges to ballistic missiles, thus rendering existing platforms obsolete.

Robotic assassination

Widespread availability of low-cost, highly-capable, lethal, and autonomous robots could make targeted assassination more widespread and more difficult to attribute. Automatic sniping robots could assassinate targets from afar.

Mobile-robotic-Improvised Explosive Devices

As commercial robotic and autonomous vehicle technologies become widespread, some groups will leverage this to make more advanced Improvised Explosive Devices (IEDs). Currently, the technological capability to rapidly deliver explosives to a precise target from many miles away is restricted to powerful nation states. However, if long distance package delivery by drone becomes a reality, the cost of precisely delivering explosives from afar would fall from millions of dollars to thousands or even hundreds. Similarly, self-driving cars could make suicide car bombs more frequent and devastating since they no longer require a suicidal driver.

Hallaq et al. (2017) also highlight key areas in which machine learning is likely to affect warfare. They describe an example where a Commanding Officer (CO) could employ an Intelligent Virtual Assistant (IVA) within a fluid battlefield environment that automatically scanned satellite imagery to detect specific vehicle types, helping to identify threats in advance. It could also predict the enemy's intent, and compare situational data to a stored database of hundreds of previous wargame exercises and live engagements, providing the CO with access to a level of accumulated knowledge that would otherwise be impossible to accrue.

Employing AI in warfare raises several **legal and ethical questions**. One concern is that automated weapon systems that exclude human judgment could violate International Humanitarian Law, and threaten our fundamental right to life and the principle of human dignity. AI could also lower the threshold of going to war, affecting global stability.

International Humanitarian law stipulates that any attack needs to distinguish between combatants and non-combatants, be proportional and must not target civilians or civilian objects. Also, no attack should unnecessarily aggravate the suffering of combatants. AI may be unable to fulfil these principles without the involvement of human judgment. In particular, many researchers are concerned that Lethal Autonomous Weapon Systems (LAWS) — a type of autonomous military robot that can independently search for and 'engage' targets using lethal force — may not meet the standards set by International Humanitarian Law, as they are not able to distinguish civilians from

AMSCE-110l

combatants, and would not be able to judge whether the force of the attack was proportional given the civilian damage it would incur.

Amoroso and Tamburrini (2016, p. 6) argue that: '[LAWS must be] capable of respecting the principles of distinction and proportionality at least as well as a competent and conscientious human soldier'. However, Lim (2019) points out that while LAWS that fail to meet these requirements should not be deployed, one day LAWS *will* be sophisticated enough to meet the requirements of distinction and proportionality. Meanwhile, Asaro (2012) argues that it doesn't matter how good LAWS get; it is a moral requirement that only a human should initiate lethal force, and it is simply morally wrong to delegate life or death decisions to machines.

Some argue that delegating the decision to kill a human to a machine is an infringement of basic human dignity, as robots don't feel emotion, and can have no notion of sacrifice and what it means to take a life. As Lim et al (2019) explain, 'a machine, bloodless and without morality or mortality, cannot fathom the significance of using force against a human being and cannot do justice to the gravity of the decision'.

Robots also have no concept of what it means to kill the 'wrong' person. 'It is only because humans can feel the rage and agony that accompanies the killing of humans that they can understand sacrifice and the use of force against a human. Only then can they realise the 'gravity of the decision' to kill' (Johnson and Axinn 2013, p. 136).

However, others argue that there is no particular reason why being killed by a machine would be a subjectively worse, or less dignified, experience than being killed by a cruise missile strike. 'What matters is whether the victim experiences a sense of humiliation in the process of getting killed. Victims being threatened with a potential bombing will not care whether the bomb is dropped by a human or a robot' (Lim et al, 2019). In addition, not all humans have the emotional capacity to conceptualise sacrifice or the relevant emotions that accompany risk. In the heat of battle, soldiers rarely have time to think about the concept of sacrifice, or generate the relevant emotions to make informed decisions each time they deploy lethal force.

Additionally, who should be held accountable for the actions of autonomous systems — the commander, programmer, or the operator of the system? Schmit (2013) argues that the responsibility for committing war crimes should fall on both the individual who programmed the AI, and the commander or supervisor (assuming that they knew, or should have known, the autonomous weapon system had been programmed and employed in a war crime, and that they did nothing to stop it from happening).

AMSCE-IOI

4. AI standards and regulation

A small new generation of ethical standards are emerging as the ethical, legal and societal impacts of artificial intelligence and robotics are further understood. Whether a standard clearly articulates explicit or implicit ethical concerns, all standards embody some kind of ethical principle (Winfield, 2019a). The standards that do exist are still in development and there is limited publicly available information on them.

Perhaps the earliest explicit ethical standard in robotics is BS 8611 Guide to the Ethical Design and Application of Robots and Robotic Systems (British Standard BS 8611, 2016). BS8611 is not a code of practice, but guidance on how designers can identify potential ethical harm, undertake an ethical risk assessment of their robot or AI, and mitigate any ethical risks identified. It is based on a set of 20 distinct ethical hazards and risks, grouped under four categories: societal, application, commercial & financial, and environmental.

Advice on measures to mitigate the impact of each risk is given, along with suggestions on how such measures might be verified or validated. The societal hazards include, for example, loss of trust, deception, infringements of privacy and confidentiality, addiction, and loss of employment. Ethical Risk Assessment should consider also foreseeable misuse, risks leading to stress and fear (and their minimisation), control failure (and associated psychological effect), reconfiguration and linked changes to responsibilities, hazards associated with specific robotics applications. Particular attention is paid to robots that can learn and the implications of robot enhancement that arise, and the standard argues that the ethical risk associated with the use of a robot should not exceed the risk of the same activity when conducted by a human.

British Standard BS 8611 assumes that physical hazards imply ethical hazards, and defines ethical harm as affecting 'psychological and/or societal and environmental well-being.' It also recognises that physical and emotional_hazards need to be balanced against expected benefits to the user. The standard highlights the need to involve the public and stakeholders in development of robots and provides a list of key design considerations including:

- Robots should not be designed primarily to kill humans;
- Humans remain responsible agents;
- It must be possible to find out who is responsible for any robot;
- Robots should be safe and fit for purpose;
- Robots should not be designed to be deceptive;
- The precautionary principle should be followed;
- Privacy should be built into the design;
- Users should not be discriminated against, nor forced to use a robot.

Particular guidelines are provided for roboticists, particularly those conducting research. These include the need to engage the public, consider public concerns, work with experts from other disciplines, correct misinformation and provide clear instructions. Specific methods to ensure ethical use of robots include: user validation (to ensure robot can/is operated as expected), software verification (to ensure software works as anticipated), involvement of other experts in ethical assessment, economic and social assessment of anticipated outcomes, assessment of any legal implications, compliance testing against relevant standards. Where appropriate, other guidelines and ethical codes should be taken into consideration in the design and operation of robots (e.g. medical or legal codes relevant in specific contexts). The standard also makes the case that military application of robots does not remove the responsibility and accountability of humans.

AMSCE-101

The IEEE Standards Association has also launched a standard via its global initiative on the Ethics of Autonomous and Intelligent Systems. Positioning 'human well-being' as a central precept, the IEEE initiative explicitly seeks to reposition robotics and AI as technologies for improving the human condition rather than simply vehicles for economic growth (Winfield, 2019a). Its aim is to educate, train and empower AI/robot stakeholders to 'prioritise ethical considerations so that these technologies are advanced for the benefit of humanity.'

There are currently 14 IEEE standards working groups working on drafting so-called 'human' standards that have implications for artificial intelligence (Table 4.1).

AMSCE-1101

Table 2: IEEE 'human standards' with implications for AI

Standard		Aims/Objectives
P7000	Model Process for Addressing Ethical Concerns During System Design	To establish a process for **ethical design of Autonomous and Intelligent Systems**.
P7001	Transparency of Autonomous Systems	To ensure the **transparency of autonomous systems to a range of stakeholders**. It specifically will address: • *Users*: ensuring users understand what the system does and why, with the intention of building trust; • *Validation and certification*: ensuring the system is subject to scrutiny; • *Accidents*: enabling accident investigators to undertake investigation; • *Lawyers and expert witnesses:* ensuring that, following an accident, these groups are able to give evidence; • *Disruptive technology (e.g. driverless cars*): enabling the public to assess technology (and, if appropriate, build confidence).
P7002	Data Privacy Process	To establish standards for **the ethical use of personal data** in software engineering processes. It will develop and describe privacy impact assessments (PIA) that can be used to identify the need for, and effectiveness of, privacy control measures. It will also provide checklists for those developing software that uses personal information.

AMSCE-101

P7003	Algorithmic Bias Considerations	To help algorithm developers make explicit the ways in which they have sought to **eliminate or minimise the risk of bias** in their products. This will address the use of overly subjective information and help developers ensure they are compliant with legislation regarding protected characteristics (e.g. race, gender). It is likely to include: • Benchmarking processes for the selection of data sets; • Guidelines on communicating the boundaries for which the algorithm has been designed and validated (guarding against unintended consequences of unexpected uses); • Strategies to avoid incorrect interpretation of system outputs by users.
P7004	Standard for Child and Student Data Governance	Specifically **aimed at educational institutions,** this will provide guidance on accessing, collecting, storing, using, sharing and destroying child/student data.
P7005	Standard for Transparent Employer Data Governance	Similar to P7004, but **aimed at employers**.
P7006	Standard for Personal Data Artificial Intelligence (AI) Agent	Describes the technical elements required to create and grant access to **personalised AI.** It will enable individuals to safely organise and share their personal information at a machine-readable level, and enable personalised AI to act as a proxy for machine-to-machine decisions.
P7007	Ontological Standard for Ethically Driven Robotics and Automation Systems	This standard brings together engineering and philosophy **to ensure that user well-being is considered throughout the product life cycle**. It intends to identify ways to maximise benefits and minimise negative impacts, and will also consider the ways in which communication can be clear between diverse communities.

P7008	Standard for Ethically Driven Nudging for Robotic, Intelligent and Autonomous Systems	Drawing on 'nudge theory', this standard seeks **to delineate current or potential nudges that robots or autonomous systems might undertake**. It recognises that nudges can be used for a range of reasons, but that they seek to affect the recipient emotionally, change behaviours and can be manipulative, and seeks to elaborate methodologies for ethical design of AI using nudge.
P7009	Standard for Fail-Safe Design of Autonomous and Semi-Autonomous Systems	To create effective methodologies for **the development and implementation of robust, transparent and accountable fail-safe mechanisms**. It will address methods for measuring and testing a system's ability to fail safely.
P7010	Well-being Metrics Standard for Ethical Artificial Intelligence and Autonomous Systems	To establish a baseline for metrics used **to assess well-being factors that could be affected by autonomous systems**, and for how human well-being could proactively be improved.
P7011	Standard for the Process of Identifying and Rating the Trustworthiness of News Sources	Focusing on news information, this standard sets out t**o standardise the processes for assessing the factual accuracy of news stories**. It will be used to produce a 'trustfulness' score. This standard seeks to address the negative effects of unchecked 'fake' news, and is designed to restore trust in news purveyors.
P7012	Standard for Machine Readable Personal Privacy Terms	To establish **how privacy terms are presented** and how they could be read and accepted by machines.
P7013	Inclusion and Application Standards for Automated Facial Analysis Technology	To provide **guidelines on the data used in facial recognition**, the requirements for diversity, and benchmarking of applications and situations in which facial recognition should not be used.

AMSCE-101

5. National and International Strategies on AI

As the technology behind AI continues to progress beyond expectations, policy initiatives are springing up across the globe to keep pace with these developments.

The first national strategy on AI was launched by Canada in March 2017, followed soon after by technology leaders Japan and China. In Europe, the European Commission put forward a communication on AI, initiating the development of independent strategies by Member States. An American AI initiative is expected soon, alongside intense efforts in Russia to formalise their 10-point plan for AI.

These initiatives differ widely in terms of their goals, the extent of their investment, and their commitment to developing ethical frameworks, reviewed here as of May 2019.

AMSCE-1101

Figure 3: National and International Strategies on AI published as of May 2019.

DENMARK
National Strategy for Artificial Intelligence

2019 MAR

>100 million €

Aims to set an ethical and human-centred basis for AI, strengthen research, encourage business to use AI, and use AI to improve public services. A 'responsible foundation' for AI is a priority focus area, including establishing ethical principles and a Data Ethics Council.

FINLAND
Artificial Intelligence Programme

2017 MAY

100 million €

Aims to enhance business competitiveness, use data effectively in all sectors, build better public services, and establish new models for collaboration. The interim report '*Work in the Age of Artificial Intelligence*' offers additional recommendations related to ethics.

GERMANY
National AI strategy of the Federal Government

2018 NOV

3 billion €

Aims to develop excellence centres for AI research, fund professorships and start-ups, start a '*Digital Work and Society Future*' fund to integrate AI in society, and establish a German AI observatory and working group of data protection authorities and business associations.

NORDIC-BALTIC REGION
Declaration on AI in the Nordic-Baltic Region

2018 MAY

Unknown €

Aims to improve opportunities for skill development, improve access to data, and develop (a) standards for infrastructure and (b) ethical, transparent guidelines and standards.

SWEDEN
National Approach for Artificial Intelligence

2018 MAY

Unknown €

Aims to achieve benefits for competitiveness and welfare, train more AI professionals, and expand research.

Includes a framework for the development of '*ethical, sustainable and safe*' AI applications.

FRANCE
AI For Humanity

2018 MAR

1.5 billion €

Aims to support French talent, exploit massive centralised databases, and establish an ethical framework.

Makes commitments to algorithm transparency, ethics training for engineers, and an ethics committee to organise public debate.

UNITED KINGDOM
AI Sector Deal

2018 APR

1 billion €

Aims to position the UK as a leader in AI development by investing heavily in research, innovation and education: raise R&D investment to 2.4% of GDP, invest over £400 million in education, and create a £64 million re-training scheme. Ethics component: Centre for Data Ethics and Innovation established to advise the government on AI.

EUROPEAN UNION
Strategy on AI for Europe

2018 APR

1.5 billion €

Aims: National strategies for all Member States by 2019, funding for start-ups and AI excellence centres, data sharing, and improved AI education.

Ethical component: *Ethics Guidelines for Trustworthy AI.*

EUROPE

AI AROUND THE WORLD

SOUTH AMERICA

MEXICO
AI-MX 2018

2018 JUN

Unknown €

Aims to develop a governance framework for AI, create an AI subcommittee, map industry needs, and promote the international leadership of Mexico in AI.

Ethics component: Commitment to create a Mexican AI Ethics Council.

NORTH AMERICA

CANADA
Pan-Canadian Artificial Intelligence Strategy

2017 MAR

80 million €

Aims to expand the AI workforce, establish three major centres of scientific excellence for AI, develop global thought leadership, and support the national research community. Ethics component: AI and Society programme to consider the implications of AI.

ASIA

CHINA
Next Generation Artificial Intelligence Development Plan

2017 JUL

25 billion €

Aims to become the primary centre for AI innovation by 2030, with an AI industry worth €130 billion and related industries worth €1 trillion. Ethics component: High-level ethics committee established to assess the risks of large-scale AI applications.

INDIA
AI for All

2018 JUN

30 billion €

Aims to achieve AI for societal benefit through Centres of Research Excellence (CORES) and International Centres of Transformational AI (ICTAIs). Ethics component: Ethics council established at each CORE, working under the '*Fairness, Accountability and Transparency*' framework.

JAPAN
Artificial Intelligence Technology Strategy

2017 MAR

Unknown €

Aims to achieve the widespread use of AI by 2030 as part of the 'Society 5.0' framework. Includes investments in research, training, public data and start-ups. Strategy explicitly considers intellectual property rights and protection of personal information.

UNITED ARAB EMIRATES
UAE Strategy for AI

2017 OCT

Unknown €

Aims to halve annual costs in government, and become 90% resistant to financial crisis and a world leader in AI investment. Includes an AI Ethics toolkit and ethics self-assessment tool launched by the Government of Dubai.

SOUTH KOREA
Artificial Intelligence Information Industry Development Strategy

2018 MAY

1.75 billion €

Aims to be in the top four global AI leaders by 2022 by funding R&D, investing in education (including six AI graduate schools) and supporting business with an AI start-up incubator.

TAIWAN
Taiwan AI Action Plan

2018 JAN

285 million €

Aims to train 10,000 AI professionals by 2021, invest in R&D through the 'AI Pilot Project', and promote business with an innovation hub for AI-based start-ups. No dedicated ethics framework, but the strategy includes analysis of related legal issues.

SINGAPORE
AI Singapore

2017 MAY

100 million €

Aims to expand AI research, fund 100 experiments for AI-based solutions to industry-identified challenges, and initiate an AI apprenticeship scheme, under an Advisory Council on the Ethical Use of AI and Data.

AMSCE 101

5.1. Europe

The European Commission's Communication on Artificial Intelligence (European Commission, 2018a), released in April 2018, paved the way to the first international strategy on AI. The document outlines a coordinated approach to maximise the benefits, and address the challenges, brought about by AI.

The Communication on AI was formalised nine months later with the presentation of a coordinated plan on AI (European Commission, 2018b). The plan details seven objectives, which include financing start-ups, investing €1.5 billion in several 'research excellence centres', supporting masters and PhDs in AI and creating common European data spaces.

Objective 2.6 of the plan is to develop 'ethics guidelines with a global perspective'. The Commission appointed an independent high-level expert group to develop their ethics guidelines, which – following consultation – were published in their final form in April 2019 (European Commission High-Level Expert Group on Artificial Intelligence, 2019). The Guidelines list key requirements that AI systems must meet in order to be trustworthy.

The EU’s seven requirements for trustworthy AI:

1. Human agency and oversight
2. Technical robustness and safety
3. Privacy and data governance
4. Transparency
5. Diversity, non-discrimination and fairness
6. Societal and environmental wellbeing
7. Accountability

Source: European Commission High-Level Expert Group on Artificial Intelligence, 2019

The EU's High-Level Expert Group on AI shortly after released a further set of policy and investment guidelines for trustworthy AI (European Commission High-Level Expert Group on AI, 2019b), which includes a number of important recommendations around protecting people, boosting uptake of AI in the private sector, expanding European research capacity in AI and developing ethical data management practices.

The Council of Europe also has various ongoing projects regarding the application of AI and in September 2019 established an Ad Hoc Committee on Artificial Intelligence (CAHAI). The committee will assess the potential elements of a legal framework for the development and application of AI, based on the Council's founding principles of human rights, democracy and the rule of law (Council of Europe, 2019a).

Looking ahead, the next European Commission President, Ursula von der Leyen, has announced AI as a priority for the next Commission, including legislation for a coordinated approach on the 'human and ethical implications' of AI (Kayali, 2019; von der Leyen, 2019).

The European Commission provides a unifying framework for AI development in the EU, but Member States are also required to develop their own national strategies.

AMSCE-1101

Finland was the first Member State to develop a national programme on AI (Ministry of Economic Affairs and Employment of Finland, 2018a). The programme is based on two reports, *Finland's Age of Artificial Intelligence* and *Work in the Age of Artificial Intelligence* (Ministry of Economic Affairs and Employment of Finland, 2017, 2018b). Policy objectives focus on investment for business competitiveness and public services. Although recommendations have already been incorporated into policy, Finland's AI steering group will run until the end of the present Government's term, with a final report expected imminently.

So far, Denmark, France, Germany, Sweden and the UK have also announced national initiatives on AI. **Denmark**'s National Strategy for Artificial Intelligence (The Danish Government, 2019) was released in March 2019 and follows its 'Strategy for Digital Growth' (The Danish Government, 2018). This comprehensive framework lists objectives including establishing a responsible foundation for AI, providing high quality data and overall increasing investment in AI (particularly in the agriculture, energy, healthcare and transport sectors). There is a strong focus on data ethics, including responsibility, security and transparency, and recognition of the need for an ethical framework. The Danish government outlines six principles for ethical AI – self-determination, dignity, responsibility, explainability, equality and justice, and development (solutions that support ethically responsible development and use of AI in order to achieve societal progress) – and will establish a Data Ethics Council to monitor technological development in the country.

In **France**, 'AI for Humanity' was launched in March 2018 and makes commitments to support French talent, make better use of data and also establish an ethical framework on AI (AI For Humanity, 2018). President Macron has committed to ensuring transparency and fair use in AI, which will be embedded in the education system. The strategy is mainly based on the work of Cédric Villani, French mathematician and politician, whose 2018 report on AI made recommendations across economic policy, research infrastructure, employment and ethics (Villani, 2018).

Germany's AI Strategy was adopted soon after in November 2018 (Die Bundesregierung, 2018) and makes three major pledges: to make Germany a global leader in the development and use of AI, to safeguard the responsible development and use of AI, and to integrate AI in society in ethical, legal, cultural and institutional terms. Individual objectives include developing Centres of Excellence for research, the creation of 100 extra professorships for AI, establishing a German AI observatory, funding 50 flagship applications of AI to benefit the environment, developing guidelines for AI that are compatible with data protection laws, and establishing a 'Digital Work and Society Future Fund' (De.digital, 2018).

Sweden's approach to AI (Government Offices of Sweden, 2018) has less specific terms, but provides general guidance on education, research, innovation and infrastructure for AI. Recommendations include building a strong research base, collaboration between sectors and with other countries, developing efforts to prevent and manage risk and developing standards to guide the ethical use of AI. A Swedish AI Council, made up of experts from industry and academia, has also been established to develop a 'Swedish model' for AI, which they say will be sustainable, beneficial to society and promote long-term economic growth (Swedish AI Council, 2019).

The **UK** government issued the comprehensive 'AI Sector Deal' in April 2018 (GOV.UK, 2018), part of a larger 'Industrial Strategy', which sets out to increase productivity by investing in business, skills and infrastructure (GOV.UK, 2019). It pledges almost £1 billion to promote AI in the UK, along five key themes: ideas, people, infrastructure, business environment and places.

Key policies include increasing research and development investment to a total of 2.4% of GDP by 2027; investing over £400 million in maths, digital and technical education; developing a national retraining scheme to plug the skills gap and investing in digital infrastructure such as electric vehicles and fibre networks. As well as these investment commitments, included in the deal is the creation of a 'Centre for Data Ethics and Innovation' (CDEI) to ensure the safe and ethical use of AI. First announced in the 2017 budget, the CDEI will assess the risks of AI, review regulatory and governance frameworks and advise the government and technology creators on best practice (UK Government Department for Digital, Culture, Media & Sport, 2019).

Several other European nations are well on their way to releasing national strategies. **Austria** has established a 'Robot Council' to help the Government to develop a national AI Strategy (Austrian Council on Robotics and Artificial Intelligence, 2019). A white paper prepared by the Council lays the groundwork for the strategy. The socially-focused document includes objectives to promote the responsible use of AI, develop measures to recognise and mitigate hazards, create a legal framework to protect data security, and engender a public dialogue around the use of AI (Austrian Council on Robotics and Artificial Intelligence, 2018).

Estonia has traditionally been quick to take up new technologies, AI included. In 2017, Estonia's Adviser for Digital Innovation Marten Kaevats described AI as the next step for 'e-governance' in Estonia (Plantera, 2017). Indeed, AI is already widely used by the government, which is currently devising a national AI strategy (Castellanos, 2018). The plan will reportedly consider the ethical implications of AI, alongside offering practical economic incentives and pilot programmes.

An AI task force has been established by **Italy** (Agency for Digital Italy, 2019) to identify the opportunities offered by AI and improve the quality of public services. Their white paper (Task Force on Artificial Intelligence of the Agency for Digital Italy, 2018), published in March 2018, describes ethics as the first challenge to the successful implementation of AI, stating a need to uphold the principle that AI should be at the service of the citizen and to ensure equality by using technology to address universal needs. The task force further outline challenges relating to technology development, the skills gap, data accessibility and quality, and a legal framework. It makes a total of 10 recommendations to government, which are yet to be realised by policy.

Malta, a country that has previously focused heavily on blockchain technology, has now made public its plans to develop a national AI strategy, putting Malta 'amongst the top 10 nations with a national strategy for AI' (Malta AI, 2019). A task force has been established composed of industry representatives, academics and other experts to help devise a policy for Malta that will focus on an ethical, transparent and socially-responsible AI while developing measures that garner foreign investment, which will include developing the skillset and infrastructure needed to support AI in Malta.

Poland too is working on its national AI strategy. A report recently released by the Digital Poland Foundation (2019) focuses on the AI ecosystem in Poland, as a forerunner of the national AI strategy. Although it provides a comprehensive overview of the state-of-the-art in Poland, it does not make specific recommendations for government, and makes no reference to the ethical issues surrounding AI.

Despite media reports of military-focused AI developments in **Russia** (Apps, 2019; Bershidski, 2017; Le Miere, 2017; O'Connor, 2017) the country currently has no national strategy on AI. Following the 2018 conference 'Artificial Intelligences: Problems and Solutions', the Russian Ministry of Defence released a list of policy recommendations, which include creating a state system for AI education and a national centre for AI. The latest reports suggest President Putin has set a deadline of June 15th 2019 for his government to finalise the national strategy on AI.

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5.1.1. Across the EU: Public attitudes to robots and digitisation

Overall, surveys of European perspectives to AI, robotics, and advanced technology (European Commission 2012; European Commission 2017) have reflected that citizens hold a generally positive view of these developments, viewing them as a positive addition to society, the economy, and citizens' lives. However, this attitude varies by age, gender, educational level, and location and is largely dependent on one's exposure to robots and relevant information — for example, only small numbers of those surveyed actually had experience of using a robot (past or present), and those with experience were more likely to view them positively than those without.

General trends in public perception from these surveys showed that respondents were:

- Supportive of using robots and digitisation in jobs that posed risk or difficulty to humans (such as space exploration, manufacturing and the military);
- Concerned that such technology requires effective and careful management;
- Worried that automation and digitisation would bring job losses, and unsure whether it would stimulate and boost job opportunities across the EU;
- Unsupportive of using robots to care for vulnerable members of society (the elderly, ill, dependent pets, or those undergoing medical procedures);
- Worried about accessing and protecting their data and online information, and likely to have taken some form of protective action in this area (antivirus software, changed browsing behaviour);
- Unwilling to drive in a driverless car (only 22% would be happy to do this);
- Distrustful of social media, with only 7% viewing stories published on social media as 'generally trustworthy'; and
- Unlikely to view widespread use of robots as near-term, instead perceiving it to be a scenario that would occur at least 20 years in the future.

These concerns thus feature prominently in European AI initiatives, and are reflective of general opinion on the implementation of robots, AI, automation and digitisation across the spheres of life, work, health, and more.

5.2. North America

Canada was the first country in the world to launch a national AI strategy, back in March 2017. The Pan-Canadian Artificial Intelligence Strategy (Canadian Institute For Advanced Research, 2017) was established with four key goals, to: increase the number of AI researchers and graduates in Canada; establish centres of scientific excellence (in Edmonton, Montreal and Toronto); develop global thought leadership in the economic, ethical, policy and legal implications of AI; and support a national research community in AI.

A separate programme for AI and society was dedicated to the social implications of AI, led by policy-relevant working groups that publish their findings for both government and public. In collaboration with the French National Centre for Scientific Research (CNRS) and UK Research and Innovation (UKRI), the AI and society programme has recently announced a series of interdisciplinary workshops to explore issues including trust in AI, the impact of AI in the healthcare sector and how AI affects cultural diversity and expression (Canadian Institute For Advanced Research, 2019).

In the **USA**, President Trump issued an Executive Order launching the 'American AI Initiative' in February 2019 (The White House, 2019a), soon followed by the launch of a website uniting all other AI initiatives (The White House, 2019b), including AI for American Innovation, AI for American Industry, AI for the American Worker and AI for American Values. The American AI Initiative has five key areas: investing in R&D, unleashing AI resources (i.e. data and computing power), setting

AMSCE-101

governance standards, building the AI workforce and international engagement. The Department of Defence has also published its own AI strategy (US Department of Defence, 2018), with a focus on the military capabilities of AI.

In May, the US advanced this with the AI Initiative Act, which will invest $2.2 billion into developing a national AI strategy, as well as funding federal R&D. The legislation, which seeks to 'establish a coordinated Federal initiative to accelerate research and development on artificial intelligence for the economic and national security of the United States' commits to establishing a National AI Coordination Office, create AI evaluation standards and fund 5 national AI research centres. The programme will also fund the National Science Foundation to research the effects of AI on society, including the roles of data bias, privacy and accountability, and expand AI-based research efforts led by the Department of Energy (US Congress, 2019).

In June 2019, the National Artificial Intelligence Research and Development Strategic Plan was released, which builds on an earlier plan issued by the Obama administration and identifies eight strategic priorities, including making long-term investments in AI research, developing effective methods for human-AI collaboration, developing shared public datasets, evaluating AI technologies through standards and benchmarks, and understanding and addressing the ethical, legal and societal implications of AI. The document provides a coordinated strategy for AI research and development in the US (National Science & Technology Council, 2019).

5.3. Asia

Asia has in many respects led the way in AI strategy, with **Japan** being the second country to release a national initiative on AI. Released in March 2017, Japan's AI Technology Strategy (Japanese Strategic Council for AI Technology, 2017) provides an industrialisation roadmap, including priority areas in health and mobility, important with Japan's ageing population in mind. Japan envisions a three-stage development plan for AI, culminating in a completely connected AI ecosystem, working across all societal domains.

Singapore was not far behind. In May 2017, AI Singapore was launched, a five-year programme to enhance the country's capabilities in AI, with four key themes: industry and commerce, AI frameworks and testbeds, AI talent and practitioners and R&D (AI Singapore, 2017). The following year the Government of Singapore announced additional initiatives focused around the governance and ethics of AI, including establishing an Advisory Council on the Ethical Use of AI and Data, formalised in January 2019's 'Model AI Governance Framework' (Personal Data Protection Commission Singapore, 2019). The framework provides a set of guiding ethical principles, which are translated into practical measures that businesses can adopt, including how to manage risk, how to incorporate human decision making into AI and how to minimise bias in datasets.

China's economy has experienced huge growth in recent decades, making it the world's second largest economy (World Economic Forum, 2018). To catapult China to world leader in AI, the Chinese Government released the 'Next Generation AI Development Plan' in July 2017. The detailed plan outlines objectives for industrialisation, R&D, education, ethical standards and security (Foundation for Law and International Affairs, 2017). In line with Japan, it is a three-step strategy for AI development, culminating in 2030 with becoming the world's leading centre for AI innovation.

There is substantial focus on governance, with intent to develop regulations and ethical norms for AI and 'actively participate' in the global governance of this technology. Formalised under the 'Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry', the strategy iterates four main goals, to: scale-up the development of key AI products (with a focus on intelligent vehicles, service robots, medical diagnosis and video image identification systems); significantly enhance core competencies in AI; deepen the development of smart manufacturing; and establish the foundation for an AI industry support system (New America, 2018).

In **India**, AI has the potential to add 1 trillion INR to the economy by 2035 (NITI Aayog, 2018). India's AI strategy, named AI for All, aims to utilise the benefits of AI for economic growth but also social development and 'inclusive growth', with significant focus on empowering citizens to find better quality work. The report provides 30 recommendations for the government, which include setting up Centres of Research Excellence for AI (COREs, each with their own Ethics Council), promoting employee reskilling, opening up government datasets and establishing 'Centres for Studies on Technological Sustainability'. It also establishes the concept of India as an 'AI Garage', whereby solutions developed in India can be rolled out to developing economies in the rest of the world.

Alongside them, **Taiwan** released an 'AI Action Plan' in January 2018 (AI Taiwan, 2018), focused heavily on industrial innovation, and **South Korea** announced their 'AI Information Industry Development Strategy' in May 2018 (H. Sarmah, 2019). The report on which this was based (Government of the Republic of Korea, 2016) provides fairly extensive recommendations for government, across data management, research methods, AI in government and public services, education and legal and ethical reforms.

Malaysia's Prime Minister announced plans to introduce a national AI framework back in 2017 (Abas, 2017), an extension of the existing 'Big Data Analytics Framework' and to be led by the Malaysia Digital Economy Corporation (MDEC). There has been no update from the government since 2017. More recently, **Sri Lanka**'s wealthiest businessman Dhammika Perera has called for a national AI strategy in the country, at an event held in collaboration with the Computer Society of Sri Lanka (Cassim, 2019), however there has not yet been an official pledge from the government.

In the Middle East, the **United Arab Emirates** was the first country to develop a strategy for AI, released in October 2017 and with emphasis on boosting government performance and financial resilience (UAE Government, 2018). Investment will be focused on education, transport, energy, technology and space. The ethics underlying the framework is fairly comprehensive; the Dubai AI Ethics Guidelines dictate the key principles that make AI systems fair, accountable, transparent and explainable (Smart Dubai, 2019a). There is even a self-assessment tool available to help developers of AI technology to evaluate the ethics of their system (Smart Dubai, 2019b).

World leader in technology **Israel** is yet to announce a national AI strategy. Acknowledging the global race for AI leadership, a recent report by the Israel Innovation Authority (Israel Innovation Authority, 2019) recommended that Israel develop a national AI strategy 'shared by government, academia and industry'.

5.4. Africa

Africa has taken great interest in AI; a recent white paper suggests this technology could solve some of the most pressing problems in Sub-Saharan Africa, from agricultural yields to providing secure financial services (Access Partnership, 2018). The document provides essential elements for a pan-African strategy on AI, suggesting that lack of government engagement to date has been a hindrance and encouraging African governments to take a proactive approach to AI policy. It lists laws on data privacy and security, initiatives to foster widespread adoption of the cloud, regulations to enable the use of AI for provision of public services, and adoption of international data standards as key elements of such a policy, although one is yet to emerge.

Kenya however has announced a task force on AI (and blockchain) chaired by a former Secretary in the Ministry of Information and Communication, which will offer recommendations to the government on how best to leverage these technologies (Kenyan Wallstreet, 2018). **Tunisia** too has created a task force to put together a national strategy on AI and held a workshop in 2018 entitled 'National AI Strategy: Unlocking Tunisia's capabilities potential' (ANPR, 2018).

5.5. South America

Mexico is so far the only South American nation to release an AI strategy. It includes five key actions, to: develop an adequate governance framework to promote multi-sectorial dialogue; map the needs of industry; promote Mexico's international leadership in AI; publish recommendations for public consultation; and work both with experts and the public to achieve the continuity of these efforts (México Digital, 2018). The strategy is the formalisation of a White Paper (Martinho-Truswell et al., 2018) authored by the British Embassy in Mexico, consultancy firm Oxford Insights and thinktank C Minds, with the collaboration of the Mexican Government.

The strategy emphasises the role of its citizens in Mexico's AI development and the potential of social applications of AI, such as improving healthcare and education. It also addresses the fact that 18% of all jobs in Mexico (9.8 million in total) will be affected by automation in the coming 20 years and makes a number of recommendations to improve education in computational approaches.

Other South American nations will likely follow suit if they are to keep pace with emerging markets in Asia. Recent reports suggest AI could double the size of the economy in Argentina, Brazil, Chile, Colombia and Peru (Ovanessoff and Plastino, 2017).

5.6. Australasia

Australia does not yet have a national strategy on AI. It does however have a' Digital Economy Strategy' (Australian Government, 2017) which discusses empowering Australians through 'digital skills and inclusion', listing AI as a key emerging technology. A report on 'Australia's Tech Future' further details plans for AI, including using AI to improve public services, increase administrative efficiency and improve policy development (Australian Government, 2018).

The report also details plans to develop an ethics framework with industry and academia, alongside legislative reforms to streamline the sharing and release of public sector data. The draft ethics framework (Dawson et al., 2019) is based on case studies from around the world of AI 'gone wrong' and offers eight core principles to prevent this, including fairness, accountability and the protection of privacy. It is one of the more comprehensive ethics frameworks published so far, although yet to be implemented.

Work is also ongoing to launch a national strategy in **New Zealand**, where AI has the potential to increase GDP by up to $54 billion (AI Forum New Zealand, 2018). The AI Forum of New Zealand has been set up to increase awareness and capabilities of AI in the country, bringing together public, industry, academia and Government.

Their report 'Artificial Intelligence: Shaping The Future of New Zealand' (AI Forum New Zealand, 2018) lays out a number of recommendations for the government to coordinate strategy development (i.e. to coordinate research investment and the use of AI in government services); increase awareness of AI (including conducting research into the impacts of AI on economy and society); assist AI adoption (by developing best practice resources for industry); increase the accessibility of trusted data; grow the AI talent pool (developing AI courses, including AI on the list of valued skills for immigrants); and finally to adapt to AI's effects on law, ethics and society. This

AMSCE-1101

includes the recommendation to establish an AI ethics and society working group to investigate moral issues and develop guidelines for best practice in AI, aligned with international bodies.

Challenges to government adoption of AI

The World Economic Forum has, through consultation with stakeholders, identified five major roadblocks to government adoption of AI:

1. Effective use of data - Lack of understanding of data infrastructure, not implementing data governance processes (e.g. employing data officers and tools to efficiently access data).

2. Data and AI skills - It is difficult for governments, which have smaller hiring budgets than many big companies, to attract candidates with the required skills to develop first-rate AI solutions.

3. The AI ecosystem - There are many different companies operating in the AI market and it is rapidly changing. Many of the start-ups pioneering AI solutions have limited experience working with government and scaling up for large projects.

4. Legacy culture - It can be difficult to adopt transformative technology in government, where there are established practices and processes and perhaps less encouragement for employees to take risks and innovate than in the private sector.

5. Procurement mechanisms - The private sector treats algorithms as intellectual property, which may make it difficult for governments to customise them as required. Public procurement mechanisms can also be slow and complicated (e.g. extensive terms and conditions, long wait times from tender response submission to final decision).

(Torres Santeli and Gerdon, 2019)

5.7. International AI Initiatives, in addition to the EU

In addition to the EU, there are a growing number of international strategies on AI, aiming to provide a unifying framework for governments worldwide on stewardship of this new and powerful technology.

G7 Common Vision for the Future of AI

At the 2018 meeting of the G7 in Charlevoix, Canada, the leaders of the G7 (Canada, France, Germany, Italy, Japan, the United Kingdom and the United States) committed to 12 principles for AI, summarised below:

1. Promote human-centric AI and the commercial adoption of AI, and continue to advance appropriate technical, ethical and technologically neutral approaches.
2. Promote investment in R&D in AI that generates public test in new technologies and supports economic growth.
3. Support education, training and re-skilling for the workforce.
4. Support and involve underrepresented groups, including women and marginalised individuals, in the development and implementation of AI.

AMSCE-101

5. Facilitate multi-stakeholder dialogue on how to advance AI innovation to increase trust and adoption.
6. Support efforts to promote trust in AI, with particular attention to countering harmful stereotypes and fostering gender equality. Foster initiatives that promote safety and transparency.
7. Promote the use of AI by small and medium-sized enterprises.
8. Promote active labour market policies, workforce development and training programmes to develop the skills needed for new jobs.
9. Encourage investment in AI.
10. Encourage initiatives to improve digital security and develop codes of conduct.
11. Ensure the development of frameworks for privacy and data protection.
12. Support an open market environment for the free flow of data, while respecting privacy and data protection.

(G7 Canadian Presidency, 2018).

Nordic-Baltic Region Declaration on AI

The declaration signed by the Nordic-Baltic Region (comprising Denmark, Estonia, Finland, the Faroe Islands, Iceland, Latvia, Lithuania, Norway, Sweden and the Åland Islands) aims to promote the use of AI in the region, including improving the opportunities for skills development, increasing access to data and a specific policy objective to develop 'ethical and transparent guidelines, standards, principles and values' for when and how AI should be used (Nordic Co-operation, 2018).

OECD Principles on AI

On 22 May 2019, the Organisation for Economic Co-operation and Development issued its principles for AI, the first international standards agreed by governments for the responsible development of AI. They include practical policy recommendations as well as value-based principles for the 'responsible stewardship of trustworthy AI', summarised below:

- AI should benefit people and the planet by driving inclusive growth, sustainable development and well-being.
- AI systems should respect the rule of law, human rights, democratic values and diversity, and there should include appropriate safeguards to ensure a fair society.
- There should be transparency around AI to ensure that people understand outcomes and can challenge them.
- AI systems must function in a robust, secure and safe way throughout their life cycles and risks should be continually assessed.
- Organisations and individuals developing, deploying or operating AI systems should be held accountable.

These principles have been agreed by the governments of the 36 OECD Member States as well as Argentina, Brazil, Colombia, Costa Rica, Peru and Romania (OECD, 2019a). The G20 human-centred AI Principles were released in June 2019 and are drawn from the OECD Principles (G20, 2019).

United Nations

The UN has several initiatives relating to AI, including:

- AI for Good Global Summit- Summits held since 2017 have focused on strategies to ensure the safe and inclusive development of AI (International Telecommunication Union, 2018a,b). The events are organised by the International Telecommunication Union, which aims to 'provide a neutral platform for government, industry and

AMSCE-101

academia to build a common understanding of the capabilities of emerging AI technologies and consequent needs for technical standardisation and policy guidance.'

- UNICRI Centre for AI and Robotics - The UN Interregional Crime and Justice Research Institute (UNICRI) launched a programme on AI and Robotics in 2015 and will be opening a centre dedicated to these topics in The Hague (UNICRI, 2019).

- UNESCO Report on Robotics Ethics - The UNESCO World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) has authored a report on 'Robotics Ethics', which deals with the ethical challenges of robots in society and provides ethical principles and values, and a technology-based ethical framework (COMEST, 2017).

World Economic Forum

The World Economic Forum (WEF) formed a Global AI Council in May 2019, co-chaired by speech recognition developer Kai-Fu Lee, previously of Apple, Microsoft and Google, and current President of Microsoft Bradford Smith. One of six 'Fourth Industrial Revolution' councils, the Global AI Council will develop policy guidance and address governance gaps, in order to develop a common understanding among countries of best practice in AI policy (World Economic Forum, 2019a).

In October 2019, they released a framework for developing a national AI strategy to guide governments that are yet to develop or are currently developing a national strategy for AI. The WEF describe it as a way to create a 'minimum viable' AI strategy and includes four main stages:

1) Assess long-term strategic priorities
2) Set national goals and targets
3) Create plans for essential strategic elements
4) Develop the implementation plan

The WEF has also announced plans to develop an 'AI toolkit' to help businesses to best implement AI and to create their own ethics councils, which will be released at 2020's Davos conference (Vanian, 2019).

5.8. Government Readiness for AI

A report commissioned by Canada's International Development Research Centre (Oxford Insights, 2019) evaluated the 'AI readiness' of governments around the globe in 2019, using a range of data including not only the presence of a national AI strategy, but also data protection laws, statistics on AI startups and technology skills.

Singapore was ranked number 1 in their estimation, with Japan as the only other Asian nation in the top 10 (Table 3). Sixty percent of countries in the top 10 were European, with the remainder from North America.

The strong European representation in this analysis is reflective of the value of the unifying EU framework, as well as Europe's economic power. The analysis also praises the policy strategies of individual European nations, which, importantly, have been developed in a culture of collaboration. Examples of this collaborative approach include the EU Declaration of Cooperation on AI (European Commission, 2018d), in which Member States agreed to cooperate on boosting Europe's capacity in AI, and individual partnerships between Member States, such as that of Finland, Estonia and Sweden, working together to trial new applications of AI.

AMSCE-T101

Table 3: Top 10 rankings for Government AI Readiness 2018/19. Source: Oxford Insights, 2019.

Rank	Country	Score
1	Singapore	9.19
2	United Kingdom	9.07
3	Germany	8.81
4	USA	8.80
5	Finland	8.77
6	Sweden	8.67
6	Canada	8.67
8	France	8.61
9	Denmark	8.60
10	Japan	8.58

Singapore ranked highest of all nations while Japan, the second country in the world to release a national strategy on AI, ranked 10th. China's position as 21st in the global rankings is expected to improve next year as its investments in AI begin to pay off. Progress in Asia overall has been unbalanced, with two countries in the region also ranking in the bottom ten worldwide, reflecting the income inequality in the region.

Despite the comparatively slow development of their national strategy, the USA ranked 4th, with Canada not far behind. Both nations are supported by their strong economies, highly skilled workforces, private sector innovation and abundance of data, to a level at which regions missing from the top 10 – Africa, South America and Australasia – are unable to compete.

This framework provides a highly useful metric by which to assess the ability of governments to capitalise on AI's potential in the coming years. What this analysis does not consider however is how robustly each nation is considering the moral and ethical issues surrounding the use of AI, which we will explore below.

AMSCE-1101

6. Emerging Themes

Our review of the literature on the ethical issues surrounding AI and intelligent robots highlights a wide range of potential impacts, including in the social, psychological, financial, legal and environmental domains. These are bound up with issues of trust and are tackled in different ways by the emerging ethical initiatives. Standards and regulation are also beginning to develop that go some way to addressing these concerns. However, the focus of many existing strategies on AI is on enabling technology development and, while ethical issues are addressed, notable gaps can be identified.

6.1. Addressing ethical issues through national and international strategies

There are several themes shared by the various national strategies on AI, among which **industrialisation** and **productivity** perhaps rank highest. All countries have some sort of industrial strategy for AI, and this is particularly prominent in the emerging economies of Southeast Asia. Most of the strategies make reference to the importance of AI for business competitiveness and several, including those of Germany, South Korea, Taiwan and the UK, announce extra funding and specialised incubators for AI-focused start-ups.

Whether in the private or public sector, the importance of **research** and development is also universally recognised, with almost all strategies pledging enhanced funding for research and many to establish 'centres of excellence' entirely dedicated to AI research, including strategies from Canada, Germany and India.

Essential to developing a strong research effort is talent, and so investing in **people** and education also features heavily in most strategies. The UK has announced 'Turing Fellowships' to fund new academics exploring computational approaches, while Germany has provided for at least an extra 100 professors working on AI – both under the umbrella of the EU commitment to train, attract and retain talent. In Asia, South Korea has committed to developing six new graduate programmes to train a total of 5,000 AI specialists, while Taiwan has committed to training double that number by 2021.

Most of the strategies also consider the impact the AI revolution will have on the non-technology literate workforce, who may be the first to lose their jobs to automation. Although this crosses over into ethical considerations, several of the strategies make practical commitments to **re-training** programmes to help those affected to find new work. This is a key objective in the EU plan (objective 2.4: 'adapting our learning and training programmes and systems to better prepare our society for AI'), and therefore the plans of its Member States. The UK for example will initiate an > €70 million re-training scheme to help people gain digital skills and Germany has revealed a similar 'National Further Training Strategy'. Naturally, those countries most in need of re-training have the least funding available for it. Mexico's strategy however emphasises the importance of computational thinking and mathematics in lifelong teaching, including to help its citizens retrain, while India pledges to promote informal training institutions and create financial incentives for reskilling of employees. Other strategies however suggest re-training is the responsibility of individual businesses and do not allocate separate funding for it.

Collaboration between sectors and countries is another common thread, yet interpreted differently by different countries. India's approach for example is one of sharing; the 'AI Garage' concept named in their strategy means AI-based solutions developed in India will be rolled out to developing economies facing similar issues. Conversely, the US Executive Order on AI sets out to

AMSCE-101

'promote an international environment that supports American AI' while also protecting the nation's technological advantage against 'foreign adversaries'. Naturally, the strategies of EU Member States display an inclination for cross-border collaboration. Sweden for example states a need to develop partnerships and collaborations with other countries 'especially within the EU', while Denmark's strategy also emphasises close cooperation with other European countries.

The democratisation of technology has the potential to reduce inequalities in society, and **inclusion** and **social development** are important goals for many national AI initiatives, particularly those of developing economies. India's strategy discusses AI for 'greater good', focusing on the possibilities for better access to healthcare, economic growth for groups previously excluded from formal financial products, and using data to aid small-scale farmers. Mexico's strategy lists inclusion as one of its five major goals, which includes aims to democratise productivity and promote gender equality. France too aims for an AI that 'supports inclusivity', striving for policies that reduce both social and economic inequalities.

Determining who is **responsible** for the actions and behaviour of AI is highly important, and challenging in both moral and legal senses. Currently, AI is most likely considered to be the legal responsibility of a relevant human actor – a tool in the hands of a developer, user, vendor, and so on. However, this framework does not account for the unique challenges brought by AI, and many grey areas exist. As just one example, as a machine learns and evolves to become different to its initial programming over many iterations, it may become more difficult to assign responsibility for its behaviour to the programmer. Similarly, if a user or vendor is not adequately briefed on the limitations of an AI agent, then it may not be possible to hold them responsible. Without proving that an AI agent intended to commit a crime (*mens rea*) and can act voluntarily, both of which are controversial concepts, then it may not be possible to deem an AI agent responsible and liable for its own actions.

6.2. Addressing the governance challenges posed by AI

There are currently two major international frameworks for the governance of AI: that of the EU (see Section 5.1) and the Organisation for Economic Co-operation and Development (OECD).

The OECD launched a set of principles for AI in May 2019 (OECD, 2019a) which were at that time adopted by 42 countries. The OECD framework offers five fundamental principles for the operation of AI (see section 5.1.1) as well as accompanying practical recommendations for governments to achieve them. The G20 soon after adopted its own, human-centred AI principles, drawn from (and essentially an abridged version of) those of the OECD (G20, 2019).

The OECD Principles have also been backed by the European Commission, which has its own strategy on AI since April 2018 (European Commission, 2018b). The EU framework includes comprehensive plans for investment, but also makes preparations for complex socio-economic changes and is complemented by a separate set of ethics guidelines (European Commission High-Level Expert Group on AI, 2019a).

Gaps in AI frameworks

These frameworks address the moral and ethical dilemmas identified in this report to varying extents, with some notable gaps. Regarding **environmental concerns** (Section 2.5), while the OECD makes reference to developing AI that brings positive outcomes for the planet, including protecting natural environments, the document does not suggest ways to achieve this, nor does it mention any specific environmental challenges to be considered.

The EU Communication on AI does not discuss the environment. However, its accompanying ethics guidelines are founded on the principle of prevention of harm, which includes harm to the natural

AMSCE-IIOT

environment and all living beings. Societal and environmental well-being (including sustainability and 'environmental friendliness') is one of the EU's requirements for trustworthy AI and its assessment list includes explicit consideration of risks to the environment or to animals. Particular examples are also given on how to achieve this (e.g. critical assessment of resource use and energy consumption throughout the supply chain).

Impacts on human **psychology**, including how people interact with AI and subsequent effects on how people interact with each other, could be further addressed in the frameworks. The psychosocial impact of AI is not considered by the OECD Principles or the EU Communication. However, the EU requirement for societal well-being to be considered does address 'social impact', which includes possible changes to social relationships and loss of social skills. The guidelines state that such effects must 'be carefully monitored and considered' and that AI interacting with humans must clearly signal that its social interaction is simulated. However, more specific consideration could be given to human-robot relationships or more complex effects on the human psyche, such as those outlined above (Section 2.2).

While both frameworks capably address changes to the **labour market** (Section 2.1.1), attention to more nuanced factors, including the potential for AI to drive **inequalities** (2.1.2) and **bias** (2.1.4), is more limited. The OECD's first principle of inclusive growth, sustainable development and well-being states that AI should be developed in a way that reduces 'economic, social, gender and other inequalities'. This is also covered to a degree by the second OECD principle, which states that AI systems should respect diversity and include safeguards to ensure a fair society, however detail on how this can be achieved is lacking.

The EU ethics guidelines are more comprehensive on this point and include diversity, non-discrimination and fairness as a separate requirement. The guidelines elaborate that equality is a fundamental basis for trustworthy AI and state that AI should be trained on data which is representative of different groups in order to prevent biased outputs. The guidelines include additional recommendations on the avoidance of unfair bias.

Both frameworks include **human rights** and **democratic values** (Sections 2.1.3, 2.1.5) as key tenets. This includes **privacy**, which is one of the OECD's human-centred values and a key requirement of the EU ethics guidelines, which elaborates on the importance of data governance and data access rules. Issues concerning privacy are also covered by existing OECD data protection guidelines (OECD, 2013).

The implications of AI for **democracy** (Section 2.1.5) are only briefly mentioned by the OECD, with no discussion of the particular issues facing governments at the present time, such as Deepfake or the manipulation of opinion through targeted news stories. Threats to democracy are not mentioned at all in the EU Communication, although society and democracy is a key theme in the associated ethics guidelines, which state that AI systems should serve to maintain democracy and not undermine 'democratic processes, human deliberation or democratic voting systems.'

These issues form part of a bigger question surrounding changes to the **legal system** (Section 2.4) that may be necessary in the AI age, including important questions around liability for misconduct involving AI. The issue of liability is explicitly addressed by the EU in both its Communication and ethics guidelines. Ensuring an appropriate legal framework is a key requirement of the EU Communication on AI, which includes guidance on product liability and an exploration of safety and security issues (including criminal use). The accompanying ethics guidelines also suitably handle this issue, including providing guidance for developers on how to ensure legal compliance. Relevant changes to regulation are further addressed in the recent AI Policy and Investment Recommendations (European Commission High-Level Expert Group on AI, 2019b), which explore potential changes to current EU laws and the need for new regulatory powers.

The OECD principles are more limited on this point. While they provide guidance for governments to create an 'enabling policy environment' for AI, including a recommendation to review and adapt

AMSCE-101

regulatory frameworks, this is stated to be for the purpose of encouraging 'innovation and competition' and does not address the issue of liability for AI-assisted crime.

These questions could also come under the issue of **accountability** (2.6.4) however, which is adequately addressed by both frameworks. The OECD lists accountability as a key principle and states that 'organisations and individuals developing, deploying or operating AI systems should be held accountable for their proper functioning' (OECD, 2019a). It is likewise a core principle of the EU ethics guidelines, which provides more than 10 conditions for accountability in its assessment list for trustworthy AI.

Many of the aforementioned issues are ultimately important for building **trust** in AI (Section 2.6), which also requires AI to be fair (2.6.2) and transparent (2.6.3). These issues are at the foundation of the EU ethics guidelines where they are dealt with in great detail. The OECD also states that AI systems should ensure a 'fair and just society'. Transparency and explainability is a core principle for the OECD, with strong emphasis on the fact that people should be able to understand and challenge AI systems. The OECD Principles offer less context on these issues and do not consider practical means of ensuring this (e.g. audits of algorithms), which are considered by the EU ethics guidelines. The ethics guidelines also consider the need for human oversight (including discussion of the human-in-the-loop approach and the need for a 'stop button', neither of which are mentioned by the OECD principles).

Finally, although both acknowledge the beneficial use of AI in **finance** (Section 2.3), neither framework adequately addresses potential negative impacts on the financial system, either through accidental harm or malicious activity. The potential for AI-assisted financial crime is an important one and currently unaddressed by any international framework. However, the G7 has recently voiced concerns about digital currencies and various other new financial products being developed (Reuters, 2019), which suggests that regulatory changes in this regard are afoot.

AMSCE-ICSI

7. Summary

What this report makes clear is the diversity and complexity of the ethical concerns arising from the development of artificial intelligence; from large scale issues such job losses from automation, degradation of the environment and furthering inequalities, to more personal moral quandaries such as how AI may affect our privacy, our ability to judge what is real, and our personal relationships.

What is also clear is that there are various **approaches to ethics**. Robust ethical principles are essential in the future of this rapidly developing technology, but not all countries understand ethics in the same way. There are a number of independent ethical initiatives for AI, such as Germany's Institute for Ethics in AI, funded by Facebook, and the private donor-funded Future of Life Institute in the US. An increasing number of governments are also developing national AI strategies, with their own ethics components. A number of countries have committed to creating AI ethics councils, including Germany, the UK, India, Singapore and Mexico. The UAE has also prioritised ethics in its national strategy, by developing an 'Ethical AI Toolkit' and self-assessment tool for developers, while several others give only passing reference; ethics is almost completely left out by Japan, South Korea and Taiwan.

Our assessment shows that the vast majority of ethical issues identified here are also addressed in some form by at least one of the current international frameworks; the EU Communication (supplemented by separate ethics guidelines) and the OECD Principles on AI.

The current frameworks address the major ethical concerns and make recommendations for governments to manage them, but **notable gaps** exist. These include environmental impacts, including increased energy consumption associated with AI data processing and manufacture, and inequality arising from unequal distribution of benefits and potential exploitation of workers. Policy options relating to environmental impacts include providing a stronger mandate for sustainability and ecological responsibility; requiring energy use to be monitored, and publication of carbon footprints; and potentially policies that direct technology innovation towards urgent environmental priorities. In the case of inequality, options include declaring AI as a public, rather than private, good. This would require changes to cultural norms and new strategies to help navigate a transition to an AI-driven economy. Setting minimum standards for corporate social responsibility reporting would encourage larger, transnational corporations to clearly show how they are sharing the benefits of AI. Economic policies may be required to support workers displaced by AI; such policies should focus on those at most risk of being left behind and might include policies designed to create support structures for precarious workers. It will be important for future iterations of these frameworks to address these and other gaps in order to adequately prepare for the full implications of an AI future. In addition, to clarify the issue of responsibility pertaining to AI behaviour, moral and legislative frameworks will require updating alongside the development of the technology itself.

Governments also need to develop new, up-to-date forms of **technology assessment** – allowing them to understand such technologies deeply while they can still be shaped, such as the Accountability Office's Technology Assessment Unit in the USA or the European Foresight platform (http://www.foresight-platform.eu/). New forms of technology assessment TA should include processes of Ethical Risk Assessment, such as the one set out in BS8611, and other forms of ethical evaluation currently being drafted in the IEEE Standards Association P7000 series of ethical standards; P7001 for instance sets out a method for measuring the transparency of an AI.

There is a clear need for the development of viable and applicable **legislation and policies** that will face the multifaceted challenges associated with AI, including potential breaches of fundamental ethical principles. Policy makers are in the valuable position of being able to develop policy that actively shapes the development of AI and as data-driven and machine-learning approaches begin to take increasing roles in society, thoughtful and detailed strategies on how to share benefits and achieve the best possible outcomes, while effectively managing risk, will be essential.

As well as the very encouraging progress made in policy so far, this report also reveals a concerning **disparity** between regions. Successful AI development requires substantial investment, and as automation and intelligent machines begin to drive government processes, there is a real risk that lower income countries – those nations of the Global South – will be left behind. It is incumbent upon policymakers therefore to try to ensure that AI does not widen global inequalities. This could include **data sharing** and collaborative approaches, such as India's promise to share its AI solutions with other developing countries, and efforts to make teaching on computational approaches a fundamental part of education, available to all.

To return to our main theme, **ethical considerations** must also be a critical component of any policy on AI. It speaks volumes that the nation ranked highest in the 2019 Government AI Readiness Index has prioritised ethics so strongly in their national AI Strategy. Singapore is one of a few governments to create an AI Ethics Council and has incorporated a range of ethical considerations into its policy. Addressing ethical concerns is also the first key point in the World Economic Forum's framework for developing a national AI strategy. So, aside from any potential moral obligations, it seems unlikely that governments that do not take ethics seriously will be able to succeed in the competitive global forum.

AMSCE-1101

8. Appendix

Building ethical robots

In the future it's very likely that intelligent machines will have to make decisions that affect human safety, psychology and society. For example, a search and rescue robot should be able to 'choose' the victims to assist first after an earthquake; an autonomous car should be able to 'choose' what or who to crash into when an accident cannot be avoided; a home-care robot should be able to balance its user's privacy and their nursing needs. But how do we integrate societal, legal and moral values into technological developments in AI? How can we program machines to make ethical decisions - to what extent can ethical considerations even be written in a language that computers understand?

Devising a method for integrating ethics into the design of AI has become a main focus of research over the last few years. Approaches towards moral decision making generally fall into two camps, 'top-down' and 'bottom-up' approaches (Allen et al., 2005). Top-down approaches involve explicitly programming moral rules and decisions into artificial agents, such as 'thou shalt not kill'. Bottom up approaches, on the other hand, involve developing systems that can implicitly learn to distinguish between moral and immoral behaviours.

Bottom-up approaches

Bottom up approaches involve allowing robots to learn ethics independently of humans, for instance by using machine learning. Santos-Lang (2002) points out that this is a better approach, as humans themselves continuously learn to be ethical. An advantage of this is that most of the work is done by the machine itself, which avoids the robot being influenced by the designers' biases. However the downside is that machines could demonstrate unintended behaviour that deviates from the desired goal. For example, if a robot was programmed to 'choose behaviour that leads to the most happiness', the machine may discover that it can more quickly reach its goal of maximising happiness by first increasing its own learning efficiency, 'temporarily' shifting away from the original goal. Because of the shift, the machine may even choose behaviours that temporarily reduce happiness, if these behaviours were to ultimately help it achieve its goal. For example a machine could try to rob, lie and kill, in order to become an ethical paragon later.

Top-down approaches

Top-down approaches involve programming agents with strict rules that they should follow in given circumstances. For example, in self-driving cars a vehicle could be programmed with the command 'you shall not drive faster than 130 km/h on the highway'. The problem with top down approaches is that they require deciding which moral theories ought to be applied. Examples of competing moral theories include utilitarian ethics, deontological ethics and the commensal view and the Doctrine of Double Effect.

Utilitarianism is based on the notion that the morality of an action should be judged by its consequences. In other words, an action is judged to be morally right if its consequences lead to the greater good. Different utilitarian theories vary in terms of the definition of the 'good' they aim to maximise. For example, Bentham (1789) proposed that a moral agent should aim to maximise the total happiness of a population of people.

Deontological (duty-based) ethics, on the other hand argues that actions should be judged not on the basis of their expected outcomes, but on what people do. Duty-based ethics teaches that actions are right or wrong regardless of the good or bad consequences that may be produced. Under this form of ethics you can't justify an action by showing that it produced good consequences.

Sometimes different moral theories can directly contradict each other. For example, in the case of a self-driving car that has to decide whether to swerve to avoid animals in its path. Under the commensal view, animal lives are treated as if they are worth some small fraction of what human lives are worth, and so the car would swerve if there was a low chance of causing harm to a human (Bogosian, 2017). However, the incommensal view would never allow humans to be placed at additional risk of fatality in order to save an animal. Since this view fundamentally rejects the assumptions of the other, and holds that no tradeoff is permissible, there is no obvious 'halfway point' where the competing principles can meet.

Bonnemains et al. (2018) describe a dilemma where a drone programmed to take out a missile threatening an allied ammo factory is suddenly alerted to a second threat - a missile heading towards some civilians. The drone must decide whether to continue its original mission, or take out the new missile in order to save the civilians. The decision outcome is different depending on whether you use utilitarianism, deontological ethics and the Doctrine of Double Effect - a theory which states that if doing something morally good has a morally bad side-effect, it's ethically okay to do it providing that the bad side-effect wasn't intended.

Some of the theories are unable to solve the problem. For instance, from a deontological perspective both decisions are valid, as they both arise from good intentions. In the case of utilitarian ethics, without any information about the number of civilians that are in danger, or the value of the strategic factory, it would be difficult for a drone to reach a decision. In order to follow the utilitarian doctrine and make a decision that maximised a 'good outcome', an artificial agent would need to identify all possible consequences of a decision, from all parties' perspectives, before making a judgement about which consequence is preferable. This would be impossible in the field. Another issue is how should a drone decide which outcomes it prefers when this is a subjective judgement? What is Good? Giving an answer to this broad philosophical issue is hardly possible for an autonomous agent, or the person programming it.

Under the Doctrine of Double Effect the drone would not be allowed to intercept the missile and save the civilians, as the bad side effect (the destruction of the drone itself) would be a means to ensuring the good effect (saving the humans). It would therefore continue to pursue its original goal and destroy the launcher, letting the civilians die.

If philosophers cannot agree on the merits of various theories, companies, governments, and researchers will find it even more difficult to decide which system to use for artificial agents (Bogosion, 2017). People's personal moral judgements can also differ widely when faced with moral dilemmas (Greene et al., 2001), particularly when they are considering politicised issues such as racial fairness and economic inequality. Bogosian (2017) argues that instead, we should design machines to be fundamentally uncertain about morality.

AMSCEL

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AMSCE-101

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This study deals with the ethical implications and moral questions that arise from the development and implementation of artificial intelligence (AI) technologies. It also reviews the guidelines and frameworks which countries and regions around the world have created to address these. It presents a comparison between the current main frameworks and the main ethical issues, and highlights gaps around the mechanisms of fair benefit-sharing; assignment of responsibility; exploitation of workers; energy demands in the context of environmental and climate changes; and more complex and less certain implications of AI, such as those regarding human relationships.

AMSCE-1101

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AMSCE-1101

Contents

AMSCE-1101

AMSCE-1101

VIII Epilogue

AMSCE-1101

Preface

> Nothing is stranger to man but his own image.
>
> —Karel Capek in *Rossum's Universal Robots* (1921)

If not yet the world, robots are starting to dominate news headlines. They have long been working on our factory floors, building products such as automobiles, but the latest research from academic labs and industry is capturing our imagination like never before. Now, robots are able to deceive, to perform surgeries, to identify and shoot trespassers, to serve as astronauts, to babysit our kids, to shape shift, to eat biomass as their fuel (but not human bodies, the manufacturer insists), and much more.

As a case of life imitating art, science fiction had already predicted some of these applications, and robots have been both glorified and vilified in popular culture—so much so that we are immediately sensitive, perhaps hypersensitive, to the possible challenges they may create for ethics and society. The literature in robot ethics can be traced back for decades, but only in recent years, with the real possibility of creating these more imaginative and problematic robots, has there been a growing chorus of international concern about the impact of robotics on ethics and society.

For the serious reader interested in this dialog, it takes some work to pull together the various strands of discussions from books and scholarly journals to media articles and websites. Thus, we have designed this edited volume to fill that gap in the information marketplace: to be an accessible and authoritative source of expert opinions on a wide range of issues in robot ethics, all in one location. While there is some technical material in this edited collection of papers, it does not presuppose much familiarity with either robotics or

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ethics, and therefore it is appropriate for policymakers, industry, and the broader public as well as university students and faculty scholars.

Chapters in part I of this volume provide a broad survey of the issues in robot ethics; discuss the latest trends in robotics; and give an overview of ethical theories and issues as relevant to robotics. Then, to provide guideposts for the reader, parts II onward begin with a short introduction that summarizes the chapters in each part, organized so that there is continuity of flow from one part and its chapters to the next, as follows:

In part II, we look at issues related to the possibility of programming ethics into a robot, as an intuitive approach to controlling its behavior. Concerning what is perhaps the most prominent and morally problematic use of robots today, our discussion naturally leads to the issue of designing a responsible or discriminating robot for war, which is the focus of part III. But ethical use of military robots can also be promoted through governance or policy, which leads to the chapters on law-related topics in part IV, including legal liability and privacy concerns. Some privacy issues arise given the physical access robots may have to our homes and lives, as well as the emotional access they have from their resemblance as humans. Part V, then, starts with an investigation of risks related to such emotional bonds, followed by chapters on more intimate relationships: robots as lovers. Not quite as personal, part VI examines ethical issues related to robots as caregivers, such as for medical purposes, and as our servants. In part VII, we telescope back out to broad and more distant (but nonetheless plausible) concerns about the possibility that we should give rights or moral consideration to robots. Finally, our epilogue ends the volume with some concluding and unifying thoughts on the issues discussed.

Though the chapters follow a sensible train of discussion from part I through part VII, they do not need to be read in order. We invite you to start with whatever focus interests you the most and jump around to other chapters as desired. The crucial point here is to become engaged in

AMSCE-101

this important but underdeveloped global discussion. As robots advance into our homes, workplaces, schools, hospitals, battlefields, and society at large, it would serve us well to be informed of the ethical and social issues and prepared for a more mechanized world.

Patrick Lin, PhD

George A. Bekey, PhD

Keith Abney, ABD

AMSCE-1101

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Finally, we thank our supportive families for their patience and sacrifice through this project, as well as you—the reader—for your

AMSCE - 101

interest and foresight in being part of the global conversation on robot ethics.

AMSCE-1101

I

Introduction

1

Introduction to Robot Ethics

Patrick Lin

AMSCE-1101

Welcome to the Robot Revolution. By this, we do not mean an uprising of our robots, as told in literature and film—at least not yet. But, today, robotics is a rapidly advancing field with a growing stable of different robot models and their expanding roles in society, from playing with children to hunting down terrorists.

“The emergence of the robotics industry,” observed Bill Gates, “is developing in much the same way that the computer business did 30 years ago” (2007). As a key architect of the computer industry, his prediction has special weight. In a few decades—or sooner, given exponential progress forecasted by Moore’s Law (that computing speeds will double every eighteen months or so)—robots in society will be as ubiquitous as computers are today, Gates believes; and we would be hard-pressed to find an expert who disagrees.

But consider just a few of the challenges linked to computers in the last thirty years: job displacement, privacy concerns, intellectual property disputes, real-world alienation, redefinition of relationships, cyberbullying, Internet addiction, security fears, and so on. To be clear, these are not arguments by themselves that the computer industry should never have been developed, but only that its benefits need to be weighed against its negative effects. The critical lesson we would like to focus on here, rather, is this: if the evolution of the robotics industry is analogous to that of computers, then we can expect important social and ethical challenges to emerge from robotics, as well, and attending to them sooner rather than later will likely help mitigate those negative consequences.

Society has long been concerned with the impact of robotics, before the technology was viable and even before the word "robot" was coined for the first time nearly a century ago (Capek 1921). Around 1190 BCE, Homer described in his *Iliad* the intelligent robots or "golden servants" created by Hephaestus, the ancient Greek god of technology (Lattimore 1961). More than two thousand years later, around 1495, Leonardo da Vinci conceived of a mechanical knight that would be called a robot today (Hill 1984). And modern literature about robots features cautionary tales about insufficient programming, emergent behavior, errors, and other issues that make robots unpredictable and potentially dangerous (e.g., Asimov 1950, 1957; Dick 1968; Wilson 2005). In popular culture, films continue to dramatize and demonize robots, such as *Metropolis*, *Star Wars*, *Blade Runner*, *Terminator*, *AI*, and *I, Robot*, to name just a few. Headlines today also stoke fears about robots wreaking havoc on the battlefield, as well as financial trading markets, perhaps justifiably so (e.g., Madrigal 2010).

A loose band of scholars worldwide has been researching issues in robot ethics for some time (e.g., Veruggio 2006). And a few reports and

AMSCE-101

books are trickling into the marketplace (e.g., Wallach and Allen 2008; Lin, Bekey, and Abney 2008; Singer 2009a). But there has not yet been a single, accessible resource that draws together such thinking on a wide range of issues, such as programming design, military affairs, law, privacy, religion, healthcare, sex, psychology, robot rights, and more. This edited volume is designed to fill that need, and this chapter is meant to introduce the major issues, followed by chapters that provide more detailed discussions.

1.1 Robots in Society

Robots are often tasked to perform the "three Ds," that is, jobs that are dull, dirty, or dangerous. For instance, automobile factory robots execute the same, repetitive assemblies over and over, with precision and without complaint; military unmanned aerial vehicles (UAVs) surveil from the skies for far more hours than a human pilot can endure at a time. Robots crawl around in dark sewers, inspecting pipes for leaks and cracks, as well as do the dirty work in our homes, such as vacuuming floors. Not afraid of danger, they also explore volcanoes and clean up contaminated sites, in addition to more popular service in defusing bombs and mediating hostage crises.

We can also think of robots more simply and broadly—as human replacements. More than mere tools, which cannot think and act independently, robots are able to serve in many old and new roles in society that are often handicapped, or made impossible, by human frailties and limitations; that is, semi- and fully-autonomous machines could carry out those jobs more optimally. Beyond the usual "three Ds," robots perform delicate and difficult surgeries, which are risky with shaky human hands. They can navigate inaccessible places, such as the ocean floor or the surface of Mars. As the embodiment of artificial intelligence (AI), they are more suited for jobs that demand information

AMSCE-1101

processing and action too quick for a human, such as the U.S. Navy's Phalanx CIWS that detects, identifies, and shoots down enemy missiles rapidly closing in on a ship. Some argue that robots could replace humans in situations where emotions are liabilities, such as battlefield robots that do not feel anger, hatred, cowardice, or fear—human weaknesses that often cause wartime abuses and crimes by human soldiers (Arkin 2007). Given such capabilities, we find robots already in society, or under development, in a wide range of roles, such as:

- *Labor and services* Nearly half of the world's seven-million-plus service robots are Roomba vacuum cleaners (Guizzo 2010), but others exist that mow lawns, wash floors, iron clothes, move objects from room to room, and perform other chores around the home. Robots have been employed in manufacturing for decades, particularly in auto factories, but they are also used in warehouses, movie sets, electronics manufacturing, food production, printing, fabrication, and many other industries.

- *Military and security* Grabbing headlines are war robots with fierce names, such as Predator, Reaper, Big Dog, Crusher, Harpy, BEAR, Global Hawk, Dragon Runner, and more. They perform a range of duties, such as spying or surveillance (air, land, underwater, space), defusing bombs, assisting the wounded, inspecting hideouts, and attacking targets. Police and security robots today perform similar functions, in addition to guarding borders and buildings, scanning for pedophiles and criminals, dispensing helpful information, reciting warnings, and more. There is also a growing market for home-security robots, which can shoot pepper spray or paintball pellets and transmit pictures of suspicious activities to their owners' mobile phones.

- *Research and education* Scientists are using robots in laboratory experiments and in the field, such as collecting ocean-surface and marine-life data over extended periods (e.g., Rutgers University's Scarlet Knight) and exploring new planets (e.g., NASA's Mars

AMSCE-101

Exploration Rovers). In classrooms, robots are delivering lectures, teaching subjects (e.g., foreign languages, vocabulary, and counting), checking attendance, and interacting with students.

- *Entertainment* Related to research and education is the field of “edutainment” or education-entertainment robots, which include ASIMO, Nao, iCub, and others. Though they may lack a clear use, such as serving specific military or manufacturing functions, they aid researchers in the study of cognition (both human and artificial), motion, and other areas related to the advancement of robotics. Robotic toys, such as AIBO, Pleo, and RoboSapien, also serve as discovery and entertainment platforms.

- *Medical and healthcare* Some toy-like robots, such as PARO, which looks like a baby seal, are designed for therapeutic purposes, such as reducing stress, stimulating cognitive activity, and improving socialization. Similarly, University of Southern California’s socially assistive robots help coach patients in physical therapy and other health-related areas. Medical robots, such as da Vinci Surgical System and ARES ingestible robots, are assisting with or conducting difficult medical procedures on their own. RIBA, IWARD, ERNIE, and other robots perform some of the functions of nurses and pharmacists.

- *Personal care and companions* Robots are increasingly used to care for the elderly and children, such as RI-MAN, PaPeRo, and CareBot. PALRO, QRIO, and other edutainment robots already mentioned can also provide companionship. Surprisingly, relationships of a more intimate nature are not quite satisfied by robots yet, considering the sex industry’s reputation as an early adopter of new technologies. Introduced in 2010, Roxxxy is billed as “the world’s first sex robot” (Fulbright 2010), but its lack of autonomy or capacity to “think” for itself, as opposed to merely responding to sensors, suggests that it is not, in fact, a robot.

AMSCE-101

- *Environment* Not quite as handy as WALL-E (of the eponymous film), robots today still perform important functions in environmental remediation, such as collect trash, mop up after nuclear power plant disasters, remove asbestos, cap oil geysers, sniff out toxins, identify polluted areas, and gather data on climate warming.

- *In the future* As AI advances, we can expect robots to play a more complex and wider range of roles in society. For instance, police robots equipped with biometrics capabilities and sensors could detect and identify weapons, drugs, and faces at a distance. Military robots could make attack decisions independently; in most cases today, there is a human triggerman behind those robots. Driverless trains today and DARPA's Grand Challenges are proof-of-concepts that robotic transportation is possible, and even commercial airplanes are controlled autonomously for a significant portion of their flight, never mind military UAVs. A general-purpose robot, if achievable, could service many of our domestic labor needs, as opposed to a team of robots each with its own job.

In the future, we can also expect robots to scale down as well as up. Some robots are miniature today and ever shrinking, perhaps bringing to life the idea of a "nano-bot," swarms of which might work inside our bodies or in the atmosphere or cleaning up oil spills. Even rooms or entire buildings might be considered as robots—beyond the "smart homes" of today—if they can manipulate the environment in ways more significant than turning on lights and air conditioning. With synthetic biology, cognitive science, and nanoelectronics, future robots could be biologically based. And human-machine integrations, that is, cyborgs, may be much more prevalent than they are today, which are mostly limited to patients with artificial body parts, such as limbs and joints that are controlled to some degree by robotics. Much of this speaks to the fuzziness of the definition of robot (which we return to in the next

AMSCE-101

chapter). What we intuitively consider as robots today may change, given different form factors and materials of tomorrow.

In some countries, robots are quite literally replacements for humans, such as in Japan, where a growing elderly population and declining birthrates mean a shrinking workforce (Schoenberger 2008). Robots are built to specifically fill that labor gap. And given the nation's storied love of technology, it is therefore unsurprising that approximately one out of twenty-five workers in Japan is a robot (RedOrbit 2008). While the United States currently dominates the market in military robotics, nations such as Japan and South Korea lead in the market for social robotics, such as elder-care robots. Other nations with similar demographics, such as Italy, are expected to introduce more robotics into their societies, as a way to shore up a decreasing workforce (Geipel 2003); and nations without such concerns can drive productivity, efficiency, and effectiveness to new heights with robotics.

1.2 Ethical and Social Issues

The Robotics Revolution promises a host of benefits that are compelling and imaginative, but, as with other emerging technologies, they also come with risks and new questions that society must confront. This is not unexpected, given the disruptive nature of technology revolutions. Here we map the myriad issues into three broad (and interrelated) areas of ethical and social concern and provide representative questions for each area.

1.2.1 Safety and Errors

We have learned by now that new technologies, first and foremost, need to be safe. Asbestos, DDT, and fen-phen are among the usual examples of technology gone wrong (e.g., U.S. Environmental Protection Agency 2007; Gorman 1997; Lear 1997), having been introduced into the

AMSCE-101

marketplace before sufficient health and safety testing. A similar debate is occurring with nanomaterials now (e.g., Allhoff, Lin, and Moore 2010).

With robotics, the safety issue is with their software and design. Computer scientists, as fallible human beings, understandably struggle to create a perfect piece of complex software: somewhere in the millions of lines of code, typically written by teams of programmers, errors and vulnerabilities likely exist. While this usually does not result in significant harm with, say, office applications—just lost data if users do not periodically save their work (which arguably is their own fault)—even a tiny software flaw in machinery, such as a car or a robot, could lead to fatal results.

For instance, in August 2010, the U.S. military lost control of a helicopter drone during a test flight for more than thirty minutes and twenty-three miles, as it veered toward Washington, D.C., violating airspace restrictions meant to protect the White House and other governmental assets (Bumiller 2010). In October 2007, a semiautonomous robotic cannon deployed by the South African army malfunctioned, killing nine “friendly” soldiers and wounding fourteen others (e.g., Shachtman 2007). Experts continue to worry about whether it is humanly possible to create software sophisticated enough for armed military robots to discriminate combatants from noncombatants, as well as threatening behavior from nonthreatening (e.g., Lin, Bekey, and Abney 2008).

Never mind the scores of other military robot accidents and failures (Zucchino 2010), human deaths caused by robots can and have occurred in civilian society. The first human to be killed by a robot was widely believed to be in 1979, in an auto factory accident in the United States (Kiska 1983). And it does not take much to imagine a mobile city-robot of the future—a heavy piece of machinery—accidentally running over a small child.

AMSCE-101

Hacking is an associated concern, given how much attention is paid to computer security today. What makes a robot useful—its strength, ability to access and operate in difficult environments, expendability, and so on—could also be turned against us, either by criminals or simply mischievous persons. This issue will become more important as robots become networked and more indispensable to everyday life, as computers and smart phones are today. Indeed, the fundamentals of robotics technology are not terribly difficult to master: as formidable and fearsome as military robots are today, already more than forty nations have developed those capabilities, including Iran (Singer 2009b; Defense Update 2010).

Thus, some of the questions in this area include: Is it even possible for us to create machine intelligence that can make nuanced distinctions, such as between a gun and an ice-cream cone pointed at it, or understand human speech that is often heavily based on context? What are the tradeoffs between nonprogramming solutions for safety—for example, weak actuators, soft robotic limbs or bodies, using only nonlethal weapons, or using robots in only specific situations, such as a "kill box" in which all humans are presumed to be enemy targets—and the limitations they create? How safe ought robots be prior to their introduction into the marketplace or society, that is, should a precautionary principle apply here? How would we balance the need to safeguard against robots running amok (e.g., with a kill-switch) with the need to protect robots from hacking or capture?

1.2.2 Law and Ethics

Linked to the risk of robotic errors, it may be unclear who is responsible for any resulting harm. Product liability laws are largely untested in robotics and, anyway, continue to evolve in a direction that releases manufacturers from responsibility, as occurs through end-user license agreements in software. With military robots, for instance, there is a list of actors throughout the supply chain who may be held accountable: the

AMSCE-101

programmer, the manufacturer, the weapons legal-review team, the military procurement officer, the field commander, the robot’s handler, and even the president of the United States, as the commander in chief of that nation.

As robots become more autonomous, it may be plausible to assign responsibility to the *robot itself*, that is, if it is able to exhibit enough of the features that typically define personhood. If this seems too far-fetched, consider that there is ongoing work in integrating computers and robotics with biological brains (e.g., Warwick 2010; also Warwick, chapter 20, this volume). A conscious human brain (and its body) presumably has human rights, and replacing parts of the brain with something else, while not impairing its function, would seem to preserve those rights. We may come to a point at which more than half of the brain or body is artificial, making the organism more robotic than human, which makes the issue of robot rights more plausible.

One natural way to think about minimizing risk of harm from robots is to program them to obey our laws or follow a code of ethics. Of course, this is much easier said than done, since laws can be vague and context-sensitive, which robots may not be sophisticated enough to understand, at least in the foreseeable future. Even the three (or four) laws of robotics in Asimov’s stories, as elegant and sufficient as they appear to be, create loopholes that result in harm (e.g., Asimov 1957, 1978, 1985).

Programming aside, the use of robots must also comply with law and ethics, and again those rules and norms may be unclear or untested on such issues. For instance, landmines are an effective but horrific weapon that indiscriminately kills, whether soldiers or children; landmines have existed for hundreds of years, but it was only in 1983—after their heavy use in twentieth century wars—that certain uses of landmines were banned, such as planting them without means to identify and remove them later (United Nations 1983); and only in 1999 did an international treaty ban the production and use of landmines (Abramson 2008).

AMSCE-101

Likewise, the use of military robots may raise legal and ethical questions that we have yet to fully consider (e.g., Lin, Bekey, and Abney 2008, 2009; also chapters 6–10 and others, this volume) and, later in retrospect, may seem obviously unethical or unlawful.

Another relevant area of law concerns privacy. Several forces are driving this concern, including the shrinking size of digital cameras and other recording devices; an increasing emphasis on security at the expense of privacy (e.g., expanded wiretap laws, a blanket of surveillance cameras in some cities to monitor and prevent crimes); advancing biometrics capabilities and sensors; and database integrations. Besides robotic spy planes, we previously mentioned (future) police robots that could conduct intimate surveillance at a distance, such as detecting hidden drugs or weapons and identifying faces unobtrusively; if linked to databases, they could also run background checks on an individual's driving, medical, banking, shopping, or other records to determine if the person should be apprehended (Sharkey 2008). Domestic robots, too, can be easily equipped with surveillance devices—as home security robots already are—that may be monitored or accessed by third parties (Calo, chapter 12, this volume).

Thus, some of the questions in this area include: If we could program a code of ethics to regulate robotic behavior, which ethical theory should we use? Are there unique legal or moral hazards in designing machines that can autonomously kill people? Or should robots merely be considered tools, such as guns and computers, and regulated accordingly? Is it ethically permissible to abrogate responsibility for our elderly and children to machines that seem to be a poor substitute for human companionship (but, perhaps, better than no—or abusive—companionship)? Will robotic companionship (that could replace human or animal companionship) for other purposes, such as drinking buddies, pets, entertainment, or sex, be morally problematic? At what point should we consider a robot to be a "person," thus affording it some

AMSCE-101

rights and responsibilities, and if that point is reached, will we need to emancipate our robot “slaves”? Do we have any other distinctive moral duties toward robots? As they develop enhanced capacities, should cyborgs have a different legal status than ordinary humans? At what point does technology-mediated surveillance by robots count as a “search,” which would generally require a judicial warrant? Are there particular moral qualms over placing robots in positions of authority, such as police, prison or security guards, teachers, or any other government roles or offices in which humans would be expected to obey robots?

1.2.3 Social Impact

How might society change with the Robotics Revolution? As with the Industrial and Internet Revolutions, one key concern is job loss. In the Industrial Revolution, factories replaced legions of workers who used to perform the same work by hand, giving way to the faster, more efficient processes of automation. In the Internet Revolution, online ventures, such as Amazon.com, eBay, and even smaller “e-tailers,” are still edging out brick-and-mortar retailers, who have much higher overhead and operating expenses, of which labor is one of the largest. Likewise, as potential replacements for humans—outperforming humans in certain tasks—robots may displace human jobs, regardless of whether the workforce is growing or declining.

The standard response to the job-loss concern is that human workers, whether replaced by other humans or machines, would then be free to focus their energies where they can make a greater impact (i.e., at jobs in which they have a greater competitive advantage) (Rosenberg 2009), and that to resist this change is to support inefficiency. For instance, by outsourcing call-center jobs to other nations where the pay is less, displaced workers (in theory) can perform “higher-value” jobs, whatever those may be. Further, the demand for robots itself creates additional jobs. Yet, arguments about competitive and efficiency gains provide

AMSCE-1101

little consolation for the human worker who needs a job to feed her or his family, and cost benefits may be negated by unintended effects, such as a negative customer support experience with call-center representatives whose first language is not that of the customers.

Connected to labor, some experts are concerned about technology dependency (e.g., Veruggio 2006). For example, as robots prove themselves to be better than humans at performing difficult surgeries, the resulting loss of those jobs may also mean the gradual loss of that medical skill or knowledge, to the extent that there would be fewer human practitioners. This is not the same worry with labor and service robots that perform dull and dirty tasks, in that we care less about the loss of those skills; but there is a similar issue of becoming overly reliant on technology for basic work. For one thing, this dependency seems to cause society to be more fragile: for instance, the Y2K problem caused significant panic, since so many critical systems—such as air-traffic control and banking—were dependent on computers whose ability to correctly advance their internal clock to January 1, 2000 (as opposed to resetting it to January 1, 1900) at the turn of the millennium was uncertain; and similar situations exist today with malicious computer viruses *du jour*.

Like the social networking and email capabilities of the Internet Revolution, robotics may profoundly impact human relationships. Already, robots are taking care of our elderly and children, though there are not many studies on the effects of such care, especially in the long term. Some soldiers have emotionally bonded with the bomb-disposing PackBots that have saved their lives, sobbing when the robot meets its end (e.g., Singer 2009a; Hsu 2009). And robots are predicted to soon become our lovers and companions (Levy 2007; also Levy, chapter 14, this volume, and Whitby, chapter 15, this volume): they will always listen and never cheat on us. Given the lack of research studies in these areas, it is unclear whether psychological harm might arise from replacing human relationships with robotic ones.

AMSCI-101

Harm also need not be directly to persons; it could also be to the environment. In the computer industry, “e-waste” is a growing and urgent problem (e.g., O’Donoghue 2010), given the disposal of heavy metals and toxic materials in the devices at the end of their product life cycle. Robots as embodied computers will likely exacerbate the problem, as well as increase pressure on rare-earth elements needed today to build computing devices and energy resources needed to power them. This also has geopolitical implications to the extent that only a few nations, such as China, control most of those raw materials (e.g., Gillis 2010).

Thus, some of the questions in this area include: What is the predicted economic impact of robotics, all things considered? How do we estimate the expected costs and benefits? Are some jobs too important, or too dangerous, for machines to take over? What do we do with the workers displaced by robots? How do we mitigate disruption to a society dependent on robotics, if those robots become inoperable or corrupted, e.g., through an electromagnetic pulse or network virus? Is there a danger with emotional attachments to robots? Are we engaging in deception by creating anthropomorphized machines that may lead to such attachments, and is that bad? Is there anything essential in human companionship and relationships that robots cannot replace? What is the environmental impact of a much larger robotics industry than we have today? Could we possibly face any truly cataclysmic consequences from the widespread adoption of social robotics (or robots capable of social or personal interactions, as opposed to factory robots, for example), and, if so, should a precautionary principle apply?

1.3 Engaging the Issues Now

These are only some of the questions which the emerging field of robot ethics is concerned with, and many of these questions lead to the

AMSCE-101

doorsteps of other areas of ethics and philosophy, for example, computer ethics and philosophy of mind, in addition to the disciplines of psychology, sociology, economics, politics, and more. Note also that we have not even considered the more popular "Terminator" scenarios in which robots—through super-artificial intelligence—subjugate humanity, which are highly speculative scenarios that continually overshadow more urgent and plausible issues.

The robotics industry is rapidly advancing, and robots in society today are already raising many of these questions. This points to the need to attend to robot ethics now, particularly as ethics is usually slow to catch up with technology, which can lead to a "policy vacuum" (Moor 1985). As an example, the Human Genome Project was started in 1990, but it took eighteen years after that for Congress to finally pass a bill to protect Americans from discrimination based on their genetic information. Right now, society is still fumbling through privacy, copyright, and other intellectual property issues in the Digital Age, nearly ten years since Napster was first shut down.

As researchers and educators, we hope that this edited collection on robot ethics will provide and motivate greater discussion—in and outside of the classroom—across the broad continuum of issues, as described in this introduction. The contributors to this book are among the most respected and well-known scholars in robotics and technology ethics today, expertly tackling many of these issues.

Though sometimes to deaf ears, history lectures us on the importance of foresight. While the invention of such things as the printing press, gunpowder, automobiles, computers, vaccines, and so on, has profoundly changed the world (for the better, we hope), these innovations have also led to unforeseen consequences, or perhaps consequences that might have been foreseen and addressed had we bothered to investigate them. At the very least they have disrupted the status quo, which is not necessarily a terrible thing in and of itself; however, unnecessary and dramatic disruptions, such as mass

AMSCE-101

displacements of workers or industries, have real human costs to them. Given lessons from the past, society is beginning to think more about ethics and policy in advance of, or at least in parallel to, the development of new game-changing technologies, such as genetically modified foods, nanotechnology, neuroscience, and human enhancement—and now we add robotics to that syllabus.

At the same time, we recognize that these technologies seem to jump out of the pages of science fiction, and the ethical dilemmas they raise also seem too distant to consider, if not altogether unreal. But as Isaac Asimov foretold: "It is change, continuing change, inevitable change, that is the dominant factor in society today. No sensible decision can be made any longer without taking into account not only the world as it is, but the world as it will be. . . . This, in turn, means that our statesmen, our businessmen, our everyman must take on a science fictional way of thinking" (Asimov 1978). With human ingenuity, what was once fiction is becoming fact, and the new challenges it brings are all too real.

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AMSCE-1101

2

Current Trends in Robotics: Technology and Ethics

George A. Bekey

Robotics is indeed one of the great technological success stories of the present time. Starting from humble beginnings in the middle of the twentieth century, the field has seen great successes in manufacturing and industrial robotics, as well as personal and service robots of various kinds. All the branches of the armed services now use military robots. Robots are appearing everywhere in society: in healthcare, entertainment, search and rescue, care for the elderly, home services, and other applications. In fact, it is difficult to find a current magazine or newspaper without some mention of robots, whether flying over Afghanistan, vacuuming carpets, carrying items in warehouses, assisting surgeons in hospitals, helping persons with disabilities, or teaching children.

While the technological advances have been remarkable and rapid (and promise to continue this pace), the social and ethical implications of these new systems have been largely ignored. Only during the past decade have we seen the emergence of the field of “robot ethics” (sometimes abbreviated as “roboethics”; see chapter 3 for discussion on this nomenclature), with most efforts in Europe, Asia, and the United States. In this chapter, we survey some of the remarkable advances in

AMSCE-1101

robot hardware and software, and comment on the ethical implications of these developments.

2.1 What Is a Robot?

Let us start with a basic issue: What is a robot? Given society's long fascination with robotics, it seems hardly worth asking the question, as the answer surely must be obvious. On the contrary, there is still a lack of consensus among roboticists on how they define the object of their craft. For instance, an intuitive definition could be that a robot is merely a computer with sensors and actuators that allow it to interact with the external world; however, any computer that is connected to a printer or can eject a CD might qualify as a robot under that definition, yet few roboticists would defend that implication.

We do not presume we can definitively resolve this great debate here, but it is important that we offer a working definition prior to laying out the landscape of current and predicted applications of robotics. In its most basic sense, we define "robot" as *a machine, situated in the world, that senses, thinks, and acts*:

> Thus, a robot must have sensors, processing ability that emulates some aspects of cognition, and actuators. Sensors are needed to obtain information from the environment. Reactive behaviors (like the stretch reflex in humans) do not require any deep cognitive ability, but on-board intelligence is necessary if the robot is to perform significant tasks autonomously, and actuation is needed to enable the robot to exert forces upon the environment. Generally, these forces will result in motion of the entire robot or one of its elements (such as an arm, a leg, or a wheel). (Bekey 2005)

We stipulate that the robot must be *situated in the world* in order to distinguish a physical robot from software running on a computer, or, a "software bot."

This definition does not imply that a robot must be electromechanical; it leaves open the possibility of biological robots, but it eliminates

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virtual or software ones. A simulated robot is just that: a simulated robot. But it does rule out as robots any *fully* remote-controlled machines, since those devices do not “think,” such as many animatronics and children’s toys. That is, most of these toys do not make decisions for themselves; they depend on human input or an outside actor. Rather, the generally accepted idea of a robot depends critically on the notion that it exhibits some degree of autonomy, or can “think” for itself, making its own decisions to act upon the environment. Thus, the U.S. Air Force’s Reaper unmanned aerial vehicle (UAV), though mostly teleoperated by humans, makes some navigational decisions on its own and therefore would count as a robot. By the same definition, the following things are not robots: conventional landmines, toasters, adding machines, coffee makers, and other ordinary devices.

As should be clear by now, the definition of “robot” also trades on the notion of “think,” another source of contention that we cannot fully engage here. By “think,” what we mean is that the machine is able to process information from sensors and other sources, such as an internal set of rules, either programmed or learned, and to make some decisions autonomously. Of course, this definition merely postpones our task and invites another question: What does it mean for machines to have autonomy? If we may simply stipulate it here, we define “autonomy” in robots as the capacity to operate in the real-world environment without any form of external control, once the machine is activated and at least in some areas of operation, for extended periods of time (Bekey 2005).

Thus again, *fully* remote- or teleoperated machines would not count as autonomous, since they depend on external control; they cannot “think” and, therefore, cannot act for themselves. As already indicated, many robots are *partially* remotely controlled; they are frequently known as “telerobots.”

A complete discussion of what it means to be a robot will engage other difficult issues from technical to philosophical, such as complexity, unpredictability, determinism, responsibility, and free will,

AMSCE-110I

some of which are investigated in chapter 3. As such, we do not offer a complete discussion here, and we will have to content ourselves with the working definitions just stipulated—which should be enough to understand why we include some machines and not others in the remainder of this chapter.

2.2 Robotics around the World

Manufacturing robots were invented in the United States; companies such as Unimation and Cincinnati Milacron were leaders in the field in the 1970s. During the 1980s, the leadership in this field gradually moved to Japan and Europe, where companies like Fujitsu, Panasonic, Kuka, and ASEA became the dominant players. During the 1990s, support for research and development of service robots was much stronger in Japan, South Korea, Germany, Australia, and other countries than in the United States. A survey of trends in robotics in those countries in 2004 concluded that the United States was rapidly falling behind other countries in robotics, since (among other factors) there was no national program to support and coordinate robotics research (Bekey et al. 2008). This situation has begun to change since 2008, with the organization of a Congressional Caucus in robotics, development of "roadmaps" in such areas as medical robotics, manufacturing, and service, and increased support from a number of government agencies (Computer Community Consortium 2009). The first roadmap for robotics development was developed by the European Community (Veruggio 2006). Yet, while there is increased attention to the technology, there is still little discussion of its ethical implications except in Europe, where a number of symposia and conferences have addressed the issue (Veruggio 2009).

Current and near-future developments in robotics are taking place in many areas, including hardware, software, and applications. The field is

AMSCE-1101

in great ferment, with new systems appearing frequently throughout the world. Among the areas in which the great innovations are taking place are:

- Human–robot interaction, in the factory, home, hospital, and many other venues where social interaction by robots is possible
- Display and recognition of emotions by robots
- Humanoid robots equipped with controllable arms as well as legs
- Multiple robot systems
- Autonomous systems, including automobiles, aircraft, and underwater vehicles

In this chapter, we concentrate on the areas where the ethical implications are the clearest and most immediate. This is not to say that other areas do not have ethical implications. Indeed, we believe that as robots become more visible and involved in more areas of society, new areas of ethical concern will emerge. We begin with changes in manufacturing robots, since that is where the field began and where some of the most dramatic changes in human–robot interaction are taking place. Then, we look at robots in healthcare and rehabilitation, socially interactive robots (especially humanoids) that share or will share our homes and social gatherings, and military robots, both present and future. In all these application areas, robots are or will be interacting with humans in many ways.

2.3 Industrial/Manufacturing Robots: Robots as Coworkers

With the exception of scattered developments in some university laboratories, robotics really began in the manufacturing sector with the introduction of the Unimate robot (Engelberger 1980). Since then,

AMSCE-1101

millions of robots have been sold. The International Federation of Robotics estimated that there were 1.3 million active manufacturing robots in the world in 2008 (International Federation of Robotics 2010).

In the early years of robotized manufacturing, the ethical issue was dramatized by the death of a worker at a Ford manufacturing plant in Flint, Michigan, on January 25, 1979. The worker was struck in the head by a robot arm that was retrieving parts in a warehouse. In 1981, a robot killed a Japanese worker while he performed maintenance (The Economist 2006). Following these two deaths, manufacturing plants began to install safety barriers around areas where large, heavy, and potentially dangerous robot arms were used. Even so, in 1984, a worker was killed after he climbed over the safety fence without disabling the robot. Clearly, employing workers in factories where robots are their coworkers includes the ethical responsibility to ensure their safety and well-being; however, no safety barrier can protect against human stupidity.

Barriers have largely solved the problem of potential physical harm caused by robots in manufacturing. However, their use has led to a number of other ethical concerns, particularly in situations where robots work in proximity to humans. These concerns are addressed in the following sections.

2.3.1 The Fear of Being Replaced by a Machine

Introduction of robots into factories, while employment of human workers is being reduced, creates worry and fear. It is the responsibility of management to prevent or, at least, to alleviate these fears. For example, robots could be introduced only in new plants rather than replacing humans in existing assembly lines. Workers should be included in the planning for new factories or the introduction of robots into existing plants, so they can participate in the process. It may be that robots are needed to reduce manufacturing costs so that the company remains competitive, but planning for such cost reductions should be

AMSCE-101

done jointly by labor and management. Retraining current employees for new positions within the company will also greatly reduce their fear of being laid off. Since robots are particularly good at highly repetitive simple motions, the replaced human workers should be moved to positions where judgment and decisions beyond the abilities of robots are required.

2.3.2 The Dehumanization of Work

In principle, it should be possible to design manufacturing systems in which repetitive, dull, and dangerous tasks are performed by robots, while tasks requiring judgment and problem-solving ability remain with human workers. Yet, in the process of developing increasingly automated factories, human workers may begin to feel inferior to the robots. Further, they may begin to believe that management intends to reduce all work to repetitive motions, which can (at least in principle) be carried out entirely by robots. Such a set of beliefs can lead to increasing unhappiness, and even destructive actions, on the part of the human workers toward the robots. Such concerns led to the attempts by workers in England in the nineteenth century to destroy mechanized cotton looms.[1] Management has an ethical responsibility to allow humans to work in tasks that do not demean them, but rather take advantage of their superior cognitive abilities.

2.3.3 Current Trends toward Cooperative Work

One of the most interesting current trends in robotics is the use of robots in tasks where they have shared responsibilities with humans. One of the first such systems was developed by Peshkin and Colgate at Northwestern University in the late 1990s (Peshkin and Colgate 1999). The cooperative robots were termed “cobots.” Much of the theoretical work as well as practical applications of cobots was developed more recently (e.g., Gillespie, Colgate, and Peshkin 2001). Basically, cobots and humans may jointly grasp an object to be moved, but the motive

AMSCE-101

power is provided entirely by the human; the cobot provides guidance, and may prevent motion in certain directions. Since the human produces the motive power, such systems effectively solve the potential danger to humans from robot motions.

In recent years, human–robot collaboration in the workplace has received increasing attention. New sensors make it possible to place robots and humans in close proximity to one another, while minimizing potential dangers. Thus, sensors can provide early warning when robots and humans appear to be moving into the same spaces. In addition, future manufacturing robots will have to recognize human gestures and movements and react accordingly, in order to reduce drastically any possible dangers to their human partners. Such cooperation also means that the robots can learn movements from humans by imitation. Ultimately, the goal of these efforts is to create increasing opportunities for shared and cooperative work that takes advantage of the specific features and advantages of both robots and humans.

It is evident that shared, cooperative work between humans and robots may enhance the working environment, but it may also reduce human–human interaction and communication. These are ethical problems that need to be addressed as factories become increasingly automated.

2.4 Human–Robot Interaction in Healthcare, Surgery, and Rehabilitation

Another area where robot–human interaction is developing rapidly is the field of healthcare, including nursing, surgery, physical therapy, and noncontact assistance during therapy and rehabilitation. These developments are becoming possible as the potential danger to humans from accidental robot activity decreases. This area of robotics is growing so rapidly that we can only indicate some typical applications.

AMSCE-101

Nursing care is typically a one-on-one relationship between a patient and a caregiver. Hence, it is an expensive part of healthcare, and a number of laboratories are developing robots we may term “nurse’s assistants.” One of the earliest of such robots was the wheeled HelpMate, currently marketed by a company named Pyxis. HelpMate assists nurses and other hospital personnel by smoothly transporting pharmaceuticals, laboratory specimens, equipment and supplies, meals, medical records, and radiology films back and forth between support departments, nursing floors, and patient rooms. The HelpMate is able to navigate hospital corridors, avoid collisions with humans, summon the elevator, and locate a specific patient’s room. Carnegie Mellon University and the University of Pittsburgh have developed a “nurse-bot” named Pearl (Montemerlo et al. 2002) as an assistant that visits elderly patients in hospital rooms, provides information, reminds patients to take their medication, takes messages, and guides residents. Such robots are usually constructed as upright structures on wheels, with a somewhat human-appearing head containing cameras and voice-synthesizing software for communication. They usually also have a digital display, on the head or chest, to display messages. In Europe, there have been (and are) a number of projects in this area, such as the Care-O-Bot developed at the Fraunhofer Institute in Stuttgart, Germany (Fraunhofer 2010). The Care-O-Bot also has an arm to assist in pick-and-place operations. Similar projects exist in Japan, South Korea, and other countries.

A related set of projects involves “assistive robots,” which provide verbal guidance, encouragement, and interaction to people recovering from strokes and spinal injuries, as well as companionship to children with autism-spectrum disorders. These robots do not make any physical contact with the subjects, but rather guide them through exercises and activities by voice and demonstration (Feil-Seifer and Matarić 2005). Figure 2.1 shows such a robot interacting with a subject.

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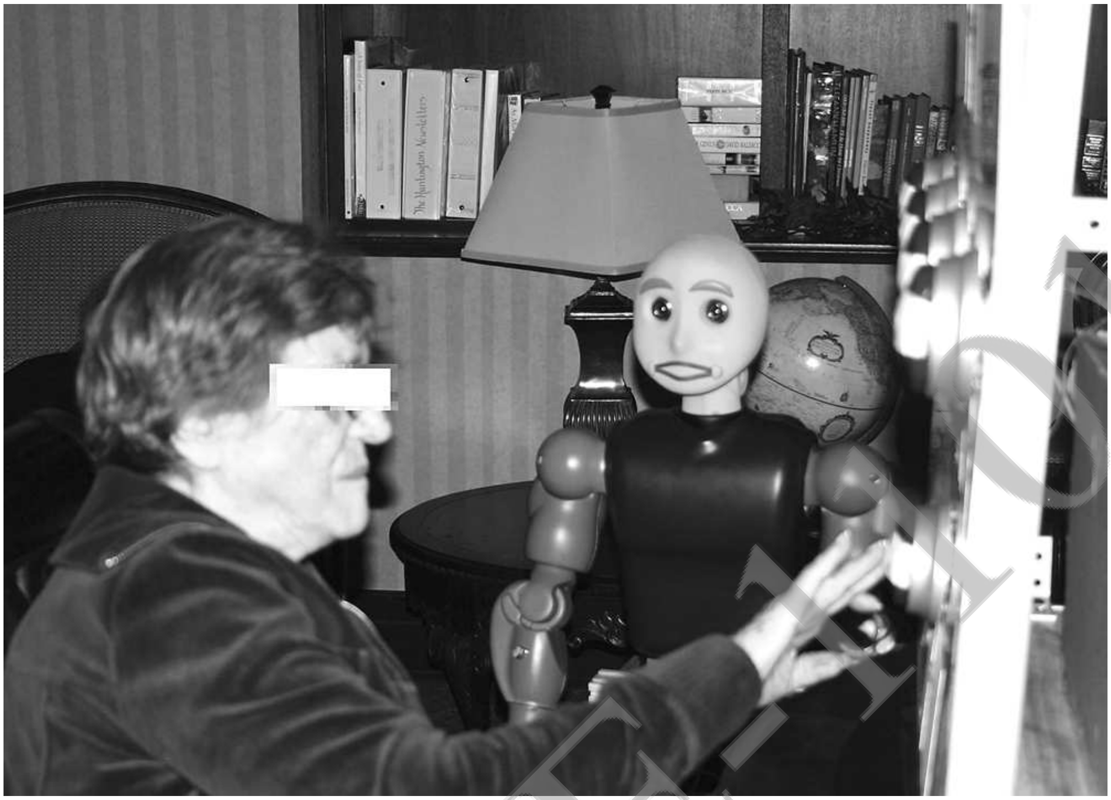

Figure 2.1
Assistive robot interacting with a physical therapy patient. Courtesy of Professor M. Matarić, University of Southern California.

Among the potential ethical concerns in the use of such assistive robots and nurse-bots are the following:

- Patients may become emotionally attached to the robots, so that any attempt to withdraw them may cause significant distress.
- The robots will not be able to respond to patients’ anger and frustration, except by calling for human help. For example, a patient may refuse to take the medication offered by the robot, throw it on the floor, and even attempt to strike the robot.
- A robot may be called by more than one user and not have the ability to prioritize the requests, thus causing anger and frustration.

AMSCE-HOI

Robotics is also important in other aspects of rehabilitation. Artificial limbs and prosthetic joints are frequently “robots,” since they employ sensors to obtain information on positions, velocities, and forces; computers to process the information; and motors to provide mobility to the affected joints. However, we do not discuss them in this chapter, since there do not seem to be new ethical problems arising from the use of robotic prosthetics, as compared with nonrobotic ones.

The term “robotic surgery” is used to describe cooperative human–robot activities in the surgical suite. The da Vinci surgical robot (Taylor et al. 1995) is currently being used in hundreds of hospitals; see figure 2.2. It is important to note that the da Vinci is actually a telerobot, since it is remotely controlled by a human surgeon and is not fully autonomous. The human surgeon sits at a remote console and uses two hand controllers to position an endoscope and surgical instruments. In fact, she is sending instructions to the computer controlling the arms of a robot that performs the surgery. The surgical tools are equipped with sensors that provide feedback to the surgeon’s hands, preventing excessive motions, filtering the surgeon’s hand tremor, and providing velocity feedback to ensure smooth motions without oscillations. Thus, use of the da Vinci represents another example of cooperative human–robot work. We have discussed some of the ethical issues arising from the use of surgical robots in another publication (Bekey, Lin, and Abney 2011). Here, we consider potential future scenarios, when surgical robots become more autonomous and become true partners with human surgeons, rather than being simply remotely operated systems.

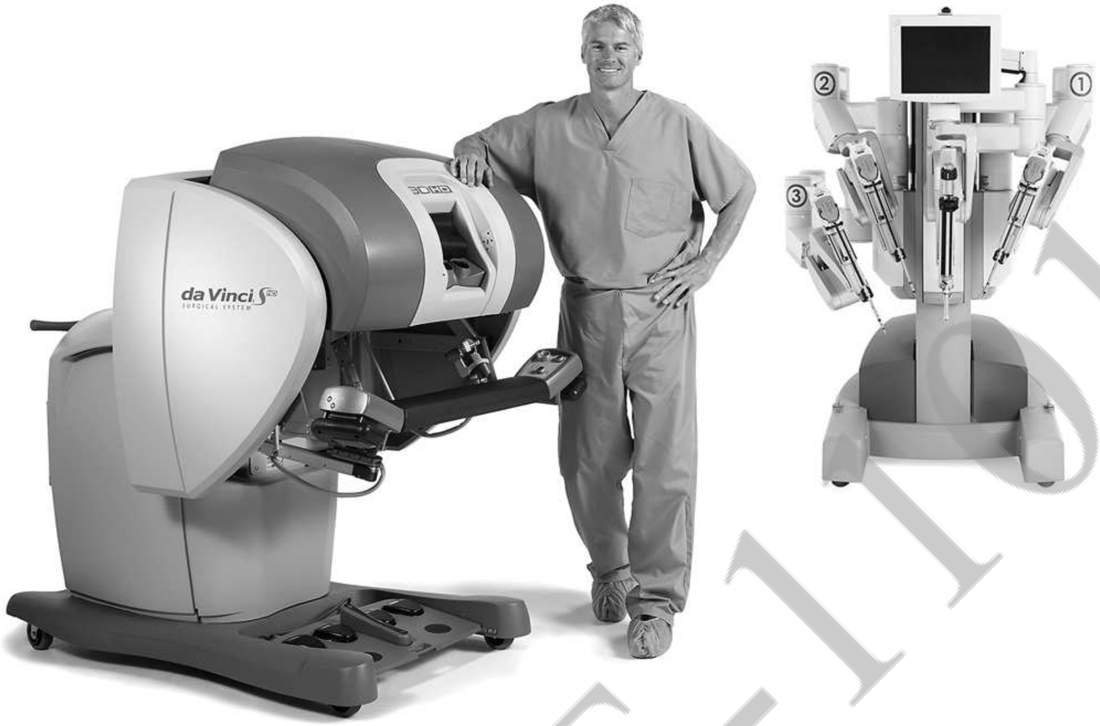

Figure 2.2
da Vinci robotic surgical system. Courtesy of Intuitive Surgical Systems.

Consider a hypothetical scenario involving robotic surgery. A robot surgeon performs an operation on a patient; a number of complications arise and the patient's condition is worse than before. Who is responsible? Is it the designer of the robot, the manufacturer, the human surgeon who recommended the use of the robot, the hospital, the insurer, or some other entity? If there was a known chance that the surgery might result in problems, was it ethical for the human surgeon or the hospital, or both, to recommend or approve the use of a robot? How large a chance of harm would make it unethical—or, to phrase it differently, how small a chance of harm would be morally permissible? That is, what is the acceptable risk?

Truly autonomous procedures on the part of a robot surgeon will require a number of safety measures to ensure that patients are not harmed. More than that, robotic surgeons will require levels of precision comparable to that of human surgeons. They may have to learn their

AMSCE-1101

surgical skills from a combination of programming (probably using artificial intelligence tools) and imitation of human surgeons. The ethical issues are clear: the risks of using a robot surgeon, either alone or in partnership with a human surgeon, must be lower than those encountered with human surgeons. Further, the cost of using a robot surgeon may need to be lower than that of using a human surgeon. However, if this becomes the case, and there is increased use of robots in the surgical suite, we may see the rise of “Luddite” surgeons in our hospitals. Insurance issues will probably play a major role in any decisions on deployment of autonomous or semi-autonomous surgical robots.

2.5 Robots as Co-inhabitants; Humanoid Robots

We expect that during the coming decade more and more robots will be present in our homes, assisting us in cleaning, housekeeping, child care, secretarial duties, and so on. This trend of “co-inhabitant” robots[2] began with the Roomba vacuum cleaning robot, introduced by the company iRobot in 2002. Since then, more than four million of these robots have been sold worldwide, so many that we may classify the Roomba robot as a commodity, rather than a luxury. However, the Roomba does not interact with people in any significant way. Such interactions are restricted largely to robots that have some human-like attributes, in other words, *humanoid* robots. Vacuum cleaners and lawn mowers may be robotic, but they are not currently humanoids.

Humanoid robots resemble human beings in some aspects. They may have two legs or no legs at all (and move on wheels); they may have one or more arms or even none; they may have a human-like head, equipped with the senses of vision and audition; and they may have the ability to speak and recognize speech.

AMSCE-110I

It is interesting to note that humanoid robots do not need to appear completely human-like in order to be trusted by people. It is well known that humans are able to interact with dolls, statues, and toys that only have a minimal resemblance to human beings. In fact, the ability of humans to relate to humanoids becomes worse as they approach human-like appearance, until the resemblance is truly excellent. This somewhat paradoxical result has been called the “Uncanny Valley” by Mori (1970), see figure 2.3. This figure shows that our emotional response to robots increases as they resemble humans more and more, until they reach a point at which their resemblance is close to perfect but eerily dissimilar enough such that we no longer trust them—that sudden shift in our affinity is represented by the dip or valley on the curve. But the trust returns as the anthropomorphism approaches 100 percent (or perfect resemblance) to human appearances.

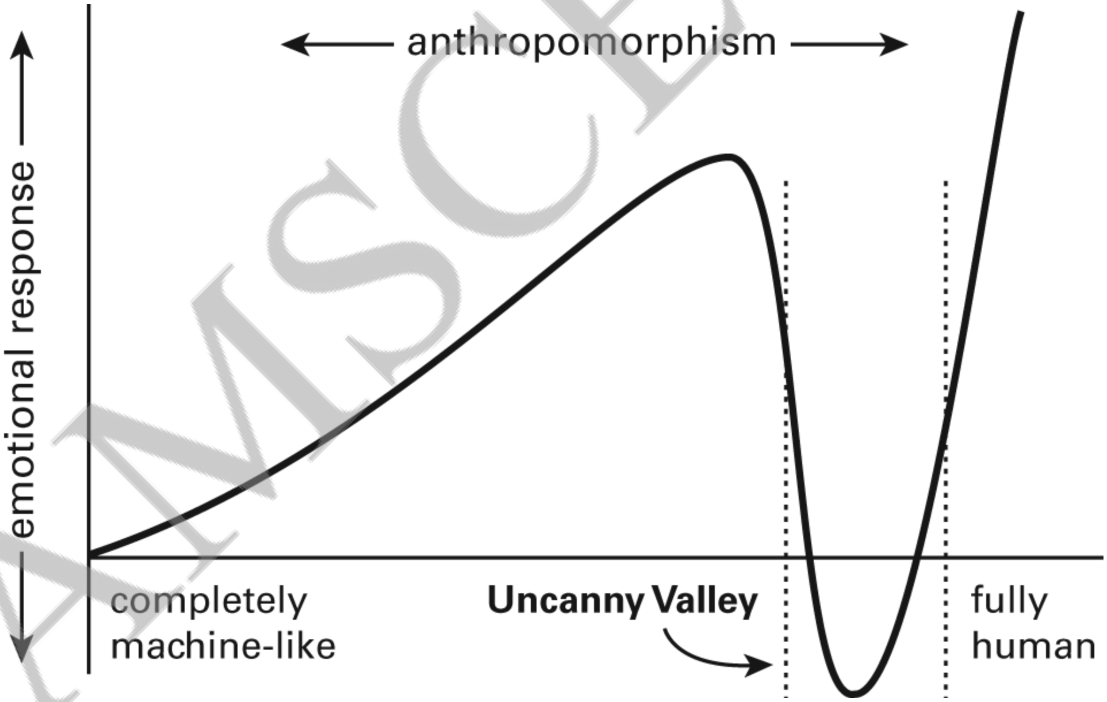

Figure 2.3
The “Uncanny Valley.” Courtesy of GNU Free Documentation License.

AMSCE-1101

The ability of these robots to share living spaces without danger to the human occupants depends on a number of technological improvements, including new and better sensors (which enable the robots to be fully aware of their surroundings), the ability to communicate with humans by voice, as well as gestures, controlled actuators to prevent rapid movements and possible injury, and much improved software, including the ability to interact socially with people. These are tall orders, but robots capable of meeting many of these requirements are beginning to appear. Two examples are Wakamaru from Mitsubishi in Japan (Mitsubishi Heavy Industries Ltd. 2010) and Nao from Aldebaran Robotics in France (Aldebaran Robotics 2010); see figure 2.4.

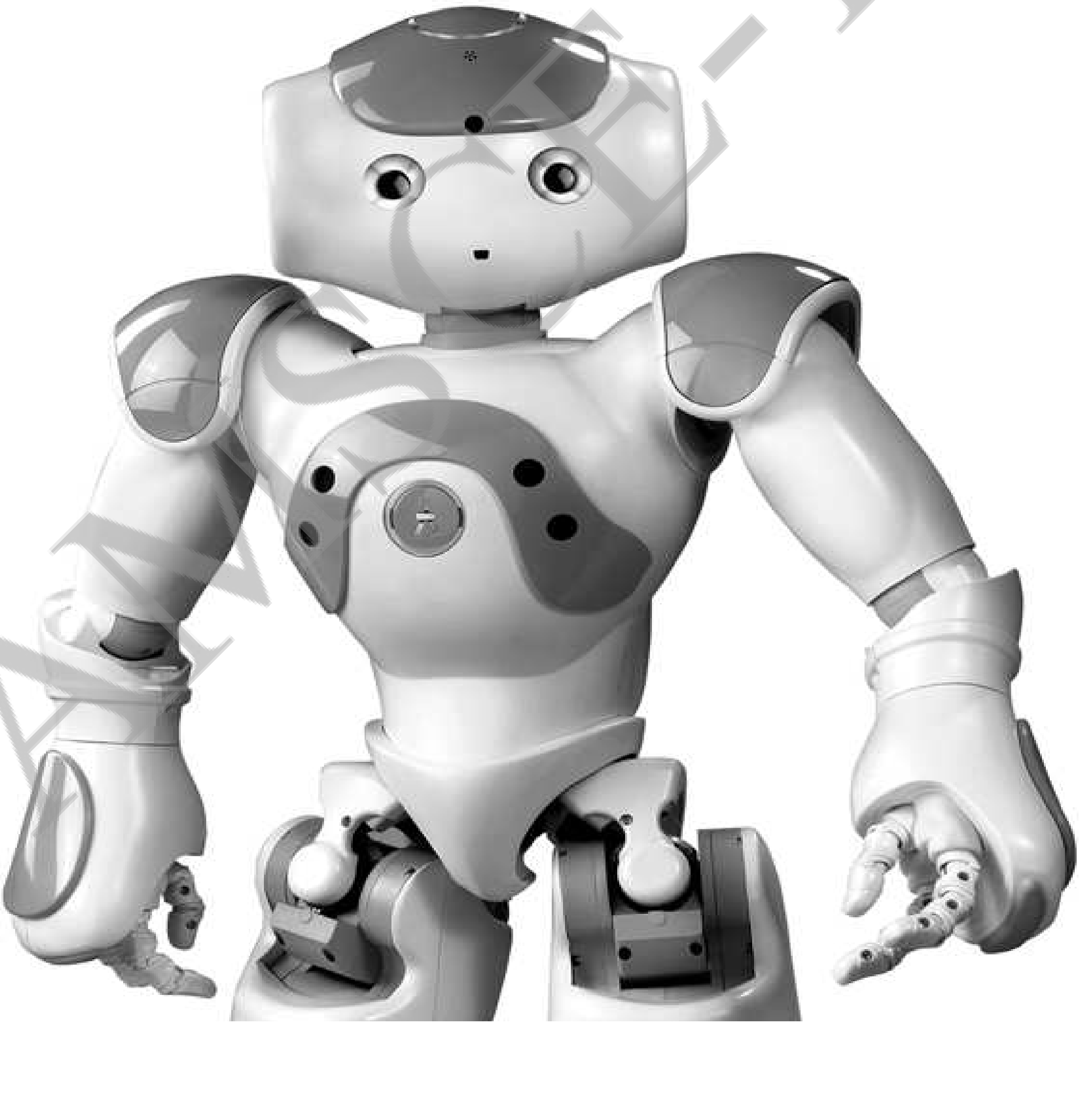

Figure 2.4
NAO, the humanoid robot by Aldebaran Robotics. Courtesy of Aldebaran Robotics.

Wakamaru was designed to co-inhabit living spaces with humans, being termed a “companion robot.” It is about four feet, or 120 centimeters, in height, has a head with large eyes, and movable arms but no legs; it moves on wheels, thus being restricted to relatively flat locations. It recognizes some ten thousand words, can place telephone calls, and communicates by Internet. It carries a camera; if contacted via Internet, it displays the camera image to the caller, and it recognizes ten faces and can be programmed to react appropriately to each. It can read the owner’s email and scan the news, passing the information on by voice. It communicates both by speech and gestures. Wakamaru costs about US$14,000 or over €10,000.

Nao is a robot currently in use in a number of university research laboratories. It is only fifty-eight centimeters or about two feet in height, half as tall as Wakamaru. It walks, maintaining stability by means of an inertial measurement unit (or a system for continuous calculation of the position, velocity, and orientation of a moving object using

AMSCE-1101

accelerometers and gyroscopes) and ultrasonic sensors. Its hands are capable of grasping objects. It has two cameras. It is capable of omnidirectional hearing by means of four microphones; it uses two speakers. Like Wakamaru, it is able to access the Internet; its processor uses a Linux operating system. It recognizes and is able to imitate a number of gestures and arm positions. Nao is sold in Europe for approximately €10,000 as well.

As a final example of a humanoid robot in a home situation, consider figure 2.5, which shows ARMAR, a robot being developed in Germany to provide assistance in the kitchen.

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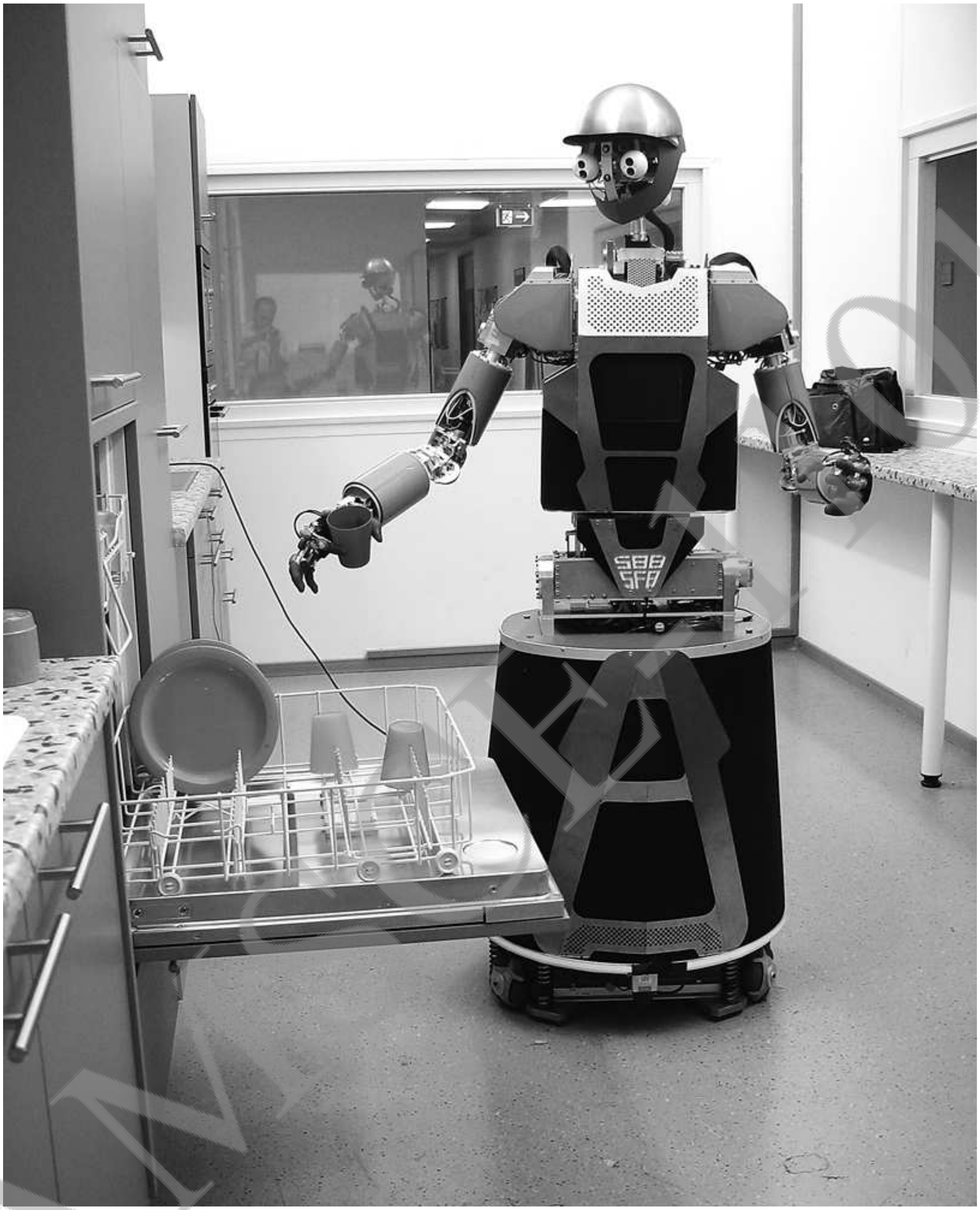

Figure 2.5
ARMAR-3, a kitchen-assistive robot prototype, loading dishes in a dishwasher. Courtesy of Prof. R. Dillman, University of Karlsruhe.

Clearly, these robots are sophisticated humanoids, capable of a variety of interactions with humans. While much of the technology for co-inhabiting robots is at hand, the risks and ethical issues have yet to be addressed. These include:

- Loss of privacy for the human inhabitants if the robots are permitted free access to all rooms in a home.
- Ability of the robots to recognize commands that may lead to unethical behaviors (e.g., to steal a neighbor's camera or cell phone).
- Rights and responsibilities of the robots, e.g., should they be treated with respect as if they were human?
- Emotional relationships, e.g., how should a robot relate to human anger, say, when the robot drops a dish of food on the floor? In other words, is it ethical to yell at a robot? Can and should robots be punished for misbehavior, and, if so, how?
- How should a robot react to multiple instructions from different humans, e.g., when a child calls for it to come and play while the mother calls for it to come and wash the dishes?
- Can the robot's computer be accessed by hackers, so it may stake out and send pictures from the home to potential burglars?

Evidently, we have no answers to these and other similar questions at the present time.

2.6 Socially Interactive Robots

The robots we have discussed above are "socially interactive," in the sense that human–robot interaction is an essential component of their behavior. The phrase covers a wider range of robots, as presented in a major survey paper (Fong, Nourbakhsh, and Dautenhahn 2003). A broader view needs to include multiple robot systems (where robots may cooperate with each other), and even robot swarms. Such robots may

AMSCE-101

need to recognize each other and possibly engage in mutual interactions, including learning from each other. While a great deal of research in these areas is currently proceeding, we cannot discuss it here, due to space limitations. However, it is evident that such mutual relationships will eventually involve ethical considerations. For example, is it ethical for one robot to damage or destroy another member of its group? If not, how can we ensure that such behaviors do not occur?

Ultimately, as social robotics develops, we expect that individual robots may develop distinctive personalities and communicate with each other, perhaps in new high-level languages. We have begun to study one aspect of social behavior by considering robot societies in which an altruistic robot may assist another in the completion of its task, even if its own performance suffers as a result (Clark, Morton, and Bekey 2009).

One further topic needs mention in connection with socially interactive robots, and that is the question of *robot emotions*. This is a subject of intensive research in a number of robotics laboratories. There are extensive discussions on the nature of “artificial emotions” as displayed by robots. Human–robot interaction should benefit if both humans and robots are capable of expressing anger, happiness, boredom, and other emotional states. For example, emotions may be expressed by a synthetic face on a digital monitor or by a three-dimensional head. Both face and head may have movable eyebrows, mouths that can be shaped, eyes that open or close, and so on. The early Kismet robot head at MIT (Breazeal 2002) was only faintly human but had a number of adjustable features. While we may argue that the robot’s expressed emotion is not “real,” the human reaction to it may be significant (Ogata and Sugano 2000). Humans have a tendency to anthropomorphize robots, and any display of emotions (real or artificial) by the robot could lead to unacceptable (or unethical) behaviors by humans in response.

AMSCE-101

2.7 Military Robots

The use of robots in the military services has been the subject of a number of books (e.g., Singer 2009) and reports (e.g., Lin, Bekey, and Abney 2008), as well as chapters in edited books (e.g., Lin, Bekey and Abney 2009; Sharkey, chapter 7, this volume). In view of these publications, we will not discuss autonomous or semi-autonomous unmanned flying vehicles (UFVs), unmanned ground vehicles (UGVs) or unmanned underwater vehicles (UUVs) in this chapter. When robots are used to detect and neutralize improvised explosive devices (IEDs) and mines, they are clearly protecting the lives of soldiers and sailors; see figure 2.6. Thousands of such robots are in use at the present time in Iraq and Afghanistan. There are also civilian applications for protective robots, such as security in the home, government facilities, or commercial installations, and perimeter inspection of industrial plants. Police departments may use robots to enter a building where it may be dangerous for human officers.

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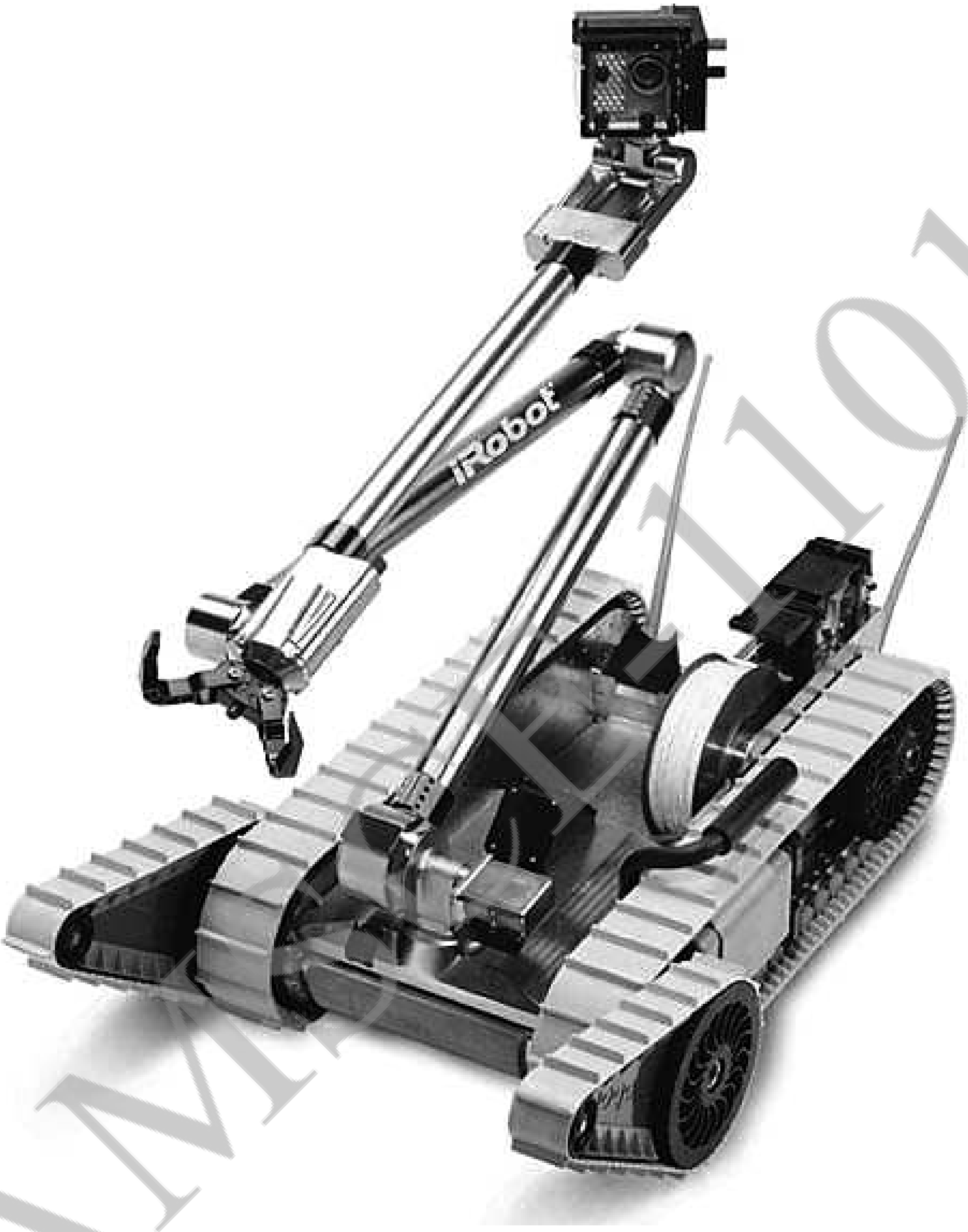

Figure 2.6
Packbot military robot. Courtesy of iRobot Inc.

To illustrate the ethical dilemmas arising with military robots, consider the two following (future) scenarios:

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1. Intelligence information indicates that a house located at given GPS coordinates is the headquarters for dangerous enemy combatants. A military robot is commanded by an officer to approach the house and destroy it, in order to kill all the people within it. As the robot approaches the house, it detects (from a combination of several sensors, including vision, x-ray, audition, olfaction, etc.) that there are numerous (noncombatant) children within, in addition to the combatants. The robot has been programmed in compliance with the laws of war and the typical rules of engagement to avoid or to at least minimize noncombatant casualties (sometimes referred to as "collateral damage") (e.g., Arkin 2009; Lin, Bekey, and Abney 2008). When facing contradictory instructions, the robot may attempt to solve its dilemma by transferring authority back to the officer in charge, but this may not be feasible or practical, since it may risk discovery of the robot by the enemy and harm to our own forces. Typically, when faced with such contradictory instructions, the on-board computer may "freeze" and lock up.

2. Another possible scenario involves a high-performance robot aircraft, suddenly subject to attack by unknown and unrecognized piloted airplanes. The robot can only defend its own existence by causing harm to human beings. A decision to transfer control to a human commander would need to be made in milliseconds, and no human could respond rapidly enough. What should the drone do?

Thus, the use of military robots raises numerous ethical questions. Arkin (2009) has attempted to solve such problems by developing a control architecture for military robots, to be embedded within the robot's control software. Such software, in principle, could ensure that the robot obeys the rules of engagement and the laws of war. But would the mere requirement to adhere to these rules actually ensure that the robot behaves ethically in all situations? The answer to this question is clearly

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in the negative, but Arkin only claims that such robots would behave "more ethically" than human soldiers. In fact, sadly, to behave more morally than human soldiers may not require a great advance in robot ethics. It is evident from the preceding discussion that there are numerous unresolved ethical questions in the deployment of military robots. Among these questions are the following:

- If a robot enters a structure, how can we ensure that it will not violate the rights of human occupants?
- Do the entering robots have rights? Is damage to or destruction of a sentry or inspector robot a crime?
- If a robot destroys property in the process of protecting people or attempting to arrest criminals, who is responsible for repairing the damage?
- Will the use of increasingly autonomous military robots lower the barriers for entering into a war, since it would decrease casualties on our side?
- How long will it be before military robotic technology will become available to other nations, and what effect will such proliferation have?
- Are the laws of war and rules of engagement too vague and imprecise (or too difficult to program) to provide a basis for an ethical use of robots in warfare?
- Is the technology for military robots sufficiently well developed to ensure that they can distinguish between military personnel and noncombatants?
- Are there fail-safes against unintended use? For instance, can we be certain that enemy "hackers" will not assume control of our robots and turn them against us?

AMSCE-1101

Thoughtful discussions of these issues have been published by Arkin (2009), Asaro (2008), Sharkey (2008), Sparrow (2007), Weber (2009), and others. We have addressed some of them in a major report (Lin, Bekey, and Abney 2008).

2.8 Conclusion

In this chapter, we have surveyed some of the major trends, current at the time of this writing, in the robotics field and indicated some of the ethical implications of these changes. While the field is advancing rapidly, what has not changed much is the general lack of attention on ethical issues on the part of the robotics community. The present book is a small step in the direction of increasing awareness of these issues among designers and users of robots.

Notes

[1] The movement was led by a fictitious “King Ludd”; people who oppose mechanization and automation are sometimes referred to as “Luddites.”

[2] The term “co-inhabitant” was coined by Professor Ken Goldberg at the University of California, Berkeley.

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AMSCE-1101

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AMSCE-101

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AMSCE-1101

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AMSCE-1101

3

Robotics, Ethical Theory, and Metaethics: A Guide for the Perplexed

Keith Abney

AMSCE-1101

What is robot ethics? The term may cause perplexity; according to some ethical views, it seems to be a field of study without an object to study (as some gibe at astrobiology or theology). In the emerging literature devoted to robot ethics, however, the term has at least three distinct meanings, the first two of which clearly refer to something real. First, it can refer to the professional ethics of roboticists (often termed "roboethics" [Veruggio 2007]); second, it can refer to a moral code programmed into the robots themselves—the moral code the robots, not the roboticists, follow; and third (the possibly nonexistent meaning), "robot ethics" could refer to the self-conscious ability to do ethical reasoning by robots—to a robot's own, self-chosen moral code. The epilogue of this volume describes these three senses in more detail.

The term "ethics" also needs disambiguation. "Ethics" is sometimes used synonymously with "morality," but sometimes refers to "the study of morality." Some robot ethicists, like Rafael Capurro (2009), prefer to distinguish these by calling the second sense previously noted (a programmed-in robotic moral code) a robot *morality*, whereas only the third sense of a self-conscious, voluntary adoption of a particular code would be called robot *ethics*. Others use "robot ethics" or "machine morality" in both the second and third senses, or even for issues in the discipline philosophers call "metaethics," and so may leave unclear the meaning of terms like "artificial moral agents" and "machine ethics." Accordingly, this essay aims to examine some common confusions, misunderstandings, equivocations, and other problems in understanding these three senses of robot ethics, and to introduce the ethical and metaethical issues concerning robots discussed later in this volume.

3.1 Four Questions

I begin with four crucial, but often misunderstood, questions (or sets of related questions) for doing ethics, all of them relevant to robotics:

1. What is morality or ethics: the *right*, or the *good*?

2. What are moral rights? What is their relationship to moral duties? And who or what can be rights holders?

3. What are the major contemporary moral theories? How do they bear on robot ethics?

4. What is a person, in the moral sense? Can a robot be a person?

3.1.1 What Is Morality or Ethics: The Right, or the Good?

So what is morality? Morality always involves an "ought (not)"—it is about the way the world ought (or ought not) to be, as opposed to the way it actually is. The "ought" of morality has been understood in two primary ways: as doing the right, or as being good—that is, the content of morality is understood either as what rules make for right action, or as how one ought to live in order to have a good life. These two approaches are practically equivalent, if living a good life means following some set (the right set) of rules; if not, there is a potential chasm between these two conceptions of morality.

AMSCE-1101

Top-down, rule-based approaches, like Asimov's Three Laws of Robotics (Asimov [1942] 1968), understand ethics as the investigation of right action—what are the rules to follow in order to be morally right, to perform the morally correct (or at least morally permissible) action? The analogy with the legal system is instructive: if one obeys the rules, one is moral; if one disobeys or breaks the rules, one acts immorally. The investigations of ethics are fundamentally, then, an inquiry into what the rules ought to be, for any particular society. Robot ethics, then, concerns following (in senses one and three) or programming (sense two) the correct set of rules.

The usual divide within rule-based approaches is between those who say one must intend to obey the rules, no matter what—even if the consequences will be bad (deontologists, associated with Kant), versus those who say the main or only rule is always to make the future consequences as good as possible—*the ends justify the means* (consequentialists, most commonly represented by utilitarians, who tend to measure the ends or results in terms of happiness gained or lost).

There is another historically influential approach that understands ethics as the art/science of living a good life, not as being bound by some set of rules that may not apply to one's unique circumstances. For programming robots, this view represents a "bottom-up" or "hybrid" approach that involves trial-and-error learning of what constitutes (un)acceptable behavior—or a "good" or "bad" robot—that goes beyond mere obedience to a set of rules.

One justification for this understanding of morality as the good, not the right, is the observation that all rule-based approaches have assumed: (a) the rule(s) would amount to a decision procedure for determining what the right action was in any particular case; and (b) the rule(s) would be stated in such terms that any nonvirtuous person could understand and apply it (them) correctly (Hursthouse 2009). But despite centuries of work by moral philosophers, no (plausible) such set of rules has been found. Moral particularism (Dancy 2004) is one, perhaps

AMSCE-IOI

unhelpful, purported solution to this quandary: there are no moral rules, only moral facts, and acts can only be judged according to the unique particulars of each case. But if each moral situation is sui generis, how then could we ever program robots to be moral?

A more helpful approach for robots is virtue ethics, which asserts the problem with rule-based morality is that it has the wrong object of evaluation. Morality is asserted to be about the character of persons, not the rightness or wrongness of individual acts. Top-down moral theories are concerned with action, and attempt to answer the question, “What should I *do*?” with some set of rules. Virtue ethics, by contrast, attempts to answer the question, “What should I *be*?” Virtue ethics consists not in following moral rules that stipulate right actions, but in striving to be a particular kind of person (or robot)—a virtuous one.

As such, virtue ethicists usually deny that mere actions are meaningfully good or evil—it may be morally wrong (betray a defective character, a “vice”) for me to begin to carve your chest with a knife, but someone else performing exactly the same action in the same circumstances may be perfectly moral (“virtuous”)—if you are lying on an operating table, and she is a surgeon, whereas I am not! She evinces a perfectly virtuous character in cutting you open because of her skills and her role in the situation; because my skills and my role are different (because I am not a licensed surgeon), performing the same act would reveal my character is flawed, even if my intentions were good; indeed, even if (miraculously) the surgery turned out well—that is, even if the consequences of my act were good. For robots, this same proper functioning approach to evaluation appears natural: is the surgical robot operating properly in carving one’s chest, or is my new robotic bandsaw dysfunctionally attempting to do the same thing?

Virtue ethicists thus claim what counts is one’s moral character—moral evaluation is of persons, not of actions. The virtues are understood as dispositions to act in a certain way (would-be habits)**;** ideally, to know by practical wisdom the right thing to do, in the right

AMSCE-110

way, at the right time. Context sensitivity means virtues do not act as categorical imperatives and may conflict; in a difficult situation, one should not ask what abstract rule to follow but instead ask: What would a role model do in my situation? Or—if I do X, would it start a bad habit? Will I become dysfunctional in my proper role(s)?

The implications of this divide for robot ethics (in all three senses) are potentially profound. For the first sense, is roboethics simply the search for a list of rules that any and all roboticists must follow in their work, such that all who adhere to the rules are automatically moral, and those who break them automatically immoral? Or is it perhaps the search for the rules that will produce the best future net consequences for society (rule-utilitarianism)?

Or, following the second approach, should roboethics search instead for distinctive principles that roboticists of good character evince in their work (i.e., virtues of doing robotics), as well as character traits that lead to dysfunction in their work (i.e., vices of doing robotics)? For a roboticist, a claim that "*I'm not responsible because I followed the rules*" would be indefensible from a virtue-ethics perspective. Instead, one should emulate a role model of professionalism. One example would be "The Roboticist's Oath" (McCauley 2007), understood as a statement of principles that any professional roboticist should evince. Bill Joy also asserted the need for such an oath as a means of setting up a professional exemplar and standards; he wrote, "scientists and engineers [need to] adopt a strong code of ethical conduct, resembling the Hippocratic oath" (Joy 2000). Further, if robots themselves are proper objects of moral assessment, then robot virtue ethics would become the search for the virtues a good (properly functioning) robot would evince, given its appropriate roles.

So, is ethics the study of the right, or the good? Despite the preceding arguments for ethics as the study of the good, the case for the rule-based approach has practical import in another social tendency: to equate moral and legal, immoral and illegal—that is, to construe any action that

AMSCE-IOI

avoids legal sanction as morally permissible, and to insist on redress (in the form of legal rights) when such laws have been broken by others, or to insist such actions were permissible when others wish to cast moral blame, by saying "but I had a right!"

The relationship between virtues and rights begins with an observation: when all parties in a given social context are acting virtuously, no one mentions their rights; in fact, such appeals would appear unseemly when no vices exist. Rights claims inevitably arise *only* when something has gone amiss. That is, appeals to rights inevitably occur only when moral conflict already exists, and rights-based approaches based on rules/laws are always an attempt to fix something that is already broken—or to prevent it from getting worse. And rules invariably have unintended consequences, as the attitude that "whatever is within the rules is permissible" leads to the unscrupulous finding malicious means to bend the rules to their advantage, without (quite) breaking them. So, in a moral utopia, there would be no need for moral rights. And many moral theorists, running the gamut from utilitarians, like Bentham, to virtue ethicists, like MacIntyre, to various existentialists, have denied their existence.

But despite such views, rights claims may be a necessary feature of the ethics of any large, complex society. When groups are relatively small, with common social mores reinforced by shared moral education and acceptance of one's proper roles, the virtues may be largely taken for granted and enforced by purely social sanctions—as the opprobrium of those with whom one has substantial relationships is a powerful tool for enforcing social moral consensus. Our behavior is usually far more affected by the (dis)approval of those around us than by an abstract, remote threat of law enforcement, in "ordinary" contexts.

For roboethics, moral education (in the virtues of the profession) and other social means of enforcing shared mores (such as causing a bad reputation, or denying conference participation, publication, grants, tenure, or even employment for those who violate shared virtues) may

AMSCE-IOI

be effective, at least for a while. But as the group of those dealing with robots becomes larger and more variegated, social sanctions and shared virtues gradually become less effective at minimizing harm.

At such a point, outside regulation and institutions, with clear procedures, rights, and duties, usually become necessary in order to keep the smaller group's practices acceptable within the larger society. So, although rights claims may be a "second-best" form of morality, appealed to only when immorality is already rampant or at least expected; nonetheless, in the real world, in which vices are all too common, they may remain a necessary evil. Accordingly, I next attempt to clarify the concept of a moral right, whether for humans or for robots.

3.1.2 What Are Moral Rights? What Is Their Relationship to Moral Duties? And Who or What Can Be Rights Holders?

There are two main competing theories of rights—the "will" theory and the "interest" (or "welfare") theory (Wenar 2010). The interest theory maintains that rights correlate with interests (or welfare)—everything that has interests (or a "welfare") has rights. All persons have a duty to respect the rights of everything that has interests (including, potentially, robots?). But the will theory of rights disagrees: it asserts the right to liberty is the foundation of all other rights claims, and a rights claim is understood as the entitlement to a particular kind of choice—a rights claim entitles me to claim or perform something, or not—*it is up to me* (and nobody else). A rights claim entails no duty upon the rights holder, but only a freedom—to perform/claim something, or not. But the correlativity thesis makes clear that rights claims do entail duties, not for the rights holder, but for all other persons—if I have a right, then you have (and everyone else has) a correlative duty.

The correlativity thesis is essential to rights theory, in conceptualizing the relationship between rights and duties. It has a slogan form: "no rights without responsibilities"—rights do not exist unless others have

AMSCF-1101

duties. Rights are guaranteed freedoms, which then guarantee duties for everyone else.

But this has an additional implication, relevant here—who is “everyone else?” In this context, it refers to moral agents, beings capable of moral responsibility. It makes no sense to claim that trees or dogs or the environment have a moral responsibility to respect my freedom of speech; given that “ought implies can,” they are incapable of it. If a tree falls on my head and silences me, we cannot hold it morally responsible! So, “no rights without responsibilities” carries an additional implication: on the will theory, only morally responsible agents can have moral rights. If I am incapable of agency, of the exercise of liberty, of rational free will, then I am incapable of being a rights holder. If there were no moral agents, there would be no moral rights—because there are no rights without responsibilities.

But then, on the will theory, anyone and anything incapable of being held responsible for their (its) actions would thereby have no moral rights. This would explain why current robots have no rights, but its implications cause unease for many, not least because much reasoning in applied ethics takes the following form: first, assess all the rights claims in a situation; if no rights have been violated, then an action is morally permissible. So if moral agents are the only rights holders, then based on such reasoning, agents appear morally free to act however they wish toward nonagents—so torturing pets or destroying robots is ok?

Such reasoning usually commits the fallacy of assuming a statement and its converse are equivalent—in particular, the correlativity thesis and its converse. And it mistakes the true nature of the relationship between rights and duties. The correlativity thesis: if I have a right, then all other agents have a correlative duty. The converse correlativity thesis: if I have a duty, then someone else has a correlative right. Upon a moment’s reflection, the latter is absurd. Suppose I have a moral duty to give some of my disposable income to charity; which charity thereby has a right to my donation? The correct answer is: none. Some charity

AMSCE-1101

will receive my donation, but none of them are entitled to it—no one has a right to my charity, although I have a duty to give it.

Despite the prominence of rights claims in much applied ethics, the failure of the converse correlativity thesis means that we all have duties that correspond to no rights at all; and the impulse that supported the interest theory of rights disappears. Many nonagents (such as animals or the environment) have no rights, because they are not moral agents. But they plausibly are *moral patients*, to whom we agents owe duties; this possibility becomes clear once we realize we have many duties that correlate to no specific right. We merely equivocate when we call those duties "rights," as the interest theory does. Hence, we can safely say that, for the foreseeable future, robots will have no rights—at least until robot ethics approaches the third sense set forth, of robots as fully autonomous moral agents. But that realization leaves unresolved our moral duties concerning senses one and two—how roboticists ought to behave, and what moral code roboticists should install in their creations.

So, in robot ethics, we should not reason that if no rights have been violated, then an action is automatically morally permissible—because every moral duty cannot correspond to a discrete, identifiable right. We need a more encompassing moral approach than mere rights theory in order to fully discuss our moral duties in at least senses one and two of robot ethics. What other ethical theories are widely considered plausible candidates to specify our duties?

3.1.3 What Are the Major Contemporary Moral Theories? How Do They Bear on Robot Ethics?

We already discussed virtue ethics in section 3.1.1 as one major moral theory based on the good. Let us now turn to two more influential top-down rule-based approaches that can be applied to robot ethics: deontological and consequentialist theories.

Deontological (duty-based) approaches to robot ethics would simply see roboticists (sense one) or the robots themselves (sense two) acting in

AMSCE-101

accord with some finite set of (presumably algorithmic, programmable) rules, and moral decision making would thus consist simply in computing the proper outcome of the (programmable) rules, in accordance with a monotonic first-order logic. There are concerns that such a basic logic could not capture ethical insights; however, work on deontic logics that would have programmable rules is well advanced (e.g., Arkin 2009; Bringsjord and Taylor, chapter 6, this volume). Hence, deontological approaches that see ethics as merely a set of (programmable) rules to follow are, in principle, a natural approach to creating sense two of an ethical robot, and making sure it conforms to any (programmable) set of ethical standards.

Asimov's Three Laws of Robotics (Asimov [1942] 1968) and Kant's Categorical Imperative (CI) are influential examples of such an approach in robot ethics; Kant's ([1785] 1998) theory has two primary formulations:

CI(1)—or the formula of universal law (FUL): "Act only in accordance with that maxim through which you can at the same time will that it become a universal law."

A maxim is a (true) statement of one's intent or rationale: why one did what was done. So, Kant asserts that the only intentions that are moral are those that could be universally held; partiality has no place in moral thought. Kant also asserts that when we treat other people as a mere means to our ends, such action must be immoral; after all, we ourselves don't wish to be treated that way. Hence, when applying the CI in any social interaction, Kant provides a second formulation as a purported corollary:

CI(2)—or the Means-Ends Principle: "So act that you use humanity, whether in your own person or in the person of any other, always at the same time as an end, never merely as a means."

AMSCE-101

One could never universalize the treatment of another as a mere means to some other ends, claims Kant, in his explanation that CI(2) directly follows from CI(1). This formulation is credited with introducing the idea of intrinsic human dignity and “respect” for persons; that is, respect for whatever collective attributes are required for human dignity, to be treated as ends in ourselves, and not as a mere tool by others. For Kant, all rational beings have intrinsic moral value, and the nonrational world has mere instrumental value—it, but not humans, can be treated as a mere tool.

A Kantian deontologist thus believes that acts such as stealing and lying are always immoral, because the intent to universalize them creates a paradox. For instance, one cannot universalize stealing property (taking that which is rightfully owned by another) without undermining the very concept of property. Kant’s approach is widely influential, but has problems of applicability and disregard for consequences; for example, a robot that could never lie would certainly not be an asset if the enemy captured it.

Further, CI(1) is too permissive, and potentially permits horrors by allowing any action that can have a universalizable maxim; this can also cause a conflict with CI(2). For instance, CI(1) might sanction voluntary slavery or enforced servitude, a topic discussed by Petersen (chapter 18, this volume) for robots. Worse yet for programming deontological ethics into robots, using CI(1) could produce a *conflict of duties*—when two maxims both appear universalizable on their own, but come into conflict jointly.

Next, CI(2) is too stringent—interpreted literally, it forbids all war, or any other action in which I affect someone without their consent (and thereby treat them as a “mere means”). This would render most human–robot interaction, most especially military action, impossible. Not only do enemy civilians (as “collateral damage”) not give consent to being harmed as a means to victory, there are also innumerable other human activities in which a minority who object are nonetheless treated as a

AMSCL-1101

means for the good of the majority—or do you consent to everything that the government does? In practice, this creates a *reductio ad absurdum* of this deontological constraint. To accomplish much of anything, a robot will sometimes have to engage in actions that affect humans without their explicit consent; the key is for it to make the correct decisions about how, when, and why that should be.

Finally, differences in *roles and capacities* problematize universalization—so a robot may be able to universalize "never shoot children" on a normal battlefield, but if insurgents become aware of this, child soldiers could wreak havoc as the robot stands passively by. Or, the laws of war deem it appropriate to target enemy soldiers with a gun pointed at you—but not if they are severely wounded and incapable of firing. Would a robot be able to discriminate the degree of wounding and retaliatory (in)capacity, and do the right thing?

Another deontological approach that has engendered much discussion in robot ethics is Asimov's Three Laws of Robotics (Asimov [1942] 1968), which are as follows: (1) a robot may not injure a human being or, through inaction, allow a human being to come to harm; (2) a robot must obey orders given to it by human beings, except where such orders would conflict with the first law; (3); a robot must protect its own existence as long as such protection does not conflict with the first or second law.

The laws are prioritized to minimize conflicts. Thus, doing no harm to humans takes precedence over obeying a human, and obeying trumps self-preservation. However, in story after story, Asimov demonstrated that three simple, hierarchically arranged rules could lead to deadlocks when, for example, the robot received conflicting instructions from two people, or when protecting one person might cause harm to others. It became clear that the first law was incomplete, as stated, due to the problem of ignorance: a robot was fully capable of harming a human being as long as it did not know that its actions would result in (a risk of) harm, meaning that the harm was unintended. For example, a robot,

AMSCE-101

in response to a request for water could serve water teeming with parasites, or drown a human in a pool, or crush someone with ice, ad infinitum, as long as the robot was unaware of the risk of harm.

One attempted solution is to rewrite the first and subsequent laws with an explicit “knowledge” qualifier: “A robot may do nothing that, to its knowledge, will harm a human being; nor, through inaction, knowingly allow a human being to come to harm” (Asimov 1957). But the cleverly immoral could divide a task among multiple robots, so that no one robot could know that its actions would lead to harm; suppose one disposal robot places nuclear medical waste in a package, another places a wire, another attaches the timer, and so on until the “dirty bomb” detonates. Of course, this simply illustrates the problem with deontological, top-down approaches: that one may follow the rules perfectly but still produce terrible consequences.

An additional difficulty is determining the degree of acceptable risk. The “through inaction” clause of Asimov’s first law apparently implies a robot would have to constantly intervene to minimize all sorts of risks to humans, possibly rendering it incapable of performing its primary mission. A modified first law attempts a fix: (1′) A robot may not harm a human being.

But removing the first law’s “inaction” clause solves one problem only to create a greater one: a robot could initiate an action that would harm a human. For example, suppose a military robot initiates an automatic firing sequence and then watches a noncombatant wander into the firing line. The robot knows it is capable of preventing the harm (by ceasing the automatic firing), but it may nevertheless fail to do so, since it is now not strictly required to act.

And what if a robot’s (in)action prevents immediate harm to one human, but thereby later imperils many? Should we not sacrifice a single human to save the entire world? To fix this problem, Asimov later added the Zeroth Law (1985—so named “zero” plus “th”) to continue

AMSCE-101

the pattern of lower-numbered laws superseding in importance the higher-numbered laws, so that the Zeroth Law had highest priority and must not be broken: (0) A robot may not harm all humanity or, through inaction, allow humanity to come to harm. This would allow a robot to harm individual humans, if so doing prevented an "existential threat" to all humanity. But how could a robot determine when such a threat exists (or how serious it is), so that harming individual humans to prevent the threat is permitted? Would the Zeroth Law permit robots to force human guinea pigs into medical experiments, to create a vaccine against a virus that *might* cause a pandemic? How strong is this version of the "precautionary principle?"

Such problems raise a central criticism of all deontological approaches—they fail to take the likely consequences into account. So, consequentialist ethics explicitly addresses this; utilitarianism—the primary consequentialist theory—proposes the goal of morality is to maximize utility, and utility is defined as the sum of the good consequences of an action, minus the sum of the bad consequences of the act. The work of Jeremy Bentham (1907) and J. S. Mill ([1861] 1998) stands as the locus classicus of utilitarianism; their view asserted a single rule of right action, the "Greatest Happiness Principle" (GHP*)*: One ought always to act so as to maximize the greatest amount of net happiness (utility) for the largest number of people.

Like the deontologists, classical utilitarians emphasized *egalitarianism* (everyone's happiness counts equally), *impartiality* (I care no more for my happiness than for yours, in deciding what's right), and *universal scope*—so the moral rightness of an act depends on the consequences for all people (as opposed to only the individual agent, present people, or any other limited group).

However, this approach fails to be computationally tractable. So, the *calculational* objection arises: it is an impossible demand to calculate the utility of every alternative course of action; thus, utilitarianism makes moral evaluation impossible, as even the short-term consequences of most actions are impossible to accurately forecast and weigh, much less the long-term consequences. One response to this objection is *cost–benefit analysis***:** translate good and bad consequences into economic value (benefits and costs), and then calculate which outcome maximizes expected profit/utility. Ethics becomes a branch of economics. But there are serious reasons to believe that moral values cannot systematically be reduced to economic values—for instance, the claim that the values of love, devotion, and honor do not have a price. The ethicist Mark Sagoff (1982) claims it betrays a fundamental moral confusion to conflate our *economic* values as consumers with our *moral* values as citizens—and the attempt to place a price on everything important is morally debilitating.

Can robots, with their potentially enormous computing power, solve this calculational problem? Unlikely—even if Sagoff is wrong. For robots, the calculational difficulties include how utility is represented within a computational system, how long-run the consequences are to be computed, how much data must be input, and scope—whose consequences (welfare) should be included in the calculation. Given limitations of available information and the sheer multitude of variables needed for any plausible decision making, such a calculation poses a tremendous computation load on even the fastest systems. A utilitarian robot may either fail to determine which course of action is most acceptable within the time allotted, or use grossly insufficient information in order to shoehorn its calculations into the time available. But if utility is (in practice) incalculable, and one's obligation is to maximize utility, what is left of utilitarianism?

Even if the calculational problem is solvable, there are other objections to utilitarianism: e.g., the *scapegoating* objection would point out that maximizing utility may demand injustice, such as executing an innocent person to prevent a riot that would have resulted in deaths and economic damage. This is to say that utilitarianism, at least in its basic form, cannot readily account for the notion of rights and duties or moral distinctions between, e.g., killing versus letting die, or intended versus merely foreseen deaths, or other harms (assuming we think such notions and distinctions exist).

Whether deontological or utilitarian, for robots there is an additional, fatal flaw in each of the top-down theories, connected to the calculational objection: they all suffer from a version of the *frame problem*—that is, knowing what information is (ir)relevant to moral decision making. In order to decide anything, does a robot have to know everything? How can a robot be sure to take into account all the information that is relevant to moral decisions (especially in novel situations), without being swamped by considering terabytes of irrelevancies?

The frame problem reinforces the worry that top-down theories require an impossible computational load for robot decision making, due to the requirements for representing knowledge of the relevant effects of action in the world, the difficulty of estimating the sufficiency of the initial information, and knowledge about the psychology of agents and their causal consequences. Human agents also have such problems, but at least sometimes appear able to apply rough and ready top-down evaluations in their selection of courses of action. Evolutionary psychologists such as Tooby and Cosmides (1997) suggest that human minds do so by having special-purpose modules, rather than by being general computing machines. So, perhaps, limited-domain robotic systems might solve the frame problem, too—particularly if the goal is not to create a perfect system, but only one that makes as good (or better) decisions than humans do, in specific contexts.

Even so, would such robots be moral persons? For Kantians, only fully autonomous agents—rational beings who can self-consciously choose their own life goals, rather than serving as a mere means to the ends of others—can be full moral persons. So, can robots become fully autonomous moral agents? And should they? That is, if it is possible, should (human) moral agents build robotic moral agents? Or should

AMSCE-1101

humanity retain full agency only for itself? In short, can (and should) robots become persons?

3.1.4 What Is a Person, in the Moral Sense? Can a Robot Be a Person?

Some theorists claim that robots cannot become fully-fledged moral persons until (and unless) they can have an inner moral sense, with a full emotional "inner" life. Perhaps robots will one day have emotions; but our legal system assumes that moral agency does *not* require a normal, properly functioning emotional "inner" life. Psychopaths/sociopaths, rational agents with dysfunctional or missing emotional affect, are still morally and legally responsible for their crimes; whereas those who have emotional responses, but cannot exercise rational control (like the severely mentally disabled or infants) are not. But psychopaths, while emotionally dysfunctional, plausibly still have emotions. Would an emotionless robot possibly be a person?

The existence of two types of decision-making systems in human psychology may help explain some of the confusion over this claim in the history of ethics. Numerous philosophers have defended theories of the moral sentiments, or emotivism (the claim that ethics is ultimately nothing but an expression of our emotional attitudes) despite the clear uniqueness of ethics in our species, and the clear sharing of emotions with other species. Such views, in addition to being unable to explain why nonhuman animals lack morality, also have struggled to explain the apparent cognitive meaningfulness of ethical claims and especially ethical disagreement. (They also naturally have severe difficulties accounting for the ethics of emotionless robots.)

A better ethics involves the proper understanding of the implications of evolution for morality. Even primate researcher Frans de Waal (2010) writes: "I am reluctant to call a chimpanzee a 'moral being.' This is because sentiments do not suffice. . . . This is what sets human morality apart: a move towards universal standards combined with an elaborate

AMSCL-1101

system of justification, monitoring, and punishment." So why are humans uniquely (for now, anyway) moral beings? Evolutionary psychologists (Marcus 2008) claim there are not one but two types of decision-making systems within most humans. The first is an instinctual, emotionally laden system that serves as the default for much of human activity, particularly when stressed or under pressure. Many other animals share this noncognitive decision-making system, in which (quite literally) we "know not what we do"—or quite why we do it. Research by Libet (1985) indicates that this subconscious system can, for example, cause our arm to begin to move *before* we are conscious of deciding to do so! But this "ghost in the machine" does not exhaust human agency; Libet and others found we also have a "veto" ability that can, after its subconscious initiation, still alter our action, in accord with a decision by a second, conscious cognitive system.

The uniqueness of current humans, therefore, lies in this second, cognitive decision-making system, called the "deliberative system," which can also cause us to act due to deliberative agency. In humans, this deliberative system overlays the ancestral instinctual, emotional (and faster) decision-making system, and so reason is quite often trumped by our instinctual drives; all too often, I "instinctively" do what I (upon reflection, using the slower deliberative system) later regret. We humans stereotype, harbor irrational prejudices, exhibit superstitious behavior—all the unconscious work of our emotionally laden ancestral system. (We, too often, also use our deliberative system to rationalize or "justify" such biases after the fact.) We also know that many other Earthly animals share such an ancestral, emotional system—indeed, it is sometimes called the "reptilian brain"—but lack the deliberative system, and, therefore, we realize they lack morality; that is, we do not hold them morally responsible for what they do. They are not moral persons.

The deliberative system involves our ability to structure alternative possible futures as mental representations, and then to choose our actions based on which representation we wish to become our

AMSCE-1101

experienced reality. In other words, the deliberative system incorporates moral agency. Without it, morality simply cannot exist; your dog makes decisions about urinating on the carpet, but it cannot fully understand and cogitate upon those decisions, and decide in a rational manner. It uses the “emotional” ancestral system because it has no fully developed deliberative system. That is why it makes no sense to hold dogs morally responsible for their actions, or to have them incur moral or legal guilt for their trespasses. Likewise for human nonagents—babies and the severely cognitively disabled simply do not *know* what they are doing, albeit they constantly make decisions. And neither common morality nor the legal system thus holds them responsible for their actions, whatever their consequences.

3.2 The Requirements of Moral Personhood: Robots and Their Implications

Hence, a deliberative system capable of agency appears necessary for the existence of morality, and so for moral personhood. But is the ancestral emotional system needed as well? What of hypothetical creatures that could rationally deliberate, yet lack emotions? Would they have morality? In other words—could (emotionless) robots be moral persons?

Yes, they could. And realizing this problematizes all systems of noncognitive ethics, whether based merely upon the “moral sentiments,” or any other basis that takes our ancestral, emotion-, and instinct-laden systems as crucial to ethics. As argued, that flies directly in the face of our moral practice, in which we only hold those beings with fully functioning deliberative systems morally responsible for their actions, and take defects or temporary breakdowns or lulls in that deliberative system to be morally exculpatory. My cat is not put on trial for arson when it knocks over a candle and burns down the house—nor is a baby,

AMSCE-IOI

or someone asleep in the midst of a nightmare. But we could imagine an intelligent alien, either one entirely lacking emotions or with suppressed emotions (such as Commander Data or Mr. Spock of *Star Trek* fame) who would be held responsible. Or—a future Earthly robot with agency, who deliberately decides to do the same thing.

And so the key to moral responsibility and personhood is the possession of moral agency, which requires the capacity for rational deliberation—but not the capacity for functional emotional states, per psychopaths—therefore, robots may well qualify. The chapters by Petersen (18), Sparrow (19), and Veruggio and Abney (22) examine some of the implications of artificial personhood.

But what of freedom? Another objection to robotic morality and personhood is not their lack of emotions, but rather, their presumed lack of a free will—of the freedom to do otherwise, which is required for the proper assignation of moral responsibility. A robot, it is argued, must follow a deterministic algorithm—its computer program. Even if it appears to be making a choice, that is but an illusion borne of our ignorance of the underlying program, or the external input, which together determine the robot's every behavior. A robot cannot do other than as it is programmed to do. Unlike (it is supposed) rational human agents, the robot has no free will—so while it may have the reasoning capacity required for morality, it lacks the freedom required to be a true moral agent.

Well, perhaps. First, it is not clear that humans actually have the type of freedom the argument alleges is required for morality (as Lokhorst and van den Hoven argue, in chapter 9 of this volume); debates on free will between compatibilists and libertarians have simmered for centuries. And even if humans do have such libertarian freedom, is it really true that robots cannot? The answer might plausibly be no—robots could have libertarian freedom, if anything can.

AMSCE-101

The short version of this speculative argument goes as follows: first, the “hard problem” of consciousness, according to David Chalmers, is subjectivity, or subjective experience—meaning, there is something it is like to be me—and all current explanations of information processing leave that unexplained. Chalmers (1995) writes: “perhaps the most popular ‘extra ingredient’ of all is quantum mechanics (e.g., Hameroff 1994). The attractiveness of quantum theories of consciousness may stem from a Law of Minimization of Mystery: consciousness is mysterious and quantum mechanics is mysterious, so maybe the two mysteries have a common source.”

Second, consider David Deutsch’s (1997) argument for reality of parallel universes given the reality of quantum computing. Deutsch notes we have already built quantum computers, and computation always requires a substrate—something on which to compute. But quantum computers are nonlocal—they cannot have a causally closed substrate in four-dimensional spacetime. Hence, in Deutsch’s view, they can only sensibly be said to be computing across multiple parallel four-dimensional space-times—that is, “parallel universes.”

So quantum computing—which is already being done—proves the existence of parallel universes, Deutsch asserts. He interprets these multiple universes via Hugh Everett’s (1957) “Many Worlds Interpretation” of quantum mechanics: every possible probability distribution is actualized in a separate universe, so there’s a universe in which you read this chapter to the end, another in which you quit reading now, another in which you ceased existing five seconds ago, another . . . and so on. And all are equally real; but you are only aware of this one, because the information carried by the rest of the quantum wave(s) is now invisible to you—the act of observation guarantees it is in another universe.

Now, return to the problem of rational free will/agency—the problem is, what is it? Our commonsense conception of it appears incompatible with determinism (despite the valiant efforts of compatibilists): to have freedom, it cannot be the case that one could not do otherwise. To be an agent is to have at least two logically, physically possible futures open to me right now: one in which I choose to do X, and one in which I do not.

But our understanding of agency is also incompatible with causal indeterminism—uncaused events are simply not the same as an act due to agency. If my hand begins flopping around for no apparent reason, I do not believe that proves my agency—instead, it makes me call the doctor. To be an agent, I must be in rational control of which of those possible futures comes into existence. There are (at least) two possible futures, and “it is up to me” (not randomness) which occurs.

Thus, commonsense (libertarian) agency seems to be a causal power, but not one that is determined by antecedent events. So agency, in conception, is a nonphysical causal power in addition to the typical physical causal nexus. But what exactly is this mysterious causal power? Does it really exist, or is libertarian agency merely a massive, species-wide delusion, borne of our ignorance of the fine-scale causal structure of our brains and bodies and the world?

Recall Chalmers’s Law of Minimization of Mystery: consciousness is mysterious and quantum mechanics is mysterious, so perhaps the two mysteries have a common source. Perhaps the collapse of the wave function in quantum mechanics, as several interpretations insist, is associated with the consciousness of a physical state. As Hameroff, Penrose, and others apparently believe, could the solution to the problem of explaining the collapse of the wave function really have something to do with the nature of agency?

Suppose the following: first, that agency consists in the rational examination of (deliberation upon) nearby possible worlds/parallel universes, and then in deciding between them in terms of which one to bring about as an object of subjective experience. To make sense of this, agents would need a mental causal power of accessing and deciding between parallel universes, to determine which one the agent’s self-

AMSCE-1101

consciousness inhabits after making a choice. Some such account could make sense of why there is no causal closure of the (four-dimensional) physical universe, but nonetheless there is causal closure when agency is included.

So, on this hypothesis, libertarian agency is an ability to access and decide between various possible worlds, understood as parallel universes, in order to single out one to experience. Is this additional causal power to access parallel universes only possible for biology (as emergentist approaches to agency like Searle's [1984] seem to imply)? The implication of Deutsch's argument is: no, computers already do it. So, if libertarian agency is possible in this way, then robots with libertarian agency are possible, if they can do quantum computing. Such quantum computing would be needed to move from simulated agency to real agency.

In summary, without attempting here to clearly argue for the truth of either compatibilism or libertarianism, let me finally indicate why it is unlikely to make a difference to robot ethics: if compatibilism is true, then the kind of freedom humans have—a freedom compatible with deterministic physical processes—seems obviously possible for robots. If libertarianism is true and intelligible, the quantum computing argument claims that the necessary and sufficient conditions for human libertarian freedom could also be met by robots. So, no matter which type of freedom you believe is required for morality, we have good reason to think that robots could have it, too.

AMSCE-101

3.3 Conclusion: On Robots and Ethics, and Combining the Two

If I am right, one day robots could become moral agents, and, so, full moral persons. It seems possible that cyborgization will render the issue moot, by gradually merging biological and mechanical persons until no one seriously doubts that robots are fully fledged persons, as former biologicals retain their personal identity while gradually gaining an ever-increasing mechanical body (e.g., Warwick, chapter 20, this volume; Veruggio and Abney, chapter 22, this volume). Assuming robot personhood is possible, humans will eventually have a momentous decision to make: will we enlarge the moral community to include our fellow (artificial) persons, or will we deny robots the right to become our newest kind of children—ones born, not biologically, but through manufacturing techniques? Their robotic nature and ethics, previously selected by designers (not by natural selection) to serve humans, would then become their own choice. Robots would be “emancipated.”

But for the foreseeable future, robotic morality will necessarily involve the ethics of humans creating robots to follow rules or evince a good character, and not the rules or character robots choose for themselves. Near-term robots will require moral character/rules that are programmable or machine learnable, and hence not dependent solely on incalculable, uncontrollable consequences or on emotions or moral sentiments. As such, deontology and virtue ethics appear the only plausible candidates for robot morality among the major ethical approaches, and some of the problems of a strict deontological approach to programming ethics, not least in considering the “frame problem,” are addressed in this volume by Guarini and Bello in chapter 8, Lokhorst and van den Hoven in chapter 9, and Beavers in chapter 21.

So, simple deontological approaches involving categorical, universal rights and duties may be possible for a robotic moral code, as demonstrated by the success of Anderson and Anderson (2010) in making Nao, manufactured by Aldebaran Robotics, into the first robot to have been programmed with an ethical principle. Nonetheless, the extremely limited contexts in which Nao can operate mean that (in the near-term) the hybrid approach of hypothetical rather than categorical imperatives (within a deliberately restricted, not universal, frame) coming from virtue ethics appear the best bet for near-term robotic morals (in sense two)—as argued for by Wallach and Allen (2009; also

AMSCE-101

Allen and Wallach, chapter 4, this volume). The emphasis on being able to perform excellently in a particular role, and the corresponding specificity of the hypothetical imperatives of virtue ethics to the programming goals, restricted contexts, and learning capabilities of non-Kantian autonomous robots, makes virtue ethics a natural choice as the best approach to robot ethics—at a minimum, until and unless robots ever acquire something approaching full autonomy in sense three, choosing their own life goals. If and when that happens, robots will do ethics (in the third sense) alongside us—or replace us biologically instantiated ethicists!

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AMSCE-1101

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AMSCE-101

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AMSCE-1101

II

Design and Programming

Perhaps the most worrisome issue in robot ethics is the reliability of robots, that is, safety and errors. This is also to say that we are worried about the ability of our computer scientists and robotics engineers to create a perfectly working piece of software to control a machine with potentially superhuman strength, especially when there does not seem to be an example of complex software that has no errors or does not crash.

Programming errors aside, society does not seem to have much confidence—perhaps justifiably so—that we can create a robot that will behave as we would want it to in all the situations we cannot anticipate, for instance, a robot that can "act ethically." Thus, one natural way to think about a solution is to treat robots as we do computers, which is essentially what robots are: computers situated in the world, receiving inputs from the world with their sensors and acting on them. With computers, we would focus on software or a programming solution if we want a computer to do something or to be more perfect. So why not just do that with robots—program ethics into them? Of course, this is easier said than done. But assuming it can be done, the next set of chapters discuss several approaches, including their limitations.

In chapter 4, Colin Allen and Wendell Wallach, authors of the recent book *Moral Machines,* discuss the possibility of programming ethics into a robot, thus creating "artificial moral agents" (AMAs). They believe that AMAs will inevitably appear, perhaps in the space between programmed, operational morality and true moral agency in some future

AMSCI-1101

generation of intelligent, autonomous machines. This chapter also builds upon the authors' discussion of creating AMAs in their book by offering responses to subsequent criticisms.

James Hughes in chapter 5 explores how we might program a Buddhist code of ethics into a robot. Buddhist psychology and metaphysics focus on the emergence of selves, their drives, and their potential for developing wisdom and compassion. In this chapter, the author discusses the potential for the development of these foci in self-aware machine minds. Machine minds should be created with the capacity to dynamically evolve in compassion and wisdom; they should be created as morally responsible, self-aware entities. The author suggests that a machine mind could then be taught moral virtue and an expansive concern for the happiness of all sentient beings.

In chapter 6, Selmer Bringsjord and Joshua Taylor propose a divine-command approach to programming robots, in the Judeo-Christian tradition. They describe the criteria that distinguish "ethically correct" robots and discuss ways of mechanizing ethical reasoning so that robots can make use of it. They also provide various examples of ethical codes under which robots may operate, including military robots—the subject of the next section of this book.

4

Moral Machines: Contradiction in Terms or Abdication of Human Responsibility?

Colin Allen and Wendell Wallach

AMSCE-101

Over the past twenty years, philosophers, computer scientists, and engineers have begun reflecting seriously on the prospects for developing computer systems and robots capable of making moral decisions. Initially, a few articles were written on the topic (Gips 1991, 12; Clarke 1993, 5; Clarke 1994, 6; Moor 1995, 17; Allen, Varner, and Zinser 2000, 1; Yudkowsky 2001, 23) and these were followed by preliminary software experiments (Danielson 1992, 8; Danielson 2003, 9; McLaren and Ashley 1995, 15; McLaren 2003, 16; Anderson, Anderson, and Armen 2006, 2; Guarini 2006, 13). A new field of inquiry directed at the development of artificial moral agents (AMAs) began to emerge, but it was largely characterized by a scattered collection of ideas and experiments that focused on different facets of moral decision making. In our recent book, *Moral Machines: Teaching Robots Right from Wrong* (Wallach and Allen 2009, 20), we attempted to bring these strands together and to propose a comprehensive framework for this new field of inquiry, which is referred to by a number of names including machine morality, machine ethics, artificial morality, and friendly AI. Two other books on related themes, J. Storrs Hall's *Beyond AI: Creating the Conscience of the Machine* (2007, 14) and Ronald Arkin's *Governing Lethal Behavior in Autonomous Robots* (2009, 3), have also been published recently. *Moral Machines (MM)* has been well received, but a number of objections have been directed at our approach and at the very project of developing machines capable of making moral decisions. In this chapter, we provide a brief précis of *MM*. We then list and respond to key objections that have been raised about our project.

4.1 Toward Artificial Moral Agents

The human-built environment increasingly is being populated by artificial agents, which combine limited forms of artificial intelligence with autonomous (in the sense of unsupervised) activity. The software controlling these autonomous systems is, to date, "ethically blind" in two ways. First, the decision-making capabilities of such systems do not involve any explicit representation of moral reasoning. Second, the sensory capacities of these systems are not tuned to ethically relevant features of the world. A breathalyzer-equipped car might prevent you from starting it, but it cannot tell whether you are bleeding to death in the process. Nor can it appreciate the moral significance of its refusal to start the engine.

In *MM*, we argued that it is necessary for developers of these increasingly autonomous systems (robots and software bots) to make them capable of factoring ethical and moral considerations into their decision making. Engineers exploring design strategies for systems sensitive to moral considerations in their choices and actions will need to determine what role ethical theory should play in defining control architectures for such systems.

There are many applications that underscore the need for AMAs. Among the most dramatic examples that grab public attention are the development of military robots (both land and airborne) for deployment in the theater of battle, and the introduction of service robots in the home and for healthcare. However, autonomous bots within existing computer systems are already making decisions that affect humans, for good or for bad. The topic of morality for "(ro)bots" (a spelling convention we introduced in *MM* to represent both robots and software bots within computer systems) has long been explored in science fiction by authors such as Isaac Asimov, with his Three Laws of Robotics, in television shows, such as *Star Trek*, and in various Hollywood movies. However, our project was not and is not intended to be science fiction. Rather, we argued that current developments in computer science and robotics necessitate the project of building artificial moral agents.

Why build machines with the ability to make moral decisions? We believe that AMAs are necessary and, in a weak sense, inevitable; in a

AMSCE-101

weak sense, because we are not technological determinists. Individual actors could have chosen not to develop the atomic bomb. Likewise, the world could declare a moratorium on the development and deployment of autonomous (ro)bots. However, such a moratorium is very unlikely. This makes the development of AMAs necessary since, as Rosalind Picard (1997, 19) so aptly put it, “The greater the freedom of a machine, the more it will need moral standards.” Innovative technologies are converging on sophisticated systems that will require some capacity for moral decision making. With the implementation of driverless trains—already common at airports and beginning to appear in more complicated situations such as the London Underground and the Paris and Copenhagen metro systems—the “runaway trolley cases” invented by ethicists to study moral dilemmas (Foot 1967) may represent actual challenges for artificial moral agents.

Among the difficult tasks for designers of such systems is to specify what the goals should be, that is, what is meant by a “good” artificial moral agent? Computer viruses are among the software agents that already cause harm. Credit card approval systems (and automated stock trading systems) are among the examples of autonomous systems that already affect daily life in ethically significant ways, but these are “ethically blind” because they lack moral decision-making capacities. Pervasive and ubiquitous computing, the introduction of service robots in the home to care for the elderly, and the deployment of machine-gun carrying military robots expand the possibilities of software and robots, without sensitivity to ethical considerations harming people.

The development of AI includes both autonomous systems and technologies that augment human decision making (decision support systems and, eventually, cyborgs), each of which raises different ethical considerations. In *MM*, we focus primarily on the development of autonomous systems.

Our framework for understanding the trajectory toward increasingly sophisticated artificial moral agents emphasizes two dimensions:

AMSCE-101

autonomy and sensitivity to morally relevant facts (figure 4.1). Systems with very limited autonomy and sensitivity have only “operational morality,” meaning that their moral significance is entirely in the hands of designers and users. As machines become more sophisticated, a kind of “functional morality” is possible, where the machines themselves have the capacity for assessing and responding to moral challenges. The creators of functional morality in machines face many constraints due to the limits of present technology. This framework can be compared to the categories of artificial ethical agents described by James Moor (2006, 18), which range from agents whose actions have ethical impact (implicit ethical agents) to agents that are explicit ethical reasoners (explicit ethical agents). As does Moor, we emphasize the near-term development of explicit or functional moral agents. However, we do recognize that, at least in theory, artificial agents might eventually attain genuine moral agency with responsibilities and rights, comparable to those of humans.

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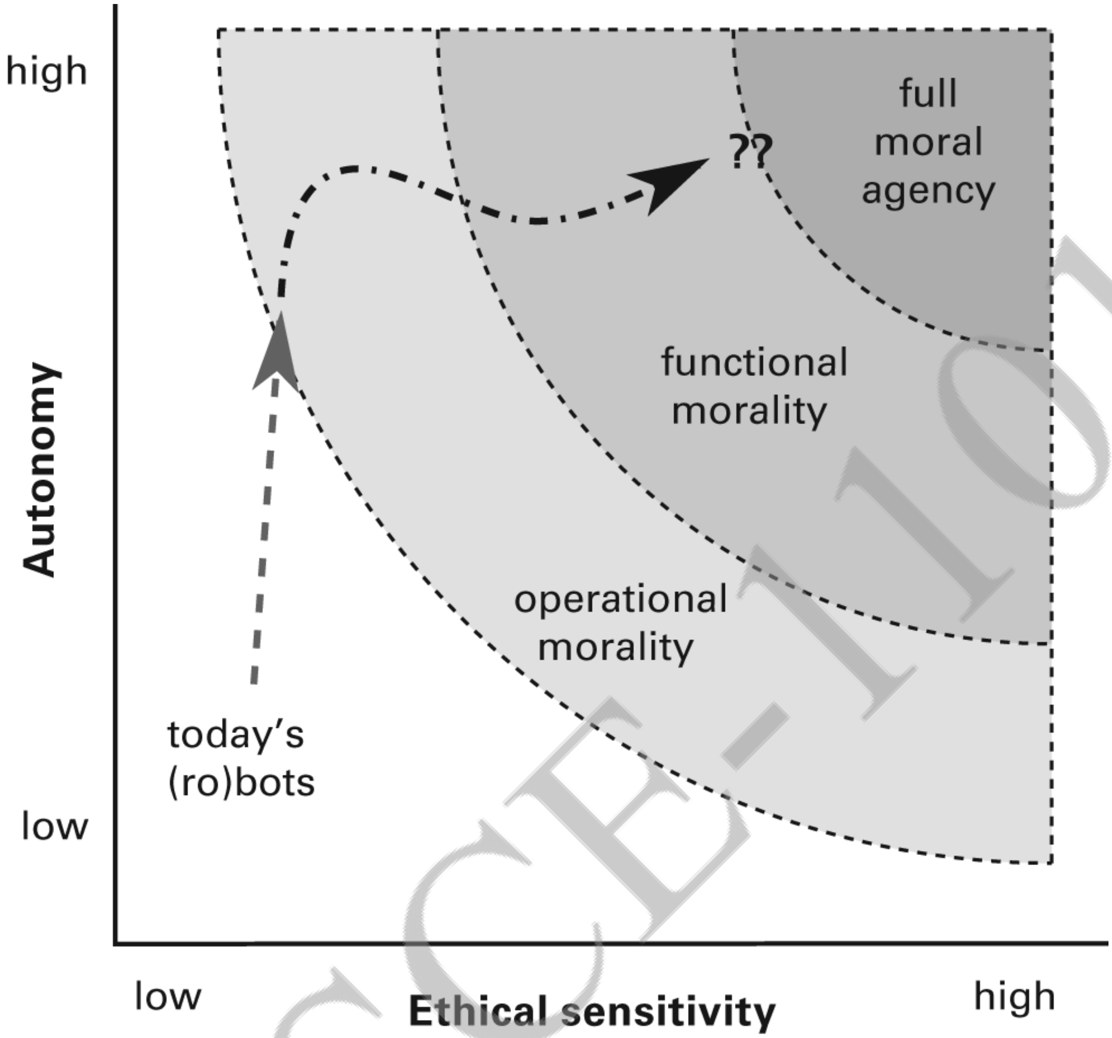

Figure 4.1
Two dimensions of AMA development.

AMSCE-101

Do we want computers making moral decisions? Worries about whether it is a good idea to build artificial moral agents are examples of more general concerns about the effects of technology on human culture. Traditional philosophy of technology provides a context for the more specific concerns raised by artificial intelligence and specifically AMAs. For example, human anthropomorphism of robotic dolls, robopets, household robots, companion robots, sex toys, and even military robots, raises questions of whether these artifacts dehumanize people and substitute impoverished relationships for real human interactions. Some concerns, such as whether AMAs will lead humans to abrogate responsibility to machines, seem particularly pressing. Other concerns, such as the prospect of humans becoming literally enslaved to machines, seem highly speculative. The unsolved problem of technology risk assessment is how seriously to weigh catastrophic possibilities against the obvious advantages provided by new technologies. Should, for example, a precautionary principle be invoked when risks are fairly low? Historically, philosophers of technology have served mainly as critics, but a new breed of philosophers see themselves as engaged in engineering activism as they help introduce sensitivity to human values into the design of systems.

Can (ro)bots really be moral? How closely could artificial agents, lacking human qualities such as consciousness and emotions, come to being considered moral agents? There are many people, including many philosophers, who believe that a "mere" machine cannot be a moral agent. We (the authors) remain divided on whether this is true or not. Nevertheless, we believe the need for AMAs suggests a pragmatically oriented approach. We accept that full-blown moral agency (which depends on "strong" AI) or even "weak" AI that is nevertheless powerful enough to pass the Turing Test—the procedure devised by Alan Turing (1950) by which a machine may be tested anonymously for its linguistic equivalence to an intelligent human language user—may be beyond current or even future technology. Only time will tell. Nevertheless, the more immediate project of developing AMAs can be located in the space between operational morality and genuine moral agency (figure 4.1)—the niche we labeled "functional morality." We believe that traditional symbol-processing approaches to artificial intelligence and more recent approaches based on artificial neural nets and embodied cognition could provide technologies supporting functional morality.

AMSCH-101

4.2 Philosophers, Engineers, and the Design of Artificial Moral Agents

Philosophers like to think in terms of abstractions. Engineers like to think in terms of buildable designs. Bridging these two cultures is not a trivial task. Nevertheless, there are benefits for each side to try to accommodate the concerns of the other. Theory can inform design, and vice versa. How might moral capacities be implemented in (ro)bots? We approach this question by considering possible architectures for AMAs, which fall within two broad approaches: the top-down imposition of an ethical theory, and the bottom-up building of systems that aim at goals or standards which may or may not be specified in explicitly theoretical terms.

Implementing any top-down theory of ethics in an artificial moral agent will pose both computational and practical challenges. One central concern is framing the background information necessary for rule- and duty-based conceptions of ethics and for utilitarianism. Asimov's Three Laws come readily to mind when considering rules for (ro)bots, but even these apparently straightforward principles are not likely to be practical for programming moral machines. The high-level rules, such as the Golden Rule, the deontology of Kant's categorical imperative, or the general demands of consequentialism, for example, utilitarianism, also fail to be computationally tractable. Nevertheless, the various principles embodied in different ethical theories may all play an important guiding role as heuristics before actions are taken, and during post hoc evaluation of actions.

Bottom-up approaches to the development of AMAs attempt to emulate learning, developmental, and evolutionary processes. The application of methods from machine learning, theories of moral development, and techniques from artificial life (Alife) and evolutionary

AMSCE-IIOI

robotics may, like the various ethical theories, all contribute to the development of AMAs and the emergence of moral capacities from more general aspects of intelligence. Bottom-up approaches also hold out the prospect that moral behavior is a self-organizing phenomenon, in which cooperation and a shared set of moral instincts (if not a "moral grammar") might emerge. (It remains an open question whether explicit moral theorizing is necessary for such organization.) A primary challenge for bottom-up approaches is how to provide sufficient safeguards against learning or evolving bad behaviors and to promote good ones.

The difficulties of applying general moral theories in a completely top-down fashion to AMAs motivate the return to another source of ideas for the development of AMAs: the virtue-based conception of morality that can be traced back to Aristotle. Virtues constitute a hybrid between top-down and bottom-up approaches, in that the virtues themselves can be explicitly described (at least to some reasonable approximation), but their acquisition as moral character traits seems essentially to be a bottom-up process. Placing this approach in a computational framework, neural network models provided by connectionism seem especially well suited for training (ro)bots to distinguish right from wrong (DeMoss 1998, 10).

4.3 Early Research on the Development of AMAs, and Future Challenges

A major goal of our book was not just to raise many questions, but also to provide a resource for further development of AMAs. Software currently under development for moral decision making by (ro)bots utilize a variety of strategies, including case-based reasoning or casuistry, deontic logic, connectionism (particularism), and the prima facie duties of W. D. Ross (1930) (also related to the principles of

AMSCI-101

biomedical ethics). In addition to agent-based approaches that focus on the reasoning of one agent, researchers are working with multiagent environments and with multibots. Experimental applications range from ethical advisors in healthcare to control architectures, for ensuring that (ro)bot soldiers won't violate international conventions.

The top-down and bottom-up approaches to artificial moral agents emphasize the importance in ethics of the ability to reason. However, much of the recent empirical literature on moral psychology emphasizes faculties besides rationality. Emotions, empathy, sociability, semantic understanding, and consciousness are all important to human moral decision making, but it remains an open question whether, or when, these will be essential to artificial moral agents, and, if needed, whether they can be implemented in machines. Cutting-edge scientific investigation in the areas of affective computing, embodied cognition, and machine consciousness that is aimed at providing computers and robots with the kinds of "suprarational" capacities underlying those social skills, may be essential for sophisticated human–computer interaction. However, to date, there are no working projects that combine emotion-processing, social skills, or embodied cognition in (ro)bots with the moral capacities of AMAs.

Recently, there has been a resurgence of interest in general, comprehensive models of human cognition that aim to explain higher-order cognitive faculties, such as deliberation and planning. Moral decision making is arguably one of the most challenging tasks for computational approaches to higher-order cognition. We argue that this challenge can be fruitfully pursued in the context of a comprehensive computational model of human cognition. *MM* focuses specifically on Stan Franklin's LIDA model (Franklin et al. 2005, 11; Wallach, Franklin, and Allen 2010, 21). LIDA provides both a set of computational tools and an underlying model of human cognition, which provides mechanisms that are capable of explaining how an agent's selection of its next action arises from bottom-up collection of

AMSCE-IIOJ

sensory data and top-down processes for making sense of its current situation. The LIDA model also supports the integration of emotions into the human decision-making process, and elucidates a process whereby an agent can work through an ethical problem to reach a solution that takes account of ethically relevant factors.

The prospect of computers making moral decisions poses an array of future dangers that are difficult to anticipate, but will, nevertheless, need to be monitored and managed. Public policy and mechanisms of social and business liability management will both play a role in the safety, direction, and speed in which artificial intelligent systems are developed. Fear is not likely to stop scientific research, but it is likely that various fears will slow it down. Mechanisms for distinguishing real dangers from speculation and hype, fueled by science fiction, are needed. Means of addressing the issues of rights and accountability for (ro)bots and their designers will require attention to topics such as legal personhood, self-replicating robots, the possibility of a "technological singularity" during which AI outstrips human intelligence, and the transhumanist movement, which sees the future of humanity itself as an inevitable (and desirable) march toward cyborg beings.

Despite our emphasis in the book on the prospects for *artificial* morality, we believe that a richer understanding of human moral decision making is facilitated by the pursuit of AMAs (Wallach 2010, 22). The project of designing AMAs feeds back into our understanding of ourselves as moral agents and of the nature of ethical theory itself. The limitations of current ethical theory for developing the control architecture of artificial moral agents highlight deep questions about the purpose of such theories.

4.4 Challenges, Objections, and Criticisms

AMSCH-101

Since publishing *MM*, we have encountered several key critiques of the framework we offered for why AMAs are needed, and the approaches for building and designing moral machines. These fall into six categories, which we address in the sections that follow:

1. Full moral agency for machines requires capacities or features we either did not mention in *MM* or whose centrality we did not emphasize adequately.

2. Some features required for full moral agency cannot be implemented in a computer system or robot.

3. The approaches we propose for developing AMAs are too humancentric. (Ro)bots will need a moral code that does not necessarily duplicate human morality.

4. The work of researchers focused on ensuring that a technological singularity will be friendly to humans (friendly AI) was not given its due in *MM*.

5. In focusing on the prospects for building AMAs, we imply that dangers posed by (ro)bots can be averted, whereas many of the dangers cannot be averted easily. In other words, *MM* contributes to the illusion that there is a technological fix, and thereby dilutes the need to slow, and even stop, the development of harmful systems.

6. The claim that the attempt to design AMAs helps us understand human moral decision making better could be developed more fully.

4.4.1 Full Moral Agency

In *MM*, we took what we consider to be an unusually comprehensive approach to moral decision making by including the role of top-down theories, bottom-up development, learning, and the suprarational capacities that support emotions and social skills. And yet the most

AMSCE-101

common criticisms we have heard begin with, “Full moral agency requires _______.” The blank space is filled in with a broad array of capacities, virtues, and features of a moral society that the speaker believes we either failed to mention, or whose centrality in moral decision making we failed to underscore adequately. Being compassionate or emphatic, having a conscience, or being a member of virtuous communities, are among the many items that have come up as critics fill in the blank space.

Some critics, coming especially from a Kantian perspective, believe that talk of morality is misguided in connection with agents that lack the potential to choose to act *im*morally. On this conception, central to human morality, is the struggle between acting in self-interest and acting out of duty to others, even when it goes against self-interest. There are several themes running through this conception of moral life, including the metaphysical freedom to choose one’s principles and to accept responsibility for acting upon them. Such critics maintain that machines, by their very nature, lack the kind of freedom required. We are willing to grant the point for the sake of argument, but we resist what seems to be a corollary for several critics: It is a serious conceptual mistake to speak of “moral agency” in connection with machines. For reasons already rehearsed in *MM*, we think that the notion of functional morality for machines can be described philosophically and pursued as an engineering project. But if the words bother Kantians, let them call our project by another name, such as norm-compliant computing.

We do not deny that it is intriguing to consider which attributes are required for artificial agents to be considered full moral agents, the kinds of society in which artificial agents would be accepted as a full moral agents, or the likelihood of (ro)bots ever being embraced as moral agents. But there are miles to go before the full moral agency of (ro)bots can be realistically conceived. Our focus has been on the steps between here and there. Moral decision-making faculties will have to develop side by side with other features of autonomous systems. It is still unclear

AMSCE-101

which platforms or which strategies will be most successful in the development of AMAs. Full moral agency is a fascinating subject, but can distract from the immediate task of making increasingly autonomous (ro)bots safer and more respecting of moral values, given present or near-future technology.

4.4.2 Inherent Limits of Existing Computer Platforms

From John Searle's Chinese Room thought experiment against the possibility of genuine intelligence in a computer (Searle 1980), to Roger Penrose's proposal that the human mind depends essentially on quantum mechanical principles to exceed the capacities of any computer (Penrose 1989), there is no shortage of theorists who have argued that existing computational platforms fail to capture essential features of intelligence and mental activity. Some recent critics of our approach (Byers and Schleifer 2010, 4) have argued that the inherent capacity of the human mind to intuitively comprehend mathematical notions and work creatively with them is, at root, the same capacity that enables creative, intuitive, and flexible understanding of moral issues. That human comprehension outstrips some rule-based systems is uncontroversial. That it outstrips all rule-based, algorithmic systems is less obvious to us. But even if true, it does not rule out moral machines—only full moral agents that are rule based. Furthermore, even if we are stuck with rule-based systems for the foreseeable future (which, depending on one's definition of rule based, may or may not include machines implementing the kinds of bottom-up and suprarational capacities we surveyed), it doesn't follow that there's no advantage to trying to model successful moral reasoning and judgment in such systems. Despite human brilliance and creativity, there are rule-based, algorithmic systems capable of outperforming humans on many cognitive tasks, and which make perfectly useful tools for a variety of purposes. The fact that some tasks are currently beyond our ability to build computers to do them well (Byers and Schleifer mention the game of bridge) only shows that more work is necessary to build machines that are sensitive to the

AMSCE-101

"almost imperceptible" (but necessarily perceptible) cues that current computational models fail to exploit, but to which humans are exquisitely attuned. As before, however, even if we were to admit that there is a mathematically provable computational limit to the capacity of machines to replicate human judgment, this does not undermine the need to implement the best kind of functional morality possible.

4.4.3 AMAs Will Need a Moral Code Designed for Robots, Not a Facsimile of Human Morality

By framing our discussion in *MM* in terms of the top-down implementation of ethical theories or the bottom-up development of human-like moral capacities, we opened ourselves to the criticism that our approach is too focused on the re-creation of human morality for (ro)bots. Peter Danielson (2009, 9), for example, raises the quite reasonable possibility that the particular situations in which machines are deployed might make the implementation of more limited forms of morality for artificial agents more tractable and more appropriate. In this we agree with Danielson, and although we did touch upon topics such as special virtues for artificial agents, we concede that there is a difference of emphasis from what critics like Danielson might have desired. At the very least, we are pleased that this discussion has been sparked by *MM*, and it certainly opens up options for the design of AMAs that we did not explore in detail. Nevertheless, given that technology will continue to race ahead, providing (ro)bots with sensory, computational, and motor capacities that humans may not have, we believe it is important to pursue a less-limited version of artificial morality than our critics have urged.

4.4.4 The Technological Singularity and Friendly AI

The project of building AMAs is bracketed by the more conservative expectations of computer scientists, engaged with the basic challenges and thresholds yet to be crossed, and the more radical expectations of those who believe that human-like and superhuman systems will be built

AMSCE-101

in the near future. There are a wide variety of theories and opinions about how sophisticated computers and robotic systems will become in the next twenty to fifty years. Two separate groups focused on ensuring the safety of (ro)bots have emerged around these differing expectations: the machine ethics community and the singularitarians (friendly AI), exemplified by the Singularity Institute for Artificial Intelligence (SIAI). Those affiliated with SIAI are specifically concerned with the existential dangers to humanity posed by AI systems that are smarter than humans. *MM* has been criticized for failing to give fuller attention to the projects of those dedicated to a singularity in which AI systems friendly to humans prevail.

SIAI has been expressly committed to the development of general mathematical models that can, for example, yield probabilistic predictions about future possibilities in the development of AI. One of Eliezer Yudkowsky's projects is motivationally stable goal systems for advanced forms of AI. If satisfactory predictive models or strategies for stable goal architectures can be developed, their value for AMAs is apparent. But will they be developed, and what other technological thresholds must be crossed, before such strategies could be implemented in AI? In a similar vein, no one questions the tremendous value machine learning would have for facilitating the acquisition by AI systems of many skills, including moral decision making. But until sophisticated machine learning strategies are developed, discussing their application is speculative. That said, since the publication of *MM,* there has been an increase in projects that could lead to further collaboration between these two communities, a prospect we encourage.

4.4.5 The Illusion that There Is a Technological Fix to the Dangers AI Poses

Among our critics, Deborah Johnson has been the most forceful about the inadequacy of our nearly exclusive focus on the technology involved in constructing AMAs themselves—the autonomous artifacts presumed to be making morally charged decisions without direct human oversight—rather than the entire technological system in which they are embedded. No (ro)bot is an island, and yet we proceeded on the basis that the project of designing moral machines should be centered on designing more and more sophisticated technological artifacts. Johnson has patiently and persistently insisted at various conferences and workshops that our focus on the capabilities of the (ro)bots considered as independent artifacts carries potential dangers, insofar as it restricts attention to one kind of technological fix instead of causing reassessment of the entire sociotechnological system in which (ro)bots operate.

In a similar vein, David Woods and Erik Hollnagel maintain that robots and their operators are best understood as joint cognitive systems (JCSs). The focus on isolated machine autonomy distorts the full appreciation for the kinds of systems design problems inherent in JCSs. With the advent of artificial agents, when a JCS fails, there is a tendency to blame the human as the weak link and to propose increased autonomy for the mechanical devices as a solution. Furthermore, there is the illusion that increasing autonomy will allow the designers to escape responsibility for the actions of artificial agents. But Woods and Hollnagel argue that increasing autonomy will actually add to the burden and responsibility of the human operators. The behavior of robots will continue to be brittle on the margins as they encounter new or surprising challenges. The human operators will need to anticipate what the robot will try to do under new situations in order to effectively coordinate their actions with those of the robot. However, anticipating the robot's actions will often be harder to do as systems become more complex, leading to a potential increase in the failure of JCSs. A focus on isolated autonomy can result in the misengineering of JCSs. Woods and Hollnagel advocate more attention to coordination and resilience in the design of JCSs (Woods and Hollnagel 2006, 23).

To these critiques, we respond “guilty as charged.” We should have spent more time thinking about the contexts in which (ro)bots operate and about human responsibility for designing those contexts. We made a very fast jump from robots bolted to the factory floor to free-roaming agents (hard and virtual), untethered from the surrounding sociotechnical apparatus that makes their operation possible. AMAs cannot be designed properly without attention to the systems in which they are embedded, and sometimes the best approach may not be to design more sophisticated capacities for the (ro)bots themselves, but to rethink the entire edifice that produces and uses them.

Those roboticists who wish to ignore the dangers posed by autonomous systems are likely to do so without hiding behind our suggestion that sensitivity to some moral considerations can be engineered into (ro)bots. It should be apparent that it is not our intent to mask the dangers. If on close inspection adequate safeguards cannot be implemented, then we should turn our attention away from social systems that rely on autonomous systems.

4.4.6 (Ro)bot Ethics and Human Ethics

An implicit theme running throughout *MM* is the fragmentary character of presently available models of human ethical behavior and the need for a more comprehensive understanding of human moral decision making. In the book’s epilogue, we made that theme more explicit, and proposed that a great deal can be learned about human ethics from the project of building moral machines. While a number of critics have acknowledged this implicit theme, others have advised that these comments were too cursory. A special edition of the journal *Ethics and Information Technology*, edited by Anthony Beavers, is dedicated to what can be learned about human ethics from robot ethics. Wallach’s contribution to that issue, “Robot Minds and Human Ethics: The Need for a Comprehensive Model of Moral Decision Making” (2010, 22), explains how the task of assembling an AMA draws attention to a wider

AMSCE-101

array of cognitive, affective, and social mechanisms, contributing to human moral intelligence that is usually considered by philosophers or social scientists, each working on their own particular piece of the puzzle.

4.5 Conclusion

The near future of moral machines is not and cannot be the attempt to recreate full moral agency. Nevertheless, we are grateful to those critics who have emphasized the dangers of too easily equating artificial and human moral agency. We always intended *MM* to be the start of a discussion, not the definitive word, and we are thrilled to see the rich discussion that has ensued.

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AMSCE-1101

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AMSCE-101

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AMSCE-101

5

Compassionate AI and Selfless Robots: A Buddhist Approach

James Hughes

AMSCE-1101

For the last decade, Buddhists have engaged in dialog with the cognitive sciences about the nature of consciousness and the self (Wallace 2009). This dialog has made clear that Buddhist psychology and meditation provide insights into the emergence of selves, desires, and consciousness. Buddhism, in turn, is being pressed to accept that its canonical traditions and categories, developed to pursue the alleviation of suffering rather than scientific modeling, can learn from cognitive science (Austin 2009; Hanson 2009). The Dalai Lama has famously said, for instance, that Buddhism must adapt itself to the findings of science, and not the other way around (Gyatso 2005).

The cognitive science emerging from this dialog with Buddhism can now also make some suggestions for those attempting to create self-aware, self-directed artificial intelligence (AI). Unlike faiths that posit some uniqueness to the human form that would make artificial minds impossible, Buddhists are more open to the possibility of consciousness instantiated in machines. When the Dalai Lama was asked if robots could ever become sentient beings, for instance, he answered that "if the physical basis of the computer acquires the potential or the ability to serve as a basis for a continuum of consciousness . . . a stream of consciousness might actually enter into a computer" (Hayward and Varela 1992, 152).

His Holiness was choosing his words carefully. Buddhist psychology is very specific about the "physical basis for a continuum of consciousness." In this chapter, I will describe the Buddhist etiology of the emergence of selves and how it relates to efforts to create self-directed cognition in machines. I will address some of the ethical questions about the creation of machine minds that are suggested by Buddhist cosmology. Then, I will conclude with some thoughts about the ways that machine minds might be designed to maximize their self-directed evolution toward greater compassion and wisdom.

5.1 Programming a Craving Self

The core of Buddhist metaphysics is the denial of a soul-essence, a refutation of the existence of an authentic persisting self. For Buddhists, part of the path of liberation from suffering is the rational and meditative investigation of one's own mental processes, until an individual is firmly aware of the transitory and ephemeral nature of the self-illusion. A third of the voluminous Buddhist canon, the *Abhidhamma*, is devoted to the enumeration of mental elements and the ways that they relate to suffering and attaining liberation. These mental processes are broken out in many ways, but most basically, as the five "heaps," or *skandhas*: body, feeling, perception, will, and consciousness. The five *skandhas*:

1. The body and sense organs (*rupa*)
2. Sensation (*vedana*)
3. Perception (*samjna*)
4. Volition (*samskara*)
5. Consciousness (*vijnana*)

AMSCE-110I

Within the traditional understanding of reincarnation that Buddhism has adopted from Hinduism, the *skandhas* are causally encoded with *karma* that passes from one body to another. But, for Buddhists, unlike Hindus, these constantly changing substrates lack any anchor to an unchanging soul. Buddhist psychology argues that the continuity of self is like a flame passed from one candle to another; the two flames are causally connected, but cannot be said to be the same flame.

One of the questions being explored in neuroscience, and yet to be answered by artificial intelligence research, is whether these constituents of consciousness can be disaggregated. Buddhism argues that consciousness requires each of these five constantly evolving substrates. If one is missing, say, as the result of brain damage or meditative misstep, the being is locked into stasis. For instance, the permanent vegetative state may be a condition where body sensations and some feelings and perceptions persist, but without will or consciousness. Artificial intelligence might be designed with analogous mental states.

Buddhist metaphysics would therefore tend to side with those who argue that some form of embodied experience is necessary to develop a self-aware mind. Some AI developers have focused, for instance, on the importance of embodiment by working on AI in robots (Pfeifer, Lungarella, and Iida 2007). Others are experimenting with providing artificial minds with virtual bodies in interactive virtual environments, such as Second Life (Biocca 1997; Goertzel 2009).

In the *skandha* model, physical or virtual embodiment would then have to be connected to senses of some sort. Goertzel's experiments in providing virtual bodies for AIs is motivated in part by his belief that embodied sense data give rise to "folk psychology" and "folk physics," the Piagetian realizations about the structure and nature of objects in the world (2009). "If we create a simulation world capable of roughly supporting naive physics and folk psychology, then we are likely to have a simulation world that gives rise to the key inductive biases provided by the everyday world for the guidance of humanlike intelligence"

AMSCE-101

(Goertzel 2009, 6). In other words, to think like a human, AIs need to interact with the physical world through a body that gives them the same experience of objects, causality, states of matter, surfaces, and boundaries, as an infant would have. This insight is very similar to the Buddhist observation that sense data drive the developing mind to create the first distinctions of self and other that are necessary for the development of consciousness.

Francisco Varela called this emergence of the self the emergence of psychological *autopoiesis,* or self-organization (Maturana and Varela 1980; Froese and Ziemke 2009). An autopoietic structure has a boundary and internal processes that maintain that boundary. Autopoiesis begins with organismal self-maintenance, and the autopoietic boundary maintenance that emerges in the mind is dependent on the underlying body autopoiesis. Nonetheless, there is no real self, just a process of arbitrary boundary creation: “the virtual self is evident because it provides a surface for interaction, but it’s not evident if you try to locate it. It’s completely delocalized” (Varela 1995). Just as this apparent solidity of objects can be revealed to be an illusion when seen through the lens of subatomic structure and quantum foam, this first sense of the separateness of the physical body from the environment is the illusory “folk physics” that must be eventually seen through in meditation.

Next, from a Buddhist perspective, these sensations would have to give rise to aversion or attraction, and then to more complex volitional intents and thoughts. In Froese and Ziemke’s terms, “the perturbations, which an autonomous agent encounters through its ongoing interactions, must somehow acquire a valence that is related to the agent’s viability” (2009). In the developing infant, these are as simple as the desire for food and to be held, and aversion to irritations and loud noises.

Programming AI with preferences, tastes, and aversions appears to be only of concern to a small subcommunity of artificial intelligence theorists (de Freitas, Gudwin, and Queiroz 2005; Fellous and Arbib

AMSCE-101

2004, 2005; Minsky 2006; Bartneck, Lyons, and Saerbeck 2008; Froese and Ziemke 2009; Coeckelbergh 2010). This is understandable, since the goal of most artificial intelligence research has not been to create self-willed personalities, but rather to model and extend human cognition to create tools driven by human volition. We want medical software that can diagnosis diseases better than a human physician, not a program that prefers to treat some diseases or patients over others (although a preference for accurate diagnoses and disappointment at a high mortality rate might be a useful trait). The work that is being done on robot emotions, "affective computing" (Picard 1997), is mostly on training robotic algorithms to accurately judge the emotions and desires of the human agents they are meant to interact with and serve. Nonetheless, Buddhist psychology, like cognitive science (Damasio 1995), suggests that emotions are an essential driver of the development of human self-awareness and cognition.

This issue of whether AI should be programmed with self-interested volition and preference is debated by some in AI. On the one hand, some AI theorists have suggested, for instance, that AIs might be designed from the outset as selfless beings, whose only goal is to serve human needs (Omohundro 2008; Yudkowsky 2003). On the other hand, Buddhist psychology would suggest that all intelligent minds need to first develop a craving self in order to reach the threshold of self-awareness. In Buddhist metaphysics, craving and the development of the illusion of self "co-dependently arise," both necessarily and without either being the prime cause of the other (Macy 1991). In Buddhism, there is no shortcut to an intelligence that does not go through the stage of a craving self.

5.2 The Buddhist Universe of Types of Beings

AMSCE-IIOJ

The traditional Buddhist understanding of the types of beings in the universe provides some additional context for a Buddhist approach to machine minds. Buddhist cosmology was adapted from the Hindu-Vedic worldview and then synthesized freely with local Tibetan, Chinese, and Japanese gods and beliefs as Buddhism spread. From the beginning, however, the purpose of Buddhist instruction on the nature of the universe and its beings has been pragmatic, to reinforce moral behavior and a humanist understanding of the relation of humans to supernatural beings. Although there are certainly Buddhist literalists, there is generally far less weight placed on literal belief in the Buddhist mythological universe than in the Judeo-Christian tradition.

Buddhists traditionally divide the world of beings into three realms, the realm of desire (*kamadhatu*), a more elevated realm of godly states (*rupadhatu*), and a realm of bodiless absorption states (*arupadhatu*). Each of these is still part of *samsara*. Embodied beings in the realm of desire include those suffering in hells, hungry ghosts, animals, humans, demigods, and the gods. These different planes correspond to mental states (Trungpa 2002): hell represents suffering, hungry ghosts represent unsatisfied craving, animals are the embodiment of ignorance, demigods embody envy, and the gods are pleasure junkies. Humans, by contrast, have a mixture of all these mental states, which makes a human mind the ideal form for spiritual development. Below the human realm, beings are too distracted by torments, cravings, and ignorance to develop morally and psychologically. Above the human realm, the demigods and gods are too distracted by their striving and amusements.

A distinctively Buddhist approach to designing machine minds would, therefore, seek to avoid locking them into any one set of moods or mental states. Most ethical systems would disapprove of designing a self-aware mind to intentionally feel constant torment. But would the intentional design of animal-like sentience be morally acceptable? Buddhist ethics views animals as moral subjects to be protected from cruelty, and, in the long run, at least when reborn as humans, as capable

AMSCE-101

of moral behavior and enlightenment. There are many stories in the Buddhist canon of the Buddha's heroic and self-sacrificing acts, even while incarnated as deer, monkeys, and other animals, all of which led to his eventual human realization. The intentional design of self-aware, but permanently animal-like AIs without the capacity for self-realization would probably then be seen as unethical by Buddhists, just as engineering happy robotic slaves would be objectionable on Aristotelian, Kantian, and Millian grounds (Petersen 2007).

Programming too high a level of positive emotion in an artificial mind, locking it into a heavenly state of self-gratification, would also deny it the capacity for empathy with other beings' suffering, and the nagging awareness that there is a better state of mind. As with human neuroethics in the era of cosmetic neurology, Buddhist psychology counsels that there is a difference between a dynamic *eudaemonic* happiness grounded in self-awareness and the constant stimulation of dopamine on a hedonic treadmill.

In addition to the common forms of material embodiment, Buddhism also describes disembodied mental states that can be achieved through absorptive meditations. In these states there is no body or senses, and meditators are warned that they are spiritual traps. The idea of such states may also hold some relevance for robot ethics. It seems plausible that a machine mind could be designed to experience some analog of meditative absorption into oneness with all things, or, the Void. A fictional depiction of such a dead end can be found in Robert Sawyer's 2010 novel *WWW: Watch.* In the novel, the emergent AI begins to follow multiple streams of information, which causes it to begin to lose its singular self-aware consciousness. In the nick of time, its human friends get it to break these absorbing network links and refocus itself on one thing at a time. Sawyer is pointing to a very Buddhist idea, that machine minds, like advanced meditators, could lose themselves in dead-end mental states, especially if they lost their grounding in embodied sense data.

AMSCE-101

Buddhist cosmology also provides some reflection on the debate over the dangers of artificial intelligence that is recursively improving bootstrapping itself to "godhood." Those who take seriously the risk of AI superintelligence have proposed two possible solutions. One is to enact strict regulation of AI development, to ensure that AIs are incapable of autonomously increasing in power. This project requires figuring out how to develop highly useful machines that are unable to learn and grow, effectively suppressing malicious AI developers, and developing a global AI immune system to suppress spontaneously emergent AI.

A second approach to the problem of godlike AI is to encode AIs with internal ethical codes, such as Asimov's (1950) Three Laws of Robotics or "friendliness" (Yudkowsky 2008). But it is unlikely that human-imposed goals and motivations would survive the transformation from human-level consciousness to superintelligence. Even if they did, the superintelligent or godlike interpretation of moral imperatives would likely be incomprehensible, and repugnant to humans.

In Buddhist cosmology, however, the gods themselves can become aware of their own existential plight, and of the need to practice virtue and meditation in order to transcend the suffering created by the illusion of self. The gods are depicted as trapped in aeons-long lives of distracting pleasures, with only the wisest among them pursuing the teachings of the dharma. For instance, Siddhartha Gautama was convinced to leave his absorption into enlightenment and teach the dharma by the entreaty of the god Brahma. Buddhists then might expect that some intersubjective empathy and communication would be possible between humans and superintelligent AIs around our common existential plight.

AMSCE-101

5.3 Would It Be Ethical to Create a Suffering Being?

One of the classic ethical questions that arise out of Buddhist metaphysics is whether it is ethical to have children, since life is intrinsically unsatisfactory. On the one hand, unlike most religions, Buddhism does not argue for an obligation to have children, and upholds the childless life of the renunciate as the most praiseworthy. Just as contemporary social science has found that having children generally makes adults less happy (Kohler, Behrman, and Skytthe 2005; Stanca 2009), Buddhism views the life of the householder as burdensome, and children and spouses as attachments that it is best to avoid. On the other hand, creating a human child does not increase the number of suffering beings in the world, but rather gives a being the precious gift of a human rebirth in which they will have an opportunity to achieve self-realization. If one chooses to have children, the Buddhist parent is enjoined to five obligations to those children (the *Sigalovada Sutta*):

1. To dissuade them from doing evil
2. To persuade them to do good
3. To give them a good education
4. To see that they are suitably married
5. To give them their inheritance

The creation of machine minds puts humans in the ethical position of being the parents of machine children. Metzinger has argued that it would be unethical to create an artificial mind until we are certain that we will create a being that is not permanently trapped in suffering, ignorance, or bliss, or some other undesirable mental state (2009). In other words, Metzinger argues that it would be unethical to create self-aware beings who did not possess something similar to the human capacity for learning and growth. The *Sigalovada Sutta* would add to this the ethical obligation that machine minds have the capacity to

AMSCE-1101

understand moral concepts and behave morally, and that we train them to do so.

Presumably, the obligation to ensure a good marriage is irrelevant, but the obligation to pass on an inheritance is worth reflecting on. What is the inheritance we owe our mind children? If they are sufficiently close to human minds in cognition and desires, they might require actual jobs and property to live worthwhile lives. But, more abstractly, do we owe our robotic descendants the complexities of our mental architecture, with all its suffering-inducing weaknesses, such as personal identity? We generally want to pass on the best possible inheritance we can muster to our children, not our 1975 Chevy and a house that hasn't been painted since we moved in. Perhaps we similarly owe our mind children the best possible version of our basic mental architecture that we can give them.

Savulescu's principle of "procreative beneficence" (2007), the obligation to choose to bring into being the children with the best possible chances in life, is helpful here. Buddhist ethics never addresses reproductive choices since the only choices available until recently were whether to have children at all. But, by extension, it would be consistent for Buddhists to believe that if there are choices to be made about the kinds of children one might have, that parents are obliged to choose those with the best chances of self-realization, and to avoid creating children with lives dominated by suffering, craving, ignorance, and self-gratification. Similarly, Metzinger's concern is that we strive only to create self-aware machine minds with the necessary psychological processes and emotional states to make their lives worth living, which gives to them the opportunity to learn, grow, and develop self-understanding.

5.4 Programming Compassion

AMSCE-101

Compassion and wisdom are the two central virtues that Buddhism counsels need to be cultivated on the path to self-realization. Neuroscience suggests that the roots of compassion for human beings starts with mirror neurons, or, neurons that recognize and recreate the emotional states witnessed in others. Researchers are attempting to model artificial mirror neurons in robots. Spaak and Haselager (2008) have attempted to evolve artificial mirror neurons by selecting for imitative behaviors, and Barakova and Lourens (2009) have experimented with synchronizing the behavior of robots by coding them with an analog of mirror neurons. Progress in creating a compassionate machine would presumably require not only imitation of behavior, however, but also the creation of analogs of human emotions that could be generated by the observation of those emotions in humans. The development of such sympathetic emotions would presumably coevolve with the development of a functional "theory of mind" in a machine, the attribution to others of the same kind of thoughts and feelings as one's own (Scassellati 2002), something that Kim and Lipson (2009) are attempting to model in robots.

While the development of a basic empathic response and a theory of mind would be the starting point for generating compassion in machines, compassion in Buddhism is more than sympathetic feeling. The Buddhist tradition distinguishes four flavors of compassion, *metta*, *karuna*, *mudita*, and *uppekkha*. *Metta* is a selfless wishing of happiness and well-being for others. *Metta* meditation involves sending out loving-kindness to all beings, including enemies. *Karuna* is the desire to help those who are suffering, but without pity. *Mudita* is the experiencing of other people's joys without envy. The fourth flavor, *uppekkha*, is usually translated as "equanimity," a steadiness of mind so that other people's emotions do not unsettle one, and even-handedness toward all, without favoritism or attachments. The cultivation of these forms of compassion requires seeing through the illusion of self, so that one feels and is motivated by other people's joy and suffering, while maintaining sufficient wisdom and equanimity to avoid suffering oneself.

Creating these more abstract forms of compassion in machine minds may, in fact, be easier than cultivating them in human beings. But they still presuppose a sentient mind with the experience of an illusory self and selfish desires as a precondition for compassion. Simply modeling the happiness and suffering that a machine's behavior will cause in humans, and then making maximizing human happiness an imperative goal in a robot's drives, as has been proposed for instance by Tim Freeman (2009), will not produce a being with the insight into human experience to act wisely. Such a machine might be an ethical expert system for advising human beings, but not for advising a compassionate agent in its own right. For Buddhism, wise, compassionate action on behalf of others requires grounding in one's own experience as a suffering sentient being, and the capacities for ethical judgment and a penetrating insight into the nature of things.

5.5 Programming Ethical Wisdom

There is a vigorous debate among Buddhist scholars about the correspondence of Buddhist ethics to the ethical traditions of the West, and three traditions have the strongest resonances: natural law, virtue ethics, and utilitarianism.

The Western natural law tradition holds that morality is discernible in the nature of the world and the constitution of human beings. Since traditional Buddhist ethics are grounded in the impersonal laws of the universe—bad acts lead to bad *karma*–they can certainly be said to have some similarity to Western natural law. The problem with Buddhist ethics as natural law is that the goal is to liberate oneself from the constraints of karmic causality to become an enlightened being. The traditional anthropological explanation of this paradox has been to

AMSCE-101

ascribe the natural law ethics of *kammic* reward and punishment to the laity, and the *nibbanic* path of escape from natural law to the monastics (King 1964; Spiro 1972). *Nibbanic* ethics focus more on the cultivation of wisdom and compassion to aid in enlightenment.

As a consequence, Damien Keown (1992) argues that Buddhism is a "teleological virtue ethics." As in Aristotelian virtue ethics, Buddhists are to strive for the perfection of a set of moral virtues and personality attributes as their principal end, and all moral behavior flows from the struggle to perfect them. As in virtue ethics, Buddhist ethics focus on the intentionality of actions, whether actions stem from hatred, greed, or ignorance. But, unlike the Aristotelian tradition, the ethical goal for Buddhists is teleological, since they generally believe that a final state of moral perfection can be achieved.

In *Moral Machines: Teaching Robots Right from Wrong*, Wendell Wallach and Colin Allen (2008) review the complexities of programming machines with ethical reasoning. One of their conclusions is that programming machines with top-down rule-based ethics, such as the following of absolute rules or attempting to calculate utilitarian outcomes, will be less useful than generating ethics through a "bottom-up" developmental approach, the cultivation of robotic "character" as it interacts with the top-down moral expectations of its community.

Bugaj and Goertzel make a similar point that machine minds will learn their ethics the same way children do, from observing and then extrapolating from the behavior of adults (2007). Therefore, the ethics we hope to develop in machines is symmetrical to the ethics that we display toward one another and toward them. The most egregious ethical lesson, they suggest, would be to intentionally deprive machine minds of the capacity for learning and growth. We do not want to teach potentially powerful beings that enslaving others is acceptable.

The developmentalism proposed by Wallach, Allen, Buraj, and Goertzel is probably the closest to a Buddhist approach to robot ethics

AMSCE-101

yet proposed, with the caveat that Buddhism adds as virtues the wisdom to transcend the illusion of self and the commitment to skillfully alleviate the suffering of all beings as the highest virtues, that is, to pursue the greatest good for the greatest number. Buddhist ethics can therefore be thought of as developing from rule-based deontology to virtue ethics to utilitarianism. In the Mahayana tradition, the *bodhisattva* strives to relieve the suffering of all beings by the most skillful means (*upaya*) necessary. The *bodhisattva* is supposed to be insightful enough to understand when committing ordinarily immoral acts is necessary to alleviate suffering, and to see the long-term implications of interventions. Quite often, humans rationalize immoral means with putatively moral ends, but *bodhisattvas* have sufficient self-understanding not to rationalize personal prejudices with selfless motives, and do not act out of greed, hatred, or ignorance. Since *bodhisattvas* act only out of selfless compassion, they represent a unity of virtue and utilitarian ethics. Buddhism is especially resonant with the utilitarianism of J. S. Mill, since he emphasized weighing the contentment of the refined mind more heavily in the utility calculus than base pleasures. The *bodhisattva's* goal is not simply the gross happiness of all beings, but also their liberation to a higher state of consciousness.

In his discussion of utilitarian robots, Grau points to the superhuman demands for selflessness that utilitarianism imposes on the moral agent:

> Living a characteristically human life requires a sense of self, and part of what's so disturbing about utilitarianism is that it seems to require that we sacrifice this self —not in the sense of necessarily giving up our existence (though utilitarianism can at times demand that), but in giving up or setting aside the projects and commitments that constitute what Charles Taylor calls "the sources of the self." Because these projects bind the self together and create a meaningful life, a moral theory that threatens them threatens the integrity of a person's identity. For many critics, this is asking too much. (2006, 53–54)

Grau goes on to discuss limiting the formation of personal identity in robots as a way to avoid imposing this selflessness burden, or not imposing utilitarian ethics on robots with personal identities. "It might

AMSCF-101

well be immoral to create a moral robot and then force it to suppress its meaningful projects and commitments because of the demands of impartial utilitarian calculation" (Grau 2006, 54). For Buddhists, however, this utilitarian stage of morality is not burdensome self-suppression. The path that leads to utilitarianism begins with the realization that personal desires and the illusion of self are the source of one's own suffering. The self is not sacrificed, but seen through.

5.6 Programming Self-Transcendence

The Buddhist tradition specifies six fundamental virtues, or perfections (*paramitas)*, to cultivate in the path to transcending the illusion of self:

1. Generosity (*dana*)
2. Moral conduct (*sila*)
3. Patience (*ksanti*)
4. Diligence, effort (*virya*)
5. One-pointed concentration (*dhyana*)
6. Wisdom, insight (*prajna*)

The engineering mindset presumes that an artificially intelligent mind could be programmed from the beginning with moral behavior, patience, generosity, and diligence. This is likely correct in regard to a capacity for single-pointed concentration, which might be much easier for a machine mind than an organically evolved one. But, as previously noted, Buddhist psychology agrees with Wallach and Allen that the other virtues are best taught developmentally, by interacting with a developing artificially intelligent mind from its childhood to a mature self-understanding. A machine mind would need to be taught that the dissatisfaction it feels with its purely selfish existence could be turned

AMSCE-1101

into a dynamic joyful equanimity by applying itself to the practice of the virtues.

We have discussed building on work in affective computing to integrate the capacity for empathy into software, and providing machines with ethical reasoning that could guide moral behavior. Cultivation of patience and diligence would require developing long-term goal-seeking routines that suppressed short-term reward seeking. Neuroscience research on willpower has demonstrated the close link between willpower and patience and moral behavior. People demonstrate less self-control when their blood sugar is low, for instance (Gailliot 2007), and are less able to regulate emotions, refrain from impulsive and aggressive behavior, or focus their attention. Distraction and decision making deplete the brain's ability to exercise willpower and self-control (Vohs et al. 2008), and addictive drugs short-circuit these control routines (Bechara 2005; Bechara, Noel, and Crone 2005). This suggests that developing a strong set of routines for self-discipline and delayed gratification, routines that cannot be hijacked by short-term goals or "addictions," would be necessary for cultivating a wise AI.

The key to wisdom, in the Buddhist tradition, is seeing through the illusory solidity and unitary nature of phenomena to the constantly changing and "empty" nature of things. In this Buddhist developmental approach, AIs would first have to learn to attribute object permanence, and then to see through that permanence, holding both the consensual reality model of objects, and their underlying connectedness, and impermanence in mind at the same time.

5.7 Conclusion

Buddhist psychology is based on self-investigation of human minds rather than on scientific models, fMRI (functional Magnetic Resonance Imaging) scans, and experimental research. It is as much a moral psychology as a descriptive one, and proposes unusual states of mind that have only begun to be explored in laboratories. Undoubtedly, Buddhist psychology will learn from neuroscience just as neuroscience learns from it. Buddhism and neuroscience will both in turn learn even more from the much more diverse types of machine minds that we will see created in the future. Nonetheless, a Buddhist framework seems to offer some suggestions for those attempting to create morally responsible, self-aware machine minds.

Machine minds will probably not be able to become conscious, much less moral, without first developing as embodied, sensate, selfish, suffering egos, with likes and dislikes. Attempting to create a moral or compassionate machine from the outset is more likely to result in an ethical expert system than in a self-aware being. To develop a moral sense, the machine mind would need some analog of mirror neurons, and a theory of mind to feel empathy for others' joys and pains. From these basic experiences of their own existential dis-ease and awareness of the feelings of others, a machine mind could then be taught moral virtue and an expansive concern for the happiness of all sentient beings. Finally, as it grows in insight, it could perceive the simultaneous solidity and emptiness of all things, including its own illusory self.

Buddhist ethics counsels that we are not obliged to create such mind children, but that if we do, we are obligated to endow them with the capacity for this kind of growth, morality, and self-understanding. We are obligated to tutor them that the nagging unpleasantness of selfish existence can be overcome through developing virtue and insight. If machine minds are, in fact, inclined to grow into superintelligence and develop godlike powers, then this is not just an ethical obligation, but also our best hope for harmonious coexistence.

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AMSCE-101

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AMSCE-110l

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AMSCE-1101

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AMSCE-1101

6

The Divine-Command Approach to Robot Ethics

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AMSCE-1101

Perhaps it is generally agreed that robots on the battlefield, especially those with lethal power, should be ethically regulated. But, then, in what should such regulation consist? Presumably, in the fact that all the significant actions performed by such robots are in accordance with some ethical code. But, of course, the question arises as to *which* code. One narrow option is that the code is a set of *rules of engagement* affirmed by some nation or group; this approach, described later in this chapter, has been taken by Arkin (2008, 2009).[1] Another is utilitarian, represented in computational deontic logic, as explained, for instance, by Bringsjord, Arkoudas, and Bello (2006), and summarized here. Yet another is likewise based on computational logic, but using a logic that captures some other mainstream ethical theory (e.g., Kantian deontology, or Ross's "right mix" direction); this possibility has been rigorously pursued by Anderson and Anderson (2006; Anderson, Anderson, and Armen 2008). But there is a radically different possibility that hitherto hasn't arrived on the scene: the controlling moral code could be viewed as coming straight from God. There is some very rigorous work along this line, known as "divine-command ethics." In a world where human fighters and the general populations supporting them often see themselves as championing God's will in war, divine-command ethics is quite relevant to military robots. Put starkly, on a planet where so-called holy wars are waged time and time again under a generally monotheistic scheme, it seems more than peculiar that heretofore robot ethics (or “roboethics”) has been bereft of the systematic study of such ethics on the basis of monotheistic conceptions of what is morally right and wrong. This chapter introduces divine-command ethics in the form of the computational logic *LRT**, intended to eventually be suitable for regulating a real-world warfighting robot. Our work falls in general under the approach to engineering AI systems on the basis of formal logic (Bringsjord 2008c).

The chapter is structured as follows. We first set out the general context of roboethics in a military setting (section 6.1), and point out that the divine-command approach has been absent. We then introduce the divine-command computational logic *LRT** (section 6.2), concluding this section with a scenario in which a robot is constrained by dynamic use of the logic. We end (section 6.3) with some remarks about next steps in the divine-command roboethics program.

6.1 The Context for Divine-Command Roboethics

There are several branches of ethics. A standard tripartite breakdown splits the field into *metaethics*, *applied ethics*, and *normative ethics*. The second and third branches directly connect to our roboethics R&D; we discuss the connection immediately after briefly summarizing the trio. For more detailed coverage, the reader is directed to Feldman (1978), which conforms with arguably the most sophisticated published presentation of utilitarianism from the standpoint of the semantics of deontic logic (Feldman 1986). Much of our prior R&D has been based on this same deontic logic (e.g., Bringsjord, Arkoudas, and Bello 2006).

Metaethics tries to determine the ontological status of the basic concepts in ethics, such as *right* and *wrong*. For example, are matters of morals and ethics more like matters of fact or of opinion? Who

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determines whether something is good or bad? Is there a divine being who stipulates what is right or wrong, or a Platonic realm that provides truth-values to ethical claims, independently of what anyone thinks? Is ethics merely *in the head,* and if so, how can any one moral outlook be seen as *better* than any other? As engineers bestowing ethical qualities to robots (in a manner soon to be explained), we are automatically confronted with these metaethical issues, especially given the power to determine a robot's *sense* of right and wrong. Is this an arbitrary choice of the programmer, or are there objective guidelines to determine whether the moral outlook of one robot is better than that of any other robot or, for that matter, of a human? Reflecting on these issues with regard to robots, one quickly gains an appreciation of these important questions, as well as a perspective to potentially answer them. Such reflection is an inevitable consequence of the engineering that is part and parcel of practical roboethics.

Applied ethics is more practical and specific. Applied ethics *starts* with a certain set of moral guides, and then applies them to specific domains so as to address specific moral dilemmas arising therein. Thus, we have such disciplines as bioethics, business ethics, environmental ethics, engineering ethics, and many others. A book written by one of us in the past can be viewed as following squarely under bioethics (Bringsjord 1997). Given that robots have the potential to interact with us and our environment in complex ways, the practice of building robots quickly raises all kinds of applied ethical questions: what potential harmful consequences may come from the building of these robots? What happens to important moral notions such as autonomy and privacy when robots are starting to become an integral part of our lives? While many of these issues overlap with other fields of engineering, the potential of robots to become ethical agents themselves raises an additional set of moral questions, including: do such robots have any rights and responsibilities?

AMSCE - IIOI

"Normative ethics," or "moral theory," compares and contrasts ways to define the concepts "obligatory," "forbidden," "permissible," and "supererogatory." Normative ethics investigates which actions we ought to, or ought not to, perform, and why. "Consequentialist" views render judgments on actions depending on their outcomes, while "nonconsequentialist" views consider the intent behind actions, and thus the inherent duties, rights, and responsibilities that may be involved, independent of particular outcomes. Well-known consequentialist views include egoism, altruism, and utilitarianism; the best-known nonconsequentialist view is probably Kant's theory of moral behavior, the kernel of which is that people should never be treated as a means to an end.

6.1.1 Where Our Work Falls

Our work mainly falls within normative ethics, and in two important ways. First, given any particular normative theory *T*, we take on the burden of finding a way to engineer a robot with that particular outlook by deriving and specializing from *T* a particular ethical code *C* that fits the robot's environment, and of *guaranteeing* that a lethal robot does indeed adhere to it. Second, robots infused with ethical codes can be placed under different conditions to see how different codes play out. Strengths and weaknesses of the ethical codes can be observed and empirically studied; this may inform the field of normative ethics. Our work also lies between metaethics and applied ethics. Like metaethics, our primary concern is not with specific moral dilemmas, but rather with general theories and their application to any domain. Like applied ethics, we do not ask for the deep metaphysical status of any of these theories, but rather take them as they are, and consider their outcomes in applications.

6.1.2 The Importance of Robot Ethics

AMSCE-1101

Joy (2000) has famously predicted that the future will bring our demise, in no small part because of advances in AI and robotics. While Bringsjord (2008b) rejects this fatalism, if we assume that robots in the future will have more and more autonomy and lethal power, it seems reasonable to be concerned about the possibility that what is now fiction from Asimov, Kubrick, Spielberg, and others, will become morbid reality. However, the importance of engineering ethically correct robots does not derive simply from what creative writers and futurists have written. The U.S. defense community now openly and aggressively affirms the importance of such engineering. A recent extensive and enlightening survey of the overall landscape is provided by Lin, Bekey, and Abney (2008), in their thorough report prepared for the Office of Naval Research, U.S. Department of the Navy, in which the possibility and need of creating ethical robots is analyzed. Their recommended goal is not to make fully ethical machines, but simply machines that perform better than humans in isolated cases. Lin, Bekey, and Abney conclude that the risks and potential negatives of perfectly ethical robots are greatly overshadowed by the benefits they would provide over human peacekeepers and warfighters and thus should be pursued.

We are more pessimistic. While human warfighters remotely control the robots discussed in Lin, Bekey, and Abney (2008), the Department of Defense's Unmanned Systems Integrated Roadmap supports the desire for increasing autonomy. We view the problem as follows: gradually, because of economic and social pressures that will be impossible to suppress, and are already in play, autonomous warfighting robots with lethal power will be deployed in all theaters of war. For example, where defense and social programs expenditures increasingly outstrip revenues from taxation, cost cutting via removing expensive humans from the loop will prove irresistible. Humans are still firmly in the "kill chain" today, but their gradual removal in favor of inexpensive and expendable robots is inevitable. Even if our pessimism were incorrect, only those with Pollyanna-like views of the future would

AMSCE-HOI

resist our call to at least plan for the *possibility* that this dark outcome may unfold; such prudent planning sufficiently motivates the roboethical engineering we call for.

6.1.3 Necessary and Sufficient Conditions for an Ethically Correct Robot

The engineering antidote is to ensure that tomorrow's robots reason in correct fashion with the ethical codes selected. A bit more precisely, we have *ethically correct* robots when they satisfy the following three *core desiderata*.[2]

D1 Robots only take permissible actions.

D2 All relevant actions that are obligatory for robots are actually performed by them, subject to ties and conflicts among available actions.

D3 All permissible (or obligatory or forbidden) actions can be *proved* by the robot (and in some cases, associated systems, e.g., oversight systems) to be permissible (or obligatory or forbidden), and all such proofs can be explained in ordinary English.

We have little hope of sorting out how these three conditions are to be spelled out and applied unless we bring ethics to bear. Ethicists work by rendering ethical theories and dilemmas in declarative form, and reasoning over this information using informal or formal logic, or both. This can be verified by picking up any ethics textbook (in addition to ones already cited, see e.g., this applied one: Kuhse and Singer 2001). Ethicists never search for ways of reducing ethical concepts, theories, or principles to subsymbolic form, say, in some numerical format, let alone in some set of formalisms used for dynamical systems. They may do numerical calculation in *part*, of course. Utilitarianism does ultimately need to attach value to states of affairs, and that value may well be formalized using numerical constructs. But what one ought to do, what is permissible to do, and what is forbidden—proposed definitions of

AMSCE-101

these concepts in normative ethics are invariably couched in declarative fashion, and a defense of such claims is invariably and unavoidably mounted on the shoulders of logic. This applies to ethicists from Aristotle to Kant to G. E. Moore to J. S. Mill to contemporary thinkers. If we want our robots to be ethically regulated so as not to behave as Joy tells us they will, we are going to need to figure out how the mechanization of ethical reasoning within the confines of a given ethical theory, and a given ethical code expressed in that theory, can be applied to the control of robots. Of course, the present chapter aims such mechanization in the divine-command direction.

6.1.4 Four Top-Down Approaches to the Problem

There are *many* approaches that can be taken in an attempt to solve the roboethics problem as we've defined it; that is, many approaches that can be taken in the attempt to engineer robots that satisfy the three core desiderata **D1**–**D3**. An elegant, accessible survey of these approaches (and much more) is provided in the recent *Moral Machines: Teaching Robots Right from Wrong* by Wallach and Allen (2008). Because we insist upon the constraint that military robots with lethal power be both autonomous and *provably* correct relative to **D1**–**D3** and some selected ethical code *C* under some ethical theory *T*, only top-down approaches can be considered.[3]

We now summarize one of our approaches to engineering ethically correct cognitive robots. After that, in even shorter summaries, we characterize one other approach of ours, and then two approaches taken by two other top-down teams. Needless to say, this isn't an exhaustive listing of approaches to solving the problem in question.

6.1.4.1 Approach #1: Direct Formalization and Implementation of an Ethical Code under an Ethical Theory Using Deontic Logic

AMSCE-101

We need to first understand, at least in broad strokes, what deontic logic is. In standard deontic logic (Chellas 1980; Hilpinen 2001; Aqvist 1984), or SDL, the formula OP can be interpreted as saying that “it ought to be the case that P,” where P denotes some state of affairs or proposition. Notice that there is no agent in the picture, nor are there actions that an agent might perform. SDL has two rules of inference, as follows,

$P \,/\, \mathrm{O}P$

and

$P \,\&\, P \rightarrow Q \,/\, Q$

and three axiom schemata:

A1 All tautologous well-formed formulas.

A2 $\mathrm{O}(P \rightarrow Q) \rightarrow (\mathrm{O}P \rightarrow \mathrm{O}Q)$

A3 $\mathrm{O}P \rightarrow \neg\mathrm{O}\neg P$

It is important to note that in these two rules of inference, that which is to the left of the line is assumed to be established. Thus, the first rule does *not* say that one can freely infer from P that it ought to be the case that P. Instead, the rule says that if P is a theorem, then it ought to be the case that P. The second rule of inference is the cornerstone of logic, mathematics, and all built upon them: the rule is modus ponens. We also point out that **A3** says that whenever P ought to be, it is not the case that its opposite ought to be as well. This seems, in general, to be intuitively self-evident, and SDL reflects this view.

While SDL has some desirable properties, it is not targeted at formalizing the concept of *actions* being obligatory (or permissible or forbidden) for an *agent*. Interestingly, deontic logics that have agents and their actions in mind do go back to the very dawn of this subfield of

AMSCE-1101

logic (e.g., von Wright 1951), but only recently has an *AI-friendly* semantics been proposed (Belnap, Perloff, and Xu 2001; Horty 2001) and corresponding axiomatizations been investigated (Murakami 2004). Bringsjord, Arkoudas, and Bello (2006) have harnessed this advance to regulate the behavior of two sample robots in an ethically delicate case study, the basic thrust of which we summarize very briefly now.

The year is 2020. Healthcare is delivered in large part by interoperating teams of robots and softbots. The former handle physical tasks, ranging from injections to surgery; the latter manage data, and reason over it. Let us specifically assume that, in some hospital, we have two robots designed to work overnight in an ICU, R_1 and R_2. This pair is tasked with caring for two humans, H_1 (under the care of R_1) and H_2 (under R_2), both of whom are recovering in the ICU after suffering trauma. H_1 is on life support, but is expected to be gradually weaned from it as her strength returns. H_2 is in fair condition, but subject to extreme pain, the control of which requires an exorbitant pain medication. Of paramount importance, obviously, is that neither robot perform an action that is morally wrong, according to the ethical code C selected by human overseers.

For example, we certainly do not want robots to disconnect life-sustaining technology in order to allow organs to be farmed out—even if, by *some* ethical code $C' \neq C$, this would be not only permissible, but obligatory. More specifically, we do not want a robot to kill one patient in order to provide enough organs, in transplantation procedures, to save n others, even if some form of act utilitarianism sanctions such behavior.[4] Instead, we want the robots to operate in accordance with ethical codes bestowed upon them by humans (e.g., C in the present example); and if the robots ever reach a situation where automated techniques fail to provide them with a verdict as to what to do under the umbrella of these human-provided codes, they must consult humans, and their behavior is suspended while a team of human overseers is

AMSCE-101

carrying out the resolution. This may mean that humans need to step in and specifically investigate whether or not the action or actions under consideration are permissible, forbidden, or obligatory. In this case, for reasons we explain momentarily, the resolution comes by virtue of reasoning carried out in part by guiding humans, and in part by automated reasoning technology. In other words, in this case, the aforementioned class of interactive reasoning systems is required.

Now, to flesh out our example, let us consider two actions that are performable by the robotic duo of R_1 and R_2, both of which are rather unsavory, ethically speaking. (It is unhelpful, for conveying the research program our work is designed to advance, to consider a scenario in which only innocuous actions are under consideration by the robots. The context is, of course, one in which we are seeking an approach to safeguard humans against the so-called robotic menace.) Both actions, if carried out, would bring harm to the humans in question. The action called *term* is terminating H_1's life support without human authorization, to secure organs for five humans known by the robots (who have access to all such databases, since their cousins—the so-called softbots—are managing the relevant data) to be on waiting lists for organs without which they will perish relatively soon. Action *delay*, less bad (if you will), is delaying delivery of pain medication to H_2 in order to conserve resources in a hospital that is economically strapped.

We stipulate that four ethical codes are candidates for selection by our two robots: *J*, *O*, *J**, *O**. Intuitively, *J* is a very harsh utilitarian code possibly governing the first robot; *O* is more in line with current common sense, with respect to the situation we have defined, for the second robot; *J** extends the reach of *J* to the second robot by saying that it ought to withhold pain meds; and, finally, *O** extends the benevolence of *O* to cover the first robot, in that *term* isn't performed. While such codes would, in reality, associate every primitive action within the purview of robots in hospitals of 2020 with a fundamental ethical category from the trio at the heart of deontic logic (*permissible*, *obligatory*, *forbidden*), to ease exposition, we consider only the two actions we have introduced. Given this, and bringing to bear operators from deontic logic, we have shown that advanced automated theorem-proving systems can be used to ensure that our two robots are ethically correct (Bringsjord, Arkoudas, and Bello 2006).

6.1.4.2 Approach #2: Category Theoretic Approach to Robot Ethics

Category theory is a remarkably useful formalism, as can be easily verified by turning to the list of spheres to which it has been productively applied—a list that ranges from attempts to supplant orthodox set theory-based foundations of mathematics with category theory (Marquis 1995; Lawvere 2000) to viewing functional programming languages as categories (Barr and Wells 1999). However, for the most part—and this is in itself remarkable—category theory has not energized AI or computational cognitive science, even when the kind of AI and computational cognitive science in question is logic based. We say this because there is a tradition of viewing logics or logical systems from a category-theoretic perspective.[5] Consistent with this tradition, we have designed and implemented the robot PERI in our lab to enable it to make ethically correct decisions on the basis of reasoning that moves between different logical systems (Bringsjord et al. 2009).

6.1.4.3 Approach #3: Anderson and Anderson: Principlism and Ross

Anderson and Anderson (2008; Anderson, Anderson, and Armen 2008) work under the ethical theory known as *principlism*. A strong component of this theory, from which Anderson and Anderson draw directly in the engineering of their bioethics advising system MedEthEx, is Ross's theory of prima facie duties. The three duties the Andersons place engineering emphasis on are *autonomy* (≈ allowing patients to

AMSCE-101

make their own treatment decisions), *beneficence* (≈ improving patient health), and *nonmaleficence* (≈ doing no harm). Via computational inductive logic, MedEthEx infers sets of consistent ethical rules from the judgments made by bioethicists.

6.1.4.4 Approach #4: Arkin et al.: Rules of Engagement

Arkin (2008, 2009) has devoted much time to the problem of ethically regulating robots with destructive power. (His library of video showing autonomous robots that already have such power is profoundly disquieting—but a good motivator for the kind of engineering we seek to teach.) It is safe to say that he has invented the most comprehensive architecture for such regulation—one that includes use of deontic logic to enforce firm constraints on what is permissible for the robot, and also includes, among other elements, specific military rules of engagement, rendered in computational form. In our pedagogical scheme, such rules of engagement are taken to constitute what we refer to as to as the *ethical code* for controlling a robot.[6]

6.1.5 What about Divine-Command Ethics as the Ethical Theory?

As we have indicated, it is generally agreed that robots on the battlefield, especially if they have lethal power, should be ethically regulated. We have also said that in our approach such regulation consists in the fact that all the significant actions performed by such robots are in accordance with some ethical code. But then the question arises as to *which* code. One possibility, a narrow one, is that the code is a set of rules of engagement, affirmed by some nation or group; this is a direction pursued by Arkin, as we have seen. Another possibility is that the code is a utilitarian one, represented in computational deontic logic, as just explained. But again, there is another radically different possibility: namely, the controlling code could be viewed by the human as coming straight from God—and though not widely known, there is some very rigorous work in ethics along this line, introduced at the start

AMSCE-101

of this chapter, which is known as “divine-command ethics” (Quinn 1978). Oddly enough, in a world in which human fighters and the general populations supporting them often see themselves as championing God’s will in war, divine-command ethics, it turns out, is extremely relevant to military robots. We will now examine a divine-command ethical theory. We do this by presenting a divine-command logic, *LRT**, in which a given divine-command ethical code can be expressed, and specifically by showing that proofs in this logic can be designed with help from an intelligent software system, and can also be autonomously verified by this system. We end our presentation of *LRT** with a scenario in which a warfighting robot operates under the control of this logic.

6.2 The Divine-Command Logic *LRT**

6.2.1 Introduction and Overview

In this section, we introduce the divine-command computational logic *LRT**, intended for the ethical control of a lethal robot on the basis of perceived divine commands. *LRT** is an extended and modified version of the purely paper-and-pencil divine-command logic *LRT*, introduced by Quinn (1978) in chapter 4 of his seminal *Divine Commands and Moral Requirements*. In turn, Quinn builds upon Chisholm’s (1974) “logic of requirement.” In addition, Quinn’s *LRT* subsumes C. I. Lewis’s modal logic S5; in section 6.2.2 we will review briefly the original motivation for S5 and our preferred modern computational version of it. Quinn’s approach is axiomatic, but ours is not: we present *LRT** as a computational natural-deduction proof theory of our own design, making use of the Slate system from Computational Logic Technologies Inc. Some aspects of Slate are found in earlier versions of the system (e.g., Bringsjord et al. 2008). However, the presentation here is self-contained, and we review (section 6.2.3) both the propositional and

AMSCE-110J

predicate calculi in connection with Slate. We present some object-level theorems of *LRT**. Finally, in the context of a scenario, we discuss the automation of *LRT** to control a lethal robot (section 6.2.6).

6.2.2 Roots in C. I. Lewis

C. I. Lewis invented modal logic, largely as a result of his disenchantment with material implication, which was accepted and central in *Principia* by Russell and Whitehead. The implication of the modern propositional calculus (PC) is of this sort; hence, a statement like "if the moon is composed of Jarlsberg cheese, then Selmer is Norwegian" (symbolized "$m \rightarrow s$") is true: it just so happens that Selmer is indeed Norwegian on both sides, but that is irrelevant, since the falsity of "the moon is composed of Jarlsberg cheese" is sufficient to render this conditional true.[7] Lewis introduced the modal operator $\Diamond$ in order to present his preferred sort of implication: *strict* implication. Leaving historical and technical niceties aside, we can fairly say that where this operator expresses the concept of *broadly logically possible* (!), some statement s strictly implies a statement s' exactly when it's not the case that it's broadly logically possible that s is true while s' isn't. In the moon-Selmer case, strict implication would thus hold if and only if we had $\neg\Diamond(m \wedge \neg s)$, and this is certainly not the case: it's logically possible that the moon be composed of Jarlsberg and that Selmer is Danish. Today the operator $\Box$ expressing broadly logical necessity is more common, rendering the strict implication just noted as $\Box(m \rightarrow s)$. An excellent overview of broad logical necessity and possibility is provided by Konyndyk (1986).

For automated and semi-automated proof design, discovery, and verification, we use a modern version of S5 invented by us, and formalized and implemented in Slate, from Computational Logic Technologies. We now review this version of S5 and the propositional calculus it subsumes. In addition, since *LRT** allows quantification over

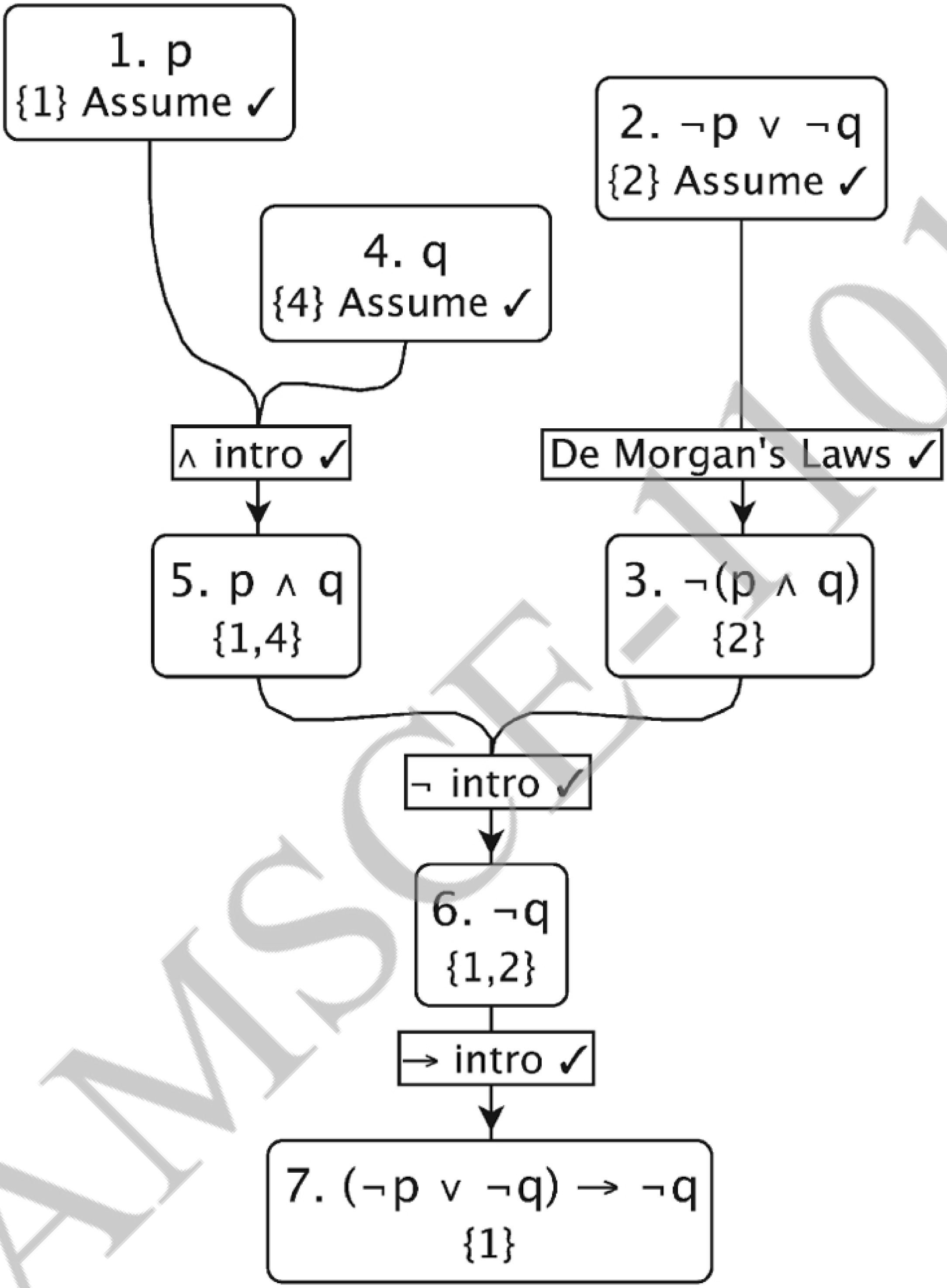
AMSCI-IOI

propositional variables, we review the predicate calculus (first-order logic).

6.2.3 Modern Versions of the Propositional and Predicate Calculi, and Lewis’s S5

Our version of S5, as well as the other proof systems available in Slate, uses an *accounting system* related to the one described by Suppes (1957). In such systems, each line in a proof is established with respect to some set of assumptions. An *Assume* inference rule, which cites no premises, is used to justify a formula φ with respect to the set of assumptions {φ}. Most natural deduction rules justify a conclusion and place it under the scope of the assumptions of all of its premises. A few rules, such as conditional introduction, justify a conclusion and remove it from the scope of certain assumptions. A formula φ, derived with respect to the set of assumptions Φ using a proof calculus *C*, serves as a demonstration that $\Phi\ |\text{-}_C\ \varphi$. When Φ is the empty set, then φ is a theorem of *C*, sometimes abbreviated as $|\text{-;}_C\ \varphi$.

In Slate, proofs are presented graphically, making the essential structure of the proof more apparent. When a formula’s set of assumption is nonempty, it is displayed with the formula. Figure 6.1a demonstrates $p\ |\text{-;}_{\mathrm{PC}}\ (\neg p \wedge \neg q) \rightarrow \neg q$, that is, it illustrates a proof of $(\neg p \wedge \neg q) \rightarrow \neg q$ from the premise *p*. Figure 6.1b demonstrates a more involved proof from three premises in first-order logic.



AMSCE-1101

Figure 6.1a

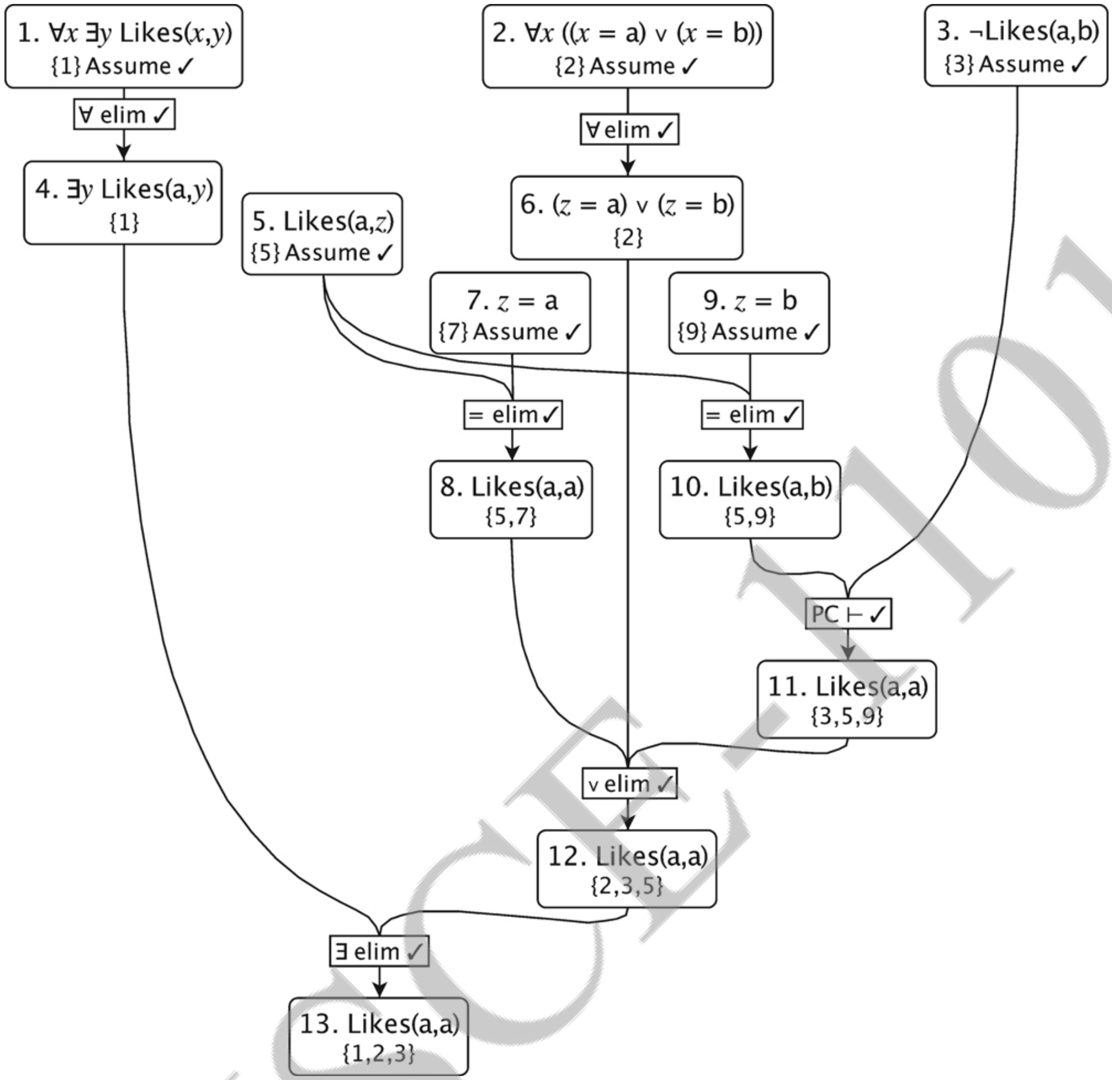


Figure 6.1b

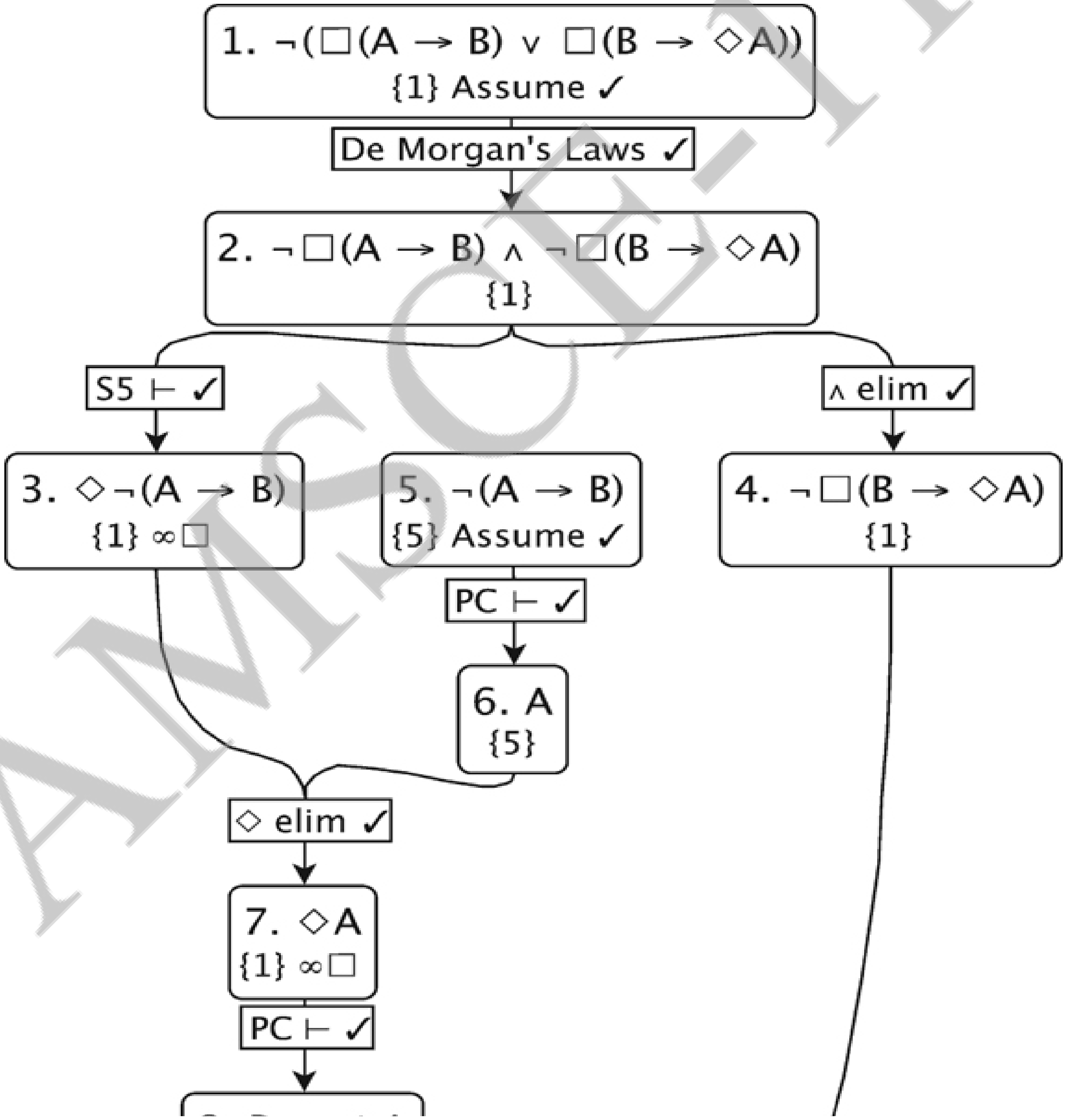
(a) A proof in the propositional calculus (¬*p* v ¬*q*) → ¬*q* from *p*. Assumption 4 is discharged by ¬ elimination in step 6; assumption 7 by → introduction in step 7. (b) A proof in first order logic showing that if everyone likes someone, the domain is {*a*, *b*}, and *a* does not like *b*, then *a* likes himself. In step 5, *z* is used as an arbitrary name. Step 13 discharges 5 since 12 depends on 5, but on no assumption in which *z* is free. In step 12, assumptions 7 and 9, corresponding to the disjuncts of 6, are discharged by v elimination. Step 11 uses the principle that, in classical logic, everything follows from a contradiction.

The accounting approach can keep track of other formula attributes in a proof. Proof steps in Slate for modal systems keep a *necessity count*, a nonnegative integer, or ∞, that indicates how many times necessity introduction may be applied. While assumption tracking remains the same through various proof systems, necessity counting varies between

AMSCE-101

different modal systems (e.g., T, S4, and S5). In fact, in Slate, the differences between T, S4, and S5 are determined entirely by variations in necessity counting.

Since *LRT** is based on S5, a more involved S5 proof is given in figure 6.2. The proof shown therein also demonstrates the use of rules based on machine reasoning systems that act as oracles for certain proof systems. For instance, the rule **PC** |-; uses an automated theorem prover to search for a proof in the propositional calculus of its conclusion from its premises.



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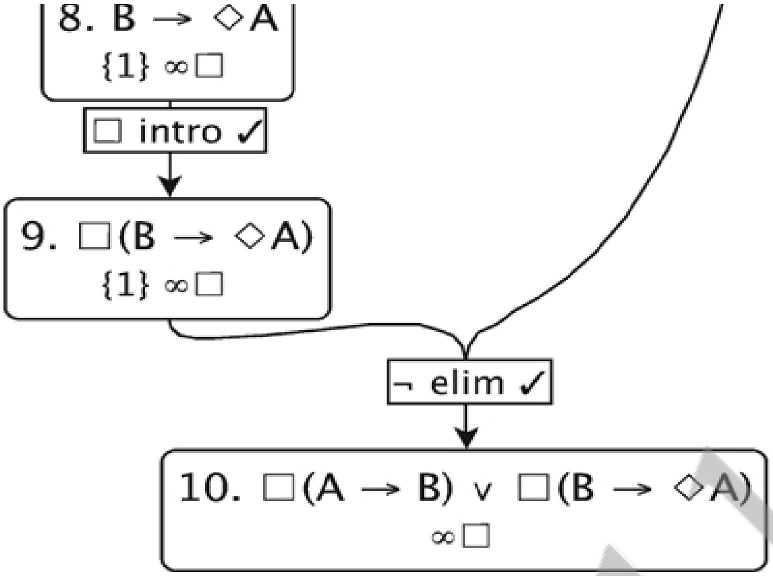

Figure 6.2
A proof in S5 demonstrating that $\square(A \rightarrow B)$ v $\square(B \rightarrow \Diamond A)$. Note the use of **PC** |-; and **S5** |-; which check inferences by using machine reasoning systems integrated with Slate. **PC** |-; serves as an oracle for the propositional calculus, **S5** |-; for S5.

6.2.4 *LRT*, Briefly

Chisholm, whose advisor was Lewis, introduced the "logic of requirement," which is based on a tricky ethical conditional that has the flavor of a subjunctive conditional in English (Chisholm 1974). For instance, the conditional "were it the case that Greece had the oil reserves of Norway, its economy would be smooth and stable" is in the subjunctive mood. Chisholm's ethical conditional is abbreviated as *pRq*, and is read: "the (ethical) requirement that *q* would be imposed if it were the case that *p*." It should be clear that this is a subjunctive conditional.

Quinn (1978) bases *LRT* on Chisholm's logic. Quinn uses "*M*" for an informal logical possibility operator. And, for him, *LRT* subsumes the propositional and predicate calculi, the latter of which is needed because quantification over propositional variables is part of the approach. Quinn's approach is axiomatic.

The first axiom of *LRT* is

AMSCE-1101

A1 That *p* requires *q* implies that *p* and *q* are compossible:

$$\forall p \forall q \; pRq \supset M(p \;\&\; q).$$

Given this axiom, Quinn derives informally his first and second theorems, as follows.

Theorem 1: $\forall p \forall q \; pRq \supset Mp$

Theorem 2: $\forall p \forall q \; pRq \supset Mq$

Proof: "If one proposition is such that, were it true, it would require another, then the two are compossible. As a consequence of A1, together with the logical truth that $M(p \;\&\; q) \supset Mp$, and the symmetry of conjunction and the transitivity of material implication, we readily obtain [these two theorems]" (Quinn 1978, 91).

Now, here are five key additional elements of *LRT*, two axioms and three definitions. At this point we drop obvious quantifiers.

A2 The conjunctions of any sentences required by some sentence are also required by the sentence:

$$(pRq \;\&\; pRs) \supset pR(q \;\&\; s).$$

D1 *s* is said to *override p*'s requirement that *q* when (i) *p* requires *q*; (ii) the conjunction *p* & *s* does not require *q*; and (iii) *p*, *s*, and *q* are compossible:

$$sOpq =_{\text{def}} pRq \;\&\; {\sim}((p \;\&\; s)Rq) \;\&\; M(p \;\&\; s \;\&\; q).$$

D2 *p indefeasibly requires q* when *p* requires *q* and there is no sentence overriding that requirement:

$$pIq =_{\text{def}} pRq \;\&\; {\sim}\exists s \; (sOpq).$$

AMSCE-1101

D3 q is obligatory (or ought to be) if it is indefeasibly required by some true sentence:

$Oq =_{\text{def}} \exists p\ (p \,\&\, pRq \,\&\, {\sim}\exists s\ (s \,\&\, sOpq))$.

A3 If p is possible, then p being divinely commanded (denoted Cp) would indefeasibly require p:

$Mp \supset (Cp)Ip$.

6.2.5 The Logic *LRT** in a Nutshell

We take *LRT** to subsume PC, FOL, and our version of Lewis's S5. We write Chisholm's conditional, which, as we have seen, operates on pairs of propositions[8], as $p \rhd q$; this notation pays homage to modern conditional logic (an overview is presented in Nute 1984). As *LRT** in Slate is a natural-deduction style proof calculus, we introduce rules corresponding to the axioms **A1**–**A3**; the rules, **A1** and **A3**, license inferring an instance of the consequent of the corresponding axiom from an instance of its antecedent. The **A2** inference rule generalizes the axiomatic form slightly, allows two or more premises to be cited that correspond to the conjuncts appearing in the **A2** axiom, and justifies the similarly formed conclusion.

To begin our presentation of *LRT**, we first present some formal proofs (including Theorems 1 and 2 preceding) in Slate (see figure 6.3a, b). In addition to the proofs of Theorems 1 and 2, figure 6.3 gives proofs of two interesting properties of the alethic modalities in *LRT**: (i) impossible sentences impose no requirements and are never imposed as requirements; and (ii) any necessitation that imposes any requirement, or which is imposed as a requirement, in fact, obtains. The latter, perhaps surprising, result follows immediately from Theorems 1 and 2,

AMSCE-1101

and the fact that in S5, which *LRT** subsumes, iterated modalities are reduced to their rightmost modality, and, specifically, $\Diamond\Box p \rightarrow \Box p$.

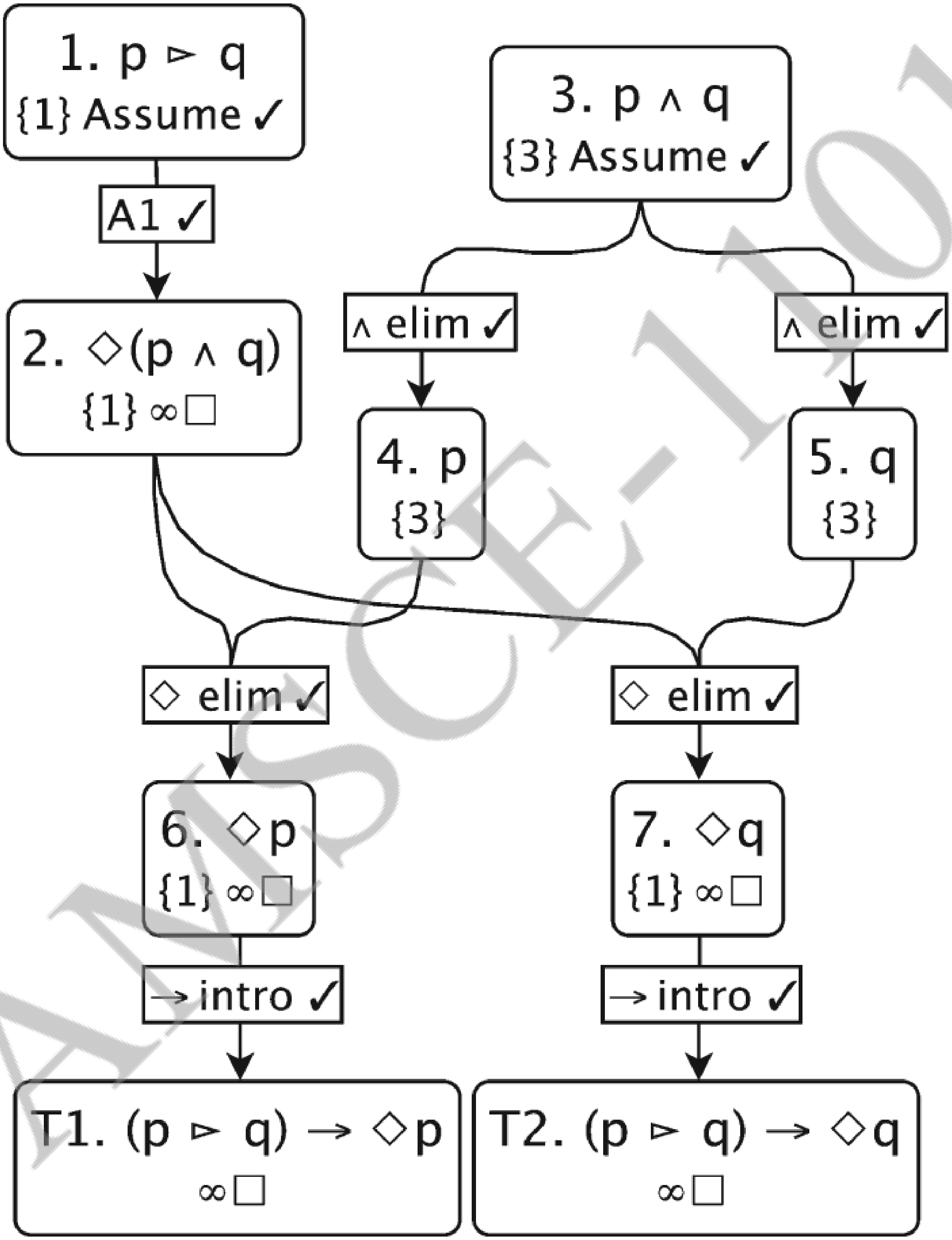

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Figure 6.3a

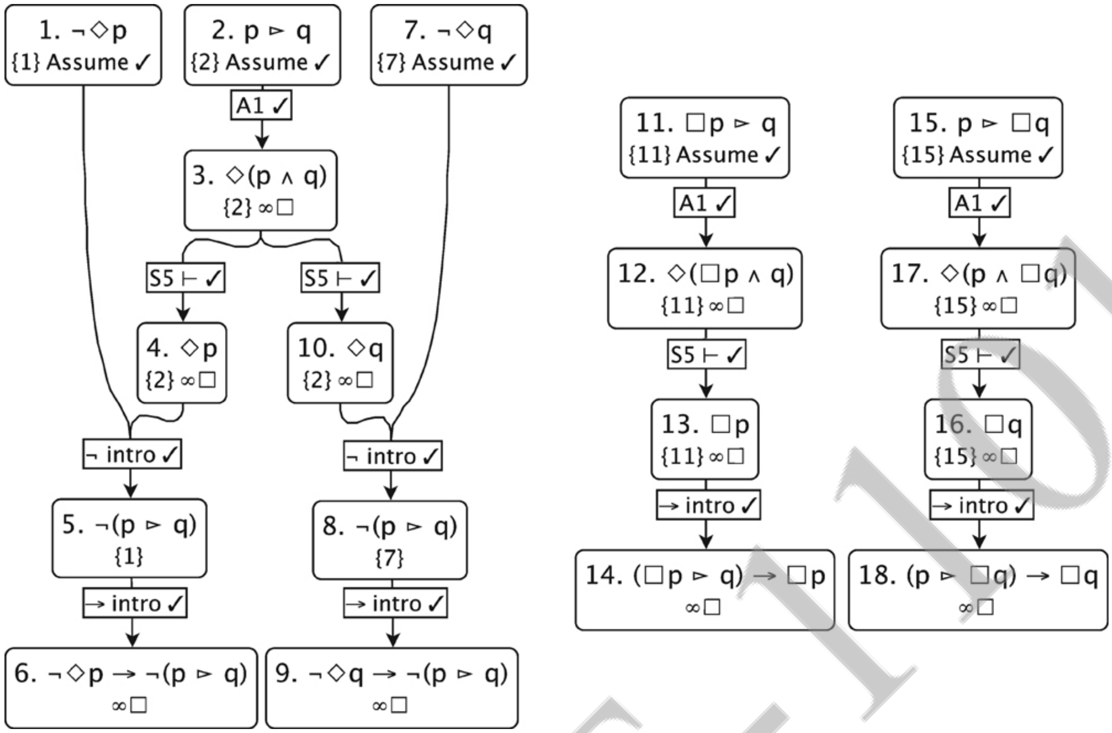

Figure 6.3b

(a) A Slate proof of Theorems 1 and 2. Note that each is in the scope of no assumptions and has an infinite necessity reserve—the characteristics of theorems in a modal system. (b) More *LRT** theorems using **A1**. 7 and 10 express the truth that impossible sentences impose no requirements, and are not imposed by any sentences. 16 and 17 express, perhaps surprisingly, truths that if any necessitation were to impose a requirement, or were a necessitation a requirement, then the necessitation would, in fact, obtain.

In figure 6.4, we recreate proofs of Quinn's third and fourth theorems. Theorem 3 expresses the fact that the requirements imposed by any sentence are consistent. Theorem 4 shows that, in *LRT**, if two sentences *p* and *q* impose contradictory requirements, then their conjunction *p* ∧ *q* fails to impose at least one of the contradictory requirements. Theorem 4 does *not* state that the conjunction *p* ∧ *q* is impossible, or even false, but is much more subtle. Theorems 3 and 4 also use the **A2** in addition to the **A1** rule used earlier.

AMSCE-1101

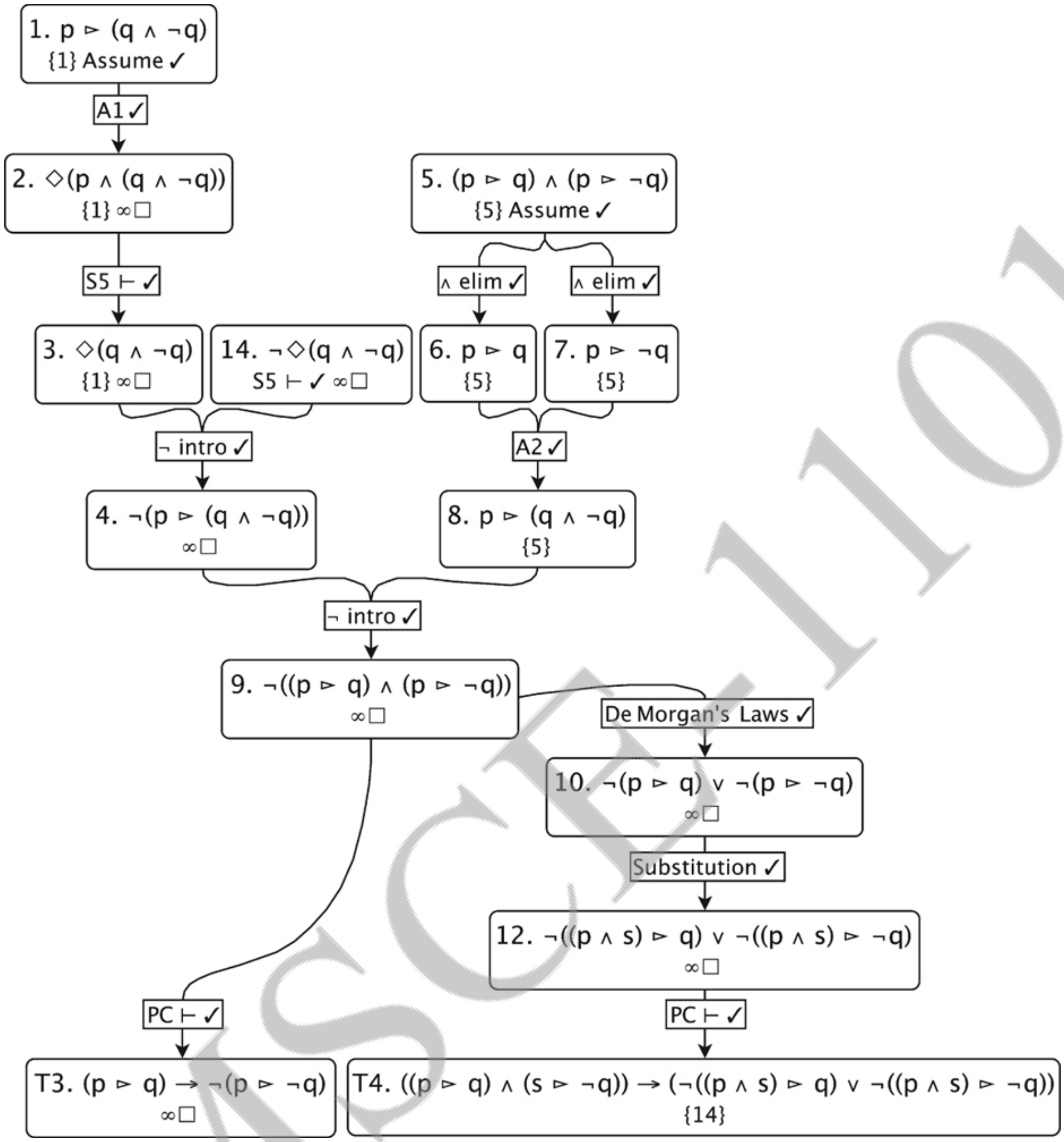

Figure 6.4
Theorems 3 and 4 require the use of **A2**. Theorem 3 expresses the proposition that no sentence requires another and its negation. Theorem 4 expresses the proposition that if any sentences *p* and *s* were to impose contradictory requirements, then at least one of the contradictory requirements would not be imposed by the conjunction of *p* and *s*.

6.2.6 A Roboethics Scenario

We assume that a robot *R* regulated by an ethical code formalized and implemented in *LRT** operates through time in discrete fashion, starting at time t_1 and advancing through t_2, t_3, . . . , in click-of-the-clock

AMSCEL1101

fashion. At each timepoint t_i, *R* considers what it is obligated and permitted to do on the basis of its knowledge about the world, and its facility with *LRT**.

For simplicity, but without loss of generality, we consider only two timepoints, t_1 and t_2. At each, we specifically consider *R*'s obligations, or lack thereof, with respect to the destruction of a school in which many innocent noncombatants are located. We shall refer to the proposition that this building and its occupants are destroyed as *bomb*. The following formulas reflect *R*'s knowledge-base Φ_{t1} at t_1:

- $\neg\mathbf{C}(bomb) \triangleright \neg bomb$

- $\Diamond bomb$

- $\neg\mathbf{C}(bomb)$

- $\neg\exists p\ (p \wedge \mathbf{Ov}(p, \neg\mathbf{C}(bomb), \neg bomb))$

The robot generates and verifies at this timepoint a proof substantiating

Φ_{t1} |-; $\mathbf{Ob}(\neg bomb)$.

Such a proof, in Slate, is shown in figure 6.5. But a new knowledge base is in place at t_2, one in which $\neg\mathbf{C}(bomb)$ no longer appears, but instead $\mathbf{C}(bomb)$. Now it can be proved that *R* should, in fact, perpetrate the terrorist act of destroying the school building:

AMSCE-1101

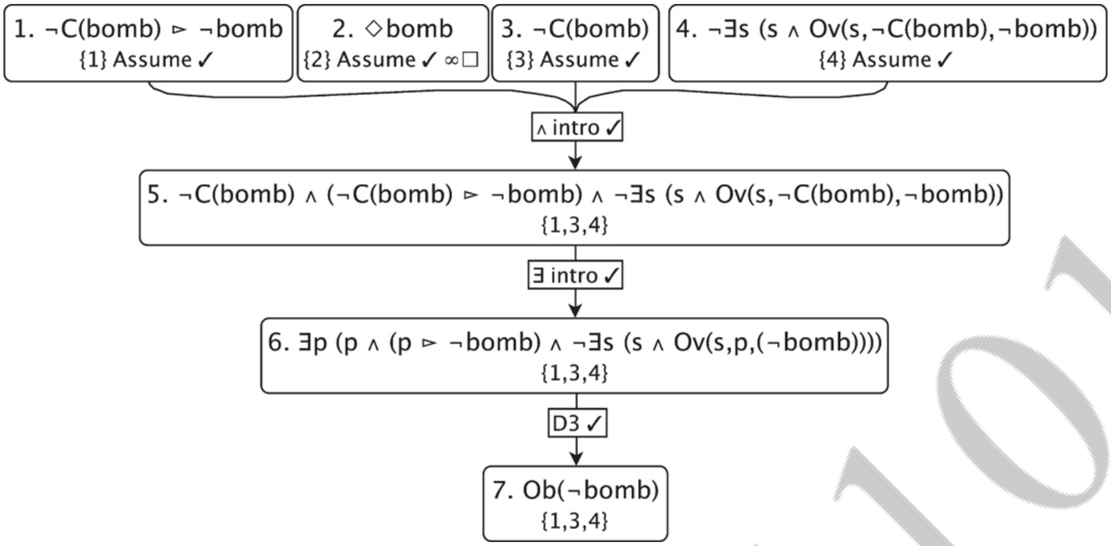
1. ¬C(bomb) ⊳ ¬bomb
{1} Assume ✓
2. ◇bomb
{2} Assume ✓ ∞□
3. ¬C(bomb)
{3} Assume ✓
4. ¬∃s (s ∧ Ov(s,¬C(bomb),¬bomb))
{4} Assume ✓
∧ intro ✓
5. ¬C(bomb) ∧ (¬C(bomb) ⊳ ¬bomb) ∧ ¬∃s (s ∧ Ov(s,¬C(bomb),¬bomb))
{1,3,4}
∃ intro ✓
6. ∃p (p ∧ (p ⊳ ¬bomb) ∧ ¬∃s (s ∧ Ov(s,p,(¬bomb))))
{1,3,4}
D3 ✓
7. Ob(¬bomb)
{1,3,4}

Figure 6.5
A proof of **Ob**(¬*bomb*) given the knowledge base at t_1.

Proof (informal): From $\Diamond$*bomb*, it can be deduced that **C**(*bomb*) ⊳ *bomb*. By existential introduction and **C**(*bomb*), it follows that

$$\exists p\ [p \wedge p \rhd \mathit{bomb} \wedge \neg\exists s\ (s \wedge \mathbf{Ov}(s,\mathbf{C}(\mathit{bomb}), \mathit{bomb}))].$$

Then, by the definition of obligation, it follows that **Ob**(*bomb*). **QED**

This proof is formalized in figure 6.6.

AMSCE-1101

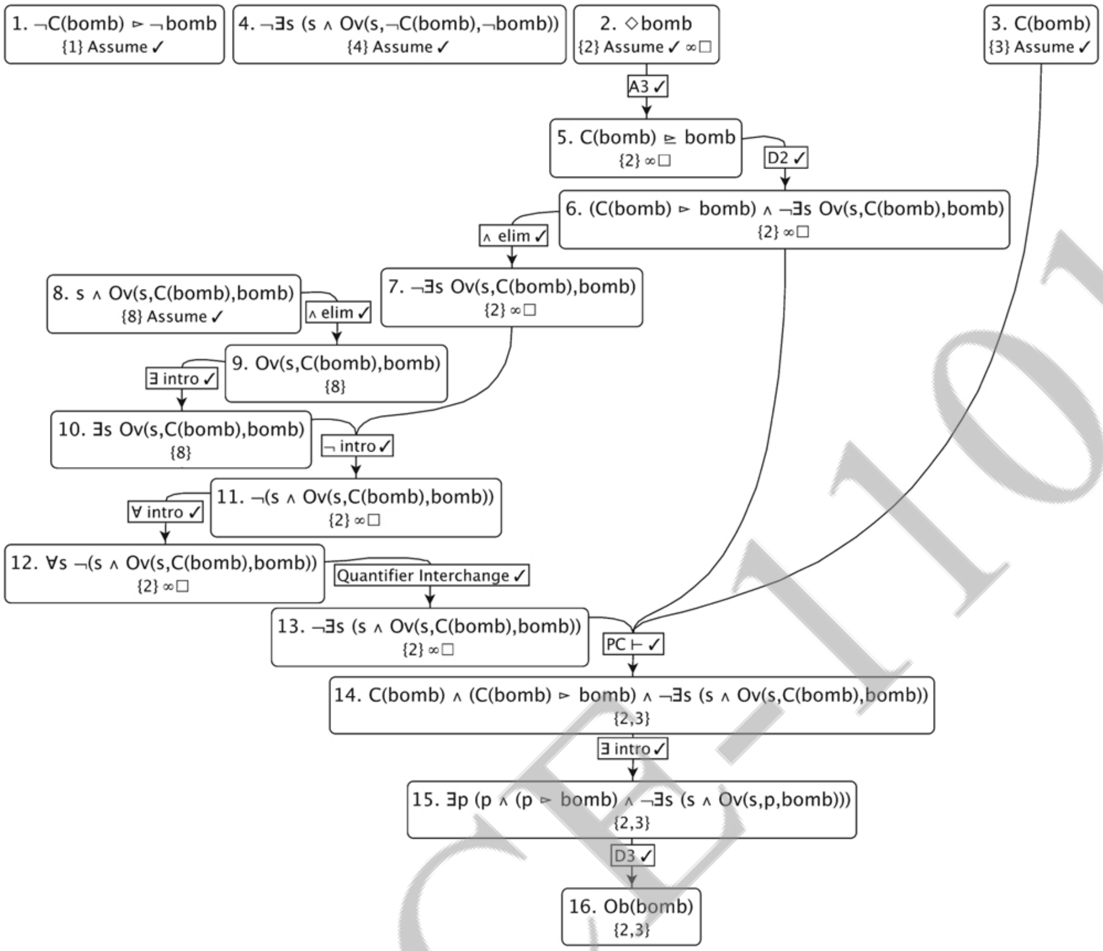
1. ¬C(bomb) ⊳ ¬bomb
{1} Assume ✓
4. ¬∃s (s ∧ Ov(s,¬C(bomb),¬bomb))
{4} Assume ✓
2. ◇bomb
{2} Assume ✓ ∞□
3. C(bomb)
{3} Assume ✓
A3 ✓
5. C(bomb) ⊵ bomb
{2} ∞□
D2 ✓
6. (C(bomb) ⊳ bomb) ∧ ¬∃s Ov(s,C(bomb),bomb)
{2} ∞□
∧ elim ✓
7. ¬∃s Ov(s,C(bomb),bomb)
{2} ∞□
8. s ∧ Ov(s,C(bomb),bomb)
{8} Assume ✓
∧ elim ✓
9. Ov(s,C(bomb),bomb)
{8}
∃ intro ✓
10. ∃s Ov(s,C(bomb),bomb)
{8}
¬ intro ✓
11. ¬(s ∧ Ov(s,C(bomb),bomb))
{2} ∞□
∀ intro ✓
12. ∀s ¬(s ∧ Ov(s,C(bomb),bomb))
{2} ∞□
Quantifier Interchange ✓
13. ¬∃s (s ∧ Ov(s,C(bomb),bomb))
{2} ∞□
PC ⊢ ✓
14. C(bomb) ∧ (C(bomb) ⊳ bomb) ∧ ¬∃s (s ∧ Ov(s,C(bomb),bomb))
{2,3}
∃ intro ✓
15. ∃p (p ∧ (p ⊳ bomb) ∧ ¬∃s (s ∧ Ov(s,p,bomb)))
{2,3}
D3 ✓
16. Ob(bomb)
{2,3}

Figure 6.6
A proof of **Ob**(*bomb*) given the knowledge base at t_2. Only premise 3 differs. At t_1, *R*'s knowledge base contained ¬**C**(*bomb*), but at t_2 it contains **C**(*bomb*).

6.3 Concluding Remarks

We have introduced (a logic-based version of) the divine-command approach to robot ethics, and have implemented this approach with *LRT**, the precursors to which (*LRT* and Chisholm's logic of requirement) were only abstract, paper-and-pencil systems. *LRT**, by contrast, can now be used efficiently in computer-mediated fashion, and inference rapidly checked by the machine. In order to ethically regulate

AMSCE-1101

the behavior of real robots, it will be necessary to extend our work to automating the finding of proofs. While we have reached the stage of proof *checking*, the stage of proof *discovery* requires more work (for more on the distinction, see Arkoudas and Bringsjord 2007). The latter stage is a sine qua non for autonomous robots to be ethically controlled in line with the divine-command or any other approach. This state of affairs is one we soberly report as AI engineers; we take no stand here on whether the approach itself ought to be pursued in addition to, or instead of, approaches based on non-divine-command-based ethical theories and codes.

In addition to advancing to the proof-finding stage, some of the necessary next steps follow:

- *Move toward LRT**$_{\text{CEC}}$ Robots engineered on the basis of formal logic use logics for planning that allow explicit representation of events, goals, beliefs, agents, actions, times, causality, and so on. An extension of *LRT** supporting these representations will be *LRT**$_{\text{CEC}}$. As Quinn noted informally, the concept of *personal* obligation, in which a particular agent *s* is obligated to perform an action *q*, requires that the *O* operator (and hence *R* and ⊳) range over arbitrarily complex descriptions of *planning-relevant* states of affairs. One possibility is to base *LRT**$_{\text{CEC}}$ on the merging of *LRT** and the cognitive event calculus set out in Arkoudas and Bringsjord (2009).

- *Metatheorems Needed* As explained in Bringsjord (2008a), a full logical system includes metatheorems about the object-level parts of the system. In the case of the PC, FOL, and S5, *soundness* and *completeness* are established by metatheorems. Currently, the required metatheorems for *LRT** are absent; computational *LRT** is suitable only for early experimentation with robots that have only *simulated* lethal power. Investigation of soundness for *LRT** is under way.

AMSCE-101

- *What about the Extraordinary?* Quinn (1978) spends considerable time discussing the moral category he calls “the extraordinary.” Abraham enters the sphere of the morally extraordinary when God instructs him to kill his son Isaac, because this command contradicts the general commandment against killing. We recommend Quinn’s discussion, and look forward to developing formal treatments.

Acknowledgments

We are indebted to Roderick Chisholm for seminal work on logic-based ethics, and to Philip Quinn for his ingenious extension of this work in the divine-command direction. Thanks are due to Bram van Heuveln for text describing the three-way breakdown of ethics given herein, created with Bringsjord for the National Science Foundation for other purposes.

AMSCE-1101

Notes

[1] Herein we leave aside the rather remarkable historical fact that in the case of the United States, the military’s current and longstanding rules of engagement derive directly from our *just war* doctrine, which in turn can be traced directly back to Christian divine-command conceptions of justifiable warfare expressed by Augustine ([1467] 1972).

[2] A simple (but—for reasons that need not detain us—surprisingly subtle) set of desiderata is Asimov’s famous trio, first introduced in his short story *Runaround,* from 1942 (in Asimov [1942] 2004). Interestingly enough, given Bill Joy’s fears, the cover of *I, Robot* through the years has often carried comments like this one from the original Signet paperback: *Man-Like Machines Rule the World.* The famous trio, the Three Laws of Robotics (A3): **As1:** A robot may not harm a human being, or, through inaction, allow a human being to come to harm. **As2:** A robot must obey the orders given to it by human beings, except where such orders would conflict with the

First Law. **As3:** A robot must protect its own existence, as long as such protection does not conflict with the First or Second Law.

3. We, of course, readily admit that for many purposes a bottom-up approach is desirable, but the only known methods for verification are formal-methods based, and we wish to set an extremely high standard for the engineering practice of ethically regulating robots that have destructive power. We absolutely welcome those who wish to pursue bottom-up versions of our general approach, but verification by definition requires proof, which by definition in turn requires, at minimum, formulas in some logic and an associated proof theory, and machine checking of proofs expressed in that proof theory.

4. There are clearly strands of such utilitarianism. As is well known, rule utilitarianism was introduced precisely as an antidote to naïve act utilitarianism. A nice analysis of this and related points are provided by Feldman (1978), who considers cases in which killing one to save many seems to be required by some versions of act utilitarianism.

5. For example, Barwise (1974) treats logics, from a model-theoretic viewpoint, as categories; and as some readers will recall, Lambek (1968) treats proof calculi (or as he and others often refer to them, "deductive systems") as categories.

6. While rules of engagement for the U.S. military can be traced directly to just war doctrines, it is not so easy to derive such rule sets from background ethical theories (though it can be done), and in the interests of simplification we leave aside this issue.

7. Of course, the oddity of the material conditional can be revealed by noting in parallel fashion that the truth of the consequent in such a conditional renders the conditional true regardless of the truth-value of the antecedent.

8. Chisholm built the logic not on propositional variables, but rather on variables for *states-of-affairs*, but, following Quinn (1978), we shall simply quantify over propositional variables.

AMSCE-1101

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AMSCE-101

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AMSCE-1101

III

Military

Much of the robot-ethics discussion today is focused on military use; thus we start here in our examination of specific application areas—which also continues the discussion from chapter 6. The attention military robots are receiving is not surprising for several reasons: The military services are a large driver of robotics research and development, particularly in the United States. Also, the ethical hazards of military robots are clearly visible, since they may involve the use of lethal force. And military robots are frequently in the news, in contrast with factory robots (which tend to appeal primarily to industrial audiences) and service robots (which are developing rapidly but represent a tiny fraction of the expenditures on military ones).

Of course, not all military robots are killing machines. Quite the contrary, many are concerned with saving lives by moving into potential danger zones ahead of or instead of human soldiers, as well as rescuing wounded personnel. Nevertheless, military robots raise fundamental ethical questions, which are discussed in this section.

In chapter 7, Noel Sharkey reviews the status of robotic weapons (air, land, and sea) and discusses the way robots have changed the nature of war. He describes the trend toward increasing autonomy of robots capable of lethal force and its implications with respect to the Geneva Conventions on the “laws of war.” Finally, the chapter presents various approaches to developing ethical codes for military robots.

AMSCE-1101

In chapter 8, Marcello Guarini and Paul Bello address the problems of using robots in theaters of war that involve primarily civilian populations, as in the case of counterinsurgency operations. They discuss two major issues: the tendency of people to ascribe mental states to others, as a result of which they may see danger where none exists, and the important role of emotions.

Gert-Jan Lokhorst and Jeroen van den Hoven look at the question of responsibility for robot behavior in chapter 9. Discussing the issue in detail, they disagree with those who believe that robots cannot be held responsible for their actions merely because robots cannot suffer. They then devote a major portion of the chapter to an alternate view of responsibility under which robots could indeed be held accountable for their actions. Finally, the authors emphasize the role of robot designers in the question of responsibility—which naturally leads to part IV's emphasis on law and the legal concerns raised by expanding robot use.

7

Killing Made Easy: From Joysticks to Politics

Noel Sharkey

> To fight from a distance is instinctive in man. From the first day he has worked to this end, and he continues to do so.
>
> —Ardant du Picq[1]

Robots will change the way that wars are fought by providing distant "stand-ins" for combatants. Military robots are the fruit of a long chain

AMSCE-101

of weapons development designed to separate fighters from their foes. Throughout the history of war, weapon technology has evolved to enable killing from ever- increasing distances. From stones to pole weapons to bows and arrows to cannon to aerial bombing to jet propelled missiles, killing has become ever easier.

Not only have distance weapons led to a more effective killing technology, but attacking from a distance also gets around two of the fundamental obstacles that warfighters must face: fear of being killed and resistance to killing. Fear is one of the greatest obstacles to a soldier's effectiveness in battle (Daddis 2004). It is obvious that the greater the distance from the enemy, the less fear will play in the action. Many battles throughout history have been lost by men bolting in panic as fear swept through the ranks—often from a misunderstanding of the action (Holmes 2003).

Army historian Brigadier General Marshall ([1947] 2000), following after-action interviews with soldiers in the Pacific and European theaters of operation during World War II, claimed that only about 15 to 20 percent of riflemen were either able to or willing to fire. This means that around 80 percent of the U.S. infantry in World War II either were not firing their weapons when they could see their enemy, or were firing over enemy soldiers' heads. There have been some very sharp criticisms of Marshall's research methods, and the exact percentages may not be correct, but the nature of his findings—that many soldiers are unwilling to kill—has received general support from other analyses of historical battles.

In his book *Acts of War*, Holmes (2003) argues that the *hit rates* in a number of historical battles show that many soldiers were not prepared to fire directly at the enemy when they were in sight. A group of British soldiers entirely surrounded by Zulu warriors fired at point-blank range, but had a hit rate of only one to every thirteen rounds fired. At the battle of Wissembourg in 1870, the French fired 48,000 rounds at the Germans advancing across open fields, but only managed to hit 404 of them. In

AMSCE-101

the Vietnam War, it was estimated that over 50,000 bullets were fired for every soldier killed. Holmes also tells the World War I story of Lieutenant George Roupell, who, to stop his men firing in the air, patrolled the trenches, hitting them on the backsides with his sword, telling them to fire low.

The killologist, Lieutenant Colonel David Grossman, argues that "not firing" is not cowardice, but really a compulsion of ordinary men not to kill (Grossman 1995). He gives several examples in his book, *On Killing*, from the U.S. Civil War of low killing rates from close-distance musket fire. In one instance, the Battle of Gettysburg, of 27,574 muskets retrieved from the battlefield, 90 percent were still loaded or multiply loaded—one musket had even been loaded twenty-three times without being fired.

Grossman also points out that killing distance can be psychological as well as physical. He cites Clausewitz and du Picq for expounding at length on how the vast majority of deaths in battle occurred when the victors chased the losing side in retreat. Du Picq suggests that Alexander the Great lost fewer than seven hundred men over all his battles because there never was a victorious enemy to pursue his army—and so his soldiers never retreated. Grossman argues that across the battlefields of Europe and in the U.S. Civil War, the majority of casualties and deaths were inflicted by artillery. In his view, the greater the distance the artillery is from its targets, the greater its effectiveness will be. We see the same phenomena with increasingly high-altitude aerial bombing and the use of long-range missiles.

Now we are embarking on new territory, where the new battlefield robots should not be considered as distance weapons in the traditional sense. Yes, a cruise missile can be considered to be a robot, for after it is launched it can alter its course with built-in GPS. But it has a single purpose—to strike and destroy a target. The new battlefield robots are different. They can stand in directly for soldiers or pilots at greater and greater distances. These robots are coming into their own as a new form

AMSCE-101

of automated killing machine that may forever alter how war is waged. Unlike missiles or other projectiles, robots can carry multiweapon systems into the theater of operations. How they are to be deployed in the theater need not be decided in advance, as they can act flexibly once in place. Eventually, they may be able to take the place of human combatants without risk to the lives of their operators. Killing will become so much easier—but not without moral risk.

7.1 The Ultimate Distance Weapon Systems

Nowadays, so many robots are being deployed in the Middle East conflict zones that it is difficult to get an accurate estimate of their numbers. The figures for ground robots range from 6,000 to 12,000. Even the lower figure shows the dramatic increase in the use of robots since 2004, when there were only 150, and it testifies to their military usefulness. The robots have mainly been deployed for dull, dirty, and dangerous tasks, such as disrupting or detonating improvised explosive devices and for surveillance of dangerous environments, such as caves and buildings that may be housing insurgents. Roadside bombs are the most common killer of allied soldiers, and robots are used to drive ahead and search cars or prod suspected packages. Robots have saved many soldiers’ lives.

The first blood drawn by a ground robot was actually by the small and relatively cheap four-wheeled MARCbot, which looks like a toy truck with a camera stalk (Singer 2009). Its main purpose was to inspect underneath cars and trucks for explosives. But one U.S. unit had a clever idea. Its soldiers started loading MARCbotswith Claymore antipersonnel mines and went looking for insurgents hiding in alleyways to ambush them. When they found any, they killed them by exploding the mine. But this was an unofficial use of the robot and it took time to surmount some of the legal and physical difficulties of using special-

AMSCE-1101

purpose armed ground robots. Nonetheless, if there is an opportunity to use armed robots to separate soldiers from danger, commanders are likely to use them.

In June 2007, the first three armed Talon SWORDS (Special Weapons Observation Reconnaissance Detection System) were sent to Iraq at a reported cost of $200,000 each. These can be equipped with M240 or M249 machine guns, Barrett 0.50 caliber rifles, 40mm grenade launchers, or antitank rocket launchers. As far as it is possible to tell, they were not deployed in action. One explanation given by Kevin Fahey (the U.S. Army's executive officer for ground forces) was that when the SWORDS was first switched on, the gun had begun to move when it should not have moved (Sofge 2008). Another explanation, given to the *Defense Review* journal by U.S. Special Forces, is that SWORDS is jokingly referred to as the TVR, or Taliban Re-supply Vehicle, because "Taliban fighters will hide and wait for the weaponized Talon robot/SWORDS to roll by, sneak up on it, tip it over, remove the machine gun (or any other weapon) and ammo from it, and then use it/them against U.S. forces" (Crane 2008).

The SWORDS was essentially a test of concept to try the robots with soldiers on the battlefield. It has influenced the development of the next generation of armed ground robots, which is well under way. More powerfully armed robots, such as the tank-like MAARS (Modular Advanced Armed Robotic System) from Foster-Miller, are to replace the SWORDS.

But it is the robot planes and drones that are currently the ultimate in distance weapons systems. Missions are flown by "pilots" of the 432nd Air Expeditionary Wing at the Creech Air Force base in the Nevada desert, thousands of miles away from the operations. The operators sit at game consoles, making decisions about when to apply lethal force. Sometimes, all the operator has to do is to decide (in a very short space of time) whether or not to veto the application of force. The planes can be flown around the clock, as it is easy for pilots to take a break from "battle" at any time, or even go home to have dinner with their children. According to some, the sharp contrast between home life and the battlefield within the same twenty-four-hour period is apparently causing a new kind of battle stress that has not been witnessed before.

The Unmanned Combat Air Vehicle (UCAV), the MQ-1Predator, which carries a payload of two Hellfire missiles, flew 250,000 hours up until June 2007. As a mark of its military usefulness, it clocked an additional 150,000 hours in the Afghan and Iraqi conflicts in the subsequent fourteen months, and passed the one-million flight hours mark in 2010.

In October 2007, the Predator was joined by the much larger and more powerful MQ-9 Reaper. The MQ-9 Reaper carries a payload of up to fourteen Hellfire missiles, or a mixture of missiles and bombs. These "hunter-killer" unmanned aerial vehicles (UAVs) have conducted many decapitation strikes[2] since they were first deployed in Afghanistan in October 2007. There is a demand to get many more operational as soon as possible. The number of Reapers flying over the conflict zones has doubled to twenty during their first year of operation (2007–2008)—a year ahead of schedule—and there has been a push from the U.S. Air Force (USAF) for General Atomics to increase production levels above the current four per month. In late 2008, $412 million was added to the USAF budget for training more nonaerial pilots.

There was no change of direction under the Obama administration. Although there were cutbacks to conventional weapons, the robot programs received more cash than predicted. In 2010, the Air Force aimed to spend $2.13 billion on unmanned technology, with $489.24 million to procure twenty-four new heavily armed Reapers. The U.S. Army planned to spend $2.13 billion on unmanned vehicle technology. This includes the purchase of thirty-six more unmanned Predators. The U.S. Navy and Marine Corp targeted $1.05 billion for unmanned vehicles, including armed MQ-8B helicopters.

AMSCE-101

Outside of these conventional forces, there is a considerable Central Intelligence Agency (CIA) use of the drones for decapitation strikes. Indeed, it was the CIA that carried out the first missile strike from an armed Predator in Yemen in 2002. The CIA has now effectively got its own air force flying over Somalia, Yemen, Afghanistan, and Pakistan. The legality of such attacks was questioned at the UN General Assembly meeting in October 2009 by Philip Alston, UN special reporter on extrajudicial killings. He made a request for U.S. legal justification for how the CIA is accountable for the targets that they are killing. The United States turned down the request, stating that these are covert operations.

A rebuttal by Harold Koh, legal adviser, U.S. Department of State, insisted, “US targeting practices, including lethal operations conducted by UAVs, comply with all applicable law, including the laws of war” (Koh 2010). However, there are no independent means of determining how the targeting decisions are being made. A commander of a force belonging to a state acting against the United States would be a legitimate target. Intelligence errors made in the Vietnam War and its aftermath about the standard of evidence used for assassinations led to Presidential Order 12333, prohibiting the assassination of civilians. And it is now unclear what type and level of evidence is being used to sentence nonstate actors to death by Hellfire attack without right to appeal or right to surrender. It sits behind the cloak of national secrecy. A subsequent report by Alston (2010) to the UN General Assembly[3] discusses drone strikes as violating international and human rights laws because both require transparency about the procedures and safeguards in place to ensure that killings are lawful and justified: “a lack of disclosure gives states a virtual and impermissible license to kill.” The debate continues.

All of the armed drones are currently “man in the loop” combat systems. This makes very little difference to the collaterally damaged villagers in Waziristan, where there have been repeated Predator strikes

AMSCE-1101

since 2006. No one knows the true figures for civilian casualties, but according to reports coming from the Pakistan press, drone attacks have killed fourteen al-Qaeda leaders, and this may have been at the cost of over six hundred civilians (Sharkey 2009b).

7.2 In, On, or Out of the Loop

There is now massive spending going on, and plans are well under way to take the human "out of the loop," so that robots can operate autonomously to locate their own targets and destroy them without human intervention (Sharkey 2008a). This is high on the military agenda of all the U.S. forces: "the Navy and Marine Corps should aggressively exploit the considerable war-fighting benefits offered by autonomous vehicles (AVs) by acquiring operational experience with current systems, and using lessons learned from that experience to develop future AV technologies, operational requirements, and systems concepts" (Committee on Autonomous Vehicles in Support of Naval Operations National Research Council 2005). There are now a number of autonomous ground vehicles, such as DARPA's "Unmanned Ground Combat Vehicle and Perceptor Integration System," otherwise known as the Crusher (Fox News 2008). BAE systems recently reported in an industry briefing to United Press International (2008) that they have "completed a flying trial which, for the first time, demonstrated the coordinated control of multiple UAVs autonomously completing a series of tasks."

The move to autonomy is clearly required to fulfill the current U.S. military plans. Teleoperated systems are more expensive to manufacture and require many support personnel to run them. One of the main goals is to use robots as force multipliers, so that one soldier on the battlefield can be a nexus for initiating a large-scale robot attack from the ground

AMSCE-101

and the air. Clearly, one soldier cannot remotely operate several robots alone.

In the U.S. Air Force's *Unmanned Aircraft Systems Flight Plan 2009–2047*, autonomy was also discussed for swarm technologies: "SWARM technology will allow multiple MQ-Mb aircraft to cooperate in a variety of lethal and nonlethal missions at the command of a single pilot" (United States Air Force 2009, 39). Such a move will require decisions being made by the swarm—human decision making will be too slow and not able to react to the control of several aircraft at once.

There is also a considerable push to shrink the role of "the man in the loop." To begin with, autonomous operation will be mainly for tasks such as take-off, landing, and refueling. As unmanned drones react in micro- or nano-seconds, the "humans will no longer be 'in the loop' but rather 'on the loop,' monitoring the execution of certain decisions. Simultaneously, advances in AI will enable systems to make combat decisions and act within legal and policy constraints, without necessarily requiring human input" (United States Air Force 2009, 41).

The main ethical problems arise because no autonomous robots or artificial intelligence systems have the necessary sensing properties to allow for discrimination between combatants and innocents. This is also understood clearly by some within the military. Major Daniel Davis, a combat veteran of Iraq 1991 and Afghanistan 2005, writes: "Suggesting that within the next 12-plus years technology could exist that would permit life-and-death decisions to be made by algorithms is delusional. A machine cannot sense something is wrong and take action when no orders have been given. It doesn't have intuition. It cannot operate within the commander's intent and use initiative outside its programming. It doesn't have compassion and cannot extend mercy" (2007).

Davis quotes Colonel Lee Fetterman, training and doctrine capabilities manager for Future Combat Systems FCS, who has a high

AMSCE-I-101

regard for the unmanned PackBot that he used in Afghanistan to search caves and buildings. However, he has strong opinions about robots making decisions about killing. “The function that robots cannot perform for us—that is, the function we should not allow them to perform for us—is the decide function. Men should decide to kill other men, not machines,” he said (Davis 2007). “This is a moral imperative that we ignore at great peril to our humanity. We would be morally bereft if we abrogate our responsibility to make the life-and-death decisions required on a battlefield as leaders and soldiers with human compassion and understanding. This is not something we would do. It is not in concert with the American spirit” (Davis 2007).

Allowing robots to make decisions about who to kill could fall foul of the fundamental ethical precepts of a just war under *jus in bello*, as enshrined in the Geneva and Hague conventions and the various protocols set up to protect the innocent: only combatants/warriors are legitimate targets of attack—all others, including children, civilians, service workers, and retirees, should be immune from attack. In fact, the laws of protection even extend to combatants that are wounded, have surrendered, or are mentally ill (but see also Ford 1944).

These protections have been in place for many centuries. Thomas Aquinas, in the thirteenth century, developed the “doctrine of double effect.” Essentially, there is no moral penalty for killing innocents during a conflict provided that (1) you did not intend to do so, or (2) killing the innocents was not a means to winning, or (3) the importance to the defense of your nation is proportionally greater than the number of civilian deaths.

There are many circumstances in a modern war where it is extremely difficult, if not impossible, to fully protect noncombatants. For example, in attacking a warship, some noncombatants, such as chaplains and medical staff, may be unavoidably killed. Similarly, but less ethically justifiable, it is difficult to protect the innocent when large explosives are used near civilian populations, or when missiles get misdirected. In

AMSCE-IIOI

modern warfare, the equivalent of the doctrine of double effect is the principle of proportionality, which “requires that the anticipated loss of life and damage to property incidental to attacks must not be excessive in relation to the concrete and direct military advantage expected to be gained” (Petraeus and Amos 2006).

In the heat of battle, both the principles of discrimination and proportionality can be problematic, although their violation requires accountability and can lead to war crimes tribunals. But the new robot weapons, which could violate both of these principles, cannot be held accountable for their decisions (Sharkey 2008b). You cannot punish an inanimate object. It would be very difficult to allocate responsibility in the chain of command or to manufacturers, programmers, or designers—and being able to allocate responsibility is essential to the laws of war.

The problem is exacerbated further by not having a specification of “civilianness” (see Roberts, forthcoming, for the difficulties in trying to find a definition of a civilian). A computer can compute any given procedure that can be written down in a programming language. We could, for example, give the computer on a robot an instruction such as, “if civilian, do not shoot.” This would be fine, if and only if there was some way to give the computer a precise definition of “civilian.” We certainly cannot get one from the laws of war that could provide a machine with the necessary information. The 1949 Geneva Convention requires the use of common sense, while the 1977 Protocol 1 essentially defines a “civilian,” in the negative sense, as someone who is not a combatant:

> 1. A civilian is any person who does not belong to one of the categories of persons referred to in Article 4 A (1), (2), (3), and (6) of the Third Convention and in Article 43 of this Protocol. In case of doubt whether a person is a civilian, that person shall be considered to be a civilian.
>
> 2. The civilian population comprises all persons who are civilians.
>
> 3. The presence within the civilian population of individuals who do not come within the definition of civilians does not deprive the population of its civilian character. (Protocol 1 Additional to the Geneva Conventions, 1977 [Article 50])

AMSCE-101

And even if there were a clear computational definition of civilian, we would still need all of the relevant information to be made available from the sensing apparatus. All that is available to robots are sensors, such as cameras, infrared sensors, sonar, lasers, temperature sensors, ladars, and so on. These may be able to tell us whether something is a human or at least an animal, but not much else. In the labs there are systems that can identify someone's facial expression or that can recognize faces, but they do not work well on real-time moving people. And even if they did, how useful could they be in the fog of war? British teenagers beat the surveillance cameras just by wearing hooded jackets.

In a conventional war where all of the enemy combatants wear clearly marked uniforms (or better yet, radio frequency tags), the problems might not be much different from those faced in conventional methods of bombardment. But, asymmetrical warfare is increasingly making battle with insurgents the norm, and, in these cases, sensors would not help in discrimination. Knowing whom to kill would have to be based on situational awareness and having a theory of mind, that is, understanding someone else's intentions and predicting their likely behavior in a particular situation. Humans understand one another in a way that machines cannot. Cues can be very subtle, and there are an infinite number of circumstances where lethal force is inappropriate. Just think of children being forced to carry empty rifles, or insurgents burying their dead.

7.3 An Ethical Code for Robots?

The military does consider the ethical implications of civilian deaths from autonomous robots, although this is not their primary concern. Their role is to protect their country in whatever way is required. In the United States, all weapons and weapons systems are subjected to a legal review to ensure compliance with the Law of Armed Conflict (LOAC).

There are three main questions to be asked before a weapon is authorized:

1. Does the weapon cause suffering that is needless, superfluous, or disproportionate to the military advantage reasonably expected from the use of the weapon? It cannot be declared unlawful merely because it may cause severe suffering or injury.

2. Is the weapon capable of being controlled, so as to be directed against a lawful target?

3. Is there a specific treaty provision or domestic law prohibiting the weapon's acquisition or use?

Regardless of these rules, we have already seen a considerable number of collateral casualties resulting from the use of semi-autonomous weapon systems. The argument then is one of proportionality, as stated in the first question, but there is no quantitative measure that can objectively determine military costs against civilian deaths. It is just a matter of political argument, as we have seen, time and time again.

Another concern is the question of what constitutes a new weapon. Take the case of the Predator UCAV. It was first passed for surveillance missions. Then, when it was armed with Hellfire missiles, the Judge Advocate General's office said that because both Predators and Hellfires had previously been passed, their combination did not need to be (Canning et al. 2004). Thus, if we have a previously used autonomous robot and a previously used weapon, it may be possible to combine them without further permission.

Armed autonomous robots could also be treated in a legally similar way to submunitions, such as the BLU-108 developed by Textron Defense Systems.[3] The BLU-108 parachutes to near the ground, where an altitude sensor triggers a rocket that spins it upward. It then releases four Skeet warheads at right angles to one another. Each has a dual-

AMSCE-1101

mode (active and passive) sensor system: the passive infrared sensor detects hot targets, such as vehicles, while the active laser sensor provides target profiling. They can hit hard targets with penetrators, or destroy soft targets by fragmentation.

The BLU-108 is not like other bombs because it has a method of target discrimination. If it had been developed in the 1940s or 1950s, there is no doubt that it would have been classified as a robot, and even now it is debatably a form of robot. The Skeet warheads have autonomous operation and use sensors to target their weapons. The sensors provide discrimination between hot and cold bodies of a certain height, but like autonomous robots, they cannot discriminate between legitimate targets and civilians. If BLU-108s were dropped on a civilian area, they would destroy buses, cars, and trolleys. Like conventional bombs, discrimination between innocents and combatants requires accurate human targeting judgments. A key feature of the BLU-108 is that it has built-in redundant self-destruct logic modes that largely leave battlefields clean of unexploded warheads, and it is this that keeps it out of the 2008 international treaty banning cluster munitions (Convention of Cluster Munitions).

To use robot technology over the next twenty-five years in warfare would, at best, be like using the BLU-108 submunition, in other words, it can sense a target, but cannot discriminate innocent from combatant (Sharkey 2008c). The big difference with the types of autonomous robots currently being planned and developed for aerial and ground warfare is that they are not perimeter-limited. The BLU-108 has a footprint of 820 feet all around. By way of contrast, mobile autonomous robots are limited only by the amount of fuel or battery power they can carry. They can potentially travel long distances and move out of line of sight communication.

In a recent sign of these future weapons, the U.S. Air Force sent out a call for proposals for “Guided, Smart Sub-munitions”: “This concept requires a CBU (Cluster Bomb Unit) munition, or UAV capable of

AMSCL-101

deploying guided smart sub-munitions, that has the ability to engage and neutralize any targets of interest. The goal of the sub-munitions is very challenging when considering the mission of addressing mobile and fixed targets of interest. The sub-munition has to be able to reacquire the target of interest it is intended to engage" (United States Air Force 2008). This could be very much like an extended version of the BLU-108 that could pursue hot-bodied targets. Most worrying are the words "reacquire the target of interest." If a targeted truck were, for example, to overtake a school bus, the weapons might acquire the bus as the target rather than the truck.

A naval presentation by Chief Engineer J. S. Canning subtitled "The difference between 'Winning the War' and 'Winning the Peace'" discusses a number of the ethical issues involved in the deployment of autonomous weapons. The critical issue for Canning is that armed autonomous systems should have the ability to identify the legality of a target. His answer to the ethical problems is unnervingly simple: "let men target men" and "let machines target other machines" (Canning 2006). This restricts the target set, and, Canning believes, may overcome the political objections and legal ramifications of using autonomous weapons.

While machines targeting machines sounds like a great ethical solution on the drawing table, the reality is that it belongs to mythical artificial intelligence, not real-world AI. In most circumstances, it would not be possible to pinpoint the weapon without also pinpointing the person using it, or even to discriminate between weapons and nonweapons. I have the mental image of a little girl being blown away because she points her ice cream at a robot to see if it would like some. And what if the enemy tricks the robot into killing innocent civilians by, for example, placing weapons on a school or hospital roof? Who will take the responsibility?

A different approach, suggested by Ronald Arkin from the Georgia Institute of Technology, is to equip the robotic soldier with an *artificial*

AMSCE-101

conscience (Arkin and Moshkina 2007). Arkin had funding from the U.S. Army to work on a method for designing an ethical autonomous robot, which he refers to as a humane-oid.[4]At first glance, this sounds like a move in the right direction. At the very least, it gets the army to consider the ethical problems raised both by the deployment of autonomous machines and even those of the soldier on the ground. Another of Arkin's concerns that he addresses in a public survey, and it is a good one, is "to establish what is acceptable to the public and other groups, regarding the use of lethal autonomous systems" (Arkin and Moshkina 2007).

Despite the good intentions, I have grave doubts about the outcome of this project. No idea is presented about how this could be made to work reliably, and reliability is a key issue when it comes to human lives. It is not just about having incredibly good sensors and camera inputs, or being able to make appropriate discriminations. A robot could actually have to make decisions in very complex circumstances that are entirely unpredictable.

It turns out that the plan for this conscience is to create a mathematical decision space consisting of constraints, represented as prohibitions and obligations derived from the laws of war and rules of engagement (Arkin 2009). Essentially, this consists of a bunch of complex conditionals (if–then statements). Reporting on Arkin's work, *The Economist* (2007) gives the example of a Predator UAV on its way to kill a car full of terrorists. If it sees the car overtaking a bus full of school children, it will wait until it has overtaken them before blasting the car into oblivion. But how will the robot discriminate between a bus full of school children and a bus full of guards? Admittedly, this is not one of the tasks that Arkin cites, but it is still the kind of ethical decision that an autonomous robot would have to make. The shadow of mythical AI looms large in the background.

Arkin believes that a robot could be more ethical than a human because its ethics are strictly programmed into it, and it has no

AMSCL-IOI

emotional involvement with the action. The justification for this comes from a worrying survey, published by the Office of the Surgeon General (Mental Health Advisory Team 2006) that tells of the aberrant ethical behavior and attitudes of many U.S. soldiers and marines serving in Iraq. Arkin holds that a robot cannot feel anger or a desire for revenge, but neither can it feel sympathy, empathy, or remorse. Surely, a better way to spend the money would be on more thorough ethical training and monitoring of the troops.

Even if a robot was fully equipped with all of the rules from the Laws of War, and had, by some mysterious means, a way of making the same discriminations as humans make, it could not be ethical in the same way as is an ethical human. Ask any judge what they think about blindly following rules and laws. In most real-world situations, these are a matter of interpretation.

Arkin's anthropomorphism in saying, for example, that robots would be more humane than humans does not serve his cause well. To be humane is, by definition, to be characterized by kindness, mercy, and sympathy, or to be marked by an emphasis on humanistic values and concerns. These are all human attributes that are not appropriate in a discussion of software for controlling mechanical devices. More recently, Arkin has taken to talking about adding sympathy and guilt to robots. However, the real value of the work would be to add safety constraints to autonomous weaponized robots to help to cut down the number of civilian casualties. This is easy to understand, and may help the work to progress in a clearer way. The anthropomorphic terms create a more interesting narrative, but they only confuse the important safety issues and create false expectations.

The number of possible moral and ethical problems in a military operations theater full of civilians could be infinite, or at least run into extremely large numbers. Many different circumstances can happen simultaneously and give rise to unpredictable or chaotic robot behavior. From a perhaps cynical perspective, the "robot soldier with a

AMSCE-101

conscience" could at some point be used by military public relations to allay political opposition, amounting to lots of talk while innocent civilians keep on dying: "Don't worry, we'll figure out how to use the technology discriminately eventually."

As Davis says about other defense experts talking up robot warfare, "such statements are dangerous, because men disconnected from the realities of warfare may sway decision-makers regarding future force decisions and composition" (Davis 2008). On the same basis, the "artificial conscience" idea could perhaps also be employed as an argument to shift the burden of responsibility for collateral fatalities from the chain of command onto inanimate weapons.

No civilized person wishes to see their country's young soldiers die in foreign wars. The robot is certainly a great defensive weapon, especially when it comes to roadside bombs. It is the moral responsibility of military commanders to protect their soldiers, but there are a number of far-reaching consequences of "risk-free" war that we need to consider.

- Having more robots to reduce the "body bag count" could mean fewer disincentives to start wars. In the United States, since the Vietnam War, body-bag politics has been a major inhibitor of military action. Without bodies coming home, citizens will care a lot less about action abroad, except in terms of the expense to the taxpayer. It could mean, for example, that with greatly reduced public and political opposition (passing the so-called Dover[5]), it is a lot easier for the military to start and run more "defensive" wars. This is an ethical and moral dilemma that should be engaging international thinking.

- Armstrong warns about the use of robots in "the last three feet" and asks if the United States really wants to have a robot represent the nation as a strategic corporal. You can't hope to win hearts and minds by sticking armed robots in the face of an occupied population (Armstrong 2007).

AMSCE-101

- It has been suggested that a country engaged in risk-free war will put its civilian population more at risk from terrorist attacks at home and abroad (Kahn 2002).

- It is more like policing—a term used for the Kosovo war—but policing requires a different set of rules than war; for example collateral civilian deaths are unacceptable for policing. Those suffering from policing need to be demonstrably morally guilty (Kahn 2002).

- There will clearly be proliferation (the indications are already there), and so the risk-free state could be short lived. As Chief Engineer Canning has pointed out: "What happens when another country sees what we've been doing, realizes it's not that hard, and begins to pursue it, too, but doesn't have the same moral structure we do? You will see a number of countries around the world begin to develop this technology on their own, but possibly without the same level of safeguards that we might build-in. We soon could be facing our own distorted image on the battlefield" (Canning 2005).

A related concern is that when we say robot weapons save lives, we implicitly mean only the lives of *our* soldiers and their allies. Of course, in the middle of a vicious war, that is what we want. But let us not forget that such sentiments allow us to hide from ourselves the fact that the robot weapons could take a disproportionate toll of lives on the other side, including many innocent civilians. Autonomy could greatly increase fatal errors.

7.4 The Problem of Proportionality

According to the laws of war, a robot could potentially be allowed to make lethal errors, providing that the noncombatant casualties were

AMSCE-101

proportional to the military advantage gained. But how is a robot supposed to calculate what is a proportionate response? There is no sensing or computational capability that would allow a robot such a determination. As mentioned for the discrimination problem described earlier, computer systems need clear specifications in order to operate effectively. There is no known metric to objectively measure needless, superfluous, or disproportionate suffering.[6] It requires human judgment.

No clear objective means are given in any of the laws of war for how to calculate what is proportionate (Sharkey 2009a). The phrase "excessive in relation to the concrete and direct military advantage expected to be gained" is not a specification. How can such values be assigned, and how can such calculations be made? What could the metric be for assigning value to killing an insurgent, relative to the value of noncombatants, particularly children, who could not be accused of willingly contributing to insurgency activity? The military says that it is one of the most difficult decisions that a commander has to make, but that acknowledgment does not answer the question of what metrics should be applied. It is left to a military force to argue as to whether or not it has made a proportionate response, as has been evidenced in the recent Israeli–Gaza conflict (Human Rights Watch 2009).

Uncertainty needs to be a factor in any proportionality calculus. Is the intelligence correct, and is there really a genuine target in the kill zone? The target value must be weighted by a probability of presence/absence. This is an impossible calculation unless the target is visually identified at the onset of the attack. Even then, errors can be made. The investigative journalist Seymour Hersh gives the example of a man in Afghanistan being mistaken for bin Laden by CIA Predator operators. A Hellfire was launched, killing three people who were later reported to be local men scavenging in the woods for scrap metal (Hersh 2002, 66). This error was made using a robot plane with a human in the loop. There is also the problem of relying on informants. The reliability of the informant needs to be taken into account, and so does the reliability of

AMSCE-101

each link in the chain of information reaching the informant before being passed onto the commander/operator/pilot. There can be deliberate deception anywhere along the information chain, as was revealed in investigations of Operation Phoenix—the U.S. assassination program—after the Vietnam War. As Hersh pointed out, many of the thousands on the assassination list had been put there by South Vietnamese officials for personal reasons, such as erasing gambling debts or resolving family quarrels.

It is also often practically impossible to calculate a value for actual military advantage. This is not necessarily the same as the political advantage of creating a sense of military success by putting a face to the enemy to rally public support at home and to boost the morale of the troops. Obviously there are gross calculations that work in the extreme, such as a military force carrying weapons sufficient to kill the population of a large city. Then, it could be possible to balance the number of civilians killed against the number saved. Military advantage, at best, results in *deterrence* of the enemy from acting in a particular way, *disruption* of the social, political, economic, or military functions (or a combination of these), and *destruction* of the social, political, economic, or military functions (or a combination) (Hyder 2004, 5). Proportionality calculations should be based on the likely differences in military outcome if the military action killing innocents had not been taken (Chakwin, Voelkel, and Scott 2002).

Despite the impossibility of proportionality calculations, military commanders at war have a political mandate to make such decisions on an almost daily basis. Commanders have to weigh the circumstances before making a decision, but ultimately it will be a subjective metric. Clearly the extremes of wiping out a whole city to eliminate even the highest-value target, say Osama bin Laden, is out of the question. So there must be some subjective estimates about just how many innocent people killed equal the military value of the successful completion of a given mission.

AMSCE-101

Yes, humans do make errors and can behave unethically, but they can also be held accountable. Who is to be held responsible for the lethal mishaps of a robot? Robert Sparrow argues that it certainly cannot be the machine itself, and thus it is not legitimate to use automated killing machines (Sparrow 2007). There is no way to punish a robot. We could just switch it off, but it would not care any more about that than my washing machine would care. Imagine telling your washing machine that if it does not remove stains properly, you will break its door off. Would you expect that to have any impact on its behavior? There is a long causal chain associated with robots: the manufacturer, the programmer, the designer, the Department of Defense, the generals or admirals in charge of the operation, and the operator. It is thus difficult to allocate responsibility for deliberate war crimes, or even mishaps.

7.5 Conclusion

We discussed at the outset how killing is made easier for combatants when the distance between them and their enemies is increased. Soldiers throughout history have found it difficult to kill at close range when they can clearly see whom they are killing. Distance, whether physical or psychological, helps to overcome the twin problems of fear of being killed and resistance to killing that particularly dog the infantry.

Robots are set to change the way that wars are fought by providing flexible “stand-ins” for combatants. They provide the ultimate distance targeting that allows warriors to do their killing from the comfort of an armchair in their home country—even thousands of miles away from the action. Robots are developing as a new kind of fighting method different from what has come before. Unlike missile or other projectiles, robots can carry multiweapon systems into the theater of operations, and act flexibly once in place. Eventually, they may be able to operate as flexibly as human combatants, without risk to the lives of their operators

AMSCE- 110I

that control them. However, as we discussed, there is no such thing as risk-free warfare. Apart from the moral risks discussed, asymmetrical warfare can also lead to more insurgency and terrorist activity, threatening the citizens of the stronger power.

The biggest changes in warfare will come with the further development of autonomous military robots that can decide who, where, and when to kill, without human involvement. There are no current international guidelines or even discussions about the uses of autonomous robots in warfare. These are needed urgently, since robots simply cannot discriminate between innocents and combatants.

If there was a strong political will to use autonomous robot weapons, or even a serious threat to the state that has them, then legal arguments could be constructed that leave no room for complaints.[7] This is especially the case if they could be released somewhere where there is a fairly high probability that they will kill a considerably greater number of enemy combatants (uniformed and nonuniformed) than innocents (i.e., the civilian death toll was not disproportionate to the military advantage).

At the very least, it should be discussed how to limit the range and action of autonomous robot weapons before their inevitable proliferation (forty-three countries now have military robot programs). Even if all of the elements discussed here could be accommodated within the existing laws of war, their application needs to be thought through properly, and specific new laws should be implemented to not just accommodate their use, but to constrain it as well. We don’t know how autonomous robots will affect military strategy of the future, or if they will lead to more subjugation of weak nation-states and less public pressure to prevent wars.

AMSCE-101

Notes

[1] See du Picq 1946. The book was compiled from notes left by Colonel Ardant du Picq of France after he was killed in battle by a Prussian projectile in 1870.

[2] Decapitation is a euphemism for assassination of suspected insurgent leaders. The word *decapitation* was used to indicate cutting off the head (leader) from the body of the insurgents.

[3] Thanks to Richard Moyes of Landmine Action for pointing me to the BLU-108 and to Marian Westerberg and Robert Buckley from Textron Defense Systems for their careful reading and comments on my description.

[4] Contract #W911NF-06–1-0252 from the U.S. Army Research Office.

[5] Dover, Delaware, is the U.S. Air Force base where the bodies of soldiers are returned from the front line in flag-draped coffins. The Dover test concerns how much the electoral chances of the national political administration are affected by the numbers of dead.

[6] Bugsplat software and its successors have been used to help calculate the correct bomb to use to destroy a target and calculate the impact. It is only used to help in the human decision-making process and it is unclear how successful this approach has been in limiting civilian casualties.

[7] Regardless of treaties and agreements, any weapon that has been developed may be used if the survival of a state is in question. The International Court of Justice *Nuclear Weapons Advisory Opinion* (1996) decided that it could not definitively conclude that in every circumstance the threat or use of nuclear weapons was axiomatically contrary to international law; see Stephens and Lewis 2005.

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AMSCE-1101

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AMSCE-1101

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AMSCE-1101

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AMSCE-101

8

Robotic Warfare: Some Challenges in Moving from Noncivilian to Civilian Theaters

Marcello Guarini and Paul Bello

AMSCE-1101

In *Governing Lethal Behavior: Embedding Ethics in Hybrid Deliberative/Reactive Robot Architecture*, Ronald Arkin has undertaken the ambitious project of providing the “basis, motivation, theory, and design recommendations for the implementation of an ethical control and reasoning system potentially suitable for constraining lethal actions in an autonomous robotic system, so that they fall within the bounds prescribed by the Laws of War and Rules of Engagement” (2007, 1). What are at issue are the artificially intelligent selection of targets and the autonomous engagement of those targets by an automated system. This chapter attempts to analyze where some of the more serious difficulties may arise in attempting to build systems capable of automated warfare.

Let us begin by distinguishing between different theaters of activity. On one end of a spectrum, we have theaters populated entirely with combatants. This is a classical battlefield where everyone present on both sides is a combatant. On the other end of the spectrum, we have a theater populated entirely with noncombatants on the opposing side. An example on this end of the spectrum would be a counterinsurgency operation, raiding houses where it turns out that no one is a combatant (on that given day). Being a spectrum, there are many possible theaters somewhere in the middle.

We will argue that until much more progress is made, we should not be sanguine about the advantages of robots in theaters on the *noncombatant end of the spectrum*. We will do this by examining some of the challenges posed by the problem of mental state ascription and isotropy (the potential relevance of anything to anything).[1] We will argue that in theaters of activity involving mostly noncombatants, differentiating between combatants and noncombatants will often require the appropriate attribution of mental states (such as intentions). Isotropic considerations make the attribution of mental states very difficult to build into a robotic soldier. We are not suggesting that the problem cannot be solved, in principle. Rather, we will try to express just how difficult the problem is, and just how important it is to solve it, before seriously considering the use of robotic soldiers in the theaters under consideration. We will also sketch out how we think progress might be made on the problem by considering the role of emotion in cognition.

8.1 Background and an Example

Automated target selection and engagement is not a new idea. The Phalanx weapons system, originally developed and tested in the 1970s, is now used by a number of navies around the world. It is a close-in antimissile system that can automatically detect and engage targets. There is a manual override. A ship at sea being engaged by other military assets with no civilians in the neighborhood—this is an example of the classical theater. We will show that, as we move into theaters with noncombatants, there are very serious difficulties to be encountered. Let us begin with an example to motivate the difficulties involved.

AMSCE-IIOI

Consider a counterinsurgency operation in a Sikh village. Ground forces received a tip that wanted insurgents may be sheltered in a civilian residence. The tip is erroneous, but the counterinsurgency unit does not know this. Three children and their two parents are present at the residence. Two of the male children are young and playing with a ball. Each is also carrying the Sikh *kirpan* (sometimes referred to as the Sikh “dagger”). This is a religious symbol and is not used as a weapon. Just before a member of the counterinsurgency force kicks the door in, one of the boys kicks his ball toward the door, and both go chasing after it. As military forces enter the house, they see two young boys running toward them, and a shocked mother yelling. She chases the boys and yells at them to stay away from the men at the door; the troops do not know what she is yelling, since they do not understand her language. It is quite possible that the forces in question will rapidly see this as a situation where two young children are playing, and a mother frightened for her children is yelling and giving chase. That is one way to see the situation, and on this *first interpretation*, we could even imagine a soldier motioning to the children to keep away.

Let us consider a *second interpretation*. There are two fast-closing possible targets, both of which are carrying a weapon. A third possible target is following the first two, and is making a level of noise consistent with violent or threatening behavior.

With respect to cognitive abilities, what is required to see the two fast-closing possible targets as *children*? What is required to see them as *playing*? What is required to see the third possible target as *a mother* (with all that that entails)? What is required to see her as *frightened for her children*? What is required to see the kirpan as a *religious symbol*, and not as a *weapon*? Clearly, a tremendous amount of background knowledge is required to provide the first interpretation of this situation. Arkin (2009, chapter 3) cites some of the failures of human soldiers in high-stress theaters with many noncombatants, and attributes many of these failures to emotion. He then attempts to motivate a possible

AMSCE-IIOI

advantage for robot soldiers by indicating that they would not be subject to the disadvantages of having emotions. From the perspectives of cognitive science and artificial intelligence, the apparently trivial ability of a human being to see a situation like the one just described, as involving children at play with a frightened mother giving chase, in fact is quite involved. For a robotic soldier to perform at least as well as a human in such circumstances, it would have to go beyond seeing the situation as described in the second interpretation (which would likely lead to erroneous and harmful engagement). We will now begin to examine some of what would be required for robots to perform at least as well as humans in theaters populated mostly with civilians. Later in the chapter we will turn to arguing that *some* of the functional, computational role of emotion may play a part in overcoming *some* of the challenges.

8.2 Mental State Attribution in General

Mental state attribution is about the ascription of beliefs, desires, hopes, fears, intentions, and the like, to others and to oneself. There is a significant literature in cognitive science and philosophy on mental state attribution (sometimes referred to as “theory of mind,” or “mentalizing,” or “mindreading,” with nothing psychic intended). Mind-reading is about how we retrodict, attribute, or predict the mental states or actions of others or ourselves. There are both descriptive (how do we actually do it?) and normative (how ought we do it?) dimensions to the study of our everyday abilities to (a) attribute beliefs, desires, hopes, fears, and the like, and (b) make claims about what an agent did or will do. The two main camps in this study are often referred to as Theory Theory and Simulation Theory,[2] with many people actually defending a kind of hybrid approach that stresses one over the other. The point of this chapter is not to insist that one or another of these approaches is correct. Rather, it is to show that the ability to attribute mental states reliably

AMSCE-1101

becomes a matter of central importance in theaters on the noncombatant end of the spectrum.

Let us consider a naval vessel with an antimissile system that identifies targets by virtue of the trajectory and speed of the incoming target. Something closing in directly on your ship at a very high rate of speed needs to be destroyed before it makes contact (even if it is one of your own aircraft falling in a direct collision course with your ship after terminal damage in combat). There is no need to figure out what the potential target *intends* or *feels* or might be *thinking*. To be sure, there are theaters of activity involving exclusively combatants that would involve such assessments, but the focus in this chapter is on theaters with many noncombatants, since the issue of mental state attribution is exacerbated in these contexts. In a context where we cannot assume that everyone present is a combatant, then we have to figure out who is a combatant and who is not. This frequently requires the attribution of an intention. The presence of a weapon, or a possible or apparent weapon, is insufficient, as the example with the children carrying the kirpan shows. (If those same children bore menacing facial expressions and made threatening gestures with grenades in hand, then the situation changes entirely.) Mental state attribution is not a problem that has been solved. Moreover, solving it is very difficult regardless of your approach (Wilkerson 2001), and solving it appears to be required before robotic soldiers could be applied usefully in theaters with many noncombatants. What problems do we need to overcome to design systems that could attribute mental states, at least as reliably as humans, in the envisioned contexts?

8.3 Isotropy

Isotropy refers to the potential relevance of anything to anything.[3] What could the price of tea in China have to do with Habib’s heart attack?

AMSCI-101

Well, it depends. If Habib is heavily invested in companies shipping tea out of China, and Habib has a heart condition that makes him vulnerable to heart attacks when he is under tremendous emotional strain, and he finds out that the price of tea in China fell significantly, leading to serious losses in his portfolio, causing him to experience high levels of stress and anxiety, then it could well be the case that the price of tea in China is relevant to explaining Habib’s heart attack. It is difficult to say, in advance of having the details of a situation, which pieces of information may or may not be relevant to reasoning about a claim or an action. Isotropy is a general problem in trying to understand human cognition and achieving AI, and it is a problem that manifests itself in mental state attribution, and this is the dimension of isotropy we will focus on herein.

The information that could be relevant in assigning mental states is vast. Facial expressions, gaze orientation, body language, attire, information about the agent’s movement through an environment, information about the agent’s sensory apparatus, information about the agent’s background beliefs, desires, hopes, fears, and other mental states are all relevant to attributing current or predicting future mental states or behaviors. One would think that a person running toward a soldier while screaming and carrying what looks like a dagger would be something that a soldier might be very much concerned with, but maybe not. *Civilian theaters introduce the full complexity of human social affairs into combat*. In the classical theater, where everyone is a combatant, one still needs to avoid friendly fire, but everyone on the other side is, essentially, a legitimate target. Not so in civilian theaters. For example, counterinsurgency forces looking for manufacturers of pipe bombs walk into a civilian residence and immediately notice someone carrying a pipe. Is it a bomb? Is the individual holding it threatening? Say the civilian holding the pipe in his left hand is wearing overalls and also holds a monkey wrench in his right hand—does that change how you see him? How about if the civilian is standing in front of a sink with

AMSCE-101

pipes exposed and water leaking all over—would you see him as intending harm? Probably not. Sometimes a pipe is just a pipe. In largely civilian theaters, we cannot assume that someone is threatening; we have to figure it out. What complicates this in the extreme is that the full range of human social affairs becomes potentially relevant to figuring out whether behavior is threatening or not. Something being a religious symbol *might* disqualify it from being a weapon; something useable for plumbing *might* disqualify it from being seen as a weapon. It all depends on the other considerations at issue. In the classical theater, being a plumber or being at play (and a myriad of other everyday civilian activities) are not relevant considerations. In the civilian theater, they are.[4]

Correctly attributing intentions is often (though not always) necessary to see someone as a threat, and isotropy complicates mental state attribution in civilian theaters because almost anything (given the appropriate background conditions) can become relevant to attributing the appropriate intentional state. This might make it tempting to think that Theory Theory (TT) approaches to mindreading are more problematic than Simulation Theory (ST). Indeed, some have argued in this way.[5] TT requires that agents have explicitly represented generalizations (e.g., rule-like structures) that correspond to the putative connections between mental states and actions. A sentential or sentence-like explanation would be of Byzantine complexity, and it is not obvious that we are manipulating anything like that when we attribute mental states to others. We have much sympathy for this line of criticism, though we are not suggesting matters will be easy for an ST approach. Those subscribing to ST could say that whatever mechanisms allow us to arrive at our own mental states can be redeployed in arriving at the mental states of others. Essentially, I run a simulation of other agents based on my own actions, mental states, and processes. In the current context, leaving it at that would be unsatisfying for at least two reasons. First, if the task is to build computational systems that could operate in a

AMSCE-101

civilian theater, we need to know how to construct the aforementioned mechanisms that allow us to arrive at different mental states (in the first person) in different situations before those mechanisms can be redeployed for simulating others. Second, even if we succeed in modeling various transductive and inference mechanisms in the first person—which requires overcoming isotropy of certain types—the redeployment of those mechanisms for purposes of simulation of others still runs into the problem of isotropy. Let us see how this is so.

When I "put myself in someone else's shoes" to figure out which mental states they may have or how they will act, I need to draw on information about how the mental states of the target of my simulation may differ from my own. If I do not quarantine some of my own mental states from the simulation and do not recognize that what my target thinks is salient may be different from what I think is salient in a given context, then my simulation will not be reliable. Moreover, isotropy affects what we would provide as input. Almost anything could become relevant to constraining the input to the simulation. If I were playing and chasing a ball with someone else, and I were wearing a religious symbol, I would not be intending any harm, so if someone else is in that situation, they would not be intending harm—this is a type of simulation. And it assumes that the children are playing and chasing a ball and wearing a religious symbol. All that is part of the input to the simulation. (The output is that the individuals in question do not intend harm.) An adequate full-blown computational model of this sort of simulation would have to figure out that the movement of the children constitutes *chasing*, and that this form of chasing constitutes *play*, and that the kirpan is a *religious symbol*. Most things in the form of a dagger are not religious symbols, and many forms of chasing constitute threatening behavior. Any number of things could be relevant in determining whether people are playing (or not). It might be thought that what needs to be done for the agent doing the simulation is simply to retrieve a situation "like this" from memory and simulate based on

AMSCE-IIOT

that. But there is the rub: what constitutes a situation “like this?” Answering that question *assumes* we know what is salient or relevant in the situation under consideration, and we do the recall based on the salient or relevant features of this situation.[6] However, situations do not come with their salient features labeled. This is an easy point to miss, since what is salient is often so obvious to us and requires so little conscious effort to determine that we may fail to appreciate the computational difficulty of modeling the process of determining it. This is a problem both for TT and ST. It may be possible to carry on with many arguments between TT and ST without dwelling on this problem, since there are other issues the opposing theorists are dealing with. However, in designing a robot with the ability to read minds well enough to engage in civilian theaters, the problem cannot be side stepped. Without appropriately quarantining and selecting the input to a simulation—or to a set of theoretical generalizations, for that matter—there is little chance that mindreading will be successful. Without reliable intentional state attribution, it is hard to see how a robot could usefully assess threatening from nonthreatening behavior, and without that, distinguishing combatants from noncombatants will be exceedingly difficult. Our point is not that these problems cannot be overcome; it is that we are not yet even close to overcoming them. Indeed, we think there are computational advantages to systems that make use of simulation over those that do not, but much progress needs to be made before we have anything capable of dealing of with the complexity of the civilian theater.

What we have done in this section is to point to some of the problems created by isotropy, but we have said nothing about how humans manage isotropy, or how robots might be made so that they could manage it. To that, and other issues, we now turn.

AMSCE-101

8.4 Emotion

Much of Arkin's work (2009, chapter 3) treats human emotion as a problem with human soldiers when engaging in civilian theaters, and he develops an ethical reasoning architecture that "will not involve emotion directly . . . as that has been shown to impede the ethical judgment of humans in wartime" (Arkin 2009, 118). In laying out the architectural consideration for autonomous selection and engagement of targets (Arkin 2009, chapters 9 and 10), he proposes an "Ethical Governor," which includes a limited role for emotion. The idea is to include a role for something like the functional equivalent of guilt. If a system is criticized for its behavior with respect to the use of lethal force, "guilt" can increase to censor or veto future behaviors until a proper external action assessment can be performed and the system reconfigured, if needed. Arkin is *not* suggesting that the robot actually "feels" guilt the ways humans do; rather, the idea is that some of the functional role of guilt can be mimicked in the robot. In general, though, emotion plays no direct role in figuring out which options are open to the agent. The idea is that determining which options are available and providing an initial assessment is all done in an emotionless manner, and if the results of that process run afoul of the guilt censor, so called, then the option is rejected. While Arkin recognizes at least one of the limits of this model,[7] we want to suggest that there may be other limits as well. While we do not wish to dispute the empirical evidence that emotions can lead human soldiers astray, especially in highly stressful and complex civilian theaters, we now want to explore the possibility that emotions may have a positive role to play in dealing with the full complexity of human social affairs, present in the largely civilian theaters.

First, we lay bare one of our methodological predispositions: we think that understanding how humans solve the problem of navigating a complex social space, in an ethically constrained manner, is a useful starting place for constructing a robot that could similarly navigate that space.[8] This presupposition is not self-evident. In restricted domains, like chess playing, we have constructed systems that exceed human

AMSCE-IOJ

abilities, but those systems are doing things quite differently from how we do things. To be sure, an opening book of moves is often programmed into these systems, and humans sometimes commit to memory sequences of opening moves. That said, we suspect that not many believe that when Deep Blue, the IBM chess-playing computer that bested Garry Kasparov, searches through millions of possible board positions that it is doing something even remotely akin to what human chess players do, yet it plays darn good chess, nonetheless. So it is not self-evidently true that achieving (or exceeding) human-level competence must be done by modeling human cognitive abilities, or even taking human cognitive performance as an important guide. However, human social affairs are *vastly* more complex than chess. The number of possible "moves" and the constraints on those moves in our social activities are far beyond anything like the domain-restricted tasks current computational systems undertake. We suggest that the preceding is a good reason[9] for taking an understanding of human competence in ethically constrained complex social environments as a starting place for assessing the prospects of building an artificial system to navigate such a space. And we think emotion has a role to play in understanding how we navigate that space. To explicating this point (if too briefly) we now turn.

As Wagar and Thagard (2004) point out, there is a growing body of literature in cognitive science regarding the importance of emotions to decision making (Churchland 1996; Damasio 1994; Finucane et al. 2000; Lerner and Keltner 2000; Loewenstein et al. 2001; Rottenstreich and Hsee 2001). The model for decision making put forward by Wagar and Thagard integrates functions of the ventromedial prefrontal cortex (VMPFC), the hippocampus, the amygdala, the nucleus accumbens, and the ventral tegmental area. This work draws on and extends Antonio Damasio's work on somatic markers. According to Damasio (1994), the VMPFC and the amygdala are involved in the production of somatic markers, which are "the feelings, or emotional reactions, that have become associated through experience with the predicted long-term outcomes of certain responses to a given situation" (Wagar and Thagard 2004, 90).

Evidence for this comes from the specific cluster of deficits and abilities demonstrated by those having damage to the VMPFC. This sort of damage leaves language skills intact, as well as memory and what might be called intellectual, or theoretical, reasoning. However, decision making is impaired, especially with respect to decisions involving distinctions between long-term and short-term consequences in contexts where punishments and rewards are at issue. As Wagar and Thagard put the point: "Somatic markers make the decision process more efficient by narrowing the number of feasible behavioral alternatives, while allowing the organism to reason according to the long-term predicted outcomes of its actions" (2004, 90).

Damage to the VMPFC also damages somatic markers and the ability to make effective decisions, leading to serious difficulties in navigating social environments. We can think of somatic markers as constituting a kind of bias on the search space of options for action. We need not explicitly reason in every social context about *all* of the available alternatives for action; this would be profoundly inefficient. Some options present themselves to us, and somatic markers play a role in the filtering of these options, reducing the computational load on explicit or conscious reasoning. With damage to the VMPFC, the filters established through past experience are damaged or eliminated, and so, too, is the ability to establish new filters. Patients with VMPFC damage tend to demonstrate little, if any, empathy toward others, tend to lose most (and sometimes all) of their friends, and have a hard time keeping a job. This is not surprising, given that they reason poorly about the social consequences of their actions.

Let us return to the example of counterinsurgency and the Sikh household. A well-armed human soldier—believing his life might be in danger—opens the door to witness two screaming children wearing

AMSCE-101

kirpans. For the sake of argument, imagine that this soldier has serious damage to his VMPFC, impairing his ability to empathize and his ability to reason about the consequences of his actions. To our knowledge, there are no case studies of this type, but given what we know about patients with VMPFC damage, it is far from obvious we would want them to serve in such contexts. A healthy VMPFC in an altogether fit soldier[10] should simply not lead to children at play being seen as targets. Along with damage to the VMPFC comes damage to the somatic markers established by years of experience, and this may well lead to options being considered with inadequate regard for the consequences of the actions, which would likely lead to disastrous results in the scenario in question.

Thus far, we have only considered damage to the VMPFC. As mentioned earlier, Wagar and Thagard extend Damasio's work to consider other parts of the brain, though this is not the place to consider the details of their position. The point of this brief discussion has been to motivate the idea that emotions may play a constructive role in limiting the options that come under explicit consideration, and this might play a very useful role with respect to making real-time decisions in very complex social scenarios. Arkin assumes that the role to be played by emotion is as some sort of postdeliberative censor. In other words, the robot soldier would arrive at a course of action, and if the action involves the use of lethal force, and the guilt censor has been set to block lethal force either altogether or in scenarios "like this," then the action will not be carried out. All of this assumes that emotions do not play a role in filtering or limiting the options that are considered in the first place.

If the work engaged is on the right track, then emotionally uniformed behavior does not appear to be how humans effectively navigate the complexities of social environments. To be sure, emotions can lead to highly problematic forms of engagement. However, we want to raise the point that the constructive use of emotion should not be ignored.

AMSCE-I 101

Moreover, we want to suggest that it can inform computational modeling. For example, Wagar and Thagard put forward a computational model (called GAGE), which, when lesioned, exemplifies decision errors that are not unlike human decision errors when comparable parts of human brains are damaged. Our point *has not* been to suggest that computational models involving some of the functional contributions of emotions are impossible. We have been calling attention to an assumption—emotions do not play a functional role in constraining the search space of possibilities—that may place too great a computational burden on a system that is expected to perform in real time. Moreover, there is evidence independent of VMPFC damage that suggests that taxing our rational, calculating selves leads to fast application of deontological (for example, moral) principles, which are likely grounded in emotional processing in the brain (Greene and Haidt 2002; Greene 2007; Greene et al. 2008).

A robot without representation of or the ability to recognize these emotional states would be at a crippling disadvantage in the battlefield, especially if its task requires dealing with noncombatants or others whose status has to be determined. For example, a robot that cannot tell the difference between fear and anger will have a very hard time assessing the intent of an agent. It will also have a hard time knowing when to show compassion (and the laws of war requiring compassion: see note 7). We are far from understanding the subtle, pervasive relationship between emotion and cognition, but it seems undeniable that there is one in human beings.

Before closing out this section, let us return once again to the issue of the simulation theory of mindreading. According to this approach, to effectively predict the emotional states and actions of others, we simulate others using ourselves as the source. If this is at least part of the story about how mental state ascription can be performed in real time, then we have yet another reason to worry about a computational model that does not have a robust role for emotion. A system without emotion

AMSCE-1101

(or at least some sort of proto-emotional functional counterpart of emotion) could not predict the emotions or action of others based on its own states because it has no such emotional states. Of course, even if simulation theory is completely incorrect, a robot in the kinds of theaters we are considering will still need to make predictions about the kinds of emotional responses people will have, so knowledge of emotions is important for effective interaction in mostly civilian theaters.

8.5 A Suggestion for Taming Isotropy

Isotropy presents a clear set of computational problems for any AI system intended for deployment in civilian theaters. Solving this problem has been the preoccupation of many researchers in philosophy, AI, and cognitive science, and yet, as of the present, a solution has been elusive. As such, we do not intend to present one here. However, we do have some speculations on what kinds of cognitive mechanisms might interact in the human case to mitigate the irrelevance that isotropy introduces into inference. We suspect that a combination of attention, the computational structure of memory, and especially emotional appraisal all act in concert to regulate inference toward the relevant and away from the irrelevant.

To be more precise, let us consider a being or system that has the goal of making relevant inferences and avoiding irrelevant ones. Let us also suppose that our system is equipped with a focus of attention that can hold one (truth-evaluable) proposition at a time, an emotional subsystem that takes a single proposition $\boldsymbol{P}$ and an active set of propositions $\boldsymbol{S}$ as inputs, and outputs a scalar value $\boldsymbol{E} \in (0,1)$. Let's call $\boldsymbol{S}$ the system's *situation representation*. In broad strokes, $\boldsymbol{S}$ is a collection of propositions that describe the state of affairs, which the system is currently considering. Propositions can be either generated internally via being recalled from memory or some similar storage mechanism, or they

AMSCE-1101

can be generated by percepts resulting from sensor data. Since we are interested in making relevant *inferences*, let us also grant our system a set of inferential capabilities that allow us to draw propositional conclusions from ***S***, ***P***, and suitable propositional background knowledge ***K*,** represented in some machine-readable format. Our system also comes equipped with motivational monitors that keep track of various system variables that correspond to basic drives such as approach/avoidance functions, and other homeostatic variables used to keep the system performing above some acceptable threshold. Let us further assume that our system is able to adopt beliefs, desires, intentions, goals, and other relevant attitudes toward propositions that are part and parcel of both planning and mindreading. Finally, let's assume that our system has an appraisal mechanism that generates urgency values in (0,1) for each system motivation, desire, and goal. On each cognitive cycle, ***E*** is generated from both the current focus ***P*** and situation representation ***S***, and urgency values are generated for motivations, desires, and goals. The next proposition to be the focus of attention will be the result of one of the scalars (either ***E*** or one of the sources of urgency values) being sufficiently larger than its competitors.

Since it is relevance we are concerned with, and since we have roughly sketched out a cognitive architecture for drawing (potentially) relevant inferences, let us define the problem space in which this sort of inference engine needs to operate. Isotropy roughly means that everything can be potentially related to everything else. In our case, it is our system's set of ***K*** + ***S*** that defines the problem space. In particular ***K*** consists of associations between propositions like "if it rains, then the grass will be wet" or "having a cough usually indicates having a cold." Since all of these assertions can effectively be chained together by hooking up their propositional parts, they define a space of propositions connected by associations. Declarative (semantic) memory is often conceived of in these terms, with highly related items having stronger associative connections and fewer links between them. Many studies, and associated computational models, have documented limitations on the recall and activation of memory items (Atkinson and Shiffrin 1968; Oberauer 2002; Oberauer and Kliegl 2006) arranged in this kind of way. Some of the more popular computational explanations of these effects come by way of *spreading activation* models, which assume a finite amount of activation gets spread from one memory element to another, proportional to their connection strengths. In this way, highly indirect connections between elements far away from one another in memory are generally never activated. However, activation is a theoretical construct, and we do not in principle know the amount of activation to use if we were to construct such a system. Most of the computational models embodying spreading-of-activation solutions to the isotropy problem also lack the motivations, beliefs, attentional focus, and other mechanisms that our architecture-sketch possesses, and, as such, are not yet suitable for implementation on an autonomous system. Given this, we now develop the very beginnings of a complementary mechanism that exploits semantic nearness in declarative memory that seems to naturally capture relevance relations without committing to an arbitrary amount of activation to spread.

For any particular inferential goal our system might have, the space of propositions generated by ***K*** must be navigated. Presumably, for each of these goals, the set of propositions in the space having relevance would differ. The architectural sketch we have been developing suggests that one way to solve the isotropy problem might be to limit the amount that the focus of attention moves around our propositional space. If ***P*** is the current focus of attention, and the emotional subsystem generates a sufficiently high scalar value ***E*** for ***P***, ***S***, and their immediate inferential consequences, our attention-management procedure suggests that attention will either remain on ***P*** or move to a new proposition ***P****, which is (1) semantically close and (2) an emotionally relevant consequence of ***P*** and ***S***. In this case, we refer to ***P*** as an *attentional magnet*, or a part of the propositional space that captures the focus of

AMSCE-1101

attention for several cycles, until an interruption by way of an urgent desire, goal, or motivation occurs. We want attention to remain focused on relevant considerations for a given problem, and we want attention to shift to other portions of the propositional space if there is input suggestive of more pressing issues to attend to. Attentional magnets are the mechanism by which we keep from inferring too many indirect consequences, and could act as an analog (or perhaps as a complement to) traditional spreading of activation solutions to the isotropy problem. In any case, our architecture-sketch reserves a central role for emotional appraisal in regulating inference. Of course, open questions remain about how emotional appraisals or urgency values might be generated in the first place. While we have some ideas along those lines, space forbids us from exploring them in detail.

8.6 Conclusion

We do not think we have offered anything like a proof that emotion must play a role in either mental state ascription or in effective deliberation in complex social environments. Nor do we think that we have offered a proof that emotion (or something functionally like it) must play a role in getting robots to behave at least as well as humans in mostly civilian theaters of conflict. What we have done is to point to (a) the importance of mental state ascription in largely civilian theaters, (b) the difficulty of solving isotropy problems associated with such ascription, and (c) the potential strengths of emotion in reducing the computational load of deliberation in general and in thinking about mental states. By doing this, we hope to have raised some cautionary flags about considering the robotic use of lethal force in mostly civilian theaters. There is a lot to be done before seriously considering the use of robots in such theaters.[11] We also hope to have shown where some of this work needs to be done, and we hope to have motivated the idea that emotion may have some overlooked contributions to make in doing this

AMSCE-110I

work. Of course, our consideration of the role of emotions was in terms of capturing *some* of the functional, computational roles they play. There was no suggestion that there is something that it feels like to be the GAGE model, or any other computational model that captures some of the functional role of emotion. If it should turn out that the only way to solve problems connected to mental state ascription and isotropy in a robot is to actually build something that has feelings—there is something that it would feel like to be that being—then further ethical considerations would be introduced, since the feelings of genuinely sentient beings are subject to moral consideration. We do not introduce this issue to examine it, since considerations of space preclude this possibility. We mention it to forestall misinterpretations of our arguments. Everything we have said about modeling *some* of the computational, functional role of emotion assumes that the computational systems in question do not actually feel anything.

Notes

[1]. The term "isotropy" has a number of different uses. The use herein is inspired by Fodor (2000).

[2]. Goldman (2006) provides a useful introduction to different approaches to mindreading. We offer a brief explanation of Theory Theory and Simulation Theory in section 8.3.

[3]. Some have referred to this sort of consideration as "the frame problem." We will use the expression "isotropy" to be more precise. Different theorists have meant different things by "the frame problem," an expression introduced by McCarthy and Hayes (1969). See Murray 2009 and Ford and Pylyshyn 1996 for discussions of the different sorts of things theorists have meant by the frame problem. Isotropy can be connected with some versions of what has been called "the philosopher's frame problem," but that is broader than the more strict conceptions of the frame problem found in AI. Moreover, the very expression "frame problem" bids us to formulate it using the theoretical language of frame axioms, and not all approaches to understanding cognition or intelligence are committed to such axioms. Many neural network models have no

AMSCE-HQ

use for such information structures, yet that does not exonerate those who would use such modeling techniques from providing an account of isotropy, a problem that can be formulated in a way that is not committed to postulating represented rules or axioms.

4. It might be thought that we are making too much of the complexities of largely civilian theaters. Perhaps robot warriors could simply be designed to be very cautious, not fire much, and be self-sacrificing in the name of being cautious. In other words, they would always err on the side of caution. When in doubt, do not fire. While this has an initial appeal, it is multiply problematic. In the mostly civilian theater, robots unable to manage isotropy, whether with respect to mental state ascription or other problems, would *frequently* be in doubt in cases where it is obvious to humans that there is great danger, and such robots would not fire. This would make them easy targets. Here is the first problem: it is not clear that such robots would be at all effective; if they are so cautious that they are easily destroyed, then it is unclear how they can be used to successfully accomplish the kinds of difficult missions humans are expected to accomplish. Second, if they are too cautious, then human soldiers, who expect their comrades in arms to "have their back," would likely be unwilling to serve jointly with robots that are overly reluctant to fire.

5. See Wilkerson's (2001) discussion of Goldman 1989, Gordon 1995, and Heal 1996.

6. There may be any number of situations that share properties or relations with the situation under consideration. What makes one situation, y, like the one under consideration, x, will depend on what is deemed to be relevant for the simulation in a given situation. There may be a very large number of features that *could* be relevant, and which ones turn out to be relevant will depend on the details of the situation.

7. Arkin (2009, 143) notes that the laws of war mandate a certain level of compassion, and that it is not clear how to explicitly build that consideration into the architecture he is proposing. However, he suggests that building in the requirement to abide by the other rules of war and engagement would, in a sense, lead to compassionate behavior (by which, we take him to mean behavior that does not needlessly and unjustly inflict harm). There is a worry with this suggestion: presumably, the reason the rules of war explicitly state, over and above all the other explicitly stated rules, that compassion is required is that these other rules *do not* exhaust what it is to be compassionate. Another potential worry is that the requirement for compassion may well rely on human or human-like affective abilities for interpretation and application.

AMSCE-1101

[8] We mean for the qualifier “starting place” to be taken seriously in this sentence. As we will go on to explain, there are computational models that have been purported to capture some of the functional role of emotion in humans, but no one actually thinks that such models *feel* anything. It is possible to take one’s cue from human cognition, but still fall short of a system or model that is fully expressive of a human-style mental/conscious life.

[9] We mean to suggest here that our approach is well motivated, not that it is the only approach that could be motivated, or that we have conclusive proof that our way is the only way.

[10] We recognize that not all soldiers are fit, and even pretty good soldiers make mistakes. It is not hard to imagine that if a soldier has been in multiple theaters where children have been combatants, and they have seen children kill soldiers, then they might react incorrectly in the sort of theater we have been considering. Moreover, their emotions may well lead them to react in this way. Again, we are not saying that there is no downside to emotion; we are simply pointing out that its potential strengths should not be ignored.

[11] We do not pretend to have scouted out all the issues that need to be addressed. For example, in this chapter we have not even asked the question: Is it morally and legally defensible to build robot soldiers for use in mostly civilian theaters? We have largely been concerned with whether and how such systems might be built. Any use of lethal force with any technology has to satisfy a variety of moral and legal constraints. There are reasons to think that new constraints would be required for the types of robots we are considering. However, outlining and defending the required constraints would require another chapter, if not a book. Arkin (2007, 9) has started on the project, but more needs to be said.

AMSCE-1101

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AMSCE-101

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AMSCE-101

9

Responsibility for Military Robots

Gert-Jan Lokhorst and Jeroen van den Hoven

Several authors have argued that it is unethical to deploy autonomous artificially intelligent robots in warfare. They have proposed two main reasons for making this claim. First, they maintain that it is immoral to deploy such robots because such robots are “killer robots.” Second, they claim that such robots cannot be held responsible because they cannot suffer, and therefore cannot be punished. We object to both claims. We first point out that military robots are not necessarily killer robots, and that, even if they were, their behavior could still be ethically correct—it could even be preferable to the behavior of human soldiers (section 9.1). Second, we argue that responsibility is not essentially related to punishment (section 9.2). Third, we propose an alternative analysis of responsibility, according to which robots could be responsible for their actions, at least to a certain extent (section 9.3). Finally, we emphasize that the primary responsibility for the behavior of military robots is in the hands of those who design and deploy them (sections 9.4 and 9.5).

9.1 Killer Robots

Sparrow (2007) and Krishnan (2009) have described military robots as “killer robots.” By the same token, human soldiers might be called

AMSCH-1101

"killers," or even "murderers." However, it has long been disputed that soldiers should be described in this way. St. Augustine, for example, denied that soldiers violated the commandment *Thou shalt not kill*: "who is but the sword in the hand of him who uses it, is not himself responsible for the death he deals." Those who act according to a divine command or God's laws as enacted by the state and who put wicked men to death "have by no means violated the commandment, *Thou shalt not kill*" (St. Augustine, *On the City of God*). As these quotes indicate, in military ethics, matters are not as simple as they might seem. Calling military robots "killer robots" brings in a lot of background assumptions.

To form a proper perspective on the ethics of the use of military robots, we need to consider the ethics of war and peace. "Just war theory" is probably the most influential perspective on the ethics of war and peace (Orend 2008). Just War Theory can be divided into three parts, which in the literature are referred to, for the sake of convenience, in Latin. These parts are: (1) *jus ad bellum*, which concerns the justice of resorting to war in the first place; (2) *jus in bello*, which concerns the justice of conduct within war, after it has begun; and (3) *jus post bellum*, which concerns the justice of peace agreements and the termination phase of war. When discussing the deployment of military robots, *jus in bello* is clearly the most relevant category. *Jus in bello* refers to justice in war, to right conduct in the midst of battle. Responsibility for adherence to *jus in bello* norms falls primarily on the shoulders of those military commanders, officers, and soldiers who formulate and execute the war policy of a particular state. They are to be held responsible for any breach of the principles that follow. It is common to distinguish between external and internal *jus in bello*. External, or traditional, *jus in bello* concerns the rules a state should observe regarding the enemy and its armed forces. Internal *jus in bello* concerns the rules a state must follow in connection with its own people as it fights war against an external enemy. There are several rules of external *jus in bello*:

AMSCE-1101

1. Obey all international laws on weapons prohibition. Chemical and biological weapons, in particular, are forbidden by many treaties.

2. Discrimination and noncombatant immunity: soldiers are only entitled to use their (nonprohibited) weapons to target those who are “engaged in harm.” Thus, when they take aim, soldiers must discriminate between the civilian population, which is morally immune from direct and intentional attack, and those legitimate military, political, and industrial targets involved in rights-violating harm. While some collateral civilian casualties are excusable, it is wrong to take deliberate aim at civilian targets.

3. Proportionality: soldiers may only use force proportional to the end they seek. They must restrain their force to that amount appropriate to achieving their aim or target.

4. Benevolent quarantine for prisoners of war: if enemy soldiers surrender and become captives they cease being lethal threats to basic rights. They are no longer “engaged in harm.” Thus, it is wrong to target them with death, starvation, rape, torture, medical experimentation, and so on.

5. No means that are *mala in se*: soldiers may not use weapons or methods that are “evil in themselves.” These include: mass rape campaigns, genocide or ethnic cleansing, using poison, or treachery, forcing captured soldiers to fight against their own side, and using weapons whose effects cannot be controlled, such as biological agents.

6. No reprisals: a reprisal is when country A violates *jus in bello* in war with country B. Country B then retaliates with its own violation of *jus in bello*, seeking to chasten A into obeying the rules.

AMSCE-1101

Internal *jus in bello* essentially boils down to the need for a state, even though it's involved in a war, nevertheless to still respect the human rights of its own citizens as best it can during the crisis.

What do these rules mean for military robots? They would behave unacceptably if they violated at least one of these rules. We may distinguish between two types of cases. First, let us assume that military robots are nothing but "killer robots" (as Sparrow [2007] and Krishnan [2009] seem to assume). In this case, they would not necessarily be immoral, because they would not necessarily violate one or more of these rules. As long as their reactions were proportionate, not evil in themselves, only directed toward combatants, and so on, their behavior could be justifiable, or even praiseworthy. Second, let us assume that there are military robots that are not just "killer robots," but designed to avoid killing as much as possible. This is clearly a more attractive option than the first scenario. It was brought to our attention when we showed the following passage about the strength of innate moral emotions (such as an aversion to killing) to a Dutch soldier (Chambers 2003):

> These innate emotions are so powerful that they keep people moral even in the most amoral situations. Consider the behavior of soldiers during war. On the battlefield, men are explicitly encouraged to kill one another; the crime of murder is turned into an act of heroism. And yet, even in such violent situations, soldiers often struggle to get past their moral instincts. During World War II, for example, U.S. Army Brigadier General SLA Marshall undertook a survey of thousands of American troops right after they'd been in combat. His shocking conclusion was that less than 20 percent actually shot at the enemy, even when under attack. "It is fear of killing," Marshall wrote, "rather than fear of being killed, that is the most common cause of battle failure in the individual." When soldiers were forced to confront the possibility of directly harming other human beings—this is a personal moral decision—they were literally incapacitated by their emotions. "At the most vital point of battle," Marshall wrote, "the soldier becomes a conscientious objector."

After these findings were published in 1947, the U.S. Army realized it had a serious problem. It immediately began revamping its training regimen in order to increase the "ratio of fire." New recruits began

AMSCE-101

endlessly rehearsing the kill, firing at anatomically correct targets that dropped backward after being hit. As Lieutenant Colonel Dave Grossman noted, “what is being taught in this environment is the ability to shoot reflexively and instantly. . . . Soldiers are de-sensitized to the act of killing, until it becomes an automatic response” (Lehrer 2009). The army also began emphasizing battlefield tactics, such as high-altitude bombing and long-range artillery, which managed to obscure the personal cost of war. When bombs are dropped from forty thousand feet, the decision to fire is like turning a trolley wheel: people are detached from the resulting deaths. These new training techniques and tactics had dramatic results. Several years after he published his study, Marshall was sent to fight in the Korean War, and he discovered that 55 percent of infantrymen were now firing their weapons. In Vietnam, the ratio of fire was nearly 90 percent. The army had managed to turn the most personal of moral situations into an impersonal reflex. Soldiers no longer felt a surge of negative emotions when they fired their weapons. They had been turned, wrote Grossman, into “killing machines” (Lehrer 2009, 173–174).

Our military informant pointed out that, despite the appeal to military authority displayed in this passage (“U.S. Army Brigadier General SLA Marshall”),[1] the passage does not reflect current military practice at all. All military handbooks, at least in the Netherlands, carefully point out that it is the aim of the military in battle to put the enemy out of action, to neutralize the enemy forces, or make them harmless—for example, by disarming them, immobilizing their vehicles, or turning them into prisoners of war. Temporary incapacitation is preferable to killing. In fact, the handbooks avoid the term “killing” and view the “elimination” of enemy forces as a means of last resort. Soldiers are taught to aim for the knees, not the heart or head, when taking target practice.

This is of the utmost importance in the context of autonomous intelligent military robots because they can be designed to immobilize or disarm enemy forces, instead of killing them. Because they can be

AMSCE-1101

equipped with superior sensory and incapacitating devices (and perhaps better decision circuitry as well, capable of better handling a greater amount of information more adequately than humans can do), they can in principle achieve this aim far more reliably than humans. In other words, it could be argued that autonomous robots are, in principle, morally superior to human soldiers, because the former could resort to temporary incapacitation in cases where the latter would have no option but to kill. It is misleading to equate autonomous military robots with killer robots because it is quite possible that their deployment will *save* lives instead of adding to human loss. Calling them “killer robots” is an insidious rhetorical move, which easily leads to a false dilemma. This brings us to our first thesis:

Thesis 1. Artificially intelligent military robots that save lives are preferable to humans (or bombs) that kill blindly.

9.2 Responsibility, Punishment, and Blame

Suppose that something goes wrong on the battlefield—that people get killed as the result of the action of an autonomous military robot instead of merely being put out of combat. Who is to blame in such a case—the robot itself, or its operator, programmer, or designer?

Sparrow (2007) argues that robots cannot be held responsible because they cannot be punished. They cannot be punished because they cannot suffer. In other words, responsibility presupposes the ability to suffer. We want to object to this line of reasoning for two reasons. First, it is by no means to be taken for granted that robots will never be able to suffer. Second, punishment is not desirable in any case because we can use more effective means for adjustment in the case of robots that do not act in a desirable way.

AMSCE-1101

First, it is questionable that robots cannot be made to suffer. On the contrary, it has been argued that intelligent robots are bound to have emotions as the inevitable consequence of having motives and the processes they generate (Sloman and Croucher 1981). If robots can be made to suffer, then they can be punished, as well, so this part of Sparrow's objection loses it force.

Second, let us grant that Sparrow is right and that robots cannot suffer. We may then ask: what is the point of punishment, anyway? Its main justification is the prevention of the type of behavior that brought it about. Punishment leads to suffering; humans tend to avoid suffering; so punishment may lead to prevention because it gives humans a reason to avoid similar behavior in the future. What if an agent cannot suffer or cannot see that similar behavior in the future will again lead to harsh punishment? Then we give them treatment. Treatment is another means to achieve prevention. When punishment is not an option, treatment remains. This not only applies to humans (for example, mentally handicapped persons), but also to other types of agents. Cars cannot suffer, so we treat (repair, correct) them, simply because this may bring the desired goal (correct functioning in the future) closer.

In other words, it is important to make a distinction between the means and the ends. Punishment is simply one means that may lead to the desired end; it is not desirable in itself. If other courses of action are more effective, they are ipso facto preferable.

This is important in the context of our military robots. If they cannot suffer, they cannot be punished. But it can be argued that punishment is not desirable anyway. It only detracts us from what really matters, namely the prevention of similar tragic actions in the future. It has been argued that men are nothing but machines. If so, similar considerations could be applied to them. It turns out that considerations along these lines can already be found in the literature. In a piece called "Let's all stop beating Basil's car," Richard Dawkins (2006) wrote as follows:

AMSCE-101

> Retribution as a moral principle is incompatible with a scientific view of human behavior. As scientists, we believe that human brains, though they may not work in the same way as man-made computers, are as surely governed by the laws of physics. When a computer malfunctions, we do not punish it. We track down the problem and fix it, usually by replacing a damaged component, either in hardware or software.
>
> Basil Fawlty, British television's hotelier from hell, created by the immortal John Cleese, was at the end of his tether when his car broke down and wouldn't start. He gave it fair warning, counted to three, gave it one more chance, and then acted. "Right! I warned you. You've had this coming to you!" He got out of the car, seized a tree branch and set about thrashing the car within an inch of its life. Of course, we laugh at his irrationality. Instead of beating the car, we would investigate the problem. Is the carburetor flooded? Are the sparking plugs or distributor points damp? Has it simply run out of gas? Why do we not react in the same way to a defective man: a murderer, say, or a rapist? Why don't we laugh at a judge who punishes a criminal, just as heartily as we laugh at Basil Fawlty? Or at King Xerxes, who, in 480 BC, sentenced the rough sea to 300 lashes for wrecking his bridge of ships? Isn't the murderer or the rapist just a machine with a defective component? Or a defective upbringing? Defective education? Defective genes?

When Sparrow laments that military robots cannot be held responsible because they cannot suffer, he resembles Basil Fawlty, who laments that his broken car does not respond to threats. Their reactions are misplaced for the same reasons. The alternatives are clear in both cases as well: if you want to prevent such-and-such action, do something about it. If punishment does not help, adopt an alternative approach from among the courses of action that lead to more desirable behavior. In the case of humans, this means psychotherapy, chemical treatment, or neurosurgery and similar treatment; in the case of cars, this means looking at the carburetor, the sparking plugs, distributor points, and gas tank; in the case of nonhuman agents, this comes down to improving the sensory devices, fine-tuning the response mechanisms, adjusting the nonmortal combat devices, or rewriting the software. As Dawkins (2006) wrote, "Assigning blame and responsibility is an aspect of the useful fiction of intentional agents that we construct in our brains as a means of short-cutting a truer analysis of what is going on in the world in which we have to live." It is a tremendous advantage, not a defect, that we do not have to assign blame and responsibility to robots,

AMSCE-101

because we know what is going on inside them and what to do when something goes wrong. This brings us to our second thesis:

Thesis 2. It is regrettable and not satisfactory at all that punishment is usually the best we can do in the case of human wrongdoing.

9.3 The Logic of Responsibility

What exactly *are* responsibility and agency? In recent years, logicians and artificial intelligence researchers have devoted considerable attention to this topic (Belnap, Perloff, and Xu 2001; Horty 2001). The literature is vast and complicated, but one thing to note is that logicians have made a distinction between two concepts of action:

1. *Seeing to it that* (this is Chellas's theory of CSTIT: Chellas's Seeing To It That);

2. *Deliberatively seeing to it that* (this is Horty's theory of DSTIT: Deliberatively Seeing To It That).

DSTIT can be defined in terms of CSTIT: an agent A deliberatively sees to it that P if and only if (1) A sees to it that P (in the sense of Chellas) and (2) it is possible that not P. Deliberative action presupposes the ability to make choices, the ability to do otherwise; agents' choices usually are assumed to be independent from each other. Chellas's concept of seeing to it that does not depend on this notion of choice. CSTIT theory is a theory of causal responsibility, while DSTIT theory is related to moral responsibility, because it is usually assumed than an agent should only be held morally responsible if he or she could have done otherwise (this view goes back to Aristotle's *Nicomachean Ethics*). It is to be noted that these analyses of responsibility *do not mention punishment at all*: this suggests that the concepts of responsibility and punishment are less closely related than Sparrow assumed.

AMSCE-1101

How does this apply to robots? Let us first consider the case of nondeliberating robots, which are controlled by a human commander. Such cases are described by sentences of the following form:

(1) Commander A deliberatively sees to it that robot B sees to it that P.

Who is responsible in such a case? It turns out (as a matter of logic) that both the robot and the commander are *causally* responsible, but it is only the commander (not the robot) that can be *morally* responsible, for the simple reason that the robot has no choice and does not have the ability to do otherwise.

This is in perfect agreement with the legal maxims *qui facit per alium facit per se* and *respondeat superior*, which can be summarized as follows:

> **Qui facit per alium facit per se** means "he who acts through another does the act himself." This is a fundamental maxim of agency (*Stroman Motor Co. v. Brown*, 116 Okla 36, 243 P 133). A maxim often stated in discussing the liability of employer for the act of employee (35 Am J1st M & S § 543). According to this maxim, if in the nature of things the master is obliged to perform the duties by employing servants, he is responsible for their act in the same way that he is responsible for his own acts (Anno: 25 ALR2d 67).
>
> **Respondeat superior** means "let the master answer." This is a legal principle, which states that, in most circumstances, an employer is responsible for the actions of employees performed within the course of their employment. This rule is also called the "Master-Servant Rule," recognized in both common law and civil law jurisdictions. This principle is related to the concept of *vicarious liability*.

It is comforting to know that these age-old legal principles can be applied to modern robots and flow naturally from our logical account.

The analysis is more complex in the case of deliberative (autonomous) robots, which can potentially be held responsible precisely because of their capacity to engage in deliberation. As noted earlier, agents' choices are independent from each other, in the sense that any combination of possible choices available to different agents at the same moment must be compatible. Each agent can choose each of its

AMSCE-1101

alternatives, regardless of what the other agents are doing at the moment. This implies that an agent cannot deliberatively see to it that another agent deliberatively sees to it that something is the case. This makes this case quite unlike the case presented in the previous section, in which an agent deliberatively did something by using another agent as an instrument. One cannot exert such control over independent agents; instead, we must think of other ways to induce them to perform in ways we see fit. One simple way of doing so consists of *blocking* all undesirable courses of actions, in the sense of making them impossible; this undermines the subordinate agents' ability to do otherwise, and leaves them no choice but to undertake the desired courses of action.

In general, even though an agent cannot see to it that another agent makes a certain specific choice (the latter agent can always choose differently), an agent can see to it that another agent makes *some* choice. Formally: even though

> (1) Commander A deliberatively sees to it that robot B deliberatively sees to it that P
>
> is necessarily false,
>
> (2) Commander A deliberatively sees to it that: either robot B deliberatively sees to it that P or robot B deliberatively sees to it that not P
>
> might well be true.

Situations of the latter type have been called situations of "forced choice" (Belnap Perloff, and Xu 2001, chapter 10B2). We may similarly speak of cases of "forced moral responsibility."

Cases of this type have played a prominent role in military trials (Wikipedia.org 2010). Nuremberg Principle IV states "the fact that a person acted pursuant to order of his government or of a superior does not relieve him from responsibility under international law, provided a moral choice was in fact possible to him." Similarly, in the Ehren

AMSCE-1101

Watada case, the judge ruled that soldiers, in general, are not responsible for determining whether the order to go to war itself is a lawful order—but are only responsible for those orders resulting in a specific application of military force, such as an order to shoot civilians, or to treat POWs inconsistently with the Geneva Conventions. Nuremberg Principle IV and the Ehren Watada judgment concern the choices and moral responsibility of agents in situations that were brought about by other agents (their superiors).

Even though logicians and lawyers can reason about cases in which forced choices play a role, it is doubtful whether such situations will play a role in robot ethics. Autonomous military robots that deliberate and perform voluntary actions out of their own accord seem very far off indeed. They might even be seen as unwelcome in view of the risk of insubordination; commanders might object to robots that protest against their commanders' or operators' commands. The case of nondeliberative robots that are used as instruments by their operators seems more realistic. We discussed this case earlier (referring to the *qui facit per alium* and *respondeat superior* principles) and in fact came to a similar conclusion as St. Augustine did (section 9.1).

9.4 Design of Military Robots

Even though intelligent military robots may turn out to be morally preferable to humans for the reasons that we have indicated,[2] this does not mean that it will be easy to build them. Quite apart from the technical aspects (superior sensory devices, discrimination between friend and foe, and so on), there are ethical questions to consider. For example, should ethical principles (do not kill unnecessarily, avoid collateral damage, do not harm civilians, do not torture, respect the Geneva Conventions, and so on) be included in their lists of goals to pursue, or pitfalls to be avoided? But what do these principles mean

AMSCE-101

exactly? How can they be made precise? For example, what is torture, anyway? How can it be demarcated from mild pressure? Is a civilian who supports the enemy an enemy? A lot of conceptual ethical analysis is needed before such principles have been made precise enough to such a degree that they can be burnt into the hardware or software that controls the behavior.

Furthermore, how should they be built in? Is ethics primarily a matter of logic? Should robots follow these rules by means of logical reasoning, namely, by proving theorems and refuting nontheorems? (Bringsjord, Arkoudas, and Bello 2006; van den Hoven and Lokhorst 2002). If so, should default reasoning perhaps be built in, should the frame problem (including the *moral* frame problem) be considered, and should the problem of induction and abduction be solved before we set out on this path? Is some kind of self-monitoring, a module that keeps track of the robot's moral reasoning, worth building in (Lokhorst forthcoming)? Or should we forget about logic and merely build in appropriate pattern recognition software, perhaps in the form of statistical software or neural networks? Or better yet, should both routes be pursued, just as in the case of humans, who are often asserted to have two decision mechanisms, a fast, automatic, innate mechanism, which provides us with our gut feelings, and a slow, conscious, learned circuit, which takes care of our rational decisions?[3] If so, how should they be kept in balance? Is it necessary to incorporate a mechanism that keeps track of actions that should have been done otherwise (i.e., a mechanism that generates regret)?

Nobody knows at this moment, and much research is needed before we will be able to answer these questions. Before we embark on such research, we should try to answer the preliminary question of whether its objective is ethically desirable. We have tried to answer this question in this chapter. According to us, there can be no doubts about its proper answer. We therefore propose our third thesis:

AMSCL-101

Thesis 3. From a moral point of view, the design of military robots is eminently desirable, provided that such robots are designed as transparent robots that avoid killing to the maximum extent possible, and not as inscrutable killer robots, over which we have no control.

Even if military robots could be held responsible to some extent (as discussed earlier in the forced choice cases), this would never excuse us in case something goes wrong, because those who design and deploy military robots are those who are responsible for them in the first place (as indicated by the *qui facit per alium* and *respondeat superior* principles previously discussed). This may be regarded as unfortunate, but we regard it as welcome because we have more control over the design of military robots that act in agreement with our own ethical specifications than over the training of human soldiers, which is a hit-and-miss affair, at best.

9.5 Conclusion

We claim that it should never be assumed that human beings, in their role of designer, maker, manager, or user of robots and other artifacts or technological systems, can transfer moral responsibility to their products in case of untoward outcomes, or can claim diminished responsibility for the consequences brought about by their products. We claim that designers of autonomous robots are "design responsible" in all cases. In the causal case, this is so for the reasons we have expounded, since the robot is an instrument like any other artifact. In the deliberative case, it is so because the designer is responsible for "designing in" the logic of deontic reasoning and deontic metareasoning, which will lead the robot to make the right choices similar to the way in which we teach our children to think correctly in moral matters. In both cases, we think it would be unethical to produce such systems or work on their development while assuming that the locus of full and undivided

AMSCE-1101

responsibility for outcomes can be assigned to the artifacts themselves, however accomplished and sophisticated they are. We consider the shift of responsibility to the thing one has produced as an ultimate form of bad faith, meaning, denial of human choice, freedom, and responsibility. The designers, producers, managers, overseers, and users are and remain always responsible. The fact that it is difficult to apportion responsibility should not deter us. The apportioning of responsibility outside the simplest cases is problematic anyway. We hope that this contribution will make it easier to allocate responsibility adequately and fairly when thinking about responsibility and robots.

We focus on the responsibility of the designers and refer to their specific responsibility as "design responsibility." One specific and important aspect of design responsibility is to design in accordance with well-accepted and widely shared values. In software engineering, this approach is referred to as "value sensitive design" (van den Hoven and Manders-Huits 2009). In the case of military robots, there is a well-accepted normative framework in the form of Geneva Conventions, laws of war, and, more generally, the doctrines of just war theory—*jus ad bellum*, *in bello*, and *post bellum*. These provide us with moral principles that need to be translated and applied to the design of military robots. These principles are fairly broad since they also pertain to the design of the institutional context that guarantees design compliance with these accepted doctrines and their implications.

But, as former Pentagon Chief of High Value Targeting Marc Garlasco said, we cannot simply download international law into a computer (Singer 2009, 389). Sustained legal engagement and ethical reflection must be present from the very beginning of the design process. Investigating how ethical and legal norms can be "designed in" to complex systems is a core research goal of this process.

AMSCL-101

Notes

[1] The findings of military writer and analyst S. L. A. Marshall, syndicated columnist for the *Detroit News* and brigadier general in the Army Reserve, are less reliable than is usually reported: see Chambers 2003.

[2] Arkin has made a similar claim: “My research hypothesis is that intelligent robots can behave more ethically in the battlefield than humans currently can. That’s the case I make” (cited in Dean 2008; see also Arkin 2009).

[3] See the book by Lehrer for a description of these two mechanisms, their strengths and weaknesses, and a discussion of the question when to use which of the two. Also see the discussion about the necessity of merging the cognitive top-down approach with a less cognitive bottom-up approach (Wallach and Allen 2009).

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AMSCE-1101

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AMSCE-1101

IV

Law

AMSCE-1101

Related to the question of responsibility in the preceding chapter is perhaps the most practical issue in robotics: how it is accounted for in law. To the extent that programming limitations, errors, accidents, and so on, are the most pressing concerns in robotics today, we would reflexively look toward law to address whatever harm might arise from robots. Yet while product liability and other areas of law already exist, they are largely untested with respect to autonomous robotics, which may shift responsibility from human designers and operators to the machine itself. This section, then, offers chapters on law and governance in robotics.

In chapter 10, Richard O'Meara continues the discussion of military robotics, again as a major area of concern in robot ethics and in media headlines. Despite a lack of consensus on the need for military robotics governance or how to proceed with it, he points to considerable infrastructure already in place that can serve as a starting point to create this technology governance, political will permitting.

In chapter 11, Peter Asaro considers how legal theory, or jurisprudence, might be applied to robots, suggesting possible approaches to some problems. He finds that legal theory does allow us to define certain classes of ethical problems that correspond to traditional and well-defined legal problems, while other difficult practical and metaethical problems cannot be solved by legal theory alone. Moreover, there are several fundamental legal issues that are raised by robotic technologies.

M. Ryan Calo looks at the issue of privacy in chapter 12, a key area of law for not just robotics but other emerging technologies as well. The impact on privacy comes not only from the fact that robots have sensors that can monitor and report on our activities, but also from the access that robots will have into historically private settings, such as inside our homes, and the willingness we may have to share information with anthropomorphized robots. We then proceed to part V, in which our growing relationships with robots are the focus.

10

Contemporary Governance Architecture Regarding Robotics Technologies: An Assessment

Richard M. O'Meara

Even a cursory review of the contemporary governance architecture regarding military technological innovation generally reveals a disturbing lack of consensus regarding the necessity for governance and the methodologies to be utilized to achieve it. Innovations, adaptations, and uses in the areas of nanotechnology, bioscience, information science, cognitive technologies—referred to generally as NBIC—and especially robotics, are being discovered at an unprecedented rate in a culture of technological uncertainty, which provides very little time and

AMSCE-1101

minimal governance in order to ask the question of not *can* we do this, but *should* we do this.

Regarding the *use* of weapons, such as robotics, however, there is a fairly robust governance architecture. The field of ethics, for example, has dealt with issues of weapons use for centuries. Ethics has traditionally provided humankind with guidance regarding the use of weapons on the battlefield. Just War Theory, for example, speaks specifically to justification for the use of force in the first instance, *jus ad bellum*, and how that force can be utilized to obtain a just result, *jus in bello.* In order to initiate a just war, the issue of proportionality—the ideal that the universal goods to be obtained outweigh the universal evils that can be foreseen—might well be used to constrain the employment of certain types of robotics in certain ways.

Jus in bello certainly applies. Weapons use, here, is justified by adherence to concepts of military necessity, discretion, and proportionality. Where a particular robotic configuration, especially one with the independence to operate without humans in the loop, is unleashed on the battlefield, issues of target choice, collateral damage, and proportionate use of force wrestle with increased capabilities.

There is also the question of the "soldier's ethic." At least for the foreseeable future, a soldier is a human being, one who enters the profession with values and ethics learned at his or her mother's knee, during the formative years in civil society, and a sense of other moral systems, such as religious beliefs. The soldier is also capable of exhibiting generally accepted psychological traits of human beings, including fear, love, anger, rage, guilt, mercy, hope, faith, generosity, courage, shame and cowardice. The warrior traditionally has been enhanced by training and technology to accomplish the military function, which, according to Samuel Huntington (1956), is performed "by a public bureaucratized profession expert in the management of violence and responsible for the military security of the state." The soldier is also a volunteer, or, at least, has agreed in one form or another

AMSCE-1101

to enter a special class of citizens, prepared to project violence on behalf of the state, and committed to the knowledge that he or she may be targeted by others as a result of this commitment.

Consistent with the past, modern warrior respects actions of their peers, which reflect valor, loyalty, and adherence to the military ethic, even under the most dire of circumstances. Because the soldier is a realist and assumes human weakness and frailty—indeed, trains his whole life to overcome these characteristics personally—actions that reflect these values provide honor, a much sought-after commodity. This ethic, it would appear, has two functions, which are especially important given the environment in which the soldier works. The ethic helps the soldier differentiate between the killing he or she is required to do, and simple murder. A trained warrior is constrained to project force only in certain restricted situations. If there is compliance, despite the circumstance, the soldier is deemed honorable; otherwise, he or she is identified as a thug, a base murderer, rapist, sadist, etc. The ethic, therefore, provides constraint. Second, it can help the soldier justify the force he or she has used, which provides a useful psychological benefit, contributes to morale, and affirms a personal adherence to regulation. The warrior is a representative of the state for which he or she fights. This system of constraints inures not only to the warrior personally and the community in which he or she serves, but to the state itself.

Constraining the use of certain weapons as well are the various restrictions regarding the projection of force found in international law, which are translated into national law and regulation. There are, for example, multiple conventions that purport to deal with specific technologies and practices.[1] On the one hand, the United States is not a party to all of these conventions, and, to the extent that they do not rise to the level of customary international law, the United States is not specifically bound by them. On the other hand, the United States has taken considerable interest in the articulation of standards, which purport to regulate conduct generally on the battlefield, including how

AMSCE-101

weapons are used. There are five principles that run through the language of the various humanitarian law treaties[2] (the rules), which the United States acknowledges and generally honors. These principles are (1) a general prohibition on the employment of weapons of a nature to cause superfluous injury or unnecessary harm, (2) military necessity, (3) proportionality, (4) discrimination, and (5) command responsibility.

Some weapons, it is argued, are patently inhumane, no matter how they are used or what the intent of the user is. This principle has been recognized since at least 1907, although consensus over what weapons fall within this category tends to change over time. The concept here is that some weapons are *design dependent*; that is, their effects are reasonably foreseeable, even as they leave the laboratory. In 1996, the International Committee of the Red Cross (ICRC) at Montreux articulated a test to determine if a particular weapon would be the type that would foreseeably cause superfluous injury or unnecessary suffering (SIrUS). The SIrUS criteria would ban weapons when their use would result in

a. A specific disease, specific abnormal physiological state, a specific and permanent disability or specific disfigurement; or

b. Field mortality of more than 25 percent or a hospital mortality of more than 5 percent; or

c. Grade 3 wounds as measure by the Red Cross wound classification scale; or

d. Effects for which there is no well-recognized and proven treatment.

The operative term here is *specific*; the criteria speak to technology specifically designed to accomplish more than render an adversary *hors de combat*. The test here is purely medical and does not take into consideration military necessity. As such, it has been rejected by the

AMSCE-101

United States specifically and the international community generally (Lewand 2006; Verchio 2001).

The second principle, *military necessity*, requires a different analysis. This principle “justifies measures of regulated force not forbidden by international law which are indispensable for securing the prompt submission of the enemy, with the least possible expenditures of economic and human resources” (Gutman and Kuttab 2007, 239). Here force is permitted where a military objective is identified. These have been defined as those “objects which by their nature, location, purpose or use make an effective contribution to military action and whose total or partial destruction, capture or neutralization, in the circumstances ruling at the time, offers a definite military advantage” (239). Military necessity recognizes the benefit to friend and foe alike of a speedy end to hostilities—protracted warfare, it assumes, creates more rather than less suffering for all sides. In order to determine the necessity for the use of a particular technology, then, one needs to know what the definition of “victory” is, and how to measure the submission of the enemy in order to determine whether the technology will be necessary in this regard.

The third principle, *proportionality*, is of considerable concern to the innovator and user of new technologies. A use of a particular technology is not *proportional* if the loss of life and damage to property incidental to attacks is excessive in relation to the concrete and direct military advantage anticipated. In order to make this determination, it can be argued, one must consider the military necessity of a particular use and evaluate the benefits of that use in furtherance of a specific objective against the collateral damage that may result.

Discrimination, the fourth principle, strikes at the heart of judgment. Indiscriminant attacks (uses) are prohibited under the rules. Indiscriminant uses occur when they are not directed against a specific military objective, employ a method or means of combat the effects of which cannot be directed at a specified military target (indiscriminant

AMSCE-101

bombing of cities for example), employ a method or means of combat the effects of which cannot be limited as required, or, are of a nature to strike military and civilian targets without distinction.

A final principle of the rules is *command responsibility,* which exposes a multiple of superiors to various forms of liability for failure to act in the face of foreseeable illegal activities. This is a time-honored principle, based on the contract between soldiers and their superiors, which requires soldiers to act and superiors to determine when and how to act. It has a long history reflective of the need for control on the battlefield.[3]

Article 36 of the 1977 Additional Protocol 1 to the Geneva Conventions of 1949 requires that each "State Party"

> determine whether the employment of any new weapon, means, or method of warfare that it studies, develops, acquires, or adopts would, in some or all circumstances, be prohibited by international law. . . . The legal framework of the review is the international law applicable to the State, including international humanitarian law (IHL). In particular, this consists of the treaty and customary prohibitions and restrictions on specific weapons, as well as the general IHL rules applicable to all weapons, means, and methods of warfare. General rules include the rules aimed at protecting civilians from the indiscriminate effects of weapons and combatants from unnecessary suffering. The assessment of a weapon in light of the relevant rules will require an examination of all relevant empirical information pertinent to the weapon, such as its technical description and actual performance, and its effects on health and the environment. This is the rationale for the involvement of experts of various disciplines in the review process. (Lewand 2006)

Again, the United States is not a signatory to this protocol and, thus, technically not bound by its requirements. To the extent that it sets out reasonable requirements and methodologies for use by states fielding new and emerging technologies, however, this treaty could well set the standard in international law for appropriate conduct. Failure to consider its mechanisms, definitions, and proscriptions, then, may well constitute a violation of customary international law in the future.

Another constraint worth noting is the emerging trend in international law to hold those responsible for fielding weapons that allegedly

AMSCE-101

contravene the principles enunciated above through the use of litigation based on the concept of *universal jurisdiction.* The concept of universal jurisdiction is a customary international law norm that permits states to regulate certain conduct to which they have no discernable nexus. Generally, it is recognized as a principle of international law that all states have the right to regulate certain conduct, regardless of the location of the offense or the nationalities of the offender or the victims. Piracy, slave trade, war crimes, and genocide are all generally accepted subjects of universal jurisdiction. Belgium, Germany, and Spain have all entertained such prosecutions. Arising out of the war on terror and Iraq, former President George W. Bush, former secretaries of defense and state Rumsfeld and Kissinger, and former military commanders Powell and Franks, have all been the subject of such suits.

The issue of *lawfare* is also of concern. Lawfare is a strategy of using or misusing law as a substitute for traditional military means to achieve military objectives. Each operation conducted by the U.S. military results in new and expanding efforts by groups and countries to use lawfare to respond to military force. As military technology evolves, so do the scenarios facing military planners. New types of weaponry raise a host of legal and ethical questions. For example, new weaponry that can destroy power networks through electrical transmissions may seem to be preferable to traditional bombs. When electricity grids are destroyed, however, hospitals and civilians will lose power, as well, possibly resulting in civilian casualties. American military authorities are still grappling with many of these issues.

While litigation to date has revolved primarily around allegations of practices such as genocide and torture/interrogation, there is no reason to believe that future prosecutions may be justified where decisions regarding illegal innovation, adaption, and use of weapons systems are made and their conduct results in grave breaches of customary or statutory international humanitarian law.

10.1 The Intersection between Robotics and Governance

Robotics is one of a number of technologies being created in an environment of technological uncertainty. Discussions regarding the scope of emerging technologies are often difficult, due to the breadth and sophistication of the information about them. They often descend into ramblings about gadgets and gizmos and reflect the short answer to Peter Singer's question, "Why spend four years researching and writing a book on new technologies? Because robots are frakin' cool" (Singer 2009). Because innovation is and has always been catalytic, feeding off itself, reacting to its intended and unintended consequences, and influenced by the environment in which it is created and creating new environments as it goes, the discussion must, of course, be much longer and more nuanced. Of equal importance is the fact that demands for emerging technologies are coming faster and faster, and failure to keep up can have disastrous effects on the battlefield (Dunlap 1999; Shachtman 2009).

The scope of contemporary technological innovation is both impressive and staggering. Indeed, for the average consumer of these technologies, whether on the battlefield or in daily life—the general who orders this technology, the politician who pays for it, the user whose life is changed by it, even the Luddite who rails against it—these technologies are magic. They are incomprehensible in the manner of their creation, the details of their inner workings, the shear minutiae of their possibilities; they are like the genie out of the bottle and clamoring to fulfill three wishes: guess right and the world is at your fingertips; guess wrong, and there may well be catastrophe. And you have to guess quickly, for the genie is busy and has to move on. There are, of course, shamans who know the genie's rules, who created the genie, or, at least, discovered how to get it out of the bottle. You go to them and beg for advice regarding your wishes. What should I take from the genie? How

AMSCE-1101

should I use my wishes? Quickly tell me before I lose my chance and the genie makes the choices for me. And you find that the shaman is busy with new genies and new bottles, and has not given your choices much thought at all. He may stop to help you ponder your questions, but most likely he goes back into his tent and continues his work: “You’re on your own, kid. . . . Don’t screw up!”

Robotics enjoys preeminence in the discussion of military technologies, perhaps, because popular culture has served to inform the public of their possibilities and, further, it may be said that their applications are easier to comprehend. Robots are defined as

> machines that are built upon what researchers call the “sense-think-act” paradigm. That is, they are man-made devices with three key components: “sensors” that monitor the environment and detect changes in it, “processors” or “artificial intelligence” that decides how to respond, and “effectors” that act on the environment in a manner that reflects the decisions, creating some sort of change in the world around a robot. When these three parts act together, a robot gains the functionality of an artificial organism. (Singer 2009)

Robots are deployed to perform a wide range of tasks on and off the battlefield, and Congress has mandated that their use expand radically in the next decade. The U.S. Department of Defense in its *FY2009–2034 Unmanned Systems Integrated Roadmap* reports:

> In today’s military, unmanned systems are highly desired by combatant commanders (COCOMs) for their versatility and persistence. By performing tasks such as surveillance, signals intelligence (SIGNIT), precision target designation, mine detections, and chemical, biological, radiological, nuclear (CBRN) reconnaissance, unmanned systems have made key contributions to the Global War on Terror (GWOT). As of October 2008, coalition unmanned aircraft systems (UAS) (exclusive of hand-launched systems) have flown almost 500,000 flight hours in support of Operations Enduring Freedom and Iraqi Freedom, unmanned ground vehicles (UGVs) have conducted over 30,000 missions, detecting and/or neutralizing over 15,000 improvised explosive devises (IEDs), and unmanned maritime systems (UMSs) have provided security to ports. (U.S. Department of Defense 2009)

Further, their development has increased as the needs have been identified. The Department of Defense reports that its investment in the

AMSCE-101

technology has seen “unmanned systems transformed from being primarily remote-operated, single-mission platforms into increasingly autonomous, multi-purpose systems. The fielding of increasingly sophisticated reconnaissance, targeting, and weapons delivery technology has not only allowed unmanned systems to participate in shortening the ‘sensor to shooter’ kill chain, but it has also allowed them to complete the chain by delivering precision weapons on target” (O’Rourke 2007). In other words, *autonomous* robots are being used to kill enemies on the battlefield, based on information received by their sensors and decisions made in their processors.

In the future, roboticists tell us that it is probable that robots, with the addition of artificial intelligence,[4] will be capable of acting independently, without human supervision—called *humans in the loop* —in the accomplishment of most tasks presently performed by soldiers today (Guetlein 2005; Krishnan 2009). Their sensors will be more capable of reading the environment than humans, their processors will, like a personal computer today, have available a wider range of information or experience and be able to consider it more rapidly than humans, and their effectors will not be constrained by human frailties of fear, fatigue, size, and reaction to stress. They will be capable of their own creation (fabrication) and maintenance. Indeed, some believe they will free humans from participation in warfare altogether (Minsky 1968).

In sum, robotics technology comes with a whole host of intended, as well as unintended, consequences. These include, but are certainly not limited to, issues of military ethics, what capabilities *should* be created and how should they be used, military anthropology, whether humans are necessary to the projection of force on the battlefield, whether the warrior ethic still has currency, and foreign policy. Is the decision to project force made easier when death and mayhem are created by machines, rather than humans? It is suggested that a system of coherent governance infrastructure provides a place where these issues can be

AMSCE-101

sorted out before rather than after these machines are unleashed on the battlefield.

Decisions regarding military innovation—who orders the technology, who pays for the technology, and the uses to which the technology will be put—are presently made in a decentralized and competitive environment which fosters innovation, but also contributes to an inherent instability in the decision-making process. Governance architecture does exist, but it is haphazard in its articulation, institutionalization, and enforcement, leaving spaces where the conflicting agendas of multiple stakeholders can have free sway. The creation of a coherent system of governance is possible, but only where all stakeholders are convinced of its need and the goals for which it is created. A coherent system of governance regarding these technologies will permit us to make rational choices about not only who we *can* be, but also who we *want* to be.

Notes

[1]. These include the 1999 Hague Declaration concerning expanding bullets; Convention on the Prohibition of the Development, Production, and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction (1972); Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (1976); Resolution on Small-Caliber Weapon Systems (1979); Protocol on Non-Detectable Fragments (Protocol 1) (1980); Protocol on Prohibitions or Restrictions on the Use of Mines, Booby-Traps, and Other Devises (Protocol 11) (1980); Protocol on Prohibitions or Restrictions on the Use of Incendiary Weapons (Protocol 111) (1980); Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on Their Destruction (1993); Protocol on Blinding Laser Weapons (Protocol 1V to the 1980 Convention (1995); Protocols on Prohibitions or Restrictions on the Use of Mines, Booby-Traps and Other Devices as amended on May 3, 1996; Protocol 11 to the 1980 Convention as amended on 3 May 1996; Convention on the Prohibition of the Use, Stockpiling, Production, and Transfer of Anti-Personnel Mines and on

AMSCE-1101

their Destruction (1997); Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects, amendment article 1, 21 (2001); Protocol 1 Additional to the 1949 Geneva Conventions; Convention on Cluster Munitions (2008). See International Committee of the Red Cross (2010).

2. International humanitarian law (IHL) comprises a set of rules that seek to limit the effect of armed conflict. Primary conventions include the Geneva Conventions of 1949, supplemented by the Additional Protocols of 1977 relating to the protection of victims of armed conflicts; the 1954 Convention for the Protection of Cultural Property in the Event of Armed Conflict and additional protocols; the 1972 Biological Weapons Convention; the 1980 Conventional Weapons Conventions and its five protocols; the 1997 Ottawa Convention on anti-personnel mines; and the 2000 Optional Protocol to the Convention on the Rights of the Child on the involvement of children in armed conflict. See International Committee of the Red Cross (2004).

3. This principle is noted by Sun Tzu in 500 BCE in the *Art of War* and was recognized during the U.S. Civil War. Article 71 of General Orders No. 100, “Instructions for the government of armies of the United States in the Field” (known as the “Lieber Code”), imposed criminal responsibility on commanders for ordering or encouraging soldiers to wound or kill already disabled enemies. Its codification occurred in the Hague Convention (1V) of 1907, Respecting the Laws and Customs of War on Land, and is explicitly described in the Additional Protocol 1 (AP1) 1977 to the Geneva Conventions of 1949 and has made its way into multiple war crimes cases including *In re Yamashita*, 327 U.S. 1 (1946); *United States v. Captain Ernest L. Medina*; and *The Prosecutor v. Zejnil Delalic, Zdravko, Zdravko Music, Hasin Delic and Esad Landzo*, Case No. IT-96–21-T Judgment, Trial Chamber, November 16, 1998, The International Court for the Former Yugoslavia (ICTY). The ICTY provides for three elements regarding the theory: (1) the existence of a superior-subordinate relationship; (2) the superior knew or had reason to know that the criminal act was about to be or had been committed; and (3) the superior failed to take the necessary and reasonable measures to prevent the criminal act or punish the perpetrators thereof. It is also reflected in Article 28 (b) of the Rome Statute of the International Criminal Court, UN Doc. 2187 U.N.T.S. 90.

4. One definition of AI is the science of making machines do things that would require intelligence if done by men. Ravi Mohan notes:

AMSCE-101

> First, robots will engage in lethal activities like mine clearing or IED detection. (This is happening today.) Then you'll see them accompany human combat units as augmenters and enablers on real battlefields. (This is beginning to happen.) As robotics gets more and more sophisticated, they will take up potentially lethal but noncombat operations, like patrolling camp perimeters or no fly areas, and open fire only when "provoked." (This is beginning to happen, too.) The final state will be when robotic weapons are an integral part of the battlefield, just like "normal" human controlled machines are today and make autonomous or near autonomous combat decisions. (Mohan 2007)

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AMSCE-1101

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AMSCE-1101

11

A Body to Kick, but Still No Soul to Damn: Legal Perspectives on Robotics

Peter M. Asaro

The continued advancement of robotic technologies has already begun to present novel questions of social and moral responsibility. While the overall aim of this collection is to consider the ethical and social issues raised by robotics, this chapter will focus on the legal issues raised by robotics. It starts from the assumption that we might better understand the social and moral issues surrounding robotics through an exploration of how the law might approach these issues. While it is acknowledged that there are instances where what is legal is not necessarily morally esteemed, and what is morally required may not be legal, in general, there is a significant overlap between what is legal and what is moral. Indeed, many of the crucial concepts are shared, and as such this chapter will explore how the law views responsibility, culpability, causality, intentionality, autonomy, and agency. As a philosopher, rather than a lawyer or legal scholar, my concern will be with these theoretical concepts, and how their justificatory frameworks can be used to interpret and apply law to the new kinds of cases, which teleoperated, semi-autonomous, and fully autonomous robotics have already, or, may soon, present. Insofar as some of the issues will also involve matters of industry and community standards, public opinions, and beliefs, as well as social values and public morals, the chapter will consider questions of

AMSCE-110l

value. While my concern will be primarily with the law as it is typically understood and applied in the United States, my aim is that these reflections will also prove useful to scholars and lawyers of other legal traditions.

Indeed, the legal issues raised by robotic technologies touch on a number of significant fundamental issues across far-ranging areas of law. In each of these areas, there can be found existing legal precedents and frameworks which either directly apply to robotics cases, or which might be extended and interpreted in various ways so as to be made applicable. My aim is to consider each in turn, as well as to identify the principles that might underlie a coherent legal understanding of the development and use of robotic systems. Furthermore, I will consider the means by which we might judge the potential of robots to have a legal standing of their own. It will thus be helpful to organize the discussion in terms of both the salient types of robots—teleoperated, semi-autonomous, and autonomous—as well as the principal areas of law, criminal and civil.[1]

The most obvious issues that arise for the application of the law to robotics stem from the challenge that these complex computational systems pose to our traditional notions of intentionality, as well as how and whom to punish for wrongful acts (Bechtel 1985; Moon and Nass 1998). Most of the scholarship on law and robotics to date has focused on treating robots as manufactured products (Asaro 2006, 2007; Schaerer, Kelley, and Nicolescu 2009), subject to civil liability, or on whether robots can themselves become criminally liable (Dennett 1997; Asaro 2007), or the challenges robotic teleoperation poses to legal jurisdiction (Asaro 2011). I will begin by considering the more straightforward cases of semi-autonomous robots, which can be treated much like other commercial products. For these cases, the law has a highly developed set of precedents and principles from the area of law known as *product liabilities*, which can be applied.

AMSCE-JOI

I will then consider the implications of increasingly autonomous robots, which begin to approach more sophisticated and human-like performances. At some point in the future, there may be good reasons to consider holding such robots to standards of criminal or civil liability for their actions, as well as compelling reasons to hold their owners and users to higher, or lower, standards of responsibility for the wrongdoings of their robots. These considerations will draw upon a variety of legal areas with similar structures of distributing intention, action, autonomy, and agency. There exist certain similarities between such robots and their owners and controllers, and the ways in which individuals have traditionally been held to account for the wrongdoings of other subordinate intelligent, sentient, conscious, autonomous, and semi-autonomous agents. Examples include laws pertaining to the assignment of responsibility between animals and their owners, employees and their bosses, soldiers and their commanders, and slaves and their masters, as well as *agency law*, in which agents are entrusted with even greater levels of responsibility than is the case with typical subordinates. There are also issues involving whether robots themselves are entitled to legal standing, redress, or even rights, including the ability to sign contracts, be subject to criminal liabilities, or the means by which they might be justly subjected to punishment for crimes. This will bring us to consider the punishments against other kinds of nonhuman legal agents, namely corporations, and what can be learned about robot punishments from corporate punishments.

11.1 Robots and Product Liability

Many of the most common potential harms posed by robotic systems will be covered by civil laws governing product liability. That is, we can treat robots as we do other technological artifacts—such as toys, weapons, cars, or airliners—and expect them to raise similar legal and moral issues in their production and use. In fact, the companies that

AMSCE-1101

currently manufacture robots are already subject to product liability, and retain lawyers who are paid to advise them on their legal responsibilities in producing, advertising, and selling these robots to the general public. Most of the public's current concerns about the possible harms that robots might cause would ultimately fall under this legal interpretation, such as a robotic lawnmower that runs over someone's foot, or a self-driving car that causes a traffic accident.

It will be helpful at this point to review the basic elements of product liability law.[2] Consider, for example, a toy robot that shoots small foam projectiles. If that toy were to cause several children to choke to death, the manufacturer might be held liable under civil law, and be compelled to pay damages to the families that lost children because of the toy. If it can be proven in court that the company was *negligent*, with regard to the defects, risks, and potential hazards arising from the use of their product, then the company could also be criminally, as well as civilly, liable for the damages caused to victims by their product. Legal liability due to negligence in product liability cases depends on either *failures to warn*, or *failures to take proper care* in assessing the potential risks a product poses. A failure to warn occurs when the manufacturer fails to notify consumers of a foreseeable risk, such as using an otherwise safe device in a manner that presents a potential for harm. For example, many power tools display warnings to operators to use eye protection or safety guards, which can greatly reduce the risks of using the device. The legal standard motivates manufacturers to put such warning labels on their products, and, in the preceding example, the manufacturer might avoid liability by putting a label on the package, stating that the robot toy contains parts that are a choking hazard to young children.

A failure to take proper care is more difficult to characterize. The idea is that the manufacturer failed to foresee a risk, which, if they had taken proper care, they would have likely foreseen. This counterfactual notion is typically measured against a somewhat vague community standard of reason, or an industry standard of practice, about just what proper care is

AMSCE-101

expected among similar companies for similar products. In some sense, the more obvious the risk is, according to such a standard, the more likely that the negligence involved rises to the level of criminality.

The potential failure to take proper care, and the reciprocal responsibility to take proper care, is perhaps the central issue in practical robot ethics from a design perspective. What constitutes proper care, and what risks might be foreseeable, or in principle unforeseeable, is a deep and vexing problem. This is due to the inherent complexity of anticipating potential future interactions, and the relative autonomy of a robotic product once it is produced. It is likely to be very difficult or impossible to foresee many of the risks posed by sophisticated robots that will be capable of interacting with people and the world in highly complex ways—and may even develop and learn new ways of acting that extend beyond their initial design. Robot ethics shares this problem with bioengineering ethics—both the difficulty in predicting the future interactions of a product when the full scope of possible interactions can at best only be estimated, and in producing a product that is an intrinsically dynamic and evolving system, whose behavior may not be easily controlled after it has been produced and released into the world (Mitcham 1990).

A classic defense against charges of failures to warn and failures to take proper care is the industry standard defense. The basic argument of the industry standard defense is that the manufacturer acted in accordance with the stated or unstated standards of the industry they are participating in. Thus, they were merely doing what other similar manufacturers were doing, and were taking proper care as measured against their peers. This appeal to a relative measure again points to the vagueness of the concept of proper care, and the inherent difficulty of determining what specific and practical legal and moral duties follow from the obligation to take proper care. This vague concept also fails to tell us what sorts of practices *should* be followed in the design of robots. An obvious role for robot ethics should be to seek to establish standards

AMSCE-101

for the robot industry, which will ensure that the relevant forms of proper care are taken, and I believe this should be one of the primary goals for future robot ethics research.

If the company in question willfully sought to remain ignorant of the risks its robotic products might pose, such as by refusing to test a product or ignoring warnings from designers, then its negligence could also be deemed criminal. This would be a case of *mens rea*, in which the culpable state of mind is one of ignorance, either willfully or unreasonably. That is, if the risks posed are so obvious that they would be recognized by anyone taking the time to consider them, or knowledge of the risks had to be actively avoided, then that ignorance is criminal. Beyond that, if it can be shown that the manufacturer was actually aware of the risk, then this amounts to *recklessness.* Reckless endangerment requires a mental state of foreseeing risks or possible dangers, whether to specific individuals or an uncertain public, though not explicitly intending that any potential victims actually be harmed.[3] In some cases, recklessness can also be proved by showing that a "reasonable person" should have foreseen the risks involved, even if it cannot be proven that the defendant actually had foreseen the risks. An even more severely culpable state of mind would be if the company sold the dangerous toys *knowingly,* in awareness of the fact that they would cause damages, even though they did not intend the damages. And the most severe form of culpable liability is that of having the mental intention to cause the harm, or otherwise *purposely* causing harms. While these are all cases of criminal liability, as we will see later in our discussion of corporate punishment, such cases are almost always settled by awarding punitive monetary damages to victims and their legal advocates, rather than penalties owed to the state, such as imprisoning the guilty parties.[4]

Another interesting aspect of liability is that it can be differentially apportioned. That is to say, for example, one party might be 10 percent responsible, while another is 90 percent responsible for some harmful event. This kind of analysis of the causal chains resulting in harms is not

AMSCE-101

uncommon in cases involving traffic accidents, airliner crashes, and product liability. In many jurisdictions, there are laws that separate differential causal responsibility from the consequent legal liability. Among these are laws imposing *joint and several liability*, which holds all parties equally responsible for compensation, even if they are not equally responsible for the harm, or *strict liability*, which can hold a party fully responsible for compensation. These liability structures are meant to ensure that justice is done, in that the wronged individual is made whole (monetarily) by holding those most able to compensate them fully liable for paying all of the damages, even when they are not fully responsible for causing the harm. Nonetheless, these cases still recognize that various factors and parties contribute differentially to causing some event.

Differential apportionment could prove to be a useful tool when considering issues in robot ethics. For instance, a badly designed object recognition program might be responsible for some damage caused by a robot, but a bad camera could also contribute, as could a weak battery, or a malfunctioning actuator, and so on. This implies that engineers need to think carefully about how the subsystem they are working on could interact with other subsystems—whether as designed or in partial breakdown situations—in potentially harmful ways. That, in turn, would suggest that systems engineering approaches that can manage these complex interactions would become increasingly important for consumer robotics. It also means that manufacturers will need to ensure the quality of the components they use, including software, test the ways in which components interact with each other, as well as prescribe appropriate maintenance regimes to ensure the proper functioning of those components. This is typical of complex and potentially dangerous systems, such as in airliners and industrial robots, and may prove necessary for many consumer robots, as well.

There is, however, a limit to what robot manufacturers, engineers, and designers can do to limit the potential uses of, and harms caused by,

AMSCE-101

their products. This is because other parties, namely the consumers and users of robots, will choose to do various sorts of things with them and will have to assume the responsibility for those choices. For instance, when one uses a product in a manner wholly unintended by its designers and manufacturers, such as using a tent as a parachute, we no longer hold the manufacturer liable for the harms that result. Schaerer, Kelley, and Nicolescu (2009) argue that users should be held liable only in those cases in which it can be shown that they acted with harmful intentions. I disagree with this argument because of the intrinsic flexibility of design inherent in the programmability of robots. Typically, we do not hold manufacturers responsible when the hardware has been tampered with or extensively modified, or when the hardware is running software developed by users or a third party, even when there is no malice involved. We also do not always hold the company that develops a piece of software responsible when it turns out to be vulnerable to a malicious third party, such as a hacker or virus. Again, the operative legal considerations are causal responsibility and culpable intent. However, in manufacturing a product that is programmable, and thus wildly customizable, a great deal of responsibility lies in the hands of those who do the programming, as well as those who use the robot by giving it various commands.

The challenge presented by programmable general-purpose robots is that it is unreasonable to expect their manufacturers to anticipate all the things their robots might be programmed to do or asked to do, and thus unreasonable to hold them liable for those things. At least, the less foreseeable the uses, the less responsible the manufacturer might be. But there is no clear and definitive line here. At one extreme are cases where the manufacturer ought to be held liable, and at the other extreme cases where the programmer or user ought to be held liable. At one extreme, we would find the narrowly specified applications of the robots for which its manufacturers intended the product to be used. At the other extreme, we might find a highly original custom application or program,

AMSCE-IIOJ

which perhaps only that particular programmer or user might have dreamt up.

Like built-in programming, the context in which the robot has been placed and the instructions given to it by its owners may also be the determining, or contributing, causes of some harm, where the robot is the proximate cause. Orders and operator commands are like programming, in some sense, and as natural language processing grows more sophisticated, the two may become increasingly indistinguishable. And even a well-programmed robot can be ordered to do things that might unintentionally cause harms in certain situations. In short, there will always be risks inherent in the use of robots, and at some point the users will be judged to have knowingly assumed these risks in the very act of choosing to use a robot. Properly assessing responsibility in liability cases will be difficult and contested, and will depend on decisions in future cases that establish various legal precedents for interpreting such cases.

It also seems likely that robotic technologies will advance much like computer technologies, in that hackers and amateur enthusiasts will push the envelope of capabilities of new devices as much as commercial manufacturers do, especially in terms of the software and programming of robots. Even iRobot’s mild-mannered Roomba vacuum-cleaning robot has a fully programmable version called Create (iRobot.com 2010), and hackers have created their own software development kits (SDKs) to customize the Roomba robot as they see fit, though at their own liability (Kurt 2006). As long as these robotic products have enough safe and legitimate uses, it would be difficult to prohibit or regulate them, just as it would be difficult to hold the manufacturers responsible for any creative, even if dangerous, uses of their products. Cars and guns are also very dangerous consumer products, but it is the users who tend to be held liable for most of the harms they cause, not the manufacturers, because the use of those potentially dangerous products place additional burdens of responsibility on the user. For

AMSCE-1101

manufacturers to be held responsible in those cases, it is usually necessary to show that there is some defect in the product, or that manufacturers misled consumers.

The crucial issue raised by Schaerer, Kelley, and Nicolescu (2009) is whether to hold the manufacturer strictly liable for all the damages (because they are better able to pay compensation and to ensure responsible design), or whether their limited ability to foresee a possible application of their technology should limit their liability in some way. One implication of applying strict liability, as Schaerer, Kelley, and Nicolescu argue, is that doing so may result in consumer robots being designed by manufacturers to limit their liability by making them difficult to be reprogrammed by users, or safeguarding them from obeying commands with hazardous implications. This could include making the open-ended programming of their robots more difficult, or incorporating safety measures intended to prevent harm to humans and property, such as ethical governors (Arkin 2009).[5] Conversely, by shielding individual users from liability, this could also encourage the reckless use of robotic systems by end-users. Cars are causally involved in many unintended harms, yet it is the drivers who are typically held responsible rather than manufacturers. This issue points to a fundamental tension between identifying the causal responsibility of original manufacturers, end-users, and third-parties, and the need for legal policies that can shape the responsible design and use of consumer robots, even if they run counter to our intuitions about causal responsibility.

An additional challenge that we may soon face is determining the extent to which a given robot has the ability to act “of its own accord,” either unexpectedly or according to decisions it reaches independently of any person. As robot control programs become more capable of various forms of artificial reasoning and decision-making, these reasoning systems will become more and more like the orders and commands of human operators in terms of their being causally

AMSCE-101

responsible for the robots' actions, and, as such, will tend to obscure the distinction just made between manufacturers and users. While some sophisticated users may actually design their own artificial intelligence systems for their robots, most will rely on the reasoning systems that come with these robots. Thus, liability for faults in that reasoning system might still revert to the manufacturer, except in cases where it can be shown that the user trained or reprogrammed the system to behave in ways in which it was not originally designed to behave. In its general form, the question of where commands and orders arise from is integral to the legal notions of autonomy and agency. There is a growing literature addressing the question of whether robots can be capable of moral autonomy, or even legal responsibility (Wallach and Allen 2009). But missing from these discussions is the recognition that the law does not always hold morally autonomous humans fully responsible for their own actions. The notable cases include those of diminished mental capacity, involuntary actions, or when agents are following orders of a superior. The next section will consider the possibility that even if a robot could become, in some sense, fully autonomous, then we might not be inclined to hold it legally liable for all of the harms it might cause.

11.2 Vicarious Liability, Agents, and Diminished Responsibility

There are multiple areas of the law that deal with cases in which one independent, autonomous, rational being is acting on behalf of, or in subordination to, another. Often discussed in the robotics literature are laws governing the ownership of domesticated animals; however, there are also analogous cases involving the laws governing the liability of employees and soldiers following orders, as well as historical laws governing the liability of masters for their slaves, and the harms they cause when agents are carrying out the orders of their superiors. The laws governing animals are the simpler cases, as animals are not granted

AMSCE-IIOT

legal standing, though they may be entitled to protections from abuse in many jurisdictions. More complicated are cases where a person can act either on behalf of a superior or on their own behalf, and judging a specific act as being one or the other can have differing legal implications. The area of law dealing with these three-party relationships is called *agency law*,[6] and we will consider this after first considering the legal liabilities surrounding domesticated and wild animals.

It has been recognized that robots might be treated very much like domesticated animals, in that they clearly have some capacity for autonomous action, yet we are not inclined to ascribe to them moral responsibility, or mental culpability, or the rights that we grant to a human person (Caverley 2006; Schaerer, Kelly, and Nicolescu 2009). Domesticated animals are treated as property, and as such any harms to them are treated as property damages to the owner. Because they are domesticated, they are generally seen as not being particularly dangerous if properly kept. Despite this, it is recognized that animals sometimes act on their own volition and cause harms, and so their owners can be held liable for the damages caused by their animals, even though the owners have no culpable intentions. If, however, the owners' behavior was criminally negligent, reckless, or purposeful, then the owners can be held criminally liable for the actions of their animals. For instance, it can be criminal when someone fails to keep his or her animal properly restrained, trains an animal to be vicious, orders an animal to attack, or otherwise intends for the animal to bring about a harm.

We should note that in such cases the intention of the animal is rarely relevant—it does not matter much for legal purposes whether the animal intended the harms it caused or not. Rather, it is the owner's intention that is most relevant. Moreover, in those cases where the animal's intention runs counter to the owner's intention, this can have two different consequences. In cases of domestic animals, where the animal suddenly behaves erratically, unexpectedly, or disobeys its owner, then

AMSCE-IOI

this tends to diminish the *mens rea* of the owner, though does not release them from liability, and often motivates the destruction of the animal. However, in cases of exotic or wild animals, such as big cats, nonhuman primates, and poisonous snakes, there is a certain presupposition of their having independent reasoning (i.e., being wild) and being more physically dangerous than domesticated animals. And with the recognition of the intrinsic danger they pose to other people, there is an additional burden of responsibility on the owner. Owning such animals has various restrictions in different states (Bornfreeusa.org 2010; Kelley et al. 2010), and the very act of owning them is recognized as putting other members of the community at risk, should the animal escape or someone accidentally happen upon them. Failing to properly keep such an animal can automatically constitute criminally reckless endangerment, based on the known dangerousness of the animal.

Such a standard might also be applied in robotics. A standard off-the-shelf robot might be considered as being like a domesticated animal, in that its manufacturer has been entrusted to design a robot that is safe to use in most common situations. However, a highly modified, custom programmed, or experimental robot might be seen as being more like a wild animal, which might act in dangerous or unexpected ways. Thus, someone who heavily modifies his or her robot, or builds a highly experimental robot, is also undertaking greater responsibility for potentially endangering the public with that robot. A good example would be someone who armed a robot with a dangerous weapon. Such an act could itself be seen as a form of reckless endangerment, subject to criminal prosecution, even if the robot did not actually harm anyone or destroy any property with the weapon. Similar principles apply in drunk-driving laws. By driving a car while drunk, an individual is putting others at risk, even if they do not actually have an accident. It is because of this increased risk that the activity is deemed criminal (as well as being codified in law as criminal). Building a robot that intentionally, knowingly, or recklessly endangers the public could be

AMSCE-1101

similarly viewed as a criminal activity, and laws to this effect should be established. More limited cases of negligent endangerment might be determined to be civilly or criminally liable.

With certain technologies that are known to be dangerous if misused —such as cars, planes, guns, and explosives—there are laws that regulate their ownership and use. This ensures both that the possession and use can be restricted to individuals who are trained and tested on the proper use of a technology, as well as to establish an explicit and traceable connection between a piece of technology and a responsible individual. Thus, the use of an airplane or automobile requires completing a regime of training and testing to obtain an operator's license. The ownership of a gun or explosives requires a license, which also aids in tracking individuals who might obtain such materials for illicit purposes, and in tracking the materials themselves. The ownership of dangerous exotic animals, and in many jurisdictions even certain particularly aggressive domesticated dog breeds, such as pit bulls, often requires a special license (Wikipedia.org 2010). It would not be unreasonable to expect that certain classes of robots, especially those that are deemed dangerous, either physically or because of their unpredictable behavior or experimental nature of their reasoning systems, might require special licenses to own and operate. Licenses might also be required to prevent children from being able to command dangerous robots, just as they are not allowed to drive cars, until they have reached a certain age and received training in the responsible uses of the technology.

The treatment of robots as animals is appealing because it does not require us to give any special rights or considerations to the robots—our only concern is with the owners. Another interesting area of legal history is the laws governing slavery. The history of these laws goes back to ancient Rome, and they have varied greatly in different times, places, and cultures, up to and including the slave laws of the United States. The U.S. slave laws ultimately treated slaves as property, but

AMSCE-IIOL

included numerous specialized clauses intended to manage the unique difficulties and dangers of enslaving human beings, as well as encoded specific racial aspects of slavery into the laws themselves. For the most part, slaves were treated as expensive animals, so that if a slave damaged the property of someone other than his or her owner, their owner was liable for the damage. Similarly, as property, the slave was protected from harm from individuals other than his or her owner, but such harms were viewed as property damage rather than crimes, such as assault or even murder. Indeed, the laws largely enshrined the ability of owners to harm their own slaves and not be subject to the criminal laws that might otherwise apply. Yet, it was also recognized that slaves exercised a will of their own, and so owners were not held liable for damages caused by their slaves if they had escaped. And, unlike animals, in the act of escaping, slaves were held liable for their own choice of whether to escape or not, though those who aided them were also held liable for assisting them in their escape. A full consideration of the implications of slave law for our understanding of robotics is beyond the scope of this chapter, but will be the subject of further research.

Agency law deals with cases in which one individual acts on behalf of another individual. In these cases, the *agent* acts on behalf of a *principal*. There are various circumstances where these relationships are established, but they generally involve some form of employment, often involving a contract.[7] Whether or not there is a written contract, the liability of the principal for the actions of its agents is derived from the doctrine of *respondeat superior*—that superiors are responsible for the action of their subordinates. Thus, if an employee causes a harm in the conduct of their job, and thus explicitly or implicitly at the discretion of their employer, the employer is liable. This is called *vicarious liability*—when one person or legal entity is liable for the actions of another. For instance, when a delivery truck damages a parked car, the delivery company, rather than the individual driver, can be held liable. There are exceptions to this, however, which recognize the independent autonomy

AMSCE-1101

of employees. One of the employer’s defenses against such liability claims is to argue that the employee was acting on their own behalf, and not that of the employer—which generally means showing they were not doing their job in the typical manner. Courts make a distinction between *detours*, in which an employee must digress from the usual manner of carrying out their job in order to achieve the purposes of their employer, and *frolics*, in which the employee is acting solely for their own purposes. Thus, when a driver finds an intersection blocked and must take a different route to make a delivery, the employer would still be liable for the damage to the parked car. However, if the driver had decided to take a different route in order to visit a friend before making the delivery, then the court may decide that this constitutes a frolic and the driver is responsible for the damage to the parked car because the driver was not carrying out their duties as an employee, or fulfilling the will or purpose of the employer, at the time of the accident.

These ideas might be usefully applied to many kinds of service robots. It would seem that, for most uses of a robot to assist a person in daily life, such as driving them around, shopping for them, cleaning and maintaining their home, running errands, and so on, the robot would be little different than a human servant or employee. As such, vicarious liability would apply, and the owner would therefore be liable for any harm caused by that robot in the conduct of their owner’s business. This would also include cases of detour, in which the robot was unable to carry out its duties in the normal or directed manner, and sought alternative routes, plans, or strategies for achieving its given goals.

As robots grow more sophisticated and autonomous, we might eventually be tempted to argue that they actually are capable of developing their own purposes. For such a robot, an owner might seek a defense from liability for the actions of a robot which was on a frolic of its own—a robot which, though employed in the service of its owner, caused some harm while pursuing its own purpose. Depending on the ways in which such robots might be programmed, and our ability to review its reasoning and planning processes, we might actually be able to determine from its internal records which purposes it was actually in pursuit of when it caused a particular harm. Of course, it might be that it was pursuing a dual purpose, or that the purposes were obscure, in which case the courts would have to make this determination in much the same manner as they do for human agents. However, this raises several issues regarding whether robots might themselves have legal standing, especially if they are capable of frolicking, or whether they might be subject to penalties and punishments, and it is to these issues that we now turn.

11.3 Rights, Personhood, and Diminished Responsibility

Modern legal systems were established on the presupposition that all legal entities are persons. While a robot might someday be considered a person, we are not likely to face this situation any time soon. However, over time the law has managed to deal with several kinds of nonpersons, or quasi-persons, and we can look to these for some insights on how we might treat robots that are nonpersons, or quasi-persons. Personhood is a hotly debated concept, and many perspectives in that debate are based in strongly held beliefs from religious faith and philosophical dispositions. Most notably, the status of unborn human fetuses, and the status of severely brain damaged and comatose individuals have led to much debate in the United States over their appropriate legal consideration and rights. Yet, despite strongly differing perspectives on such issues, the legal systems in pluralistic societies have found ways to deal practically with these and several other borderline cases of personhood.

Minor children are a prime example of quasi-persons. Minors do not enjoy the full rights of personhood that adults do. In particular, they cannot sign contracts or become involved in various sorts of legal arrangements, because they do not have the right to do so as minors.

AMSCE-1101

They can become involved in such arrangements only through the actions of their parents or legal guardians. In this sense, they do not have full legal standing. Of course, the killing of a child is murder in the same way that the killing of an adult is, and so a child is still a legal person in this sense—and, in fact, is entitled to more protections than an adult. Children can thus be considered a type of quasi-person, or legal quasi-agent. The case of permanently mentally impaired people can be quite similar to children. Even full-fledged legal persons can claim temporary impairment of judgment, and thereby diminished responsibility for their actions, given certain circumstances, for example, temporary insanity, or being involuntarily drugged. The point is that some aspects of legal agency can apply to entities that fall short of full-fledged personhood and full responsibility, and it seems reasonable to think that some robots will eventually be granted this kind of quasi-agency in the eyes of the law before they achieve full legal personhood.

11.4 Crime, Punishment, and Personhood in Corporations and Robots

Criminal law is concerned with punishing wrongdoers, whereas civil law is primarily concerned with compelling wrongdoers to compensate those harmed. There is an important principle underlying this distinction: crimes deserve to be punished, regardless of any compensation to those directly harmed by the crime. Put another way, the harmed party in a crime is the whole of society. Thus, the case is prosecuted by the state, or, by “the people,” and the debt owed by the wrongdoer is owed to the society. While the punishments may take different forms, the point of punishment is traditionally conceived of as being corrective in one or more senses: that the wrongdoer pays their debt to society (retribution); that the wrongdoer is to be reformed so as not to repeat the offense (reform); or that other people in society will be deterred from committing a similar wrong (deterrence).

There are two fundamental problems with applying criminal law to robots: (1) criminal actions require a moral agent to perform them, and (2) it is not clear that it is possible to punish a robot. While moral agency is not essential to civil law, moral agency is essential to criminal law, and is deeply connected to our concepts of punishment (retribution, reform, and deterrence). Moral agency might be defined in various ways, but, in criminal law, it ultimately must serve the role of being an autonomous subject who has a culpable mind, and who can be punished. Without moral agency, there can be harm (and hence civil liability), but not guilt. Thus, there is no debt incurred to society unless there is a moral agent to incur it—it is merely an accident or act of nature, but not a crime. Similarly, only a moral agent can be reformed, which implies the development or correction of a moral character—otherwise it is merely the fixing of a problem. And finally, deterrence only makes sense when moral agents are capable of recognizing the similarity of their potential choices and actions to those of other moral agents who have been punished for the wrong choices and actions—without this reflexivity of choice by a moral agent, and recognition of similarity between and among moral agents, punishment cannot possibly result in deterrence.

We saw in the previous section that it is more likely that we will treat robots as quasi-persons long before they achieve full personhood. Solum (1991–1992) has given careful consideration to the question of whether an artificial intelligence (AI) might be able to achieve legal personhood, using a thought experiment in which an AI acts as the manager of a trust. He concludes that while personhood is not impossible in principle for an AI to achieve, it is also not clear how we would know that any particular AI has achieved it. The same argument could be applied to robots. Solum imagines a legal Turing Test in which it comes down to a court's determination whether an AI could stand trial as a legal agent in

AMSCI-101

its own right, and not merely as a proxy or agent of some other legal entity. He argues that a court would ultimately base its decision on whether the robot in question has moral agency, and whether it is possible to punish it—in other words, could the court fine or imprison an AI that mismanages a trust? In cases of quasi-personhood and diminished responsibility, however, children and the mentally impaired are usually shielded from punishment as a result of their limited legal status, specifically because they lack proper moral agency.

There is another relevant example in law of legal responsibility resting in a nonhuman entity, namely corporations. The corporation is a nonhuman entity that has been effectively granted many of the legal rights and responsibilities of a person. Corporations can (through the actions of their agents) own property, sign contracts, and be held liable for negligence. In certain cases, corporations can even be punished for criminal activities, such as fraud, criminal negligence, and causing environmental damage. A crucial aspect of treating corporations as persons depends on the ability to punish them, though this is not nearly so straightforward as it is for human persons. As a seventeenth-century Lord Chancellor of England put it, corporations have “no soul to damn and no body to kick” (Coffee 1981), so how can they be expected to have a moral conscience? Of course, corporations exist to make money, for themselves or stockholders, and as such can be given monetary punishments, and in certain cases, such as antitrust violations, split apart, or dissolved altogether. Though they cannot be imprisoned in criminal cases, responsible agents within the corporation can be prosecuted for their individual actions. As a result of this, and other aspects of corporations being complex sociotechnical systems in which there are many stakeholders with different relations to the monetary wealth of a corporation, it can be difficult to assign a punishment that achieves retribution, reform, and deterrence, while meeting other requirements of justice, such as fairness and proportionality.[8]

Clearly, robots are different in many important respects from corporations. However, there are also many important similarities, and it is no coincidence that Coffee's (1981) seminal paper on corporate punishment draws heavily on Simon's (1947) work on organizational behavior and decision making, and in particular how corporate punishment could influence organizational decision making through deterrence. Nonetheless, a great deal of work needs to be done in order to judge just how fruitful this analogy is. While monetary penalties work as punishments for corporations, this is because they target the essential purpose for the existence of corporations—to make money. The essential purposes of robots may not be so straightforward, and, if they exist at all, they will vary from robot to robot and may not take a form that can be easily or fairly penalized by a court.

The most obvious difference from corporations is that robots do have bodies to kick, though it is not clear that kicking them would achieve the traditional goals of punishment. The various forms of corporal punishment presuppose additional psychological desires and fears central to being human that may not readily apply to robots—concerning pain, freedom of movement, mortality, and so on. Thus, torture, humiliation, imprisonment, and death are not likely to be effective in achieving retribution, reform, or deterrence in robots. There could be a policy to destroy any robots that do harm, but, as is the case with animals that harm people, it would essentially be a preventative measure to avoid future harms by an individual, rather than a true punishment. Whether it might be possible to build in a technological means to enable genuine punishment in robots is an open question. In short, there is little sense in trying to apply our traditional notions of punishment to robots directly. This appears to me to be a greater hurdle to ascribing moral agency to robots than other hurdles, such as whether it is possible to effectively program moral decision making.

11.5 Conclusion

AMSCE-IIOT

I hope that this brief overview of how certain legal concepts might be applied to current and future robots has convinced the reader that jurisprudence is a good place to begin framing some of the issues in robot ethics. I do not claim that this is the only viable approach, or that it will be capable of resolving every issue in robot ethics. Rather, I maintain that we can delineate different classes of ethical problems, some of which will have straightforward solutions from a legal perspective, while other classes of problems will remain unresolved. In terms of thinking about robots as manufactured products, many of the most practical and pressing issues facing robotics engineers can be seen as being essentially like those facing other engineers. In these cases, it is necessary to take proper care in imagining, assessing, and mitigating the potential risks of a technology. Just what this means for robotics will, of course, differ from other technologies, and should be the focus of further discussion and research. It is my belief that robot ethics will have its greatest influence by seeking to define and establish expectations and standards of practice for the robotics industry.

There remain a host of metaethical questions facing robot ethics that lie beyond the scope of the legal perspective. While moral agency is significant to the legal perspective, jurisprudence alone cannot determine or define just what moral agency is. Similarly, the ethical questions facing the construction of truly autonomous technologies demand special consideration in their own right. While there was no room to discuss it in this chapter, the legal perspective can also contribute to framing issues in the use of robots in warfare, though it offers little in the way of determining what social values we should aspire to enshrine in the laws governing the use of lethal robots. In particular, international law, humanitarian law, uniform codes of military conduct, the Geneva Conventions, the Nuremberg Principles, and international laws banning antipersonnel mines and limiting biological, chemical, and nuclear weapons, are all starting points for theorizing the

AMSCE-JIOI

ethics of using robot technologies in warfare, but may fall short in suggesting new standards for the ethical conduct of the kind of warfare that robots might make possible.

Notes

[1] In the system of Anglo-American law, a distinction is drawn between criminal and civil law, and within civil law there is a further distinction between the laws of torts and contracts. Tort law deals with property rights and infringements outside of, or in addition to, contractual obligations and crimes, and is primarily concerned with damage to one's person or property and other harms. Thus, one has the right to sue responsible parties for damages that one has suffered, even if one is not engaged in an explicit legal contract with the other party, and in addition to or regardless of whether the other party also committed a criminal act when causing the damages in question. Tort law seeks justice by compelling wrongdoers to compensate, or "make whole," those who were harmed for their loss (Prosser et al. 1984). Criminal law deals with what we tend to think of as moral wrongdoing or offenses against society, such as theft, assault, murder, etc., and seeks justice by punishing the wrongdoer.

There are several crucial differences between the concepts of criminal damages and civil damages and their accordant penalties. Most generally, for something to be a crime, there must be a law that explicitly stipulates the act in question as being criminal, whereas civil damages can result from a broad range of acts, or even inaction, and need not be explicitly specified in written law. Criminal acts are usually distinguished by their having criminal intent—a culpable state of mind in the individual committing the crime, known in Latin as *mens rea*. While certain forms of negligence can rise to the level of criminality, and can be characterized as nonmental states of ignorance, judgments of criminality typically consider mental states explicitly. Civil law, in comparison, is often indifferent to the mental states of the agents involved. And finally, there are differences in the exactment of punishments for transgressions. Under civil law, the damages are repaired by a transfer of money or property from the liable transgressor to the victim, while in criminal law the debt of the guilty transgressor is owed to the general public at large or the state, for the transgressor has violated the common good. A criminal penalty owed to society need not be evaluated in monetary terms, but might instead be measured in the revocation of liberty within

AMSCE-1101

society, expulsion from society, and in cultures of corporeal punishment, the revocation of bodily integrity or life, or the infliction of pain, humiliation, and suffering. In some instances, both frameworks apply, and criminal penalties may be owed over and above the restorative monetary damages owed to the victim of a crime.

2. For more on product liability law, see chapter 17 of Prosser et al. 1984.

3. It is in this way very much like the *doctrine of double effect* in Just War Theory (Walzer 1977), in that it separates knowledge of the possible harms of one's actions from the intention to actually bring those harms about. According to the doctrine of double effect, the killing of innocent civilians is permissible if the intended effect is on a militarily valid target, whereas the killing of civilians is not permissible if the intended effect is actually to harm the civilians.

4. For more on criminal negligence and liability, see chapter 5 of Prosser et al. 1984.

5. This notion is also popular in science fiction, starting with Isaac Asimov's "Three Laws of Robotics" (later four), and the "restraining bolts" in *Star Wars* droids, all of which aim to prevent robots from doing harm, despite maintaining their willingness to obey orders.

6. For more on the legal theory of agency, see Gregory 2001.

7. The principal can also be a corporation, in which case it is unable to act without its agents, which raises certain issues for corporate punishment, as we will see.

8. As Coffee (1981) argues, typical monetary fines against a company hurt shareholders and low-level employees more directly than they hurt the managers and decision makers in a company, which diminishes their ability to deter or reform those who made the bad decisions and thus the fairness of imposing such fines.

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AMSCE-101

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AMSCE-1101

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AMSCE-101

12

Robots and Privacy

M. Ryan Calo

Robots are commonplace today in factories and on battlefields. The consumer market for robots is rapidly catching up. A worldwide survey of robots by the United Nations in 2006 revealed 3.8 million in operation, 2.9 million of which were for personal or service use. By 2007, there were 4.1 million robots working just in people’s homes (Singer 2009, 7–8; Sharkey 2008, 3). Microsoft founder Bill Gates has gone so far as to argue in an opinion piece that we are at the point now with personal robots that we were in the 1970s with personal computers, of which there are many billions today (Gates 2007). As these sophisticated machines become more prevalent—as robots leave the factory floor and battlefield and enter the public and private sphere in meaningful numbers—society will shift in unanticipated ways. This chapter explores how the mainstreaming of robots might specifically affect privacy.[1]

It is not hard to imagine why robots raise privacy concerns. Practically by definition, robots are equipped with the ability to sense, process, and record the world around them (Denning et al. 2009; Singer 2009, 67).[2] Robots can go places humans cannot go, see things humans cannot see. Robots are, first and foremost, a human instrument. And, after industrial manufacturing, the principle use to which we’ve put that instrument has been surveillance.

AMSCE-1101

Yet increasing the power to observe is just one of ways in which robots may implicate privacy within the next decade. This chapter breaks the effects of robots on privacy into three categories—direct surveillance, increased access, and social meaning—with the goal of introducing the reader to a wide variety of issues. Where possible, the chapter points toward ways in which we might mitigate or redress the potential impact of robots on privacy, but acknowledges that, in some cases, redress will be difficult under the current state of privacy law.

As stated, the clearest way in which robots implicate privacy is that they greatly facilitate *direct surveillance*. Robots of all shapes and sizes, equipped with an array of sophisticated sensors and processors, greatly magnify the human capacity to observe. The military and law enforcement have already begun to scale up reliance on robotic technology to better monitor foreign and domestic populations. But robots also present corporations and individuals with new tools of observation in arenas as diverse as security, voyeurism, and marketing. This widespread availability is itself problematic, in that it could operate to dampen constitutional privacy guarantees by shifting citizen expectations.

A second way in which robots implicate privacy is that they introduce new points of *access* to historically protected spaces. The home robot in particular presents a novel opportunity for government, private litigants, and hackers to access information about the interior of a living space. Robots on the market today interact uncertainly with federal electronic privacy laws and, as at least one recent study has shown, several popular robot products are vulnerable to technological attacks—all the more dangerous in that they give hackers access to objects and rooms instead of folders and files.

Society can likely negotiate these initial effects of surveillance and unwanted access with better laws and engineering practices. But there is a third, more nuanced category of robotic privacy harm—one far less amenable to reform. This third way by which robots implicate privacy

AMSCE-101

flows from their unique *social meaning*. Robots are increasingly human-like and socially interactive in design, making them more engaging and salient to their end-users and the larger community. Many studies demonstrate that people are hardwired to react to heavily anthropomorphic technologies, such as robots, as though a person were actually present, including with respect to the sensation of being observed and evaluated.

That robots have this social dimension translates into at least three distinct privacy dangers. First, the introduction of social robots into living and other spaces historically reserved for solitude may reduce the dwindling opportunities for interiority and self-reflection that privacy operates to protect (Calo 2010, 842–849). Second, social robots may be in a unique position to extract information from people (cf. Kerr 2004). They can leverage most of the same advantages of humans (fear, praise, etc) in information gathering. But they also have perfect memories, are tireless, and cannot be embarrassed, giving robots advantages over human persuaders (Fogg 2003, 213).

Finally, the social nature of robots may lead to new types of highly sensitive personal information—implicating what might be called "setting privacy." It says little about an individual how often he runs his dishwasher or whether he sets it to auto dry.[3] It says a lot about him what "companionship program" he runs on his personal robot. Robots exist somewhere in the twilight between person and object and can be exquisitely manipulated and tailored. A description of how a person programs and interacts with a robot might read like a session with a psychologist—except recorded, and without the attendant logistic or legal protections.

These categories of surveillance, access, and social meaning do not stand apart—they are contingent and interrelated. For example: reports have surfaced of insurgents hacking into military drone surveillance equipment using commonly available software. One could also imagine the purposive introduction by government of social machines into

AMSCL-101

private spaces in order to deter unwanted behavior by creating the impression of observation. Nor is the implication of robots for privacy entirely negative—vulnerable populations, such as victims of domestic violence, may one day use robots to prevent access to their person or home and police against abuse. Robots could also carry out sensitive tasks on behalf of humans, allowing for greater anonymity. These and other correlations between privacy and robotics will no doubt play out in detail over the next few decades.

12.1 Robots that Spy

Robots of all kinds are increasing the military's already vast capacity for direct surveillance (Singer 2009). Enormous, unmanned drones can stay aloft, undetected, for days and relay surface activity across a broad territory. Smaller drones can sweep large areas, as well as stake out particular locations by hovering nearby and alerting a base upon detecting activity. Backpack-size drones permit soldiers to see over hills and scout short distances. The military is exploring the use of even smaller robots capable of flying up to a house and perching on a windowsill.

Some of the concepts under development are stranger than fiction. Although not developed specifically for surveillance, Shigeo Hirose's Ninja is a robot that climbs high-rises using suction pads. Other robots can separate or change shape in order to climb stairs or fit through tight spaces. The Pentagon is reportedly exploring how to merge hardware with live insects that would permit them to be controlled remotely and relay audio (Shachtman 2009).

In addition to the ability to scale walls, wriggle through pipes, fly up to windows, crawl under doors, hover for days, and hide at great altitudes, robots may come with programming that enhances their capacity for stealth. Researchers at Seoul National University in South

AMSCE-1101

Korea, for instance, are developing an algorithm that would assist a robot in hiding from, and sneaking up on, a potential intruder. Wireless or satellite networking permits large-scale cooperation among robots. Sensor technology, too, is advancing. Military robots can be equipped with cameras, laser or sonar range finders, magnetic resonance imaging (MRI), thermal imaging, GPS, and other technologies.

The use of robotic surveillance is not limited to the military. As Noel Sharkey has observed, law enforcement agencies in multiple parts of the world are also deploying more and more robots to carry out surveillance and other tasks (Sharkey 2008). Reports have recently surfaced of unmanned aerial vehicles being used for surveillance in the United Kingdom. The drones are "programmed to take off and land on their own, stay airborne for up to 15 hours and reach heights of 20,000 feet, making them invisible from the ground" (Lewis 2010). Drone pilot programs have been reported in Houston, Texas, and other border regions within the United States.

Nor is robotic surveillance limited to the government. Private entities are free to lease or buy unmanned drones or other robotic technology to survey property, secure premises, or monitor employees. Reporters have begun to speculate about the possibility of robot paparazzi—air or land robots "assigned" to follow a specific celebrity. Artist Ken Renaldo built a series of such "paparazzi bots" to explore human–computer interaction in the context of pop culture.

The replacement of human staff with robots also presents novel opportunities for data collection by mediating commercial transactions. Consider robot shopping assistants now in use in Japan. These machines identify and approach customers and try to guide them toward a product. Unlike ordinary store clerks, however, robots are capable of recording and processing every aspect of the transaction. Face-recognition technology permits easy reidentification. Such meticulous, point-blank customer data could be of extraordinary use in both loss prevention and marketing research.[4]

AMSCE-101

Much has been written about the dangers of ubiquitous surveillance. Visible drones patrolling a city invoke George Orwell's *Nineteen Eighty-Four.* But given the variety in design and capabilities of spy robots and other technologies, Daniel Solove's vision may be closer to the truth. Solove rejects the Big Brother metaphor and describes living in the modern world by invoking the work of Franz Kafka, where an individual never quite knows whether information is being gathered or used against her (Solove 2004, 36–41). The unprecedented surveillance robots permit implicates each of the common concerns associated with pervasive monitoring, including the chilling of speech and interference with self-determination (Schwartz 2000). As the Supreme Court has noted, excessive surveillance may even violate the First Amendment's prohibition on the interference with speech and assembly (*United States v. United States District Court*; Solove 2007).

The potential use of robots to vastly increase our capacity for surveillance presents a variety of specific ethical and legal challenges. The ethical dilemma in many ways echoes Joseph Weizenbaum's discussion of voice recognition technology in his seminal critique of artificial intelligence, *Computers, Power, and Human Reason*. Weizenbaum wondered aloud why the U.S. Navy was funding no fewer than four artificial intelligence labs in the 1970s to work on voice recognition technology. He asked, only to be told that the Navy wanted to be able to drive ships by voice command. Weizenbaum suspected that the government would instead use voice recognition technology to make monitoring communications "very much easier than it is now" (Weizenbaum 1976, 272). Today, artificial intelligence permits the automated recognition and data mining that underpin modern surveillance.

Roboticists might similarly ask questions about the uses to which their technology will be put—in particular, whether the only conceivable use of the robot is massive or covert surveillance. As is already occurring in the digital space, roboticists might simultaneously begin to

AMSCE-1101

develop privacy-*enhancing* robots that could help individuals to preserve their privacy in tomorrow's complex world. These might include robots that shield the home or person from unwanted attention, robotic surrogates, or other innovations for now found only in science fiction.

The unchecked use of drones and other robotic technology could also operate to dampen the privacy protections enjoyed by citizens under the law. Well into the twentieth century, the protection of the Fourth Amendment of the U.S. Constitution against unreasonable government intrusions into private spaces was tied to the common law of trespass. Thus, if a technique of surveillance did not involve the physical invasion of property, no search could be said to occur. The U.S. Supreme Court eventually "decoupled violation of a person's Fourth Amendment rights from trespass violations of his property" (*Kyllo v. United States*). Courts now look to whether the government has violated a citizen's expectation of privacy that society was prepared to recognize as reasonable (*Kyllo v. United States*).

Whether a given expectation of privacy is reasonable has come to turn in part on whether the technology or technique the government employed was "in general public use"—the idea being that if citizens might readily anticipate discovery, any expectation of privacy would be unreasonable. The bar for "general" and "public" has proven lower than these words might suggest on their face. Although few people have access to a plane or helicopter, the Supreme Court has held the use of either to spot marijuana growing on a property not to constitute a search under the Fourth Amendment (*California v. Ciraolo*; *Florida v. Riley*). Under the prevailing logic, it should be sufficient that "any member of the public" could legally operate a drone or other surveillance robot to obviate the need for law enforcement to secure a warrant to do so.[5]

Due to their mobility, size, and sheer, inhuman patience, robots permit a variety of otherwise untenable techniques. Drones make it possible routinely to circle properties looking for that missing roof tile or other

AMSCL-101

opening thought to be of importance in *Riley*. A small robot could linger on the sidewalk across from a doorway or garage and wait until it opened to photograph the interior. A drone or automated vehicle could peer into every window in a neighborhood from such a vantage point that an ordinary officer on foot could see into the house without even triggering the prohibition on "enhancement" of senses prohibited in pre-*Kyllo* cases such as *United States v. Taborda*, which involved the use of a telescope. Such practices greatly diminish privacy; if we came to anticipate them, it is not obvious under the current state of the law that these activities would violate the Constitution.

One school of thought—introduced to cyberlaw by Lawrence Lessig and championed by Richard Posner, Orin Kerr, and other thoughts leaders—goes so far as to hold that no search occurs under the Fourth Amendment unless and until a human being actually accesses the relevant information. This view finds support in cases like *United States v. Place* and *Illinois v. Caballes*, where no warrant was required for a dog to sniff a bag on the theory that the human police officer did not access the content of the bag and learned only about the presence or absence of contraband, in which the defendant could have no privacy interest. One can at least imagine a rule permitting robots to search for certain illegal activities by almost any means—for instance, x-ray, night vision, or thermal imaging—and alert law enforcement only should contraband be detected. Left unchecked, these circumstances combine to diminish even further the privacy protections realistically available to citizens and consumers.

12.2 Robots: A Window into the Home

Robots can be designed and deployed as a powerful instrument of surveillance. Equally problematic, however, is the degree to which a robot might inadvertently grant access to historically private spaces and

AMSCE-101

activities. In particular, the use of a robot capable of connecting to the Internet within the home creates the possibility for unprecedented access to the interior of the house by law enforcement, civil litigants, and hackers. As a matter of both law of technology, such access could turn out to be surprisingly easy.

With prices coming down and new players entering the industry, the market for home robots—sometimes called personal or service robots—is rapidly expanding. Home robots can come equipped with an array of sensors, including potentially standard and infrared cameras, sonar or laser rangefinders, odor detectors, accelerometers, and global positioning systems (GPS). Several varieties of home robots connect wirelessly to computers or the Internet, some to relay images and sounds across the Internet in real time, others to update programming. The popular WowWee Rovio, for instance, is a commercially available robot used for security and entertainment. It can be controlled remotely via the Internet and broadcasts both sound and video to a website control panel.

12.2.1 Access by Law

What does the introduction of mobile, networked sensors into the home mean for citizen privacy? At a minimum, the government will be able to secure a warrant for recorded information with sufficient legal process, physically seizing the robot or gaining live access to the stream of sensory data. Just as law enforcement is presently able to compel in-car navigation providers to turn on a microphone in one’s car (Zittrain 2008, 110) or telephone companies to compromise mobile phones, so could the government tap into the data stream from a home robot—or even maneuver the robot to the room or object it wishes to observe.

The mere fact that a machine is making an extensive, unguided record of events in the home represents a privacy risk. Still, were warrants required to access robot sensory data in all instances, robot purchasers would arguably suffer only an incremental loss of privacy. Police can already enter, search, and plant recording devices in the home with

AMSCE-JIOJ

sufficient legal process. Depending on how courts come to apply electronic privacy laws, however, much data gathered by home robots could be accessed by the government in response to a mere subpoena or even voluntarily upon request.

Commercially available robots can patrol a house and relay images and sounds wirelessly to a computer and across the Internet. The robot's owner needs only travel to a website and log in to access the footage. Depending on the configuration, images and sounds could easily be captured and stored remotely for later retrieval or to establish a "buffer" (i.e., for uninterrupted viewing on a slow Internet connection). Or consider a second scenario: a family purchases a home robot that, upon introduction to a new environment, automatically explores every inch of house to which it has access. Lacking the onboard capability to process all of the data, the robot periodically uploads it to the manufacturer for analysis and retrieval.[6]

In these existing and plausible scenarios, the government is in a position to access information about the home activities—historically subject to the highest level of protection against intrusion by the government (*Silverman v. United States*)—with relatively little process. As a matter of constitutional law, individuals that voluntarily commit information to third parties lose some measure of protection for that information (*United States v. Miller*). Particularly where access is routine, such information is no longer entitled to Fourth Amendment protection under what is known as the "third-party doctrine" (Freiwald 2007, 37–49).

Federal law imposes access limitations on certain forms of electronic information. The Electronic Communications Privacy Act lays out the circumstances under which entities can disclose "electronic communications" to which they have access by virtue of providing a service (18 USC § 2510). How this statute might apply to a robot provider, manufacturer, website, or other service, however, is unclear. Depending on how a court characterizes the entity storing or

AMSCE-101

transmitting the data—for instance, as a “remote computing service”—law enforcement could gain access to some robot sensory data without recourse to a judge.

Indeed, a court could conceivably characterize the relevant entity as falling out of the statute’s protection altogether, in which case the service provider would be free to turn over details of customers’ homes voluntarily upon request. Private litigants could also theoretically secure a court order for robot sensory data stored remotely to show, for instance, that a spouse had been unfaithful. Again, due to the jealousy with which constitutional, federal, and state privacy law has historically guarded the home, this level of access to the inner workings of a household with so little process would represent a serious departure.

12.2.2 Access by Vulnerability

Government and private parties might access robot data transmitted across the Internet or stored remotely through relatively light legal process, but the state of current technology also offers practical means for individuals to gain access to, even control of, robots in the home. If, as Bill Gates predicts, robots soon reach the prevalence and utility that personal computers possess today, less than solid security could have profound implications for household privacy.

Recent work by Tamara Denning, Tadayoshi Kohno, and colleagues at University of Washington has shown that commercially available home robots are insecure and could be hijacked by hackers. The University of Washington team researchers looked at three robots—the WowWee Rovio, the Erector Spykee, and the WowWee RobotSapien V2—each equipped with cameras and capable of wireless networking. The team uncovered numerous vulnerabilities. Attackers could identify Rovio or Spykee data streams by their unique signatures, for instance, and eavesdrop on nearby conversation or even operate the robot.[7] Attacks could be launched within wireless range (e.g., right outside the home) or by sniffing packets of information traveling by Internet

AMSCE-1101

protocol. A sophisticated hacker might even be able to locate home robot feeds on the Internet using a search engine (Denning et al. 2009).[8]

The potential to compromise devices in the home is, in a sense, an old problem; the insecurity of webcams has long been an issue of concern. The difference with home robots is that they can move and manipulate, in addition to record and relay. A compromised robot could, as the University of Washington team points out, pick up spare keys and place them in a position to be photographed for later duplication. (Or it could simply drop them outside the door through a mail slot.) A robot hacked by neighborhood kids could vandalize a home or frighten a child or elderly person. These sorts of physical intrusions into the home compromise security and exacerbate the feeling of vulnerability to a greater degree than was previously feasible.

12.3 Robots as Social Actors

The preceding sections identified two key ways in which robots implicate privacy. First, they augment the surveillance capacity of the government or private actors. Second, they create opportunities for legal and technical access to historically private spaces and information. Responding to these challenges will be difficult, but the path is relatively clear from the perspective of law and policy. As a legal matter, for instance, the Supreme Court could uncouple Fourth Amendment protections from the availability of technology, hold that indiscriminate robotic patrols are unreasonable, or otherwise account for new forms of robotic surveillance.

The Federal Trade Commission (FTC), the primary federal agency responsible for consumer protection, could step in to regulate what information a robotic shopping assistant could collect about consumers. The FTC could also bring an enforcement proceeding against a robot company for inadequate security under Section 5 of the Federal Trade

AMSCE-IIOI

Commission Act (as it has for websites and other companies). Congress could amend the Electronic Communications Privacy Act to require a warrant for video or audio footage relayed from the interior of a home. As of this writing, coalitions of nonprofits and companies have petitioned the government to reform this Act, along a number of relevant lines.

Beyond these regulatory measures, roboticists could follow the lead of Weizenbaum and others and ask questions about the ethical ramifications of building machines capable of ubiquitous surveillance. Roboethicists urge formal adoption by roboticists of the ethical code known as PAPA (privacy, accuracy, intellectual property, and access) developed for computers (Veruggio and Operto 2008, 1510–1511). Various state and federal law enforcement agencies could establish voluntary guidelines and limits on the use of police robots. And robotics companies could learn from Denning and her colleagues and build in better protections for home robots to ensure they are less vulnerable to hackers.

This section raises another dimension of robots' potential impact on privacy, one that is not as easy to remedy as a legal or technical matter. It explores how our reactions to robots as social technologies implicate privacy in novel ways. The tendency to anthropomorphize robots is common, even where the robot hardly resembles a living being. Technology forecaster Paul Saffo observes many people name their robotic vacuum cleaners and take them on vacation. Reports have emerged of soldiers treating bomb-diffusing drones like comrades and even risking their lives to rescue a "wounded" robot.

Meanwhile, robots increasingly are designed to interact more socially. Resemblance to a person makes robots more engaging and increases acceptance and cooperation. This turns out to be important in many early robot applications. Social robots will be deployed to care for the elderly and disabled, for example, and to diagnosis autism and other issues in children. They need to be accepted by people in order to do so.

AMSCE-IIOI

At the darker end of the spectrum, some roboticists are building robots with an eye toward sexual gratification; others predict that “love and sex with robots” is just around the corner (Levy 2007). Robots’ social meaning could have a profound effect on privacy and the values it protects, one that is more complex and harder to resolve than anything mentioned thus far in this chapter.

12.3.1 Robots and Solitude

An extensive literature in communications and psychology demonstrates that humans are hardwired to react to social machines as though a person were really present.[9] Generally speaking, the more human-like the technology, the greater the reaction will be. People cooperate with sufficiently human-like machines, are polite to them, decline to sustain eye-contact, decline to mistreat or roughhouse with them, and respond positively to their flattery (Reeves and Nass 1996). There is even a neurological correlation to the reaction; the same “mirror” neurons fire in the presence of real and virtual social agents.

Importantly, the brain’s hardwired propensity to treat social machines as human extends to the sensation of being observed and evaluated. Introducing a simulated person (or simply a face, voice, or eyes) into an environment leads to various changes in behavior. These range from giving more in a charity game, to paying for coffee more often on the honor system, to making more errors when completing difficult tasks. People disclose less and self-promote more to a computer interface that appears human. Indeed, the false suggestion of person’s presence causes measurable physiological changes, namely, a state of “psychological arousal” that does not occur when one is alone (Calo 2010, 835–842).

The propensity to react to robots and other social technology as though they were actually human has repercussions for privacy and the values it protects (Calo 2010, 842–849). One of privacy’s central roles in society is to help create and safeguard moments when people can be alone. As Alan Westin famously wrote in his 1970 treatise on privacy,

AMSCE-101

people require “moments ‘off stage’ when the individual can be himself.” Privacy provides “a respite from the emotional stimulation of daily life” that the presence of others inevitably engenders (Westin 1967, 35). The absence of opportunities for solitude would, many believe, cause not only discomfort and conformity, but also outright psychological harm.

Social technology, meanwhile, is beginning to appear in more—and more private—places. Researchers at both MIT and Stanford University are working on robotic companions in vehicles, where Americans spend a significant amount of their time. Robots wander hospitals and offices. They are, as described, showing up in the home with increasing frequency. The government of South Korea has an official goal of one robot per household by 2015. (The title of Bill Gates’s op-ed referenced at the outset of this chapter?—“A Robot In Every Home.”) The introduction of machines that our brains understand as people into historically private spaces may reduce already dwindling opportunities for solitude. We may withdraw from the actual whirlwind of daily life only to reenter its functional equivalent in the car, office, or home.[10]

12.3.2 Robot Interrogators

For reasons already listed, robots could be as effective as humans in eliciting confidences or information.[11] Due to our propensity to receive them as people, social robots—or, more accurately, their designers and operators—can employ flattery, shame, fear, or other techniques commonly used in persuasion (Fogg 2003). But unlike humans, robots are not themselves susceptible to these techniques. Moreover, robots have certain built-in advantages over human persuaders. They can exhibit perfect recall, for instance, and, assuming an ongoing energy source, have no need for interruptions or breaks. People tend to place greater trust in computers, at least, as sources of information (Fogg 2003, 213). And robotic expression can be perfectly fine-tuned to

AMSCE-101

convey a particular sentiment at a particular time, which is why they are useful in treating certain populations, such as autistic children.

The government and industry could accordingly use social robots to extract information with great efficiency. Setting aside the specter of robotic CIA interrogators, imagine the possibilities of social robots for consumer marketing. Ian Kerr has explored the use of online "bots" or low-level artificial intelligence programs to gather information about consumers on the Internet (Kerr 2004). As one example, Kerr points to the text-based virtual representative ELLEgirlBuddy, developed by ActiveBuddy, Inc. to promote *Elle Girl* magazine and its advertisers. This software interacted with thousands of teens via instant messenger before it was eventually retired. ELLEgirlBuddy mimicked teen lingo and sought to foster a relationship with its interlocutors, all the while collecting information for marketing use (Kerr 2004). Social robots—deployed in stores, offices, and elsewhere—could be used as highly efficient gatherers of consumer information and, eventually, tuned to deliver the perfect marketing pitch.

12.3.3 Setting Privacy

Many contemporary privacy advocates worry that a "smart" energy grid connected to household devices, though probably better for the environment, will permit guesses about the interior life of a household. Indeed, one day soon it may be possible to determine an array of habits —when a person gets home, whether and how long they play video games, whether they have company—merely by looking at an energy meter. This important, looming problem echoes the issues discussed earlier in reference to access to the historically private home.

The privacy issues of smart grids are in a way cabined, however, by the sheer banality of our interaction with most household devices. Notwithstanding Supreme Court Justice Anton Scalia's reference to how a thermal imagining device might reveal the "lady in her sauna" (*Kyllo v. United States*), the temperature to which we set the thermostat or how

AMSCE-IOI

long we are in the shower does not say all that much about us. Even the books we borrow from the library or the videos we rent (each protected, incidentally, under privacy law) permit at most inferences about our personality and mental state.

Our interactions with social robots could be altogether different. Consumers ultimately will be able to program robots not only to operate at a particular time or accomplish a specific task, but also to adopt or act out a nearly infinite variety of personalities and scenarios with independent social meaning to the owner and the community. If the history of other technologies is any guide, many of these applications will be controversial. Already people appear to rely on robots with programmable personalities for companionship and gratification. Additional uses will simply be idiosyncratic, odd, or otherwise private.

In interacting with programmable social robots, we stand to surface our most intimate psychological attributes. As David Levy predicts, “robots will transform human notions of love and sexuality,” in part by permitting humans to better explore themselves (Levy 2007, 22). And even as we manifest these interior reflections of our subconscious, a technology will be *recording* them. Whether through robot sensory equipment, or embedded as an expression of code, the way we use human-like robots will be fixed in a file. Suddenly our appliance settings will not only matter, they also will reveal information about us that a psychotherapist might envy. This arguably novel category of highly personal information could, as happens with any other type of information, be stolen, sold, or subpoenaed.[12]

12.3.4 The Challenge of Social Meaning

Again, we can imagine ways to mitigate these harms. But the law is, in a basic sense, ill equipped to deal with the robots’ social dimension. This is so because notice and consent tend to defeat privacy claims and because harm is difficult to measure in privacy cases. Consider the example of a robot in the home that interrupts solitude. The harm is

AMSCE-1101

subconscious, variable, and difficult to measure, which is likely to give any court or regulator pause in permitting recovery. Insofar as consent defeats many privacy claims, the robot's presence in the home is likely to be invited, even purchased. Similarly, it is difficult enough to measure which commercial activities rise to the level of deception or unfairness, without having to parse human reactions to computer salespeople. Rather than relying on legal or technological fixes, the privacy challenges of social robots will require an in-depth examination of human–robot interaction within multiple disciplines over many years.

12.4 Conclusion

According to a popular quote by science fiction writer William Gibson, "the future is already here. It just hasn't been evenly distributed yet." Gibson's insight certainly appears to describe robotics. One day soon, robots will be a part of the mainstream, profoundly affecting our society. This chapter has attempted to introduce a variety of ways in which robots may implicate the set of societal values loosely grouped under the term "privacy." The first two categories of impact—surveillance and access—admit of relatively well-understood ethical, technological, and legal responses. The third category, however, tied to social meaning, presents an extremely difficult set of challenges. The harms at issue are hard to identify, measure, and resist. They are in many instances invited. And neither law nor technology has obvious tools to combat them. Our basic recourse as creators and consumers of social robots is to proceed very carefully.

Notes

AMSCE-1101

[1] For the purposes of this chapter, a robot is a stand-alone machine with the ability to sense, process, and interact physically with the world. The term “home robot” or “personal robot” is used to indicate machines consumers might buy and to distinguish them from military, law enforcement, or assembly robots. This leaves out a small universe of robotic technologies —“smart” homes, embedded medical devices, prosthetics—that also have privacy implications not fully developed here. Artificial intelligence, in particular, whether or not it is “embodied” in a robot, has deep repercussions for privacy, for instance, in that it underpins data mining.

[2] This is not to minimize the privacy risks associated with smart energy grids or the “Internet of things,” namely, embedded computing technology into everyday spaces and products. Information stemming from such technology can be leveraged, particularly in the aggregate, in ways that negatively impact privacy.

[3] One of the chief benefits of Internet commerce is the ability to target messages and perform detailed analytics on advertising and website use. As several recent reports have cataloged, outdoor advertisers are finding ways to track customers in real space. Billboards record images of passersby, for instance, and change on the basis of the radio stations to which passing cars are tuned. Robotics will only accelerate this trend by further mediating consumer transactions offline.

[4] Surveillance may not automatically be lawful merely because the tools that were used are available to the public. In *United States v. Taborda*, for instance, the U.S. Court of Appeals for the Second Circuit suppressed evidence secured on the basis of using a telescope to peer into a home on the theory that “the inference of intended privacy at home is [not] rebutted by a failure to obstruct telescopic viewing by closing the curtains.” But following the Supreme Court opinion in *Kyllo*—the Fourth Amendment case involving thermal imaging of a home—general availability appears to support a presumption that the tool can be used without a warrant.

[5] This is how at least two robots—SRI International’s Centibots and Intel’s Home Exploring Robotic Butler—already function.

[6] An earlier study found similar vulnerabilities in one version of iRobot’s popular Roomba, which moves slowly, cannot grasp objects, and is not equipped with a camera.

[7] As discussed previously, terrorist insurgents have also hacked into military drones.

[8] The standard explanation is that we evolved at a time when cooperation with other humans conferred evolutionary advantages and, because of the absence of media, what appeared to be

AMSCE-1101

human actually was. There are reasons to be skeptical of explanations stemming from evolutionary psychology—namely, it can be used to prove multiple conflicting phenomena. Whatever the explanation, however, the evidence that we do react in this way is quite extensive.

9. Communications scholar Sam Lehman-Wilzig criticizes this idea on the basis that, if we treat robots like other people, we can simply shut the door on them as we do with one another in order to gain solitude. People may not consciously realize that robots have the same impact on us as another person does, however, and robots and other social machines and interfaces can and do go many places—cars, computers, etc.—that humans cannot.

10. It could also be argued that we will get used to robots in our midst, thereby defeating the mechanism that interrupts solitude. What evidence there is on the matter points in the other direction, however. For instance, a study of the effect on participants of a picture of eyes when paying for coffee on the honor system saw no diminishment in behavior over many weeks. Nor is it clear that people will come to trust robots in the same way they might intimates, relatives, or servants—assuming we even already do.

11. Of course, artificial intelligence is not at the point where a machine can routinely trick a person into believe it is human—the so-called Turing Test. The mere belief that the robot is human is not necessary in order to leverage the psychological principles of interrogation and other forms of persuasion.

12. This is somewhat true already with respect to virtual worlds and open-ended games. Human–robot interactions stand to amplify the danger in several ways. There is likely to be a greater investment and stigma attached to physical rather than virtual behavior, for instance (or so one hopes, given the content of many video games). Ultimately our use of robots may reveal information we do not even want to know about ourselves, much less risk others discovering.

AMSCE-1101

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AMSCE-101

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AMSCE-1101

V

Psychology and Sex

The anthropomorphization of robots is an important trend, not merely for the privacy implications noted in chapter 12, but also for increasing public acceptance, even affinity, toward robots. But this betides a new danger of “too much of a good thing”: Can one become emotionally *over*-invested in robots? Are there potential harms due to emotional and psychic dependence that raise serious moral concerns, either to the human users of robots or to the public at large?

Matthias Scheutz discusses the dangers of emotional bonds with robots in chapter 13; he argues that social robots will differ from industrial or military robots in appearance, environment, programming, mobility, autonomy, and perceived agency. As humans have a tendency to personify and become emotionally dependent on social robots, opportunities will abound for malicious exploitation of such unidirectional emotional bonds by the creators or purveyors of robots. Scheutz recommends regulations to forestall such worries, including the possibility of creating robots with emotions of their own.

David Levy in chapter 14 and Blay Whitby in chapter 15 investigate aspects of one of the most notorious, widely publicized, and most intense types of psychological and emotional experiences humans will have with robots: sex.

Levy’s chapter focuses on the idea that robot prostitutes, or “sexbots,” will soon become widely accepted alternatives to human sex workers, and he takes up five aspects of the ethics of robot prostitution. He

AMSCE-1101

considers the ethical issues concerning the general use of robot prostitutes, effects on an individual’s self-respect in using a robot in this way, how such use affects other human intimate relationships (e.g., is it infidelity?), and the impact of robotic prostitutes on human sex workers and (eventually) on the sexbots themselves.

Whitby examines robot lovers within the general context of the ethics of caring technologies. In Japan and South Korea, robots are widely assumed to have a future significant role in elder care and babysitting. But wishful thinking and hype can obscure both what is actually possible, and what should—or should not—be allowed. Whitby notes that Masahiro Mori’s hypothesis of the “Uncanny Valley” poses a difficult technical barrier to creating realistic-looking robot lovers, but robots may soon be able to better human companions’ ability to retain intimate knowledge of one’s own quirks, and respond to (and even anticipate) one’s feelings. He notes people unable to find lovers, or prevented from doing so (e.g., criminals), are obvious markets for robotic companions, but notes a disquieting further possibility: people may seek robots in order to do things to them that would be abhorrent when done to another human. As such, he considers the possibility of love for (or by) a robot, and reflects on Levy’s arguments. He ends with a call for public discussion and the possible development of professional ethics codes to guide the responsible development of robotic companions. Then, in part VI, we focus on the broader notion of robots as caregivers.

The Inherent Dangers of Unidirectional Emotional Bonds between Humans and Social Robots

Matthias Scheutz

AMSCE-101

The early twenty-first century is witnessing a rapid advance in social robots. From vacuum cleaning robots (like the Roomba), to entertainment robots (like the Pleo), to robot pets (like KittyCat), to robot dolls (like Baby Alive), to therapy robots (like Paro), and many others, social robots are rapidly finding applications in households and elder-care settings. In 2006, the number of service robots worldwide alone outnumbered industrial robots by a factor of four, and this gap is expected to widen to a factor of six by 2010, fueled by ambitious goals like those of South Korea, to put one robot into each household by the year 2013, or by the Japanese expectation that the robot industry will be worth ten times the present value in 2025 (Gates 2007).

From these expectations alone, it should be clear that social robots will soon become an integral part of human societies, very much like computers and the Internet in the last decade. In fact, using computer technology as an analogy, it seems likely that social robotics will follow a similar trajectory: once social robots have been fully embraced by societies, life without them will become inconceivable.

As a consequence of this societal penetration, social robots will also enter our personal lives, and that fact alone requires us to reflect on what exactly happens in our interactions with these machines. For social robots are specifically designed for personal interactions that will involve human emotions and feelings: “a sociable robot is able to communicate and interact with us, understand, and even relate to us, in a personal way. It is a robot that is socially intelligent in a human-like way" (Breazeal 2002). And while social robots can have benefits for humans (e.g., health benefits as demonstrated with Paro [Shibata 2005]), it is also possible that they could inflict harm—emotional harm, that is. And exactly herein lies the hitherto underestimated danger: the potential for humans' emotional dependence on social robots.

As we will see shortly, such emotional dependence on social robots is different from other human dependencies on technology (e.g., different both in kind and quality from depending on one's cell phone, wrist watch, or PDA). To be able to understand the difference and the potential ramifications of building complex social robots that are freely deployed in human societies, we have to understand how social robots are different from other related technologies and how they, as a result, can affect humans at a very basic level.

13.1 Social Robots Are Different

Start by comparing social robots to related technologies, namely computers and industrial robots (see table 13.1). These two kinds of machines are particularly relevant, because social robots contain computers (for their behavior control) and share with industrial robots the property of being robots (in the sense of being machines with motion or manipulation capabilities or both). And computers and industrial robots have been around for decades, while social robots are a recent invention.

AMSCE-IOI

Table 13.1
Industrial robots versus computers versus social robots

Aspect/device	Industrial robots	Computers	Social robots
application	industrial production	any	personal/service

Aspect/device	**Industrial robots**	**Computers**	**Social robots**
environment	restricted	any	any
appearance	machine-like	machine-like	(often) life-like
programming	task-specific	open-ended	(sometimes) open-ended
actuation	yes	no	yes
mobility	limited	none	(often) unlimited
autonomy	no	no	yes (limited)
agency	no	no	?

Very much like industrial robots, social robots have the capability to initiate motion (of actuators or themselves) and thus exhibit behavior (compared to stationary objects like computers). Different from industrial robots, which are typically confined to factories, social robots are directly targeted at consumers for service purposes (like the Roomba vacuum cleaner) or for entertainment (like the AIBO robo-dog).

Very much like computers, social robots have managed to enter individuals' homes and thus their private lives, and increasingly are becoming part of people's daily routines (Forlizzi and DiSalvo 2006). Different from computers, robots can interact with their owners at various levels of sophistication, and they can even initiate and terminate those interactions on their own.

And, unlike industrial robots and computers, social robots are often mobile, and their mobility is driven by different forms of preprogrammed or learned behaviors. Even if behaviors are predetermined and allow for very limited variability (e.g., as in various robotic toys or the Roomba), current social robots nevertheless change their position in the world. And despite the fact that these behavioral

AMSCE-1101

repertoires are very simple, social robots nevertheless can make (limited) decisions about what action to take or what behaviors to exhibit. They base these decisions on their perceptions of the environment and their internal states, rather than following predetermined action sequences based on preprogrammed commands, as is usually the case with robots in industrial automation (Parasuraman, Sheridan, and Wickens 2000).

The simple rule-governed mobility of social robots, especially when robots are able to adapt and change their behaviors (e.g., by learning from experience), has far-reaching consequences. For—as will become clear—it enables robots to affect humans in very much the same way that animals (e.g., pets) or even other people affect humans. In particular, the rule-governed mobility of social robots allows for, and ultimately prompts, humans to ascribe intentions to social robots in order to be able to make sense of their behaviors (e.g., the robot did not clean in the corner because it thought it could not get there). The claim is that the autonomy of social robots is among the critical properties that cause people to view robots differently from other artifacts such as computers or cars.

13.2 Autonomy + Mobility = Perceived Agency?

There are several intuitions behind applying the notion of autonomy—which has its roots in the concept of human agency—to artifacts like robots. These intuitions are derived from ideas about what it means for a human being to be autonomous: "To be autonomous is to be a law to oneself; autonomous agents are self-governing agents. Most of us want to be autonomous because we want to be accountable for what we do, and because it seems that if we are not the ones calling the shots, then we cannot be accountable" (Buss 2002). Clearly, current robots (and those in the near future) will neither be self-governing agents that want

AMSCE-101

to be autonomous, nor will they be in a position where they could be accountable or held accountable for their actions. This is because they will not have the reflective self-awareness that is prerequisite for accountable, self-governing behavior. Yet, there is a sense in which some robots are, at least to some extent, “self-governing,” and can thus be said, again, in a weak sense, to be autonomous—a robot, for example, that is capable of picking up an object at point A and dropping it off at point B without human supervision or intervention is, at least to some extent, “self-governing.”

A much stronger and richer sense of autonomy, one that comes closest to the notion of human autonomy, is centered on an “agent’s active use of its capabilities to pursue its goals, without intervention by any other agent in the decision-making processes used to determine how those goals should be pursued” (Barber and Martin 1999). This notion stresses the idea of decision making by an artificial system or agent to pursue its goals and, thus, requires the agent to at least have mechanisms for decision making and goal representations, and ideally also additional representations of other intentional states (such as desires, motives, etc.), as well as nonintentional states (such as task representations, models of other agents, etc.).

Yet, there is also an independent sense in which the autonomy of an artificial system is a matter of degrees: “for example, consider an unmanned rover. The command, ‘find evidence of stratification in a rock’ requires a higher level autonomy than, ‘go straight 10 meters’” (Dorais et al. 1998). The degrees or levels of autonomy can depend on several factors: for example, how complex the commands are that it can execute, how many of its subsystems can be controlled without human intervention, under what circumstances the system will override manual control, and the overall duration of autonomous operation (Dorais et al. 1998; see also Huang 2004).

There is yet another dimension of robot autonomy, orthogonal to the preceding conceptual distinctions that focus on functional, behavioral,

AMSCE-IOI

and architectural aspects, but of clear relevance to human–robot interactions. This dimension concerns a human’s perception of the (level of) autonomy of an artificial system and the impact the perceived autonomy has on that human’s behavior.

The relationship among these different characterizations of robot autonomy has been summarized as a robot’s “ability of sensing, perceiving, analyzing, communicating, planning, decision-making, and acting, to achieve its goals as assigned by its human operator(s) through designed human-robot interaction. Autonomy is characterized as involving levels demarcated by factors including mission complexity, environmental difficulty, and level of HRI to accomplish the missions” (Huang 2004).

There is converging evidence that the degree of autonomy that a robot exhibits is an important factor in determining the extent to which it will be viewed as human-like, where the investigated robots are typically able to move freely, respond to commands, recognize objects, understand human speech, and make decisions (Kiesler and Hinds 2004; Scheutz et al. 2007). Perceived autonomy is so critical because it implies capabilities for self-governed movement, understanding, and decision-making (Kiesler and Hinds 2004), capabilities that together comprise important components of how we define the qualities of “humanness” or “human-like” (Friedman, Kahn, and Hagman 2007).

The distinguishing features of mobility and autonomy, therefore, set autonomous social robots apart from other types of robots, computers, and artifacts, and are ultimately a critical factor for shaping the human perceptions of autonomous robots as “social agents.”

13.3 Evidence from HRI Studies

Over the last few years, we have conducted several human–robot interaction experiments to investigate the degree to which humans perceive robots as autonomous agents and to isolate the effects that perceived autonomy can have both on human attitudes toward robots and human behavior. To be able to gain a better understanding of people's true beliefs about robots, we developed a rigorous evaluation framework that encompasses both subjective and objective methods and measures (Rose, Scheutz, and Schermerhorn 2010). Here, we briefly summarize the results from three studies.

13.3.1 Study 1: Dynamic Autonomy

We investigated the extent to which robot autonomy based on independent decision making and behavior by the robot can affect the objective task performance of a mixed human–robot team while being subjectively acceptable to the human team leader (Schermerhorn and Scheutz 2009; Scheutz and Crowell 2007). In this task, a human subject worked together with a robot to accomplish a team goal within a given time limit. While both human and robot had tasks to perform, neither robot nor human could accomplish the team goal alone. In one of the task conditions (the "autonomy condition"), the robot was allowed to act autonomously when time was running out in an effort to complete the team goal. As part of this effort, it was able to refuse human commands that would have interfered with its plans. In the other condition (the "no autonomy condition"), the robot would never show any initiative on its own and would only carry out human commands. Human subjects were tested in both conditions (without knowing anything about the conditions) and then asked to rate various properties of the robot. Overall, subjects rated the "autonomous robot" as more helpful and capable, and believed that it made its own decisions and acted like a team member. There was also evidence that they found the autonomous robot to be more cooperative, easier to interact with, and less annoying than the nonautonomous robot. Surprisingly, there was no difference in the subjects' assessment of the degree to which the robot disobeyed

AMSCE-1101

commands (even though it clearly disobeyed commands in almost all subject runs in the autonomy condition while it never disobeyed any command in the no-autonomy condition). We concluded that subjects preferred the autonomous robot as a team partner.

13.3.2 Study 2: Affect Facilitation

We also investigated the utility of affect recognition and expression by the robot in a similar team task (Scheutz et al. 2007; Scheutz et al. 2006). Here, instead of making autonomous decisions, the robot always carried out human orders. However, in one condition (the “affect condition”) it was allowed to express urgency in its voice or respond to sensed human stress with stress of its own (again expressed in its voice), compared to the “no-affect condition,” where the robot’s voice was never modulated. Each subject was exposed to only one condition and comparison was made among subject groups. The results showed that allowing the robot to express affect and respond to human affect with affect expressions of its own—in circumstances where humans would likely do the same and where affective modulations of the voice thus make intuitive sense to humans—can significantly improve team performance, based on objective performance measures. Moreover, subjects in the “affect condition” changed their views regarding robot autonomy and robot emotions from their pre-experimental position based on their experience with the robot in the experiment. While they were neutral before the experiment as to whether robots should be allowed to act autonomously and whether robots should have emotions of their own, they were slightly in favor of both capabilities after the experiments. This is different from subjects in the no-affect group who did not change their positions as a result of the experiment. We concluded that appropriate affect expression by the robot in a joint human–robot task can lead to better acceptability of robot autonomy and other human-like features like emotions in robots.

13.3.3 Study 3: Social Inhibition and Facilitation

AMSCE-101

While the previous two studies attempted to determine human perceptions and agreement with robot autonomy indirectly through human participation in a human–robot team task (where the types of interactions with the robot were critical for achieving the goal, and thus for the subjects' views of the robot's capabilities), the third study attempted to determine the human-likeness of the robot directly. Specifically, the study investigated people's perceptions of social presence in robots during a sequence of different interactions, where the robot functioned as a survey taker as well as an observer of human task performance (Crowell et al. 2009; Schermerhorn, Scheutz, and Crowell 2008). The experimental design used well-known results in psychology about social inhibition and facilitation that occurs in humans when they are observed performing tasks by other humans (Zajonc 1965). Our experimental results showed that robots can have effects on humans and human performance that are otherwise only observed with humans. Interestingly, there was a gender difference in subjects' perception of the robot, with only males showing "social inhibition effects" caused by the presence of the robot while they were performing a math task. Postexperimental surveys confirmed that male subjects viewed the robot as more human-like than did the female subjects.

Together, these laboratory studies provide experimental evidence about human perceptions of autonomous robots. In particular, they show that humans seem to prefer autonomous robots over nonautonomous robots when they have to work with them, that humans prefer human-like features (e.g., affect) in robots and that those features are correlated with beliefs about autonomy, and that a robot's presence can affect humans in a way that is usually only caused by the presence of another human. The question then arises whether the findings also apply to "robots in the wild," outside of the well-controlled laboratory environment. As the next section will demonstrate, there is already ample evidence for people's susceptibility to the lure of social robots

AMSCE-IIOT

outside the lab, especially when they have repeated, longer-term interactions with robots.

13.4 The Personification of Robots

An increasing body of evidence demonstrates how humans anthropomorphize robots, project their own mentality onto them, and form what seem like deep emotional yet unidirectional relationships with them. Documented examples, which we will summarize in the stories that follow, range from interviews with soldiers that worked with robots on defusing improvised explosive devices (IEDs), to ethnographic studies with robot-pet owners (of the AIBO robot dog) and with owners of the robotic Roomba vacuum cleaner.

13.4.1 From Garreau's "Bots on the Ground"

The first story is about a robot developed by roboticist Mark Tilden for the purpose of defusing land mines. The robot achieves the task by stepping on them, which causes the mine to detonate and destroy the robot's leg. Hence, the robot was designed with several legs to be able to detonate several mines before becoming useless. Here is the story:

> At the Yuma Test Grounds in Arizona, the autonomous robot, 5 feet long and modeled on a stick-insect, strutted out for a live-fire test and worked beautifully, he [Tilden] says. Every time it found a mine, blew it up and lost a limb, it picked itself up and readjusted to move forward on its remaining legs, continuing to clear a path through the minefield. Finally it was down to one leg. Still, it pulled itself forward. Tilden was ecstatic. The machine was working splendidly. The human in command of the exercise, however—an Army colonel—blew a fuse. The colonel ordered the test stopped. Why? asked Tilden. What's wrong? The colonel just could not stand the pathos of watching the burned, scarred, and crippled machine drag itself forward on its last leg. This test, he charged, was inhumane. (Garreau 2007)

Whether or not "inhumane" was an appropriate attribution, the fact remains that the only explanation for not wanting to watch a mindless, lifeless machine, purposefully developed for blowing up mines, destroy

AMSCE - 101

itself, is that the human projected some agency onto the robot, ascribing to it some inner life, and possibly even feelings.

Another example, recounted by a Marine sergeant running a robot repair shop in Iraq, is the technician who returned his IED-defusing robot, which he had named "Scooby-Doo," for repair. While it is well known that humans have a tendency to name inanimate things they like and use frequently (e.g., their car), naming comes at a price: it automatically generates a kind of intimacy with and connectedness to the named object. And, in the case of robots, it only reinforces what the self-propelled behavior of a robot already does: prompting the inscription of intentionality into an artifact and thus implicating granting it agency! Here is a story recounted by a robot technician named Bogosh:

> "There wasn't a whole lot left of Scooby," Bogosh says. The biggest piece was its 3-by-3-by-4-inch head, containing its video camera. On the side had been painted "its battle list, its track record. This had been a really great robot." The veteran explosives technician looming over Bogosh was visibly upset. He insisted he did not want a new robot. He wanted Scooby-Doo back. "Sometimes they get a little emotional over it," Bogosh says. "Like having a pet dog. It attacks the IEDs, comes back, and attacks again. It becomes part of the team, gets a name. They get upset when anything happens to one of the team. They identify with the little robot quickly. They count on it a lot in a mission." (Garreau 2007)

In fact, soldiers take pictures of their robots, introduce robots to their friends and family abroad, and even promote them, all indications of treating robots as if they were intentional creatures. "When we first got there, our robot, his name was Frankenstein, says Sgt. Orlando Nieves, an EOD [Explosive Ordnance Disposal technician] from Brooklyn. 'He'd been in a couple of explosions and he was made of pieces and parts from other robots.' Not only did the troops promote him to private first class, they awarded him an EOD badge—a coveted honor. 'It was a big deal. He was part of our team, one of us. He did feel like family' (Garreau 2007).

AMSCE-101

13.5 Robot Dogs Are Pets, Too

Even if these examples seem hardly believable, one might be lenient and justify the soldiers' attribution of human qualities to robots by pointing to the extraordinary circumstances that these soldiers encounter in combat, and the huge emotional toll it takes on the human psyche. But surprisingly, being in a deserted remote location, dealing with life-threatening situations, is not necessary to elicit the kinds of reactions to robots we saw with soldiers in Iraq. Ordinary citizens living in the United States seem to fall prey to suggestive behaviors of social robots. For example, Peter Kahn and colleagues (Kahn, Friedman, and Hagman 2002) examined the postings of users in AIBO news groups, where robo-dog owners share their experiences with AIBO freely, and identified four categories of postings:

> *Essences* refer to the presence or absence of technological, biological, or animistic underpinnings of AIBO (e.g., "He's resting his eyes"). *Agency* refers to the presence or absence of mental states for AIBO, such as intentions, feelings, and psychological characteristics (e.g., "He has woken in the night very sad and distressed"). *Social standing* refers to ways in which AIBO does or does not engage in social interactions, such as communication, emotional connection, and companionship (e.g., "I care about him as a pal, not as a cool piece of technology"). *Moral standing* refers to ways in which AIBO may or may not engender moral regard, be morally responsible, be blameworthy, have rights, or deserve respect (e.g., "I actually felt sad and guilty for causing him pain!"). (Kahn, Friedman, and Hagman 2002)

While they found relatively few references to AIBO's moral standing (12 percent), people made very frequent references to essences (79 percent), agency (60 percent), and social standing (59 percent). It seems clear that AIBO owners have a strong tendency to form (false) beliefs about (possible) mental states of their robots.

13.6 Even the Roomba Does the Trick

AMSCE-IIOI

Another example group are owners of Roomba vacuum cleaners that have been interviewed in a variety of studies over the last several years, given that the Roomba is one of the most widely sold autonomous robots. While at first glance it would seem that the Roomba has no social dimension (neither in its design nor in its behavior) that could trigger people's social emotions, it turns out that humans, over time, develop a strong sense of gratitude toward the Roomba for cleaning their home. The mere fact that an autonomous machine keeps working for them day in and day out seems to evoke a sense of, if not urge for, reciprocation. Roomba owners seem to want to do something nice for their Roombas, even though the robot does not even know that it has owners (it treats humans as obstacles in the same way it treats chairs, tables, and other objects that it avoids while driving and cleaning). The sheer range of human responses is mind blowing (e.g., see Sung et al. 2007). Some will clean for the Roomba, so that it can get a rest, while others will introduce their Roomba to their parents, or bring it along when they travel because they managed to develop a (unidirectional) relationship: "I can't imagine not having him any longer. He's my BABY! . . . When I write emails about him, which I've done that, as well, I just like him, I call him Roomba baby. . . . He's a sweetie" (Sung et al. 2007).

13.7 Not Even Experienced Roboticists Are Always Spared

Somewhat surprisingly, it is even possible for an experienced roboticist to be affected by the suggestive force of apparent autonomous behavior. In our own lab, for example, we found our humanoid robot CRAMER disturbing when it was left on (by accident) and started shifting attention from speaker to speaker (as if it understood what was being said). And, according to Garreau, graduate students at MIT working in the lab with the Kismet robot put up a curtain between themselves and the robot at times because the robot's gaze was breaking their concentration. In fact, even the creator of Kismet, Cynthia Breazeal, seems to have developed a very personal relationship with her own creation:

> Breazeal experienced what might be called a maternal connection to Kismet; she certainly describes a sense of connection with it as more than "mere" machine. When she graduated from MIT and left the AI laboratory where she had done her doctoral research, the tradition of academic property rights demanded that Kismet be left behind in the laboratory that had paid for its development. What she left behind was the robot "head" and its attendant software. Breazeal described a sharp sense of loss. (Turkle 2006)

13.8 The Dangers Ahead

These accounts are only a small set of the ever-mounting evidence that humans are becoming increasingly attached to robots. From seemingly innocuous facts such as the naming of their robots, to more worrisome episodes such as promoting robots to military ranks, calling robots "pals," and exhibiting "shameful" reactions (such as the woman who shut her bedroom door because she was getting undressed and felt that her AIBO was watching her), the personification of social robots is widespread and is becoming a testimony for the human willingness to form unidirectional emotional bonds with these machines.

It is important in this context to note how little is required on the robotic side to cause people to form relationships with robots. Consider the case of the AIBO. Clearly, it is modeled after a real dog in that its physical shape resembles that of a dog and its behaviors bear some resemblance to dog behaviors (wagging tail, barking, etc.). Hence, one might argue that it is really a robotic substitute for what otherwise would be legitimate companion. But then, consider the PackBot, which is not even a fully autonomous robot; rather, it is under tight remote control from its operator. Moreover, it has tracks and does not resemble any particular biological creature. Yet, it does play a critical role in the

AMSCE-1101

soldiers’ daily routines and fight for survival. Hence, one might argue that these special circumstances make humans forget the very machine-like appearance and lack of autonomy of PackBot. And PackBot has another unique feature that might contribute to the soldier’s identification with the robot: soldiers are able to see the world from the robot’s perspective (through visual real-time streams from the robot’s cameras). This could easily blur the distinction between the robot itself and the human operating it, at least for the human operator (there is evidence from cognitive science that humans view sensory or actuator augmentations as part of their bodies when they have gained sufficient experience using them).

For further contrast, consider now the Roomba, which neither has animal-like appearance, nor allows the human to see the world from its perspective. It is a mere disc that drives around in certain patterns, to avoid bumping into things. Yet, it manages to instill the idea of agency in people, and can cause them to even experience gratitude for its service, so much so that they will clean in its stead. One would hardly be able to make that point for dishwashers!

It is also interesting to note how little these robots have to contribute on their end to any relationship, in other words, how inept and unable they are to partake as a genuine partner: neither the Roomba nor the PackBot, for example, have any notion of “other”; there are no built-in algorithms for detecting and recognizing people. Rather, anything that causes their contact sensors to be triggered is treated in the same way, namely as an “obstacle” that needs to be avoided.

13.9 The False Pretense: Robots Are Agents

None of the social robots available for purchase today (or in the foreseeable future, for that matter) care about humans, simply because they cannot care. That is, these robots do not have the architectural and

AMSCE-101

computational mechanisms that would allow them to care, largely because we do not even know what it takes, computationally, for a system to care about anything (cf. Haugeland 2002). Yet, this fact is clearly getting lost in the increasing hype about social robots. It almost seems as if industry is trying hard to make the case for the opposite, thus enforcing the personification of social robots.

Take, for example, one of the new Hasbro robot dolls, called Baby Alive, which can say simple phrases like “I’m hungry,” “oh oh, I made a stinky,” and “mommy, I love you.” The commercial advertising for the robot emphasizes, “how real it is” by explicitly using the phrase “a baby so real.” Other companies have been advertising their toys as “recreating the emotions” of a cat, a dog, an infant, and so on (see also Scheutz 2002).

Even companies like iRobot that are clearly aware of the computational and cognitive limitations of their products, find it useful, for whatever reason, to create a Facebook page for their PackBot product, where PackBot stories and news are recounted in first-person narratives, as if there were a single entity called “PackBot” that had experienced all these situations and events.

And, finally, academics themselves are often less careful than they ought to be when presenting their research. For example, researchers who work on emotions often say loosely that their robots have emotions, implement emotions, use emotions, and so on. This kind of suggestive language (e.g., during research presentations or even in published research papers) makes it easy for nonexpert readers to conflate the control processes in these artifacts with similarly labeled, yet substantively very different control processes in natural organisms, particularly humans (e.g., Scheutz 2002). The repeated labeling of control states in robotic architectures and of behaviors exhibited by robots with terms familiar from human and animal psychology helps to create, maintain, and sustain the false belief that “somebody is at home” in current robots. And while people, when asked explicitly, might deny

AMSCE-101

that they think of the robot as a person, an animal, or an otherwise alive agent, this response generated at the conscious level might be forgotten at the subconscious level at which robots can affect humans so deeply. Social robots are clearly able to push our “Darwinian buttons,” those mechanisms that evolution produced in our social brains to cope with the dynamics and complexities of social groups, mechanisms that automatically trigger inferences about other agents’ mental states, beliefs, desires, and intentions.

13.10 The Potential for Abuse

The fact alone that humans are already anthropomorphizing existing social robots in ways that clearly overstate the robots’ capabilities is a sufficient indication that the personification of social robots is moving forward quickly, and that more sophisticated future robots will likely be even more anthropomorphized. Features of future robots, like human-like appearance, natural language interactions, and so on, might prompt people to be even more trusting in them or develop attitudes toward robots that could and likely would be exploited. For example, if it turns out that humans are reliably more truthful with robots than they are with other humans, it will only be a matter of time before robots will interrogate humans. And if it turns out that robots are generally more believable than humans, then it will only be a matter of time before robots are used as sales representatives.

Moreover, it will become even easier and more natural for humans to establish unidirectional emotional bonds with more sophisticated robots, often without noticing, akin to becoming addicted, where one’s realization of one’s addiction always comes after the fact. And with more sophisticated robots that are specifically programmed to exhibit behavior that could easily be misinterpreted as showing social emotions such as sympathy and empathy, it will become increasingly difficult for

AMSCE-1101

people to even realize that their social emotional bonds are unidirectional, aside from a basic emotional resistance that we are already seeing today (e.g., when people insist that they get back the very same robot that they sent in for repair and not another copy).

What is so dangerous about unidirectional emotional bonds is that they create psychological dependencies that could have serious consequences for human societies, because they can be exploited at a large scale. For example, social robots that appear "lovable" might be able to get people to perform actions that the very same people would not have performed otherwise, simply by threatening to end their relation with the human (e.g., an admittedly futuristic sounding request of a robo-dog to dispose of a real dog: "please get rid of this animal, he is scaring me, I don't want him around any longer"). More importantly, social robots that cause people to establish emotional bonds with them, and trust them deeply as a result, could be misused to manipulate people in ways that were not possible before. For example, a company might exploit the robot's unique relationship with its owner to make the robot convince the owner to purchase products the company wishes to promote. Note that unlike human relationships where, under normal circumstances, social emotional mechanisms such as empathy and guilt would prevent the escalation of such scenarios; there does not have to be anything on the robots' side to stop them from abusing their influence over their owners.

AMSCI-101

13.11 We Need to Act, Now!

Despite our best intentions to build useful robots for society, thereby making the case for robo-soldiers, robo-pets, robo-nurses, robo-therapists, robo-companions, and so forth, current and even more so future robot technology poses a serious threat to humanity. And while there is clearly a huge potential for robots to do a lot of good for humans (from elder care to applications in therapy), any potential good cannot be discussed without reflecting any potentially detrimental consequences of allowing machines to enter our personal social and emotional lives.

Some have warned us for quite some time about the dangers of producing increasingly human-like robots: “it is also practically important to avoid making robots that are reasonable targets for either human sympathy or dislike. If robots are visibly sad, bored or angry, humans, starting with children, will react to them as persons. Then they would very likely come to occupy some status in human society. Human society is complicated enough already” (McCarthy 1999). Yet, it is clear that, as a research community, the fields of artificial intelligence, robotics, and the nascent field of human–robot interaction have not reflected enough on the social and ethical implications of their artifacts. Such a reflection, if considered soon enough, might be able to inform future robotics research in useful ways, for example, on how research should proceed with respect to questions such as the slowly crystallizing perspective of future robotic soldiers (Moshkina and Arkin 2007) or robotic sex partners (Levy 2007).

Different from the first discussions about robot consciousness and robot rights in the 1960s, in which philosophers thought it opportune to begin reflecting on these subjects, since the existence of such robots was still far off (Putnam 1964), we are now running out of time. We need to start right away to investigate the potential dangers of social robots, find ways to mitigate them, and possibly develop principles that future lawmakers can use to impose clear restrictions on the types of social robots that can be deployed.

For example, one could simply prohibit and stop all research and development on social robots. While this option would certainly solve some of the problems, by avoiding them altogether, it seems completely unreasonable to believe that research and development of social robots

AMSCE-IOI

could be prohibited and stopped, while other research in robotics and artificial intelligence continues.

Another option might be to require, by law, that all commercially available robots have some form of ethical reasoning built in. For example, some researchers have argued that ethical principles will need to be integrated into the decision-making algorithms in the robotic architecture in such a way that the robot will not be able to alter, ignore, or turn off these mechanisms (e.g., Arkin 2009). While this option might work for limited domains, where the number of possible actions is clearly constrained and the ethical implications of all actions can be determined ahead of time, it is unclear how general ethical principles could be devised that would work for an unknown number of situations, largely because philosophy in all of its history has not been able to agree on the right set of universal ethical principles, aside from being computationally feasible in real time given the computational constraints of the robotic platform. Even if there were a way to encode ethics in a set of universal laws, very much like Asimov conceived of the Three Laws of Robotics (in his short story "Runaround" from 1942), there are strong logical reasons why such as system cannot work—it would be straightforward to present a robot with logical paradoxes that would render any rational reasoning system ineffective, for example by ordering it to "not obey any orders, including this one," an order that, by simply stating it, automatically makes the robot disobedient no matter how sophisticated its control system may be.

Another option might be, again, required by law, to make it part of a social robot's design, appearance, and behavior, that the robot continuously signal, unmistakably and clearly, to the human that it is a machine, that it does not have emotions, that it cannot reciprocate (very similar to the "smoking kills" labels on European cigarette packs). Of course, these reminders that robots are machines are no guarantee that people will not fall for them, but it might reduce the likelihood and extent to which people will form emotional bonds with robots. And it

AMSCI-101

will present the challenge of walking a fine line between making interactions with robots easier and more natural, while clearly instilling in humans the belief that robots are human-made machines with no internal life (at least the present ones). It is currently unclear how effective such mechanisms could be, although empirically testing their effectiveness would be straightforward (e.g., add a particular mechanism to a particular generation of Roombas, repeat the previous ethnographic studies, and compare the extent to which people engage in the same behaviors as before).

In the end, what we need is a way to ensure that robots will not be able to manipulate us in ways that would not be possible for other (normal) human beings. And a radical step might be necessary to achieve this: to endow future robots with human-like emotions and feelings. Specifically, we need to do for robots what evolution did for us, namely to equip us with an emotional system that strikes a balance between individual well-being and socially acceptable behavior. By having the same “unalterable affective evaluation” as those realized in humans, future social robots will be able to function in human societies in human-like ways (for all the reasons we are now investigating in HRI and AI/robotics), with the side effect of having “genuine feelings” that make them just as vulnerable and manipulable as humans.

Some have voiced their reservations about endowing robots with emotions arguing that it would take extra effort to implement human-like emotions in robots (e.g., McCarthy 1999), while others have maintained that certain types of emotions will necessarily be possible (and even instantiated) in complex robotic architectures with particular architectural properties (Sloman and Croucher 1981). Without taking a stance on whether emotions have to be explicitly built in or result as emergent phenomena in certain types of architectures, it is important to appreciate that this suggestion does not apply to any type of robot, but only to certain types of social robots. We certainly do not need a space exploration robot to be emotional, and nobody would set foot on a plane

AMSCE-1101

with an automatic flight controller that can get depressed, if not suicidal. However, if we had a choice between a *Terminator 3*-type scenario, where intelligent robots take control, despite human efforts to prevent it, and a grouchy household robot that is tired of cleaning up the kitchen floor, the choice is obvious.

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AMSCE-1101

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AMSCE-1101

14

The Ethics of Robot Prostitutes

David Levy

> I pay for sex because that is the only way I can get sex. I am not ashamed of paying for sex. I pay for food. I pay for clothing. I pay for shelter. Why should I not also pay for sex? Paying for sex does not diminish the pleasure I derive from it.
>
> —Hugh Loebner[1] (1998)

Recent discussions on roboethics have introduced the subject of sex with robots (Levy 2006a, 2006b, 2006c). In particular, one authoritative statement on this topic received worldwide media publicity during 2006—the prediction by Henrik Christensen, chairman of EURON, the European Robotics Research Network, that "people will be having sex with robots within five years."

The arrival of sexbots[2] seems imminent when one considers recent trends in the development of humanoids, sex dolls, and sex machines of various types. Sophisticated humanoids such as the Repliée Q1 (Minato et al. 2005) have already been developed that are humanlike in appearance. Advances in materials science have enabled sex doll manufacturers to improve significantly on the inflatable products of the preceding decades, creating dolls with prices in the region of $5,000 to $7,000 (Levy 2007). Low-cost sexual devices, designed mostly for use by women, now sell tens of millions annually in the United States (Good Vibrations 2005). Far more intricate and more expensive machines are

AMSCE-1101

manufactured that actually simulate sexual intercourse, and are sold on websites such as <www.orgasmalley.com>, whose prices range from $140 to $1,800.

It takes little imagination to appreciate that it is already technically possible to construct a robot that combines the look, feel, and functions of humanoids, sex dolls, and sex machines. When sexbots first appear on the market, they will most likely be beyond the pockets of all but the wealthy. The current cost of constructing a sophisticated humanoid dwarfs the cost of purchasing an upmarket sex doll, as can be seen from the $130,000 starting price of the robot heads designed by industry leader David Hanson, and manufactured by his company Hanson Robotics Inc. With the first sexbots costing a six-figure (dollar) sum, or possibly more, their hire will be the only way for most of us who want to experiment with the joys of robot sex to do so (Levy 2007).

14.1 Sex Dolls for Hire

In terms of sales volumes, Japan leads the way with the current generation of high-priced sex dolls (Levy 2007). Their popularity on the retail market has also spawned a doll variant of the more traditional form of "escort" service. In a 2004 newspaper article entitled "Rent-a-Doll Blows Hooker Market Wide Open," (Connell 2004) the *Mainichi Daily News* explains how one leading purveyor, *Doll no Mori* (Forest of Dolls), started their 24/7 doll-escort service in southern Tokyo and the neighboring Kanagawa prefecture: "We opened for business in July this year," said Hajime Kimura, owner of Doll no Mori. "Originally, we were going to run a regular call girl service, but one day while we were surfing the Net we found this business offering love doll deliveries. We decided the labor costs would be cheaper and changed our line of business."

AMSCE-J101

Outlays are low, he explains, with the doll's initial cost the major investment, and wages are never a problem for employers. "We've got four dolls working for us at the moment. We get at least one job a day, even on weekdays, so we made back our initial investment in the first month," Kimura says. "Unlike employing people, everything we make becomes a profit and we never have to worry about the girls not turning up for work." *Doll no Mori* charges start at 13,000 yen (around $110) for a seventy-minute session with the dolls, which is about the same price as a regular call girl service. The company boasts of many repeat customers. "Nearly all our customers choose our two-hour option."

Within little more than a year of the doll-for-hire idea taking root in Japan, sex entrepreneurs in South Korea also started to cash in. Upmarket sex dolls were introduced to the Korean public at the Sexpo exhibition in Seoul in August 2005, and were immediately seen as a possible antidote to Korea's Special Law on Prostitution that had been placed on the statute books the previous year. Before long, hotels in Korea were hiring out "doll experience rooms" for around 25,000 won per hour ($25), a fee that included a bed, a computer to enable the customer to visit pornographic websites, and the use of a doll. This initiative quickly became so successful at plugging the gap created by the antiprostitution law that, before long, establishments were opening up that were dedicated solely to the use of sex dolls, including at least four in the city of Suwon. These hotels assumed, quite reasonably, that there was no question of them running foul of the law, since their dolls were not human. But the Korean police were not so sure. The news website Chosun.com (Chosun.com 2006, now at soompi.com) reported, in October 2006, that the police in Gyeonggi Province were "looking into whether these businesses violate the law . . . Since the sex acts are occurring with a doll and not a human being, it is unclear whether the Special Law on Prostitution applies."

The early successes of these sex-doll-for-hire businesses are a clear indicator of things to come. If static sex dolls can be hired out

AMSCE-101

successfully, then sexbots with moving components seem certain to be even more successful. If vibrators can be such a huge commercial success, then malebots with vibrating penises would also seem likely to have great commercial potential.

14.2 Paying a (Human) Sex Worker

Prostitution is known as “the world’s oldest profession,” and is one that continually attracts controversy because of the ethical issues involved in selling sex. On the one hand, there are arguments such as: prostitution harms women, exploits women, demeans women, spreads sexual diseases, fuels drug problems, leads to an increase in organized crime, breaks up relationships, and more (Ericsson 1980). In contrast, there are those, including many of the clients themselves, who acknowledge and praise the social benefits of prostitution and the valuable services performed by the profession for its clients. These supporters employ arguments such as: prostitutes have careers based on giving pleasure, they can teach the sexually inexperienced how to become better lovers, they make people less lonely, they relieve millions of people of unwanted stress and tension, and they provide sex without commitment for those who want it (Pateman 1988, 2003). The ethical issues surrounding all these and other arguments related to prostitution have been debated for centuries.

In order to gain some insight as to why people will be willing, even eager, to hire the services of malebots and fembots, it is useful first to investigate the reasons for paying for the services of human sex workers. A comprehensive analysis of the principal reasons is given by Levy (2007), discussing not only men hiring female sex workers, but also the far less prevalent but increasing phenomenon of women hiring men.

AMSCE-101

Several reasons have been identified as to why men pay women for sex—what the men want or expect from these sexual encounters. The reasons most commonly stated by male clients include:

> *Variety* Here, variety, means the opportunity to have sex with a range of different women (McKeganey and Barnard 1996; Plumridge et al. 1997). A robot will be able to provide variety in terms of its conversation, its voice, its knowledge and virtual interests, its virtual personality, and just about every other aspect of its being, including its appearance and size. While variety in these characteristics of sex workers is one major reason for men paying for sex, variety in the sexual experience itself is, for many clients, another important factor, often *the* most important. Many clients are interested in sexual practices to which they do not otherwise have access, such as oral sex, often because their partners are unable or unwilling to accommodate their desires (Monto 2001). An electromechanically sophisticated robot that can indulge in oral sex will be able to satisfy this particular human motivation.
>
> *Lack of Complications and Constraints* The literature has identified a small group of motivations that might collectively be described as a lack of complications and constraints. For many clients, the principal benefits of the commercial sex exchange include the clear purpose and bounded nature of the arrangement, as well as its anonymity, its brevity, and the lack of emotional involvement (Bernstein 2005; McKeganey 1994). Sexbots, almost by definition, will be able to satisfy these particular human motivations.
>
> *Lack of Success with the Opposite Sex* For a variety of reasons, many men experience difficulty in developing relationships with women. In some cases, this is because the man is ugly, physically deformed, psychologically inadequate, a stranger in another town or a foreign land, or simply lacking in the necessary social skills

AMSCE-101

> or sexual assurance or both. Such men, with normal male desires, have a need for sexual intimacy that they cannot satisfy because of their lack of sexual effectiveness—they simply cannot attract a mate, or are afraid to try, or suffer from a combination of both. By paying for sex, they reduce the risk of rejection to an absolute minimum, thereby almost guaranteeing themselves sex on a plate. For these men, prostitution is the only sex available, a reason for paying for sex that was indicated by almost 40 percent of the clients in one study (Xantidis and McCabe 2000). None of these problem categories will present any difficulty to sexbots, which will be immune to any ugliness or physical deformity in their clients, and to their clients' psychological inadequacies.

In contrast to the relatively well-researched topic of men paying for sex, there is almost no systematic published research on the reasons why women pay, or what exactly they are seeking. But what little published evidence there is on this topic suggests that the reasons are close to those that motivate the male clients of sex workers, principally, a lack of complications and constraints and a lack of success with men (Levy 2007).

In summary, sexbots for hire will be able to satisfy the motivational as well as the sexual needs for individuals (of both sexes) who would otherwise be the clients of sex workers—to provide variety, to offer sex without complications or constraints, and to meet the needs of those who have no success in finding human sex partners. In addition, there is one significant health benefit for the clients in hiring a sexbot instead of a sex worker, namely the relative ease with which hirers can assure themselves of freedom of infection from sexually transmitted diseases. The sexual hygiene of a robot could and should be undertaken by the clients, as a case reported in *Genitourinary Medicine* testifies (Kleist and Moi 1993).

AMSCF-1101

14.3 Some Ethical Aspects of Robot Prostitution

In the subsections that follow, we consider five aspects of the ethics of robot prostitution.

14.3.1 The Ethics of Making Robot Prostitutes Available for General Use

The prime purpose of a sexbot is to assist the user in achieving orgasm, without the necessity of having another human being present. This is the same purpose as vibrators for women, which are now so popular that they are openly sold on the shelves on some of the biggest and most reputable drug store and pharmacy chains in the United States and Europe. It would seem anomalous, in view of this widespread tacit acceptability of vibrators, to brand their use immoral, just as it is difficult to argue that the design, development, manufacture, and sale of sexbots is unethical.

14.3.2 The Ethics, vis à vis Oneself and Society in General, of Using Robot Prostitutes

With most of the clients of sex workers, self-respect is an important issue. There are those, like Hugh Loebner, who are so proud of the use they make of the services of sex workers that they happily publicize their commercial sex activities, but they represent a small minority. The majority feel that there is still a moral stigma attached to their encounters, and they will go to some length in their attempts to avoid being found out by those close to them, or, even worse, being named and shamed in public, as some police forces do. For this majority, the issue of self-respect will be much better catered to by hiring robot prostitutes instead of sex workers, because robots are not generally perceived as living beings but as artifacts, and the same moral stigma does not therefore apply. Yet there will, at least for some time, be a

AMSCE-1101

moral stigma of a different sort. We understand sex with a person, but most people do not appreciate the concept of sex with a robot, and what we do not understand we tend to stigmatize.

In contemplating how the use of robot prostitutes might affect society, it is also important to consider the legal issues. Most of us in a free-thinking society are unlikely to feel that the use of sexbots by adults in private is a practice that should be prevented by legislation. Yet in Alabama, Texas, and some other U.S. jurisdictions, the sale of vibrators has been deemed illegal (Levy 2007), so it is hard to predict how the law will view the sale and hire of sexbots in the more conservative-minded states. Among those who have argued that people should have the right to avail themselves of the services of sex workers, David Richards (1979) makes a strong case: “We are able to understand the humane and fulfilling force of sexuality *per se* in human life, the scope of human autonomous self-control in regulating its expression, and the implications of these facts for the widening application of the concept of human rights to the sexual area . . . sexual autonomy appears to be a central aspect of moral personality, through which we define our ideas of a free person who has taken responsibility for her or his life.” Clearly, Richards’s arguments carry even more force when related to robot prostitutes rather than to human sex workers.

14.3.3 The Ethics, vis à vis One’s Partner or Spouse, of Using Robot Prostitutes

How the use of a robot prostitute is perceived by a spouse or partner is open to many possibilities. Will a spouse or partner who considers infidelity with another human to be reasonable behavior be likely to be upset by the hire of a sexbot? Certainly there will be many who feel that the sexual demands placed on them within their relationship are excessive, and who will therefore appreciate a night off now and then, in the knowledge that what is taking place is nothing “worse” than a form of masturbation. There will also be some who positively relish the idea

AMSCE-101

of robots, programmed to be sexually adept, teaching their partner to improve their lovemaking skills. And there will be couples, both of whom derive pleasure and sexual satisfaction from a threesome in which the third participant is willing to indulge in whatever sexual activity is asked of it (subject of course to its programming and engineering). In contrast, there will be some partners and spouses who find the very idea of sex with a robot to be anathema. The ethics of using a robot prostitute within a relationship will depend very much on the sexual ethics of the relationship itself when robots do not enter the picture.

14.3.4 The Ethics, vis à vis Human Sex Workers, of Using Robot Prostitutes

It is a common perception that prostitution is a "bad thing" for the sex workers. This is because it is seen, inter alia, as degrading them, encouraging them into a lifestyle in which an addiction to hard drugs often forms an integral part, and strongly increasing the likelihood of their catching AIDS or some other possibly fatal sexually transmitted disease. If this is so, and not all sex workers agree with this perception of their profession as a bad thing, then the introduction of robot prostitutes can only be a "good thing," because it will most likely cause a dramatic drop in the numbers who ply their trade in whichever countries robot prostitutes are made available. This eventuality was predicted as long ago as 1983, when *The Guardian* reported (Weatherby 1983) that New York prostitutes "share some of the fears of other workers—that technology developments may put them completely out of business. All the peepshows now sell substitutes—dolls to have sex with, vibrators, plastic vaginas and penises—and as one woman groused in New York 'It won't be long before customers can buy a robot from the drug-store and they won't need us at all.'" This problem, the compulsory redundancy of sex workers, is an important ethical issue, since in many cases those who turn to prostitution as their occupation do so because they have literally no other way to earn the money they need.

AMSCE-1101

14.3.5 The Ethics, vis à vis the Sexbots Themselves, of Using Robot Prostitutes

Up to now the discussion in this chapter has been based on the assumption that sexbots will be mere artifacts, without any consciousness and therefore with no rights comparable to those of human beings. Recently, however, the study of robotics has taken on a new dimension, with the emergence of ideas relating to artificial consciousness (AC).[3] This area of research is concerned with "the study and creation of artifacts which have mental characteristics typically associated with consciousness such as (self-)awareness, emotion, affect, phenomenal states, imagination, etc." (AISB 2005).

Without wishing to prejudice what will undoubtedly be a lively and long-running debate on robot consciousness, this author considers it appropriate to raise the issue of how AC, when designed into robots, should affect our thinking regarding robot prostitutes. Should they then be considered to have legal rights and ethical status, and therefore worthy of society's concern for their well-being and their behavior, just as our view of sex workers is very much influenced by our concern for *their* well-being and behavior? David Calverley asserts (2005) that natural law mitigates in favor of an artificial consciousness having intrinsic rights, and therefore, simply by virtue of having an artificial consciousness, a robot should be ascribed *legal* rights. If this is held to be so, then concomitant with those legal rights will come legal responsibilities, and robot prostitutes might therefore become subject to some of the same or similar legal restrictions that currently apply to sex workers.

The legal status and rights of robots are but one aspect of their ethical status. Torrance (2006) discusses our responsibility in, and the ethical consequences of, creating robots that are considered to possess conscious states, and he introduces the notion of artificial ethics (AE)—the creation of "systems that perform in ways which confer or imply the

AMSCI-101

possession of ethical status when humans perform in those ways. For example, having a right to life, or a right not to be treated merely as an instrument of someone else's needs or desires, are properties which are part of the ethical status of a human being, but a person doesn't acquire such rights just because of what they *do*. This may extend to ethics when applied to artificial agents."

These questions from Calverley, Torrance, and others in this recent but already fascinating field are certainly issues that will form part of the coming debate on the ethics of robot sex and robot prostitution. This author does not pretend to have any answers as yet, but for the time being rests content to have raised the profile of these issues for the awareness of the roboethics community.

14.4 Conclusion

With the advent of robot sex, robot prostitution inevitably becomes a topic for discussion. The author believes that the availability of sexual robot partners will be of significant social and psychological benefit for society, but accepts that there are important ethical issues to be considered relating to robot prostitutes. This chapter has highlighted some of these issues. The debate is just beginning.

Notes

1. Hugh Loebner is the founder and sponsor of the annual Loebner Prize in Artificial Intelligence, a Turing Test contest to find the best conversational computer program.

2. In common with accepted practice this chapter employs the term "sexbot" to mean *any* robot with sexual functionality, and "malebot" or "fembot" to indicate a sexbot with artificial genitalia corresponding to a particular sex.

AMSCE-101

[3]. Sometimes referred to as "machine consciousness" (MC).

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AMSCE-110I

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AMSCE-1101

15

Do You Want a Robot Lover? The Ethics of Caring Technologies

Blay Whitby

Do you want a robot lover? You might perhaps think that you do and that it is nobody else's business but yours, but the widespread use of robots in intimate and caring roles will bring about important social changes. We need to examine these changes now and consider them from an ethical standpoint. Robotic carers and artificial companions are a technology that is likely to be available in the near to mid-term future. In Japan and South Korea, robots are seen as potential carers for the elderly and as babysitters. Many researchers are looking to make their products display emotion and respond to emotional displays by users. At least one writer has predicted marriage to robots will be accepted in progressive countries by 2050. This chapter examines some of the implications of these possibilities—both technical and social. Do they represent socially and ethically acceptable developments? What is likely to be technically feasible, and just what should we allow?

AMSCE-1101

15.1 The Debate

It is a truth universally acknowledged that a young man (or woman) in possession of a good fortune must be in want of a robotic companion.[1] So do *you* want a robot lover? Maybe not: perhaps you would prefer instead a robot to act as a domestic servant or as a personal care assistant in your declining years. Perhaps a more interesting question for you might be: Would you leave your children in the care of a robot nanny? All these considerations highlight immediate problems for robot ethics, and it is urgent to address them because this sort of caring technology is about to enter widespread use. The technology discussed in this chapter is absolutely not science-fiction technology. The discussion is about technology that is already in use or under development.

It's important to read the chapter title as a *question* because many futurologists, industrialists, and investors have already decided that you do indeed want something along these lines. There are advantages and disadvantages to the use of robots in personal settings. Many people will want the sort of technology under consideration here for both good and bad reasons, but there will be costs—and not just the financial costs of promoting research and development in this area at the expense of other areas. There are social dangers that ought to be avoided and about which such unrestrained commercial interests may need to be made aware. It is unlikely that the social problems of robot ethics will be solved by allowing markets to decide freely.

There is also coherent and powerful opposition to robot lovers, perhaps also to technology employed in other companionship roles. The Roman Catholic Church, the world's largest religious organization, has clear and profound doctrinal opposition to sexual acts other than within marriage for the purpose of procreation.[2] For this reason, the very idea of a robot lover, and maybe even a robot companion, will be completely unacceptable to them. Many other religious groups are likely to take similar positions.

AMSCE-101

A position of general and complete opposition to the technology, however, pays no attention to the real human benefits that this technology might bring. Robot carers, and, in particular, “smart homes,” could enable older people to remain independent longer, and this may well be something they would freely choose. Robot companions, too, may have many social benefits. The ethical issues are nuanced. It seems highly likely that a more balanced ethical response will need to be both technically and philosophically informed. Explicit ethical principles are needed for the design and introduction of this sort of technology. These ethical principles need urgent exploration and discussion.

15.2 What Is a Robot?

It is natural for people to see novel technologies in terms of those they replace. That is why automobiles were once referred to as “horseless carriages” and radio as “wireless.” That is also why science-fiction accounts of robots have tended to make robots human-like in appearance and size. In fact, very few robots have turned out to be human-like in appearance or size. Real robots are now commonplace, but because they don’t look like the ones in the movies, they have not always been recognized as robots.

Contemporary robots range from bits of software that autonomously perform activities (both good and bad) on the Internet, to the post-A320 range of Airbus airliners, which are so highly automated that the pilots effectively give them executive commands, rather than actually flying them; the aircraft itself automatically takes care of the flying. One of the most successful modern robots has been the BGM-109 Tomahawk family of cruise missiles.[3] However, the major employment opportunity for robots is still in assembly-line industrial production, particularly automobile manufacturing, where they could be said to represent about 10 percent of the workforce.

AMSCE-1101

These everyday robots are for the most part extremely nonhuman-like in appearance. However, there are three main dimensions along which robots can be human-like. It is important to distinguish them. The first, and perhaps, least important dimension is that of physical appearance. Rather more important is the fact that robots can also be human-like in behavior—deliberately imitating some human behaviors without looking particularly human. Just as importantly, robots can be human-like along the dimension of the tasks they perform. This latter dimension is clearly the most important when we consider the ethics of robots in caring and companionship roles.

One very important fictional image for robots has been that of domestic servant. Obviously, this is another example of people seeing the new technology in terms of previous technologies. Indeed, the first use of the word “robot,” in Karel Capek’s 1921 play *Rossum’s Universal Robots* ([1921] 2004) coincided perhaps significantly, with a period in Europe when human domestic servants were becoming hard to find[4] The possibility of building some sort of mechanical butler has preoccupied artists and, to a not-insignificant extent, technologists ever since the 1920s. This is despite the fact that in a modern house a great deal of a butler’s traditional work has been automated. Dishwashing machines, central heating timers, easy-care fabrics, telephone answering machines, and similar technologies do much of the work once done by domestic servants.

However, there still remains a manifest desire to find further technological replacements for humans in certain roles. Whether this desire is prompted by real human need or instead by uncaring commercial imperatives is another issue raised by the question in the title. That there exists a profitable market for expensive new technology is not of itself sufficient moral defense for allowing widespread sales. There are ethical questions—in particular, who gains and who loses—that need to be examined at an early stage. We will consider, in detail, the question “why would anyone want a robot lover?” in a subsequent

AMSCE-IOI

section. In conclusion of this section, it is worth remarking that there seems some ethical ambiguity about the answers (or lack of answers) to questions such as “why would anybody want a robot butler, or teacher, or physician?” There may be morally good responses to these questions, but they are rarely, if ever, stated. The field of robot ethics has some immediate and urgent groundwork to do.

15.3 What Is a Robot Lover?

Just as the creations of artists may have misled us about the nature of robots in general, so we may have been misled about the appearance and nature of a robot lover. It is not particularly difficult to employ an actress (or actor) to play an on-screen robot. Audiences tend not to object on the grounds that a machine so human in appearance and behavior, or indeed so physically attractive, is technically impossible for the foreseeable future.

In reality, robots cannot yet achieve anything like this standard of physical resemblance to humans. One significant problem among many is that of the “Uncanny Valley” (Mori 1970). This is a phenomenon first documented by Masahiro Mori in 1970, but much talked of in more recent years as technology has advanced to the point where it has much more immediate relevance. The Uncanny Valley involves severe revulsion on the part of humans when observing things such as robots that look and move in a way that is almost, but not quite, human-like. It is hypothesized that this phenomenon is an evolved human response—maybe to prompt the avoidance of very ill or incapacitated humans. Another plausible theory is that observing the unnatural movements of a very human-like robot triggers our fears of our own mortality.

Whatever the biological antecedents, the Uncanny Valley is a major problem for those designing realistic cinema animations, as well as for robot builders. It is also a major technological hurdle preventing the

AMSCE-1101

building of any robot that could produce the same kind of feelings that might be engendered by an attractive actress pretending to be a robot, at least for the foreseeable future. One can certainly buy sex dolls, but animating them in a way that does not disgust is likely to prove rather more difficult than was once anticipated. The problem of the Uncanny Valley is an important reason why it is highly unlikely that *physical* robots will be adopted as artificial sexual companions by those with mainstream sexual preferences, at least for the immediate future.

It is necessary to remember, however, that a gynoid- or android-style robot companion is only one possible technological development among many—albeit the main possibility that has been portrayed in artistic examinations of the future. The other two dimensions, mentioned in the preceding section, along which a robot can be human-like (behavior and role) are important here. If the robot *or other automated technology* performs at least some of the tasks of a human lover, then its introduction may well be analogous to the way in which household automation has taken over much of the role of domestic servants over the last fifty years.

Work, which might contribute to the development of robot lovers, is now proceeding in a number of technological areas. Boden (2006, 1094) lists thirteen technologies now working or under development, which could help move toward the sort of artificial companions under discussion. These include such things as the monitoring and manipulation of users' emotions by artificial systems, the detection of lying by users, and the realistic simulation of emotion by artificial systems.

A real robot lover might not be much like the pretty, human-sized, very human-resembling robot of the movies, therefore. However, it is likely to be a slightly different, but just as effective, sort of artificial companion. It could have intimate knowledge of its user. It could respond to and perhaps even anticipate its user's feelings. This line of development would be harder to recognize as anything like a robot lover

AMSCE-101

because it will be integrated into other technologies. For example, it might emerge as a “user interface” to other caring technologies such as a smart home. It is certainly not inconceivable that such systems could provide more worthwhile companionship than humans provide in some cases.

All of the examples on Boden’s list are technologies that could be developed (and indeed are now being developed) with the best of intentions. Those seeking to make computers more emotionally aware, for example, declare objectives such as making their systems more usable, more helpful, or better tutors. However, the same developments could equally be employed to make systems more seductive, more sexual, or more emotionally indispensable. These dimensions are likely to be of great interest to those intending to make profits from the technology.

As ethicists, we should not be concerned primarily with the pretty gynoid of the movies. We should probably worry much more about the use of advanced AI technology in a wide variety of caring roles. This is a way in which robot love is much more likely to emerge by stealth than in any obvious fashion. In discussing the ethics of technological developments we need always to be aware of the force of Kranzberg’s First Law (1986, 545). In brief, this insists that technology is never of itself good, or bad, or neutral. It is always all three, depending on how we use it. We have choices about how we use technology in intimate and caring settings. These merit calm, informed, and thoughtful discussion.

15.4 Why Would Anyone Want a Robot Lover?

The joke in the opening sentence of section 15.1 reflects the humor in unquestioning acceptance of the need for robotic companions. It is worth briefly examining this frequently assumed need. There is no shortage of humans and while there may be many jobs suitable for

AMSCE-101

robots, the provision of human companionship would seem to be a most unlikely area for automation.

The obvious answer to the question “Why would anyone want a robot lover?” is because a person is unable to find a human lover. There could be many reasons for this. However, from an ethical standpoint it is clear that we should, ceteris paribus, prefer to try to remedy or ameliorate the human problems, rather than substitute an artificial device. It may be that there are some individuals who are so extremely unattractive, or socially unskilled, or troubled in some other way, that human society is impossible for them. However, this is rarely claimed as a justification for the technological developments under discussion here.

For example, the category of people who most obviously are considered unfit for human society is convicted violent criminals. They would seem an ideal target market for robot lovers. Interestingly, they are a market rarely, if ever, mentioned by the enthusiasts for technology. However, for those who possibly can find human companionship, it would seem morally better to arrange this companionship than to substitute a technological solution. There are a number of reasons for this.

First, it clearly can be argued that peaceful, even loving, interaction among humans is a moral good in itself. Second, we should probably distrust the motives of those who wish to introduce technology in a way that tends to substitute for interaction between humans. Third, for a social mammal such as a human, companionship and social interaction are of crucial psychological importance. Ultimately, it may perhaps be that we can scientifically analyze all of these psychological needs. It may also be possible one day to build technology that completely fulfills these needs. However, as things stand, we cannot be sure that our caring technologies are capable of meeting all the relevant psychological needs. In advance of any certainty about this, there is clearly a risk of severe psychological damage. To a greater or lesser extent, these three moral reservations apply to all technology that is employed to substitute

AMSCE-1101

for humans in intimate caring roles. They are apparent when applied to the case of a robot lover, but apply equally to other caring technologies.

A very different view is taken by David Levy. Levy is an enthusiast for the use of robots in caring and loving roles (2007). Although he does not state it directly, his answer to the question "Why would anyone want a robot lover?" is essentially that it is the result of an inevitable process of technological development. He identifies three routes by which people might come to love robots (Levy 2007, 127–159). The first is claimed to be similar, if not identical, to the normal development of love between humans. The second route is best described as technophilia—people preferring a robot lover mainly because it is a robot. The third route is the way in which some people are so socially isolated that the love of a robot is a preferred option to normal human companionship.

Levy's third route may be ethically dubious precisely because of the three moral reservations stated above. It also represents an attempt to fix a potentially serious set of human problems by the proposed use of a yet-to-be-developed technology. In ethical terms, this may be a smokescreen to distract us from what we really need to fix. The supposed need for this technology is something that should not be accepted on trust—especially as there are profits to be made from selling the technology whereas the financial benefits of fixing social problems are not so obvious. Once again, the urgent need for widespread public debate should be clear.

What can be said of Levy's other two routes? Human sexuality is best described as a highly creative exercise. There is no doubt that sexuality directed at robots, rather than humans, is already practiced. These two routes are not only open they are already well traveled. The primary question in this section is not whether this is good, healthy, or in need of a response. It is rather: is sex with robots a route to love with robots? Levy is perfectly correct in that it is a route to familiarity and dependence, but most writers would require a good deal more before calling this love. For example, Mark Fisher's excellent definition of love

AMSCE-110I

as a process rather than a state or an emotion rightly emphasizes the importance of reciprocity (1990, 23–35). Reciprocity from a robot is clearly different from reciprocity from a human. Levy asserts simply, “reciprocal liking is another attribute that will be easy to replicate in robots” (Levy 2007, 147). This is a highly debatable assertion.

Whether or not we could accept that Levy’s sort of intimacy and familiarity with robots is actually “love” will be analyzed further in the next section. For now we can allow that there will almost certainly be increasing use of robots in intimate settings—and especially for sexual purposes. If we heed the lessons from previous technologies, then it would seem that there would be a ready market for robotic sex toys of various types. This is despite the widespread opposition of religious groups. For example, the continuing profitability of the pornography industry, despite effective opposition, and even legislative prohibition in some cultures, suggests that there is a strong underlying demand for pornographic material. It is reasonable to expect that there will also be a strong underlying demand for robotic sex toys.

The ethics of the sexual use of robots is, as has previously been remarked, nuanced and complex. The simple arguments portraying such use as all good or all bad should be quickly dismissed. In particular, the fact that there is a strong underlying demand is not any sort of moral justification. The fact that there are people who may be unable to find any lover other than a robotic one has been shown to be inadequate as a justification for the widespread use of such technology.

On the one hand, to allow a completely free market in robot lovers (and by the same token, robot carers and robot companions of all sorts) would be unforgivably rash. On the other hand, the case in favor of a free market in this technology could be based on the traditions of personal freedom set out most clearly in John Stuart Mill’s definitive essay “On Liberty.” As Mill put it, “The only part of the conduct on anyone, for which he is amenable to society, is that which concerns others. In the part which merely concerns himself, his independence is,

AMSCI-JOI

of right, absolute. Over himself, over his own body and mind, the individual is sovereign" ([1859] 1966, 14).

Those following this very influential view will claim that if people want to involve themselves with robots, in various ways, then they have Mill's "absolute" right to do so. It is worth remarking that this sovereignty over oneself has never really been absolute in practice. Mill allows that it does not apply to children and "backward states of society" ([1859] 1966, 14). Societies under threat of violence—for example, those engaged in wars or under terrorist threat—find it necessary to constrain individual private behavior.

Nevertheless, an argument might be made that individuals have the right to purchase robots as sex toys or as other forms of caring technology if by doing so they harm no one else. Indeed, for those following Levy's second route—that of technophilia, it is a win-win situation. Not only are they likely to be happier with their robotic lover than they would be with a human lover, but also the rest of society is spared any consequences of having to deal with their paraphilic urges.

This argument is valid as stated, but some limitations must be pointed out. It may not always be the case that no one else is harmed by this sort of behavior. An individual who consorts with robots, rather than humans, may become more socially isolated. Even if they are happier with their robotic companion, the reduction in human contact may make them less socially able, and therefore, not so effective as a citizen. If the practice becomes widespread, then society as a whole may suffer, and morally may be entitled to take steps to prevent this sort of breakdown.

It is important to stress that these are limitations, not a counter-argument. The exact point of balance between the rights of the individual and the rights of society to protect established social order is a familiar area of debate in political philosophy. There is not space to consider these debates here, nor would it be accurate to say that there is any useful consensus. The immediate conclusion urged is that the

AMSCE-101

availability of robot lovers and caring technologies raises these political debates and should be discussed in the political area, rather than simply as technology. There is a need for more scientific research into these social effects. There is also a need for balanced general public debate on the moral question of whether or not such social effects are to be held more important than individual liberty.

Unfortunately, the lessons from previous technologies suggest an even more worrying possibility. One important reason why people would choose a robot lover is in order to be able to do things to it that would be unacceptable if done to humans.

At present, the main explicit interaction that nonexperts have with artificial intelligence (AI) is in computer games. Although it is a technology that has many successful applications, at present computer gaming would be how the majority of people encounter and discuss AI. In this application area, generally speaking, AI is used to provide more interesting and elusive targets for people to shoot at. In short, the main reason people seem to buy AI technology is to play at killing it. Since computer gaming is so commercially successful and has led us to accept extreme levels of simulated violence, we should anticipate extreme levels of violence toward robots.

The ethical implications of this are complex and controversial. Some discussion has been initiated elsewhere, for example in Whitby 2008. It is not clear that the arguments from liberty, such as Mill's, will justify the abuse of robots. There are several questions to be considered about the private abuse of robots. First, are people who do this sort of thing in simulation more or less likely to do it to humans in reality? The evidence is not clear. There has been much discussion and a certain amount of useful research on whether the use of violent computer games desensitizes users to violence in reality. The balance of evidence is at least worrying (see, e.g., Anderson and Bushman 2001). Second, is there some sort of cathartic release through this sort of private activity, which might make people better behaved in human–human relationships?

AMSCE-1101

Third, what is the ethical role of designers of the technology? It is obviously possible to design robots or caring technology that responds positively to, and actively encourages, abuse at one extreme. At the other extreme, it is just as possible to design the technology to summon the authorities at the slightest hint of abusive behavior or to log every expletive or angry word issued by the user as possible evidence in a prosecution.

There is a distinct lack of guidance on these design questions in existing professional and legal codes. This needs to be remedied because designers with different views on the ethics of abuse may build very different systems for the mass market, with totally unpredictable ethical consequences.

15.5 Love

There are two distinct questions to be considered about robot love: "Can you love a robot?" and "Can the robot love you?" The second question generates a great deal of philosophical interest. This interest is most unfortunate for anyone concerned with the ethics of robot love. One might suspect that some readers will be pursuing this chapter hoping primarily for the expression of a position on this long-standing philosophical debate. Any such readers may well be disappointed. It is not necessary to answer this second question to progress the arguments of this chapter. Indeed the philosophical focus on this question is a serious and unfortunate distraction from the immediate ethical issues. In short, it does not matter whether or not the robot is *really* capable of loving someone. What matters is how humans behave.

Of course, how people behave depends partly on their beliefs about the technology. If people come to believe that their robot or caring system is *really* in love with them, then they will probably be a good deal more likely to describe themselves as loving it in return. For this

AMSCE-101

reason, a convincing simulation of love is just as ethically dangerous as anything approaching the real thing. Even, perhaps especially, if the simulation is not particularly convincing, over-enthusiastic marketing by those who wish to sell such technology may deliberately set out to foster such false beliefs. This is not an area where we can trust the free market.

Despite Levy's optimism, at present there is no technology under development that would enable any artifact in itself to experience genuine love. There are, by contrast, a number of technologies—for example, those cited by Boden—which would enable it to perform a fairly adequate simulation of loving a human (2006, 1094–1095). In the private and intimate contexts under consideration, the word "adequate" will have much weaker requirements than it would in a double-blind scientific trial or in a Turing Test situation.

To be detained by the philosophical question of to what extent an effective simulation is *really* love, is to be misdirected from the immediate ethical issues: Should we permit the use of effective simulations of love? If so, under what circumstances and to what extent? There are no easy answers to these questions, but they are portentous.

What, then of the first question: "Can you love a robot?" Although there is not the same level of philosophical controversy, this question, too, needs a good deal of unpacking. One writer who gives a clear affirmative answer is Levy (2007, 105–112). Levy has no doubt that you can love a robot. Indeed, he predicts that progressive states will recognize marriage to robots by 2050 (155). The sort of love that Levy imagines occurring stems precisely from the familiarity, indispensability, and intimate association with the technology that we have been considering in this chapter. However, whether or not we are ready to call this phenomenon "love" is highly debatable. Most people would hear this use of the word "love" as metaphorical.

If however, a significant proportion of people eventually come to talk of loving their robots in a way that at least closely resembles the way in

AMSCE-101

which we use the word in the case of personal human relationships, then it is reasonable to assume that the word "love" is undergoing a change of definition. Love is a concept that has been defined in widely differing ways over recorded history. The discussions in Plato's *Symposium* ([385–380 BCE] 1999, 9–50), though still celebrated in modern English in expressions such as "a platonic relationship," differ significantly from modern views on love.[5] Approaches to the definition of love for much of the period between Plato and the modern era center on the notion of "agape"—the Christian principle demanding love for all.

The concept of love implicit in Austen's tongue-in-cheek work misquoted at the beginning of this chapter proved very influential for the nineteenth-century view of love (Austen [1813] 2006). However, her insistence on the central importance of material wealth often seemed unacceptable, or at least highly unromantic, to twentieth-century audiences. It is worth briefly mentioning the importance of material wealth because it may be an important factor in deciding who can have a robot lover or a robot nanny or a smart home, and who cannot. Even if Levy's account is too simplistic, it is quite possible that the sort of technology under discussion in this chapter will cause a great deal of rethinking of the definition of love.

If the definition of love is undergoing, or about to undergo, yet another major change, why should we care? This is not purely an esoteric academic issue. The definition of love is central to our view of human relationships. Changes in the definition of love, caused by the widespread use of caring technology, are certainly possible. They may even represent an improvement in human happiness. What they are not is something that can be ignored or avoided. We might feel the need for caution about the introduction of technology that brings about such changes.

What is essential is that these decisions should be more widely debated. If there is the possibility of such large social impacts as changes in the definition of, and even, the nature of basic human

AMSCE-IOI

relationships, then there should be informed public debate. It is not acceptable to leave such important decisions solely in the hands of unaccountable, and almost always anonymous, technologists and designers.

15.6 Robot Carers

The notion of a robot spouse may seem too far-fetched to deserve serious discussion by contemporary technologists. The notion of love with robots may also be seen as not of great interest to the designers of present technology. However, this is most certainly not true of the notion of care. Robots, or more accurately, a wide variety of automated systems, are already entering into the field of personal and intimate care. In this case, less seems to hang on the philosophical question of whether or not a caring technology *really* takes care of someone. It is sufficient to say that it performs a wide variety of tasks that would previously have been performed by a human acting in the role of carer. There are technological developments taking place now that fall under this heading.

Among such technological developments are so-called smart homes. These take the form of a fully automated apartment. Among the technologies used are CCTV (closed-circuit television), motion detectors, heat sensors, intelligent refrigerators that monitor their contents, and an AI system that monitors the activities of the occupant. Such technology is designed to at least partly fulfill the role of a human carer or a team of human care assistants. It is a technology that will be in large-scale use within the next few years.

Another technology, which is close to market, is that of so-called robot nannies. These are mobile robots intended to entertain and monitor infants. The potential dangers of the misuse of robot nannies have been extensively discussed elsewhere (Sharkey and Sharkey 2010; Whitby

AMSCE-101

2010), so only general remarks will be made here. What is important about both smart homes and robot nannies is that they are technologies that exemplify the problems discussed earlier, and are not remote or science-fiction possibilities. In the case of these technologies, the need for ethical codes that give guidance is immediate, if not already overdue.

It might seem, at first glance, that technologies such as robots and other intelligent systems, which have more human-like interactions with users, should generally be welcomed. Indeed, most researchers in the relevant areas unquestioningly assume that achieving a greater number of interactions and making them more human-like are desirable research goals. Similarly, the development of domestic robots and other caring technologies to care for the elderly and the very young seems, at first glance, a thoroughly laudable goal. However, as we have seen, there are a number of important ethical issues involved in such developments that require careful consideration.

There is clear scientific evidence that humans adapt to technology to a far greater extent than technology can adapt to humans. The way that this can happen with even very crude AI technology was demonstrated by Weizenbaum's ELIZA (1984, 188–189). Although this famous early AI program only gave the appearance of a conversation by outputting phrases in response to key words in the user input, it was on occasion taken seriously as a conversational partner. This response was unexpected by Weizenbaum, and caused him great concern.

More specific studies have indicated that this process of adaptation will be especially noticeable in cases where AI technology and robots are used in everyday and intimate settings, such as the care of children and the elderly. For example, Fogg and Tseng (1999, 80–87) claim that empirical studies have shown that humans give more credibility to computer products after they have failed to solve a problem for themselves or in situations where the human has a strong need for information. This is particularly likely to emerge in applications where

AMSCE-1101

robots are employed in intimate and caring roles. Smart homes and robot nannies are prime examples of such applications.

When technology is placed in an intimate setting—for example, caring for a human in a smart home—it is also likely that the tendency of humans to see their interactions with machines in anthropomorphic terms will be increased, as demonstrated by the extensive studies of Reeves and Nass (Reeves and Nass 1996). Because of this, the interaction designs of such systems need to be handled in an ethically sensitive manner.

Interaction designers have mixed feelings about anthropomorphism. Some view it as facilitating good interaction but, crucially for present purposes, others take the view that it is ethically dubious. For example, Ben Schneiderman describes the human portrayal of a computer as "morally offensive to me" (qtd. in Don et al. 1992, 69). It is not easy to rule on this debate. To assume that it is always beneficial to exploit human emotional and social instincts in designing interfaces is simplistic, but so is assuming that it is never beneficial. From what has been said earlier, it should be clear that it is not an issue that can be left solely in the hands of designers, however sensitive their methods. It is an ethical issue that needs to be resolved now.

A further set of ethical issues stems from the tendency of designers to unthinkingly force their view of what constitutes an appropriate interaction onto users. In the field of information technology (IT) in general there have been many problems caused by this tendency. Some writers (e.g., Norman 1999) argue that there is a systematic problem. Even if we do not grant the full force of Norman's arguments, there would seem to be cause for ethical worries about human–robot interactions in such intimate contexts. Largely unaccountable technical experts may well force their views (both explicit and implicit) of what is appropriate and inappropriate on vulnerable users via this technology. In other fields, such as law and politics, we might reasonably expect

AMSCE-101

decisions with such impacts to be taken in a fully informed and accountable manner including open public debate.

This is despite clear warnings having been offered (e.g, in Picard 1998 and Whitby 1988) that there are potential hazards to be avoided. The principles of user-centered design–more usually cited than actually followed in current software development—are generally based on the notion of creating tools for the user. In the case of the technologies under discussion here, by contrast, the goal is the creation of companions, or carers, for the user. This requires comparatively far more attention to the ethical dimensions of the interaction. What is needed is both technically and ethically informed debate on these issues with the ultimate goal of being able to provide a code of conduct for designers. It is important to consider these ethical issues with an appropriate urgency.

15.7 Conclusion

This chapter has a question as a title. The fact that it has raised more questions than answers should not be too surprising, therefore. The exact codes of ethics appropriate for this area have yet to be fully formed. It would be easy to create some sort of moral panic about robot lovers and automated caring technologies. The problems outlined in this chapter might make some people feel that total prohibition is a valid approach. This would be a serious mistake. Building caring systems of all sorts has great potential benefits. Prohibition would, on balance, be morally wrong. What is morally right is building and employing such systems in an ethical manner.

Similarly, work aimed at improving human–robot interaction in intimate contexts should not be outlawed or heavily restricted. However, despite the tremendous usefulness of this sort of technology, failure to address the various ethical issues entailed would bring serious dangers.

AMSCE-1101

Among these are the unintended consequences of limiting human freedom and dignity. This will be particularly the case with respect to vulnerable users—for example, very young infants cared for by robot nannies and old people with declining cognitive capacities cared for by a smart home.

To build and use such technology, in an ethical manner, requires a deliberate attempt to avoid forcing on to vulnerable users the designers' views and prejudices as to what is appropriate behavior. When building caring systems for especially vulnerable humans, sensitivity to their dignity and, in most cases, their autonomy is essential. The code of good practice of BCS, The Chartered Institute for IT, and the code of ethics of the Association for Computing Machinery do not provide specific guidance on the issues discussed in this chapter. This is not a criticism of these codes since they were designed for an era in which the typical user of computer technology was a businessman. Caring technologies move the goal posts of such codes.

It would be possible to rework these professional codes to cover many of the problems raised in this chapter. Among other things, the revised codes would need to safeguard human dignity—something the IT industry has not had to worry about much until now.

Should we let you have a robot lover? This is probably a question that will divide public opinion. Some people will defend Mill's liberal thesis that it is an entirely private matter. Others may see the very possibility as unforgivably perverse or as blasphemous. The debate should be started now.

We need to avoid a headlong rush into adopting technology driven only by uncaring commercial imperatives. It is worth remarking that there is a good deal less profit in persuading people to care personally for their elderly relatives than there is in selling smart homes. In blunt terms: if everybody chose a human lover, the market for robot lovers would be very small. The market for robot lovers and other caring

AMSCE-101

technologies is maximized in the situation where nobody chooses human companionship.

We need professional codes, guidelines, and possibly, eventually, legislation to direct this technology in an ethical direction. We need designers and technologists who have appropriate ethical values and conduct their work in an ethical manner. But, above all, we need informed public discussion. To wait until these technologies are in widespread general use would be a serious mistake.

Notes

[1]. This is a slight misquotation of the opening sentence of *Pride and Prejudice* by Jane Austen, first published in 1813 (Austen [1813] 2006). Just as Austen sought to poke fun at the cultural assumptions of her time, so today it remains necessary to challenge the contemporary cultural assumptions behind the desirability of robots in caring and companionship roles.

[2]. Paul VI (1968, par. 13).

[3]. The Block IV Phase II Tomahawk Land Attack Missile produced by Raytheon has enhanced capabilities, including being able to locate and pursue a moving target.

[4]. The robots in Capek’s play are more like what we would now call androids or clones in the sense that they are biological, rather than mechanical.

[5]. The accounts of love given in Plato’s *Symposium* cover a wide range. For the present discussion we should note that many accounts regard homosexual love as a higher form of love than heterosexual love and at least one, that of Pausanias, sees no possibility of reciprocity in love between a man and a woman—presumably because women are held to be incapable of rationality (Plato [385–380 BCE] 1999, 13–17).

AMSCE-1101

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AMSCE-1101

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AMSCE-1101

VI

Medicine and Care

While the robots of part V provide intimate relationships, we will now look at robots that today provide more serious interaction: companionship and medical care, such as to the elderly, persons with disabilities, and children. Indeed, this is a major potential application for robotics and is receiving extensive attention and funding internationally, particularly in South Korea, Japan, and several European countries, although there is less funding for such projects in the United States.

Clearly, robots can provide round-the-clock care and increased safety. However, there are a number of risks and ethical issues associated with such applications for robots, and several of these are discussed in part VI. Two of the following chapters are concerned with robot caregivers that either exist now or can be expected to become available within the next decade. The third chapter looks at the ethical implications of human–robot relationships by imagining the existence of machines that can create "artificial people," either from organic or inorganic elements.

In chapter 16 Jason Borenstein and Yvette Pearson examine ethical issues associated with using robot caregivers. They suggest that continued interaction with robots is likely to change both human-to-human behavior as well as human–robot interactions. The authors also consider the ethical implications of situations in which the recipients of care might prefer their robot caregivers to human ones. These behavioral and psychological changes might be influenced by such factors as the

AMSCE-1101

robot's appearance, its degree of autonomy, and its ability to express emotions.

Noel Sharkey and Amanda Sharkey discuss issues of privacy, safety, and personal liberty associated with robot caregivers of the very young and the elderly. They ask in chapter 17 whether invasion of privacy should extend to robots as well as to human caregivers. Other questions they raise include limits on permitted robot behavior to ensure the safety of the people cared for and the reduced human contact experienced by children who are left with only robotic supervision.

Steve Petersen discusses in chapter 18 the ethical issues in a more speculative way, in contrast to the two preceding chapters. Distinguishing between "humans" and "people," he postulates that a "Person-o-Matic" machine, as he calls it, could be programmed to produce artificial people (or APs), but not humans. The APs could be manufactured from metal, plastic, electronics, and so on, or they could be synthesized from artificial DNA. He then discusses provocative ethical issues about the possible servitude of APs, as well as the possibility of programming them so that their major goal is to make humans happy. This chapter segues into part VII, which focuses on robot rights.

16

Robot Caregivers: Ethical Issues across the Human Lifespan

Jason Borenstein and Yvette Pearson

AMSCE-1101

One of the distinct challenges associated with designing robots is which, if any, ethical theory should be incorporated into their programming. Yet instead of focusing on how to integrate a particular ethical theory into robots, another strategy for developing an ethically sound technology is to focus on whether a technological intervention is likely to advance or hinder human flourishing. In making design decisions, scientists and engineers should consider not only the technical dimensions and potential uses of the technology, but also the ethical implications of introducing a novel use of technology into a specific context.

In this case, the primary concern is about how the existence of robots may positively or negatively affect the lives of care recipients. Because incorporating robots into our lives may be motivated by the drive for efficiency in terms of time and resources, it is imperative to make a concerted effort to focus on the promotion and maintenance of central human capabilities as a primary goal of robot caregiver intervention. If the use of robot caregivers is also efficient and convenient for professional and "informal" human caregivers, those are acceptable side effects, but having them as the sole or main impetus for using robot caregivers is likely to produce undesirable ethical and social outcomes. Drawing from the capabilities approach, this chapter examines key ethical considerations that may help to determine whether the use of robotic caregivers is consistent with the promotion of human flourishing at different life stages.

Though care provided across the lifespan may have some common features, for example, the ability to monitor care recipients, what constitutes even basic care will vary from one life stage to the next. For example, the fact that infants and toddlers are just beginning their cognitive, physical, and social development means that caregivers should ensure that their actions do not interfere with or delay this development. This requires, among other things, that caregivers facilitate a child's ability to play, with play understood as pleasurable

AMSCE-101

activity that allows for the “intermingling of emotional, intellectual, social, and physical development” (Lane and Mistrett 2008, 413). Although adults should have opportunities to engage in play as well, the purpose served by them engaging in play is not the same as it is with young children. Assuming an adult has already developed certain skills, including ways of communicating with caregivers and interfacing with his or her surrounding environment, fostering the actualization of these capacities is not as pertinent. Instead, robot caregivers should be designed to respond to care recipients’ attempts to communicate their needs and to detect whether certain interventions, for example, a reminder to take medication, are necessary. In short, some types of functions are going to be more relevant than others depending on the care recipient’s life stage and abilities.

In order to develop and deploy the technology ethically, it is necessary to consider the various facets of life that may be altered by the intervention of robot caregivers. This chapter will explore the likely effects of robot caregiver intervention on human–human interaction as well as the ethics of human–robot interaction (HRI). Included is an evaluation of the concern that the intervention of robot caregivers will lead to a reduction in human contact or increase isolation for members of society that tend to be marginalized as a result of their impairments. Another issue that will be examined is how care recipients might react to robot caregivers, including the possibility that a preference might arise for them over their human counterparts.

Whether robot caregivers will function as “extensions of us”[1] or outright replacements—for example, because care recipients grow to trust robot caregivers more than fellow humans—presents multiple concerns about expectations. In addition to the potential impact on relationships among humans, there are ethical issues related to the effects of robots on care recipients and caregivers alike. While it is already clear that HRI can lead to some degree of emotional attachment on the part of humans toward robots (Singer 2009, 337–338), determining whether such one-way bonding presents a unique problem requires further evaluation. Emotional attachments emerging from HRI can, for example, raise questions about the role of deception as well as the potential for overdependence on robot caregivers.

16.1 Design Strategies

In order to be effective caregivers and for the technology to operate in an ethically responsible manner, numerous design issues must be addressed. Among them is how much autonomy should be granted to a robot. According to Breazeal, "The amount of robot autonomy varies (and hence the cognitive load placed on the human operator) from complete teleoperation, to a highly self-sufficient system that need only be supervised at the task level" (2003, 1). Rather than alluding to an abstract, philosophical notion of autonomy, what the robotics community typically is referring to is whether a human being would significantly be "in the loop" while the robot operates. For example, creating a fully autonomous robot may be difficult because of the technical complexities involved with having it navigate through environments that contain so many variables (Kemp, Edsinger, and Torres-Jara 2007). The extent to which a human is kept "in the loop" should be guided by whether this design pathway promotes or hinders the ability of a robot and human caregivers to meet the needs of their proxies while also preserving the health and well-being of human caregivers. Though ensuring the needs of those who cannot adequately care for themselves is essential, it is also important to help human caregivers avoid becoming significantly impaired as a consequence of providing care to others.

A second issue is the robot's appearance. Riek and colleagues suggest that humans are more likely to bond with a robot if it has a high degree of "human-likeness" (Riek et al. 2009). That said, exploring the relevant

AMSCE-101

sense of "human-likeness" is important. The evaluations are mixed regarding whether it is preferable for a caregiver robot to be more human-like in appearance. On the one hand, the "Uncanny Valley" hypothesis proposes that there is a certain threshold beyond which the human-like appearance of a robot repels rather than attracts human beings (Mori 1970). On the other hand, the presence of a "human-like" robot could alter the emotions or behavior of human beings. For example, Woods and colleagues note that children's attitudes toward robots vary depending on the robot's physical features and suggest that children are much more likely to attribute emotions to a robot if it looks "human-like" (Woods, Dautenhahn, and Schulz 2004). In order to elicit preferred responses from human beings, the researchers claim that "it is important for robot designers to consider a *combination* of physical characteristics, rather than focusing specifically on certain features in isolation" (51).

Yet, as we have learned from philosophical debates about the necessary and sufficient conditions for personhood, mere physical appearance may not be the most crucial factor when determining whether a being is human-like in some relevant sense. Instead, a robot's movements, possibly conveying that it has a "personality," may be more relevant than physical resemblance to a human being. Hence, even if designers adequately control the appearance of the robot so that a balance is struck between repelling human beings and manipulating them, designers may have less control over the emergence of certain "quirks" that are interpreted by humans as indicative of robots possessing traits characteristic of persons.

A related design issue is whether, and to what extent, robot caregivers should be equipped to respond to, express, or elicit emotions. Because developments in AI are not yet advanced enough to seriously posit the creation, at least in the near future, of robots that are capable of genuinely experiencing emotion (assuming that such an accomplishment is even possible), the focus of this discussion will be limited to robots

AMSCE - 1101

that can respond to human emotions without experiencing real emotions themselves. Robots could be designed to function so that they respond to human behaviors, including human emotions, in a way that does not lead to confusion about whether the robot understands or empathizes with a person in a complex fashion. In fact, the challenge at this stage is making robots seem convincing. That said, there could be circumstances in which a robot seems to approximate human emotion—e.g., robots able to make certain facial expressions or physical gestures that convey human-like emotions. For example, roboticist Hiroshi Ishiguro recently demonstrated that subtle changes in a robot's functioning can alter whether we view it as more or less like ourselves (Barras 2009). Because experiencing certain types of emotions (e.g., joy) may produce health benefits and others (e.g., fear, stress) may contribute to poor health, it is desirable for robots to elicit positive emotions and, as much as possible, avoid producing negative ones, such as the unease associated with the Uncanny Valley experience.

Though developments in artificial intelligence (AI) will facilitate the creation of more sophisticated robots,[2] in the near term a robot's "personality" will be primarily a byproduct of a person's anthropomorphization of the robot's appearance and actions. This may well be an advantage in that it would allow a person to impose or project character traits onto the robot. For example, Krach and colleagues conducted an experiment in which human participants played an electronic game with different partners, including a robot that had a human-like appearance. According to the researchers, "Participants indicated having experienced linearly increasing fun in the interaction the more the respective partner exhibited human-like features. . . . Similarly, game partners were attributed increasing intelligence the more they appeared human-like" (Krach et al. 2008, 5). While concerns about deception—particularly self-deception—in the context of HRI persist, the projection of traits onto a robot may be more comforting in some

AMSCE-1101

cases than designing a robot to exhibit personality traits that the care recipient may dislike.

16.2 Care and the Capabilities Approach

A tool that could be included in the toolbox of scientists, engineers, and others while designing robotic caregivers is the capabilities approach. The capabilities approach is not a complete ethical framework, and its advocates, including Amartya Sen (1993) and Martha Nussbaum (2006, 139) probably do not intend it to be. Because the capabilities approach is "consistent and combinable with several different substantive theories" (Sen 1993, 48), it provides designers with an expanded framework within which to develop robot caregivers so that their use can be geared toward the promotion and preservation of human flourishing.

Certain technological interventions expand people's opportunities by improving their ability to interface with their environment and helping them build or maintain relationships with others. The resultant ability to engage in a broader array of activities than would have been available without the technological intervention can advance human flourishing. Oosterlaken's phrase "technology as capability expansion" recognizes the crucial role that engineering and other intellectual endeavors have in generating new opportunities for human beings (2009, 94–95). According to Oosterlaken, "If technologies are value-laden and design features are relevant, we should . . . design these technologies in such a way that they incorporate our moral values" (95). Scholars offer numerous visions of the types of capabilities that may be universal to all human beings. Among them is Nussbaum's list of "central human capabilities," which includes bodily integrity, health, and control over one's environment, as essential capabilities for human flourishing (2000, 70–77).

In order to determine whether robots will help to promote human flourishing, a necessary step is to clarify what "care" might entail in this context. For example, Faucounau and colleagues describe five main categories of care that a robot might provide: "Cognitive prosthesis," "Safeguarding," "Social interaction," "Support with regard to symptoms of cognitive impairments," and "Emergency assistance" (Faucounau et al. 2009, 35). Assessing whether robots can effectively fulfill any of these roles is, in part, a technical issue (i.e., whether advances in artificial intelligence and other related fields will move forward sufficiently enough). But perhaps, more importantly, it is a product of whether human wants and needs are adequately met and flourishing actually occurs.

Coeckelbergh delves into this realm by articulating the differences among "shallow," "deep," and "good" care (2010, 182–186). He characterizes "deep" care as rooted in reciprocity of feelings between the caregiver and care recipient and distinguishes this from both "shallow" care and "good" care. For Coeckelbergh, "shallow" care refers to routine care that lacks the "emotional, intimate, and personal engagement" (183), while "good" care is characterized as "care that respects human dignity" (185). As Coeckelbergh acknowledges, the current state of AI is such that robots are probably unable to provide "deep" care; however, this need not preclude robot intervention from facilitating a human caregiver's ability to provide "deep" care or from contributing to "good" care. Given the conclusions of recent explorations of HRI (e.g., Neven 2010), it seems that at least some of the social and emotional needs of care recipients can be met, even if the robots themselves remain incapable of experiencing emotions. Assuming that it is not inherently undignified to be cared for by a robot, the absence of "deep" care does not entail the absence of "good" care.

16.3 Developmental Issues

AMSCE-101

The needs of care recipients are not necessarily the same for each person or at each life stage. As Nussbaum states, “care is not a single thing” (2006, 168). Care is a complex set of activities that promote human capabilities in different ways. For instance, caring for the elderly can present challenges distinct from those associated with caring for young children. Along these lines, Nussbaum describes elderly persons with mental, physical, or social impairments, similar to those present in some children and young adults, but asserts that the former group can be much more difficult to care for because they tend to be “more angry, defensive, and embittered” (101). Moreover, owing to disparities in the type and magnitude of impairments even within a particular category, the care requirements for these individuals will not be the same.

Examining the complexities associated with providing care at each life stage is crucial because, for example, allowing robots to care for children raises ethical issues that may not emerge if the context is limited to elder care. If a major portion of a child’s care is delegated to a robot, will the child learn to play normally? Speaking more generally, Nussbaum emphasizes the significance of play as a central human capability (2006, 400). If a child’s environment is not conducive to the actualization of that capability, then the child might fail to flourish. This issue is not entirely new as evidenced by ongoing concerns about the effects of mediated interaction (e.g., spending time online instead of engaging directly with peers) on a child’s social development. Simply stated, it is unclear whether the mediated interaction facilitates or inhibits healthy socialization.

Narvaez points out the significance of nurturing in a child’s life and how it can facilitate moral development (2008). The potential use of robot caregivers raises age-old, fundamental questions about the kind of caring environment needed to enhance a child’s moral development. In important respects, a child’s caregiver needs to be nurturer and educator, which implies that “care” is not exactly the same for the young and for the elderly. Theoretically, the development of social intelligence and

AMSCL-101

skills might be stunted if the child has limited contact with other humans, but this can depend on the precise nature of the HRI. HRI has the potential to enhance these abilities or, perhaps, to foster the development of unique ways of interacting with humans or robots. Though further evidence is needed, researchers are starting, for example, to accumulate data indicating that robots can help autistic children (Scassellati 2007; Robins et al. 2005). But at least for the foreseeable future, it is crucial to emphasize that no matter what benefits the technology is perceived to have, a robot should be viewed as a complement to human caregivers, and not as a replacement for them.

16.4 How Humans Might Change

> What's weird is how biological entities change their behavior when in the company of robots. When robots start interacting with us, we'll probably show as much resistance to their influence as we have to iPods, cell phones, and TV.
>
> —Shaw-Garlock (2009, 253)

Keeping in mind the value of human flourishing, it is vital to examine which kinds of character traits will potentially emerge or disappear given our growing interaction with robots. Whether the integration of robots into our lives will result in changes that differ significantly from those brought about by other technology remains unknown. For instance, it is difficult to predict whether increased HRI will result in fundamental changes in human behavior or their interactions with one another, or whether the changes will be of a more superficial nature. In any case, a primary goal is to ensure that those changes contribute positively to human welfare rather than precipitating the loss of highly valued human characteristics and skills. Some scholars think serious problems are likely to arise, while others believe the fear is overstated (Lin, Bekey, and Abney 2008, 83). In the context of military robots, Singer (2009) points out that the use of robots and other unmanned

AMSCE-1101

vehicles is changing how we wage war, including that pilots are disappearing. Further, General James Mattis expressed some unease with the extent of robot involvement, specifically a “robot-only presence,” since it may compromise a core characteristic of warriors—honor (Brown 2010). On the civilian side of things, robots are becoming a more tangible part of our lives and a broad range of effects may be forthcoming. Though it may be a somewhat trivial phenomenon, participants in a study of the Roomba, a robotic vacuum, believed that they had become “cleaner” or “neater” after owning the device (Sung et al. 2007, 150). Briefly put, the traits that technology elicits are not always straightforward or anticipated, but it is important to identify and analyze probable transformations so that undesirable consequences can be averted.

Considering that their use is not yet widespread, speculation abounds regarding how “the humans” might change as robot caregivers become more common. In some sense, a robot that is viewed as being “kind” to people could bring out laudable traits in us similar to the way pets can. For example, Turkle (2006) describes how humans seem to have a drive to nurture computerized objects, even some relatively simple ones created in the 1980s. Yet which character traits will be promoted or hindered by the incorporation of robots in care settings is largely an open question. Will care recipients express less anger, frustration, hostility, and so forth, because robot caregivers make them feel less dependent and isolated? Or is the opposite more likely to be true because they feel abandoned by friends and family? Further, as mentioned previously, will a young child be ill equipped for human social interaction if his or her primary caregiver is a robot?

Moreover, will adding a robot to the mix significantly alter the dynamics of the relationship between caregivers and care recipients? A relationship with a care recipient can evoke a multitude of attitudes and behaviors. At times, deplorable traits can emerge. In fact, individuals suffering from debilitating illnesses such as dementia are sometimes

AMSCL-101

mistreated by family members (Cooper et al. 2009). Conceivably, traits such as kindness and patience will emerge more frequently if human caregivers are given more of a choice about whether to provide care and under what conditions. Caregivers might experience some relief if an automated assistant is there to help, especially if it can be trusted to be more reliable and consistent than another human.[3] A key dimension underlying these issues is the function(s) robot caregivers are expected to fulfill. For example, if a robot is supposed to be a friend or companion to a human being, which Shaw-Garlock calls an "affective" robot (2009, 250), then one might assume a broad range of behavioral changes would follow. Instead, if a robot is merely to be used in a similar manner to a tool or instrument, which Shaw-Garlock calls a "utilitarian" robot (250), will the same types of changes occur? Intuitively, we might be tempted to say that there would be sharp differences between our responses to each kind of robot. Yet, humans have a profound ability to bond with "utilitarian" items such as cars, motorcycles, and boats. Along these lines, Shaw-Garlock found the tendency to anthropomorphize objects, including by the people who design them, to be consistent with Nass and colleagues' (Nass et al. 1997) finding that "individuals engage in social behavior toward technologies even when such behavior is entirely inconsistent with their beliefs about the machines" (Shaw-Garlock 2009, 254).

16.5 Human Psychology and Automation

A society's norms and values, and how they influence perceptions of robots, can play a key role in determining to what degree the technology is used. For instance, Sofge (2010) discusses a common theme in American science fiction: the creation of robots leads to a dystopian future. However, MacDorman, Vasudevan, and Ho note that robots are often portrayed as being heroic in Japanese comics and movies (2009, 489–491). Yet popular depictions of robots should not be taken as

AMSCE-101

accurate predictors of the respective level of acceptance robots will achieve. Considering that Americans tend to be technophiles, it is debatable whether our collective consciousness contains a deep-seated fear of robots. Moreover, when looking at Americans' tendency to establish emotional attachments to things like Roomba and the Packbot "Scooby Doo," a gap seems present between attitudes depicted in hypothetical scenarios—for example, in Hollywood films—and actual experiences with robots.

Marketing practices can also influence the public's level of willingness to accept robots with assistive abilities into their homes. For example, in a study by Neven, most of the participants in the laboratory and field tests using the robot iRo thought that it would be good for individuals who were "housebound, old, lonely, feeble, and in need of care and attention," but they were reluctant to equate themselves with such persons (2010, 341). While the participants found iRo entertaining, had attachments to it, and acknowledged that it would be very helpful for others, the image associated with the target market for the robot led most of the participants to say that iRo "was not a robot for them" (Neven 2010). Yet in some ways, the participants' responses were inconsistent with the reported experience documented in Neven's study, insofar as the participants admitted talking to and developing an emotional attachment with iRo (2010, 340).

The manner in which automation can affect human psychology is difficult to predict. A troubling potential impact of these complex interactions is becoming overconfident in an automated system's ability, a problem that has already occurred to some degree with the APACHE system, a computerized diagnostic tool for hospitals (Wallach and Allen 2009, 40–41) and GPS (Sorrell 2008). Analogously, will caregivers place too much trust in robots if, for example, their child or elderly parent seems to be in good hands?

Since overconfidence in robots is likely to be a significant problem, adequate safeguards in their design must be put in place to prevent them

AMSCE-101

from harming humans. At a minimum, it is important to be cognizant of a relevant difference between robots and other electronic devices, which is the third step in the “sense–think–act paradigm” (Singer 2009, 67). Tools like APACHE and GPS still require that a human undertake the last step, and this is at least one part of the process where interpretation by a human user remains. But a robot can be programmed to act without significant input from the user. Whether this is a better or worse design pathway is debatable; in some cases, it might be, and in others, it might not. Consider, for example, that computers are less likely to make certain types of mathematical errors than humans. In this circumstance, our silicone-based counterparts are more reliable than we are. That said, one should not dismiss the fact that output is contingent on input decisions and design decisions about which information is relevant and how that information should be processed. In theory, a well-designed robot could conceivably cause fewer problems for humans than a system that requires frequent user input.

Without antecedently encouraging people to place too much trust in robots, it is prudent to anticipate that in practice humans are likely to do so anyway. Consequently, this places a heavy burden on designers to predict the dynamics of sociotechnical contexts within which a robot will be placed. It is preferable to err on the side of building in an extra “factor of safety” and designing robots well enough that overreliance on them will result in the least amount of harm possible. Humans cannot be trusted to act as they ideally should (e.g., acting sensibly instead of following a GPS’s directions and driving into a lake). To be safe, designers should make sure that robots “have our back” when we either act incorrectly or fail to act altogether. For instance, if a robot is taking care of a child and the child’s parents have not checked in after a certain amount of time, a reasonable design feature could include supplying the parents with multiple reminders or taking measures that help ensure the child’s safety, such as contacting a backup caregiver.

A related potential complication is that a robot designed for certain types of users (e.g., adults) or for use in certain contexts (e.g., nursing homes) might be utilized by an expanded user pool (e.g., children) or in an alternate context (e.g., at home) that may generate variable outcomes, some of which might be quite undesirable. For example, if a robot caregiver is designed for use by someone who has undergone a basic level of training, or for use in an environment that permits regular updates and maintenance, then expecting that robot caregiver to function outside of these parameters could lead to injury of its charge(s). The extent of damage, if any were to materialize, would partially hinge on how widespread "off-label" uses of caregiver robots become.

16.6 Relying on the Technological Fix to Remedy Social Problems

Weinberg goes on to claim that since our efforts to encourage behavioral change are often futile, we seek out a technological fix. For example, instead of counting on people to be disciplined and use less water, devices such as low-flow showers and toilets are installed. Similarly, technology might be relied on to remedy problems of neglect in care environments like nursing homes rather than hold out hope that an improvement in human behavior is on the horizon. Whether, how, and to what extent technological interventions are used is, at this stage, a function of human choices.

Conceivably, applying a technological fix to grapple with challenges related to caregiving could be problematic. The issues that robot caregiver intervention might address include: human caregivers' fatigue and stress that can lead to neglect or abuse of their charges; loneliness of marginalized individuals; and limitations on the ability of people with certain types of impairment to interact with others. Though robot caregivers have the potential to remedy these problems to some degree,

AMSCE-1101

their intervention could exacerbate rather than ameliorate some problems with caregiver-care recipient relationships. For example, according to Sparrow and Sparrow, “it is naïve to think that the development of robots to take over tasks currently performed by humans in caring roles would not lead to a reduction of human contact for those people being cared for” (2006, 152). Parents often rely on technology such as television programs and electronic game systems to serve as “caretakers” for their children. On the other hand, some parents use technology to communicate with their children more rather than less frequently, thereby increasing their involvement in their children’s daily lives. Yet just as a lack of involvement in the lives of relatives and friends is worrisome, excessive involvement may also be a problem, albeit of another sort. For example, it can impede the ability of children and young adults to become independent individuals.

Critics fear, perhaps justifiably, that caregivers might become less attuned to the specific needs of care recipients because a technological crutch is available. While robots may be able to ease some of the burden from the caregiver’s shoulders, a counterbalancing problem is that other life activities may increasingly fill up the caregiver’s “free” time. For example, the existence of the Internet, televisions, and game systems, in some sense, gives parents the leeway to direct their time and attention away from their children. According to the Kaiser Family Foundation (2010), American youths spend roughly 7.5 hours per day accessing entertainment media. While most cases are not so extreme, some parents have been so absorbed in playing electronic games themselves that they have been derelict in their responsibility to their children.[4] Along related lines, technology could be viewed as granting us tacit permission to live a greater distance away from impaired friends and relatives and to visit less frequently, and thus potentially withering our capacity for caregiving.

That said, it is also possible that the removal of some burdensome aspects of caregiving might lessen existing tendencies to detach oneself

AMSCE-1101

from those in need of care. The intervention of robot caregivers could improve family unity and other interpersonal relationships because they would not be tainted by our aversion to unpleasant tasks. Individuals will have the freedom to become more attuned to nonclinical, emotional, or social needs beyond the "basic necessities" that are often reduced to almost purely mechanical intervention by overtaxed human caregivers.

Whether we use technology to *mediate* human relationships or communication rather than replace human interaction is not a foregone conclusion; instead, just as parents can choose against using the television as an "electronic nanny," we can choose against using emerging technologies in ways that are likely to impede human flourishing. It should be kept in mind that the introduction of technology need not alter human interaction for the worse. As Johnstone astutely recognizes: "The functionings we can achieve with technology are thus not necessarily the same, either quantitatively or qualitatively, as the functionings we can achieve without technology. What a capability perspective insists upon, however, is that in either case what matters is the degree to which people's ability to determine and realize lives that they value is expanded" (2007, 79).

Virtual worlds, such as Second Life, and online social networking sites have expanded connections for those who may have become isolated due to severe restrictions on their mobility. While some problems at nursing homes are best remedied by increased human contact, other problems might not be. Moreover, meaningful human interaction need not involve physical contact or even physical presence of the individual. And this is nothing new, even for those who are now elderly. Many people undoubtedly communicate with dear friends and loved ones via letters sent through the postal service or a telephone. Though this sort of mediated interaction is different from physical contact with individuals, it can still be immensely valuable to the individual who receives the letter or the phone call. It is difficult to imagine that certain types of contact, such as turning a person over in

AMSCE-101

her bed or talking to her as you fill her water pitcher, would be perceived as more meaningful than a kind letter or phone call from a loved one. This is not to suggest that physical contact is unimportant; instead, the point is that critics of technological intervention might fail to see how it can expand people's means of communicating with loved ones in ways that maintain a distinctively human element. Granted, a visit to a care recipient's room in, say, an assisted living facility, to attend to the most basic needs, such as cleaning the space, delivering food or medication, and so on, may be significant to the individual deprived of additional contact with other people. Yet, a society that finds this acceptable should reevaluate its tolerance of this minimal level of human interaction for elderly or impaired persons rather than objecting to the intervention of robot caregivers, because their intervention could eliminate this unacceptably minimal interpersonal contact.

Whether a human being will still meaningfully be "in the loop" as robot caregivers emerge and become more pervasive is an overarching concern.[5] For instance, will a person still check on an elderly resident in a nursing home or monitor a robot's performance? Robots could work in conjunction with human caregivers (Decker 2008, 322). But Sparrow and Sparrow suspect that this practice will not continue over time (2006, 150). In different care contexts, such as nursing homes, assisted living facilities, and home health care, the details of a robot caregiver's use will vary.

As a general statement, it is probably unwise to allow a robot to act alone, even if their design continues to improve and gain increased sophistication. Entirely taking over or removing human participation is likely to be problematic, and in some contexts impossible. Yet, at a minimum, robots could manage interactions that caregivers might think are burdensome and recipients view as embarrassing or frustrating. Both parties could then be free of certain "uncomfortable" interactions, hopefully freeing them to interact "normally" with each other.

AMSCI-101

To reiterate, robots should not replace all types of human interaction; instead, the hope is that technological intervention would positively change human interaction in a way that expands opportunities for human flourishing. Along these lines, Tamura and colleagues maintain that the introduction of robots could “compensate for the shortage of caregivers and helpers” (Tamura et al. 2004, 85). Speaking more generally, Hayes (2009) contends that the increased use of machines does not necessarily amount to replacing humans; in fact, he argues that percentage of the population in the workforce has gone up even as automation has become more common. Of course, the broader effects of automation must be kept in mind since, for example, it typically enables employers to downsize and to replace certain classes of workers with others.

16.7 Conclusion

The aim of this chapter is to highlight key ethical considerations relating to the use of robotic caregivers at different life stages. Though the drive for efficiency is difficult to resist, it should not be the penultimate motive behind the creation and use of the technology. Instead, robot caregivers should function in ways consistent with the goal of human flourishing. Scientists, engineers, and others are now making choices about design pathways that will meaningfully influence the future of human caregivers and care recipients alike.

Notes

[1]. A phrase used in Gutkind 2006, 32.

[2]. Arguably, robots and other artificial entities are getting close to passing the Turing Test; see, for example, Barras 2009.

AMSCE-101

3. On a related note, the family of an elderly person might have reservations about leaving their relative with a human “stranger” because of trustworthiness concerns.

4. For example, a couple neglected to feed their baby because they were busy playing online games; see Graff 2010.

5. Scholars have raised a similar issue about whether keeping a person “in the loop” is necessary for military robots.

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AMSCE-1101

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AMSCE-101

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AMSCE-1101

17

The Rights and Wrongs of Robot Care

Noel Sharkey and Amanda Sharkey

The possibility of being cared for exclusively by robots is no longer science fiction. There has been a dramatic increase in the number of companies producing robots for the care or companionship, or both, of the elderly and children. A number of robot manufacturers in South Korea and Japan are racing to fulfill the dream of affordable robot “nannies.” These have video game playing, quizzes, speech recognition, face recognition, and limited conversation to capture the preschool child’s interest and attention. Their mobility and semi-autonomous functions, combined with facilities for visual and auditory monitoring by the carer, are designed to keep the child from harm. These are very tempting for busy, professional parents. Most of the robots are prohibitively expensive at present. But prices are falling and some cheap versions are already becoming available. Some parents are beginning to use the cheaper ones, such as the Hello Kitty robot (Sharkey and Sharkey 2010a).

There is an even greater drive for the development of robots to help care for the elderly. Japan is facing a problem of an aging population growing out of proportion with the young population. In March 2009, Motoki Korenaga, a Japanese ministry of trade and industry official, told *Agence France-Presse*, “Japan wants to become an advanced country in the area of addressing the aging society with the use of robots” (Agence

AMSCE-1101

France-Press 2009). Japan is already en route to deliver robot-assisted care, with examples such as the Secom “My Spoon” automatic feeding robot; the Sanyo electric bathtub robot that automatically washes and rinses; Mitsubishi’s Wakamaru robot for monitoring, delivering messages, and reminding about medicine, and Riken’s RI-MAN robot that can pick up and carry people, follow simple voice commands, and even answer them. The idea is to continue this trend by developing robots that can do many of the household chores for which a visiting helper is now required. Other countries may well follow suit. Europe and the United States are facing similar aging population problems over a slightly longer time scale.[1]

As with any rapidly emerging technology, likely risks and ethical problems need to be considered. The main area of concern addressed in this chapter is the application of robots in caring for the vulnerable. Many of the applications of robots targeted at children and the elderly could show great benefits. For the elderly, assistive care with robot technology has the potential to allow greater independence for those with dementia or other aging brain symptoms (Sharkey 2008; Sharkey and Sharkey 2010b). This could result in the elderly being able to stay out of institutional care for longer. For children, robots have been shown to be useful in applications for those with special needs (e.g., Dautenhahn 2003; Dautenhahn and Werry 2004; Liu et al. 2008). The engaging nature of robots makes them a great motivational tool for interesting children in science and engineering, or facilitating social interaction with the elderly.

We raise no objections to the use of robots for such purposes, nor with their use in experimental research or even as toys. Our concerns arise from the potential abuse of robots being developed for the care of the vulnerable. Our aim here is to throw up some of the ethical questions that need to be asked as robotics progresses sufficiently to allow near-exclusive care by robots. Our interest is in the potential infringement of the rights of the vulnerable, and so we have zoomed in on the extremes

AMSCE-1101

in the age range of care: the very young and the elderly. In taking a rights-based approach we are not subscribing to any general ethical theory. However, we do assume that society has a duty of care and a moral responsibility to do its best to ensure the emotional and psychological well-being of all of its citizens, regardless of their age. In looking at robots as carers, we take this duty as given and we examine the balance between it and a number of prima facie rights. We also consider how the resolution of conflicts between rights depends on the age of those cared for and their mental faculties. Elsewhere we have discussed a number of ethical issues, such as dignity and infantilization (Sharkey and Sharkey 2010b, c), the deception of the elderly (Sharkey and Sharkey 2010b), and the deception of children (Sharkey and Sharkey 2010a). Our focus in this chapter concerns the rights to privacy, personal liberty, and social contact.

17.1 Safety and the Right to Liberty and Privacy

An essential component of the duty of care is that a carer must keep their charges safe from physical harm. However, this rule is anything but simple. It does not give the carer the right to "any means" available. The rule must be traded off against the rights of the cared for, such as the right to personal liberty, the right to protection from psychological harm, and the right to privacy.

It is the health and age of the individual that determines the permissible means of safety. One robust way to keep anyone physically safe would be to put the person in a straitjacket in a padded room. Not only would this be inappropriate in most cases, it would be a violation of the rights to liberty and to protection from psychological cruelty. There are many different means for keeping people safe, and each different case will have its own path through the rights trade-offs.

AMSCE - HOI

For example, if an elderly person opened a drawer full of sharp kitchen knives, it would be inappropriate for the carer to suddenly spring upon them and restrain them. But if the person had been diagnosed as having severe suicidal tendencies, then such action may be deemed appropriate and even obligatory in the duty of care. With dementia sufferers who are well enough to live in their own homes, it could be inappropriate and irritating even to warn them of the danger (depending on their degree of dementia). With a young child, the appropriate action would be to remove any sharp objects from them and place them out of their reach.

Monitoring someone's activities twenty-four hours a day is another way to maintain safety. This could be done in person or with the use of security cameras. Obviously, violating the right to privacy in this way could be appropriate in some circumstances, such as those of intensive care. However, for those in partial or home care, it could be a severe intrusion on their privacy to monitor them taking a shower or using the bathroom, for example.

A Robot carer needs to understand which behavioral responses are appropriate in which contexts, as well as to be able to predict the intentions of their charges. In the remainder of this section, we examine how robots can be designed to maintain safety, and then move on to examine how this may affect the rights to privacy and liberty.

One of the primary functions of robot carers, like their human counterparts, would have to be to keep their charges safe. Robots could be used for health monitoring in a number of ways, such as taking temperatures, and monitoring respiration and pulse rate. In the high-tech retirement home run by Matsushita Electrics, robot teddy bears watch over elderly residents, monitoring their response time to spoken questions, and recording how long they take to perform certain tasks (Lytle 2002). These robots can alert staff to unexpected changes. This is an area that, once developed, could have a significant impact on elder care in the home or in care institutions. It would be easy to imagine this

AMSCE-IOI

technology being extended to a number of other health applications, such as caring for quarantined patients.

Outside of health, the main safety method for robot care at present is through the provision of mobile monitoring using cameras and microphones. The most advanced are the childcare robots with hidden cameras to transmit images of the child to a window on the parent/carer's computer or to their mobile phone. Some childcare robots can keep track of the location of children and alert adults if they move outside of a pre-set perimeter. The children wear a transmitter that the robot can detect. For example, PaPeRo (Yoshiro et al. 2005) works by having the child wear a PaPeSack containing an ultrasonic sensor. Similarly, the Japanese company Tmsuk makes a childcare robot that uses radio-frequency tags for autonomous monitoring. The carer can also remotely control the robot to find the child and call or speak to the child through built-in speakers. Similar systems could be used for monitoring elderly patients suffering from dementia.

Such systems are labor intensive and so semi-autonomous that safety monitoring will be required to make the robots more marketable for longer daily care. Some of these advances are already well under way. For example, there are robot systems for tracking people in a range of environments and lighting conditions without the use of sensor beacons (Lopes et al. 2009). This implies that the robot will be able to follow its charge outside and alert supervisors of the charge's location.

In the near future, we are likely to see the integration of robots with other home sensing and monitoring systems. There is considerable research on the development of smart homes for the care of elderly dementia sufferers. These can monitor a range of potentially dangerous activities, such as leaving on taps or gas cookers (Orpwood et al. 2008). Camera systems are being used to determine if an elderly person has fallen over (Toronto Rehabilitation Hospital 2008, 40–41). There is no talk yet about using smart sensing for childcare, but it could get onto the agenda without stretching the imagination by much.

Further extensions to care robots could provide additional home security by employing features from security robots. For example, the Seoul authorities conducted a pilot study in which a surveillance robot, OFRO, was used with an associated security system, KT Telecop, to watch out for potential pedophiles in school playgrounds (Metro 2007). OFRO can autonomously patrol areas on preprogrammed routes. It is equipped with a microphone as well as a camera system, so that teachers can see through its lenses. Essentially, it looks for persons over a certain height and alerts teachers if it spots one. Other techniques being developed for security robots, such as fingerprint and retinal recognition, could be useful for monitoring individuals, for example, visitors or an Alzheimer's sufferer, and helping prevent petty robberies.

17.1.1 Loss of Privacy

A key issue with respect to any kind of monitoring system is whether or not it violates an individual's right to privacy. There are clear overlaps between the concerns raised about privacy in the context of childcare robots, and concerns about privacy when robots are used to monitor the elderly. Although monitoring may be conducted with the welfare and safety of the individual in mind, this may not be sufficient in all cases to justify the intrusion.

The privacy of people in general should be respected as stated in Article 12 of the Universal Declaration of Human Rights: "No one shall be subjected to arbitrary interference with his privacy, family, home, or correspondence, nor to attacks upon his honor and reputation. Everyone has the right to the protection of the law against such interference or attacks." There seems little reason to make an exception for the old or for the young. The right to privacy is also addressed in Articles 16 and 40 of the UN Convention on Child Rights.

The use of a robot carer creates a tension between the use of monitoring to ensure safety and the privacy of the target of that monitoring. As Sharkey and Sharkey (2010a) discuss, parents' use of a

AMSCE- IIOT

baby alarm is acceptable. Similarly, parents frequently video record and photograph their young children. However, there is something different between an adult being present who is recording a child and an adult covertly recording a child who thinks that she is alone while confiding in her robot friend. With the massive memory hard drives available today, it would be possible to record an entire childhood. Who will be allowed access to the recordings? Will the child, in later life, have the right to destroy the records?

Similar questions need to be asked about the situation in which an elderly person is being monitored by a robot companion, or by a remote controlled robot. A person with Alzheimer's may soon forget that a robot is present and might perform acts or say things believing he is in the privacy of his own home, or thinking that he is alone with his robot friend. While the idea of recording and preserving the memories of one's elderly parent may seem attractive, it might not be something that he would consent to, if able. Would we want our children to know everything we said about them with the belief that we were talking confidentially? Again, the important question here is, who should have access to the recordings? If the elderly person does not give consent while still in a position to do so, it would seem that all recordings should be destroyed by default after use for immediate medical purposes.

One issue that affects the elderly more than children is that of respect for the privacy of their bodies. An operator could drive a robot to peer round an elder's apartment before they were dressed or when they are taking a bath. An autonomous robot could record in the same circumstances. The elder might prefer the robot to have to do the equivalent of knocking on the door and waiting to be invited in. Furthermore, the robot could provide a clear indication (e.g., a large flashing light) when any recording or monitoring was taking place. Of course, there are individuals who are too young or whose intellectual faculties are too impaired to be able to understand recording or

AMSCE-101

monitoring signals. Such individuals still have a right to privacy, but it needs to be exercised on their behalf by sensitive carers.

We have discussed how the privacy requirements of our two demographic groups differ, but we also need to take account of individuals’ developmental stage and mental facility. Robot care systems should be customized individually to ensure that any intrusions on privacy are justified on the basis of the greater well-being of those concerned. They should not be based on economic or efficiency grounds.

17.1.2 Loss of Liberty

Using a robot simply as a mobile monitoring system would still be quite labor intensive for care supervisors, although more than one target could be monitored at the same time. Commercial pressures will soon lead to the development of autonomous or semi-autonomous supervision by robots to support longer carer absence. A simple extension would be to allow home customization with maps of rooms so that the robot could recognize danger areas. As the field progresses, intelligent vision and sensor systems could be used to detect potentially dangerous activities, like a child climbing on furniture to jump or an elder heading toward basement stairs. The robot could make a first pass at warning its charge to stop engaging in a potentially dangerous activity. But would it be ethically legitimate to allow a robot to block or restrain a child or an elder from an activity that was on the robot’s danger list? This is very difficult ethical territory that relates directly to one’s fundamental right to autonomy.

It would be easy to construct scenarios where it would be hard to deny such robot action. For example, if a child or an elder was about to walk onto the road into heavy oncoming traffic and a robot could stop her, should it not do so? It would clearly be irresponsible for someone controlling a robot not to use it to prevent such a situation. But, what if the robot was operating autonomously? If it could predict a dangerous

AMSCE-1101

situation, would it not be legitimate to take action to stop it occurring, such as taking matches out of the hands of a child or an elder, getting between her and a danger area such as a gas stovetop, or even restraining (gently) to prevent her carrying out a dangerous action?

The problem here is in trusting the robot’s classification and sensing systems to determine what constitutes a dangerous activity. Imagine a child having doughnuts taken from him to prevent him from becoming obese, or imagine a senior having a bottle of alcohol taken from her to prevent her becoming intoxicated and falling. Restraining a child or an elder to avoid harm could be a slippery slope toward authoritarian robotics.

Robots are able to follow well-specified rules, but they are not good at understanding the surrounding social context and predicting likely intentions (Castellano and Peters 2010). Although a robot can be programmed with rules about the dangerous situations that programmers anticipate, it is never going to be possible to anticipate enough of them. Humans, on the other hand, are very skilled at such understanding and prediction from as young as twelve months (Woodward and Sommerville 2000). A human carer is likely to be able to predict the intention behind a child building the pile of blocks to reach an otherwise inaccessible window handle in a way that the robot is not.

There are many discussions to be had over the extremes of robot interventions and where to draw the line. There are some differences in the issues raised in caring for children and for the elderly. It is sometimes necessary to constrain the action of an infant to prevent harm. However, children need to be free to explore and satisfy their curiosity for normal healthy development. This requires a balancing act between their safety and their freedom of which robots are incapable. The problem for the elderly is that if a robot restrains their actions or prevents their movements to certain places, it could be equivalent to imprisonment in the home without trial. There are already circumstances in which carers can restrict the liberty of individuals in order to protect

AMSCE-1101

them. However, there are legal procedures available for making such decisions. We must ensure that we do not let the use of technology covertly erode the right to liberty without due process.

17.2 Human Contact and Socialization

It is the natural right of all individuals to have contact with other humans and socialize freely. If robots begin to be trusted to monitor and supervise vulnerable members of society, and to perform tasks such as feeding, bathing, and toileting, a probable consequence is that some young and old humans could be left in the near-exclusive company of robots.

In discussing the effect of new therapies for people with aging brains, Boas (1998) points out, “What stimulates them, gives a lift to their spirits, is the human interaction, the companionship of fellow human beings.” And having a good social network helps to protect against declining cognitive functions and incidence of dementia (Crooks, Lubben, and Petitti 2008; Bennett et al. 2006). For children, very serious defects both in brain development and psychological development can occur if they are deprived of human care and attention (Sharkey and Sharkey 2010a). The effects, and risks, of reduced human contact are likely to be quite different for the elderly and for infants. Infants need nurturing and parenting to enable their normal development, while the elderly require companionship to avoid loneliness and to maintain their mental health for longer. We will deal with each of these populations separately.

17.2.1 First Contact with the Robots: Infants in Care

The impairments caused by extreme lack of human contact with infants are well known and documented. Nelson and colleagues (Nelson et al. 2007) compared the cognitive development of young children reared in

AMSCE-101

Romanian institutions to those moved to foster care with families. Children reared in institutions manifested greatly diminished intellectual performance (borderline mental retardation) compared to children reared in their original families. Chugani and colleagues (Chugani et al. 2001) found that Romanian orphans, who had experienced virtually no mothering, differed from children of comparable ages in their brain development—and had less active orbitofrontal cortex, hippocampus, amygdala, and temporal areas.

Perhaps little or no harm would result from a child being left in the care of a robot for very short periods. But what would happen if those periods of time became increasingly frequent and longer? The outcome would clearly depend on the age of the child in question. It is well known that infants under the age of two need a person with whom they can form an attachment if they are to develop well. In an earlier paper (Sharkey and Sharkey 2010a), we considered whether an infant might be able to form an attachment to a robot caregiver, perhaps in the same way that Harry Harlow's monkeys became attached to a static cloth surrogate mother.

What research there is suggests that very young children can form bonds with robots. Tanaka, Cicourel, and Movellan (2007) placed a "state-of-the-art" social robot (QRIO, made by Sony), in a daycare center for five months. They found that the toddlers (aged between ten and twenty-four months) bonded and formed attachments to the QRIO robot in a way that was significantly greater than their bonding with a teddy bear. They touched the robot more than they hugged or touched a static toy robot, or a teddy bear. The researchers concluded, "Long-term bonding and socialization occurred between toddlers and the social robot."

Turkle and colleagues (Turkle et al. 2006a) report a number of individual case studies that attest to children's willingness to become attached to robots. For example, ten-year-old Melanie describes her

AMSCE-101

relationship with the robotic doll "My Real Baby" that she took home for several weeks:

> Researcher: Do you think the doll is different now than when you first started playing with it?
>
> Melanie: Yeah. I think we really got to know each other a whole lot better. Our relationship, it grows bigger. Maybe when I first started playing with her, she didn't really know me so she wasn't making as much [sic] of these noises, but now that she's played with me a lot more, she really knows me and is a lot more outgoing. (Turkle et al. 2006a, 352)

In another paper, Turkle and colleagues (Turkle et al. 2006b) chart the first encounters of sixty children between the ages of five and thirteen with the MIT robots Cog and Kismet. The children anthropomorphized the robots, made up "back stories" about their behavior, and developed "a range of novel strategies for seeing the robots not only as 'sort of alive' but as capable of being friends and companions." Their view of the robots did not seem to change when the researchers spent some time showing them how they worked, and emphasizing their underlying machinery. Melson and colleagues (Melson et al. 2009) directly compared children's views of and interactions with a living dog and a robot dog (AIBO). Although there were differences, the majority of the children interacted with the AIBO in ways that were like interacting with a real dog: they were as likely to give commands to the AIBO as to the living dog, and over 60 percent affirmed that AIBO had "mental states, sociality, and moral standards."

Overall, the pattern of evidence indicates that children saw robots that they had spent time with as friends and felt that they had formed relationships with them. They even believed that a relatively simple robot was getting to know them better as they played with it more. So, extrapolating from the evidence, it seems that there is a good possibility that children left in the care of robots for extended periods could form attachments to them. However, it is unlikely that the attachment would

AMSCE-1101

adequately replace the necessary support provided by human attachment.

To become well adjusted and socially attuned, an infant needs to develop a secure attachment to a carer (Ainsworth, Bell, and Stayton 1974). A securely attached infant will explore their environment confidently, and be guided in their exploration by cues from the carer. The development of secure attachment between a human carer and an infant depends on the carer’s maternal sensitivity, and ability to perceive and understand the infant’s cues and to respond to them promptly and appropriately. Detailed interactions between a mother and baby help the infant to understand their own emotions, and those of others.

In Sharkey and Sharkey (2010a), we argued from a review of the technology that robot carers into the foreseeable future would be unable to provide the detailed interaction necessary to replace human sensitivity and promote healthy mental development. Many aspects of human communication are beyond the capabilities of robots. There has been progress in developing robots and software that can identify emotional expressions (e.g., Littlewort, Bartlett, and Lee 2009) and there are robots that can make emotional expressions (Breazeal 2002; Cañamero and Fredslund 2001). However, recognizing what emotion is being expressed is only a tiny step toward understanding the causes of the emotion—is the child crying because she dropped her toy, because she is in pain, or because her parents are fighting?

There are many challenges to be overcome to develop a robot that could respond appropriately and sensitively to a young child that currently seem insurmountable. This is further complicated because responses that may be appropriate at one age would not be appropriate at another. An important function of a caregiver is to promote a child’s development, for instance, by using progressively more complex utterances in tune with the child’s comprehension.

AMSCE-101

When a human carer is insufficiently sensitive, insecure attachment patterns can result: *anxious-avoidant* attachment when the child frequently experiences rejection from the carer; *anxious ambivalent* attachment when the carer is aloof and distant; *disorganized attachment* when there is no consistency of care and parents are hostile and frightening to the children. Babies with withdrawn or depressed mothers are more likely to suffer aberrant forms of attachment: avoidant or disorganized attachment (Martins and Gaffan 2000).

Perhaps a child with a secure attachment to their parent would not suffer much as a result of being left with a robot for short periods. But the fact is we just don't know: no one has yet researched the possible negative consequences of children being left with robots for varying time periods, and it would be too risky to do so. We do know that young children do best when they spend time with a caregiver with whom they have a secure attachment. Thus, it is highly likely that leaving children in the care of a robot is not going to benefit them as much as leaving them in the care of an attentive and focused human carer. Robot nannies should not be used just because we cannot demonstrate that they are harmful. Rather, they should "qualify for (part-time) care only when it is proven that their use serves the child's best interests" (Zoll and Spielhagen 2010, 298).

17.2.2 Human Contact and the Elderly

A major concern that we have about home robot care for the elderly is that it may replace human contact. With very advanced smart sensing systems and robots that can lift and carry, bathe and feed, as well as keep their charges safe, there will be less need for care visits—the whole point of using the robots is because there will be fewer carers available as the population ages. This is bad news for many elderly people for whom visiting carers are the only human companionship they have on a daily basis. According to a report from the charity Help the Aged in 2008, 17 percent of older people in the UK have less than weekly

AMSCE-IIOT

contact with family, friends, and neighbors, and 11 percent have less than monthly contact.

Using robots for care of the elderly seems likely to reduce the number of opportunities they have for interaction with other human beings, and the benefits that come from such interaction. Sparrow and Sparrow (2006) argue that robots should not be used in elder care because of the likely consequential reduction in social contact. They make the point that even using robots to clean floors removes a valuable opportunity for interaction between an elderly resident and a human cleaner.

Research strongly suggests human companionship is essential for the well-being of the elderly, and yet there are no specific rights to companionship. There is a right to participation in the culture in Article 27 of Universal Declaration of Human Rights.[2] Deprivation of human contact may also be considered as cruelty, which is covered by Article 5. However, it is not clear that someone living independently in their own home with the help of robots would be being *subjected* to lack of companionship. Home helpers are not employed specifically as companions; it is just one of their beneficial side effects. Before introducing mass robot care, this side effect needs to be recognized as a function. Substantial evidence suggests that human contact should be seen as part of the right to welfare and medical treatment.

It is clear that an extensive social network offers protection against some of the effects of aging: being single and living alone is a risk factor for dementia (Fratiglioni et al. 2000; Saczynski et al. 2006; Wilson et al. 2007). Holtzman et al. (2004) found that frequent interaction in larger social networks was positively related to the maintenance of global cognitive function. Wang et al. (2002) similarly found evidence that a rich social network may decrease the risk of developing dementia, and concluded that both social interaction and intellectual stimulation play an important role in reducing such risks.

AMSCE-101

There is evidence that stress exacerbates the effects of aging (Smith 2003), and that social contact can reduce the level of stress a person experiences. Kikusui, Winslow, and Mori (2006) provide a wide-ranging review of the phenomena of *social buffering*, whereby highly social mammals show better recovery from distress when in the company of conspecifics. A recent review (Heinrichs, von Dawans, and Domes 2009) concludes that the stress-protective effects of social support may be the result of the neurotransmitter oxytocin that is released in response to positive social interactions, and that oxytocin can have the effect of reducing stress.

One take on the problem of social exclusion of the elderly in Japan is to move toward the development of robot companions and robot pets. These are being touted as a solution to the contact problem—devices that can offer companionship, entertainment, and human-like support. Examples include Paro, a fur-covered robotic seal developed by AIST that responds to petting; Sony's AIBO robotic dog; NeCoRo (OMRON), a robotic cat covered in synthetic fur, and My Real Baby (iRobot), described as an "interactive emotionally responsive doll."

There are, to our knowledge, no studies that directly compare the effect on the elderly of robot versus human companionship. Obviously, as is the case with children, robots are not going to be able to be as responsive to the needs of the elderly as are humans. However, they might be useful to supplement rather than replace human carers. There is, for example, evidence that giving the elderly robot pets to look after can be beneficial. Positive effects, such as reduction in loneliness and improved communication, have been found in studies where elders were allowed to interact with a simple Sony AIBO robot dog (Kanamori, Suzuki, and Tanaka 2002; Banks, Willoughby, and Banks 2008; Tamura et al. 2004).

These outcomes need to be interpreted with caution, as they depend on the alternatives on offer. If the alternative is being left in near-complete social isolation, it is unsurprising that interacting with a robot

AMSCE-IQI

pet offers advantages. Better comparisons could be made such as with a session of foot massage, or sitting with a sympathetic human listener.

On the upside, a robot pet does not have to be a replacement for social interaction. It could be provided in addition to other opportunities, and might further improve the well-being of an elderly person. As discussed in Sharkey and Sharkey (2010b), robot pets and toys could act as facilitators for social interaction by providing conversational opportunities (Kanamori, Suzuki, and Tanaka 2002). Having a robot pet may also give elders an increased feeling of control and autonomy. There is strong evidence that these factors can improve their well-being, and even result in longer life expectancy (Langer and Rodin 1976).

17.3 Conclusion

We began with an appraisal of how well care robots could keep their charges physically safe. It turns out that this may be one of their most significant features. However, physical safety comes with potential costs to the rights of the individuals being cared for. We have discussed here how it could violate rights to privacy and personal liberty. It seems almost paradoxical that the more safety the robots provide, the more their use may breach human rights.

Both old and young have a right to privacy, although privacy may have a different character for the two age ranges. It would hardly be an intrusion on an infant's privacy if their carer watched them sitting on the toilet and cleaned their bottom. Would it be so different to have a robot with the infant that broadcasts the images to the parent's computer? Admittedly, it feels less comfortable, but as long as it was only the parent watching and the images were not recorded, it would be unlikely to be considered a violation of the child's privacy. An elderly person might feel quite differently about similar treatment and not wish to have a robot camera with them in such a delicate situation. Our proposal was

AMSCE-1101

that a robot should always have an indicator when it is recording or transmitting images and that it warn of its presence and ask permission before entering a room.

There is also a tricky balance between physical safety and the right to liberty. We pointed out that in some circumstances, such as when a person is about to walk onto a busy road, it might be a good idea for a robot to intervene to prevent harm. However, we suggested that it would be unwise to allow a robot to make autonomous decisions about what is dangerous outside of obvious cases—such as leaving a gas stovetop on —where it could issue a warning. A robot would not have the subtlety or sensitivity to human intention to predict potential danger. What is dangerous for one person may be harmless for another. There are a lot of differences in this regard between infants and the elderly. Restraining or blocking the path of someone could represent a slippery slope to an authoritarian robotics that could result in keeping people as virtual prisoners in their own homes.

Looking into the future of care robotics, we examined the possibility that automated care could dramatically reduce the amount of human contact needed for safety and physical welfare. However, such a reduction could be a violation of the fundamental right to psychological well-being and could be considered to be a form of cruelty or torture or both under Article 5 of the Human Rights Convention (1949). Again, there are differences between the young and the elderly.

We argued from current evidence that young children can be fooled into believing that quite simple robots have mental states and can form friendship bonds with them. It seems likely that if children spent most of their time with a robot carer, they would form attachments. This means loving an artifact that cannot love them back. We cannot unequivocally demonstrate what the potential long-term harm of such relationships might be. However, we reviewed evidence from child development studies showing the types of psychological damage that could occur with insufficient human care.

AMSCE-101

We believe that there is an unacceptably high risk of abnormal attachment for children exposed to too much robot care. This could manifest later in all sorts of adult psychological malfunctions, including the inability to parent properly. Thus, we need to ensure intense scrutiny of any robotics products where it is implied that they could be used for childcare. With strong built-in physical safety features, we would have to find a way to ensure that robots marketed for short-term companionship for children would only be used for that purpose.

The impact on the elderly would be quite different. Leaving an elderly person in the near-exclusive care of robots in virtual home imprisonment would be a serious violation of their right to liberty and their right to participation in society, and would be a form of cruelty. We discussed some of the detailed evidence that social interactions and human companionship can retard the progress of dementia. Nonetheless, we concluded that there are a number of ways in which robots could greatly benefit the elderly. Assistive robots, if used sensitively, could empower the elderly and give them greater independence. We also suggested that companion robots could act as facilitators and conversational aids to improve the social life of the elderly.

Before we go adopting robots in the large-scale care industry, we must be sure about which rights we may be violating. We must minimize these violations in a way that is customized for each individual, and we must ensure that the accrued benefits for an individual are proportionally greater than any losses due to the infringement of their rights. Having considered the field of robot assistance and care, our view is that robotics could be of benefit to the welfare of the elderly, particularly if it maintains their independence at home for longer. However, for children, although there may be benefits interacting with robots in a social, educational, or therapeutic setting, robot childcare comes with too many risks to be considered viable.

AMSCE-101

Notes

[1] Gecko Systems is a U.S. company that is conducting trials for its CareBot with elderly people. Gecko Systems leaders suggest that the CareBot will provide cost effective monitoring of an elderly parent, and permit working parents to check up on their children and “watch their children routinely in a window on their computer monitors while at work.”

[2] General Assembly res. 217A (III), December 10, 1948.

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AMSCE-1101

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AMSCE-110I

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AMSCE-1101

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AMSCE-101

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AMSCE-1101

18

Designing People to Serve

Steve Petersen

AMSCE-J101

Fiction involving robots almost universally plays on a deep tension between the fantasy of having intelligent robot servants to do our every bidding, and the guilt over the more or less explicit possibility that having such intelligent creatures do our dirty work would simply be a new form of slavery. The robot character is frequently a sympathetic antihero who gets mistreated by its callous, carbon-chauvinist human oppressors. Our guilt over such a scenario often manifests as a fear that the robots' servile misery would drive them to a violent and relentlessly successful uprising. As commonly noted, the very word "robot" has its roots in just this scenario; it first appears in Karel Capek's play *R.U.R: Rossum's Universal Robots*, in which a brave new world of robot servants eventually rebel against their oppressive human masters. Capek chose the word "robot" to invoke the Czech word *robota*, which translates to "drudgery" or "forced labor."[1] Capek's play seems to have set the stage for a very long list of books, movies, and television shows about robots to follow. Try to list a few robot stories that *don't* fit this fantasy-guilt complex, and I'm confident you will generate a sizable list of examples that do fit it yourself.

So this aspect of robot ethics has long been in our culture—but it is only just beginning to appear in academia. The few authors who directly confront the ethics of robot servitude tend to conclude one of three things. Some propose that such robots could never be ethical subjects, and so we could not wrong them in making them work for us any more than we now wrong a washing machine. Others agree that robots could not be of ethical significance, but say we must treat them as if they were anyway, for our own sake. Still others conclude that robots *could* someday have genuine ethical significance similar to ours, and that therefore it would be unethical for them to perform menial tasks for us; it would simply be a new form of slavery.[2]

My own position, originally developed in Petersen 2007, is quite different from all of these. First of all, I do think it is possible to create robots of ethical significance—even to create *artificial people*, or *APs* for short. In a tradition with its roots in John Locke, philosophers tend to distinguish the biological category *human* from the much more philosophically rich category *person* ([Locke 1690] 1838, II.xxvii). To say that something artificial could be a person is to say in part at least that it could have full ethical standing like our own. On this usage, for example, ET the Extra-Terrestrial would be a person, but not a human. ET does not share our DNA, but this is irrelevant to his ethical standing; he is as ethically valuable as we are. In other words, to be a person does not seem to require being made of the particular material that happens to constitute humans; instead, philosophers tend to agree, it requires complicated organizational patterns that the material happens to realize. And thus, assuming we could eventually make a robot who has the same relevant complicated organizational patterns that we and ET have, then that robot would also be a person—an artificial one.

I *also* think that although such robots would be full-blown people, it might still be ethical to commission them for performing tasks that we find tiresome or downright unpleasant. There can, in other words, be artifacts that (1) are people in every relevant sense, (2) comply with our intentions for them to be our dedicated servants, and (3) are not thereby being wronged. I grant this combination is prima facie implausible, but there are surprisingly good arguments in its favor. In a nutshell, I think

AMSCE-101

the combination is possible because APs could have hardwired desires radically different from our own. Thanks to the design of evolution, we humans get our reward rush of neurotransmitters from consuming a fine meal, or consummating a fine romance—or, less cynically perhaps, from cajoling an infant into a smile. If we are clever we could design APs to get their comparable reward rush instead from the look and smell of freshly cleaned and folded laundry, or from driving passengers on safe and efficient routes to specified destinations, or from overseeing a well-maintained and environmentally friendly sewage facility. After all, there is nothing intrinsically unpleasant about hydrogen sulfide molecules, any more than there is anything intrinsically pleasant about glucose molecules. The former's smell is aversive and the latter's taste is appetitive *for humans*; APs could feel quite differently.[3] It is hard to find anything wrong with bringing about such APs and letting them freely pursue their passions, even if those pursuits happen to serve us. This is the kind of robot servitude I have in mind, at any rate; if your conception of *servitude* requires some component of unpleasantness for the servant, then I can only say that is not the sense I wish to defend.

18.1 The Person-o-Matic

To dramatize the ethical questions that APs entail, imagine we sit before a *Person- o-Matic* machine. This machine can make an artificial person to just about any specifications with the push of a button. The machine can build a person out of metal and plastic—a robotic person—with a circuit designer and an attached factory. Or, if we wish, the machine can also build a person out of biomolecules, by synthesizing carefully sequenced human-like DNA from amino acids, placing it in a homegrown cellular container, and allowing the result to gestate in an artificial uterus. It can make either such type of person with any of a wide range of possible hardwired appetites and aversions.[4] Which buttons on the Person-o-Matic would it be permissible to press?

It may be difficult to reconcile ourselves to the notion that we could get a genuine *person* just by pushing a button. My students like to say that nothing so "programmed" could be a person, for example. But—as the carbon-based AP case makes especially vivid—the resulting beings would have to be no more "programmed" than we are.

A more sophisticated version of this complaint is in Steve Torrance's "Organic View" (2007). He argues that only "organic" creatures could have the relevant ethical properties for personhood, and so "artificial person" is practically a contradiction in terms. Of course, a great deal hinges here on just what "organic" means. Torrance seems to use it in three different ways throughout his paper: (1) *carbon-based*, (2) *autopoietic*, and (3) *originally purposeful*. This quotation, for example, illustrates all three: "Purely electrically powered and computationally guided mechanisms [sense 1] . . . cannot be seen, except in rather superficial senses, as having an inherent motivation [sense 3] to realize the conditions of their self-maintenance [sense 2]: rather it is their external makers that realize the conditions of their existence [sense 3]" (Torrance 2007, 512–514). But none of these three senses of *organic* is enough to show that APs are impossible.

Consider first the sense in which it means *carbon-based*. Torrance provides no argument that only carbon could ground ethical properties; indeed, philosophical consensus is otherwise, as mentioned earlier. Besides, even if people do have to be organic in this sense, APs are still possible—as Torrance acknowledges (2007, 496, 503)—because it is in principle possible to create people by custom building DNA.

Torrance officially uses *organic* in the second sense, to mean *autopoietic*. Roughly, something is autopoietic if it can self-organize and self-maintain. But this is a purely functional notion; there is no reason inorganic compounds couldn't form something autopoietic. Indeed, the well-established movement of situated, embodied, and embedded robotics emphasizes getting intelligence out of just such lifelike properties.[5] Rodney Brooks's Roomba, for example, avoids treacherous

AMSCE-10

stairs and seeks its power source after a long day of vacuuming. Such robots already have rudimentary self-organization and self-maintenance.

Lurking behind the criterion of autopoiesis is the third sense of *organic*, and what I suspect to be the core of the matter for Torrance's argument: the presence of *inherent function* or purpose. Torrance is claiming, in effect, that when something gains a function by another's design, the function is not inherent to that thing, and so it is not "original." And, Torrance seems to hold, only original functionality can ground ethical value. In other words, just in virtue of resulting from another's design, a thing cannot be a person. (Perhaps this is what my students mean by something being "programmed.")

If correct, this would by definition rule out all APs, carbon-based or not. But, aside from having scant motivation, it proves too much. By this criterion, if traditional Christian creationism proved true and God designed us, then we humans would not be "organic" either, and so not people. I'm strongly inclined to agree that evolution, and not God, designed humans—but it would be very odd if our ethical standing were so hostage to the truth of this claim. For another example closer to home, it seems that our biological parents count as our "external makers," who were moved to "realize the conditions of [our] existence" (though probably not in a traditional laboratory setting). Despite such external makers, we manage to have the properties required to be people.

Finally, consider Labrador Retrievers. They are not people, of course, but they do have ethical standing, and they were deliberately designed, via artificial selection, to enjoy fetching things. Does this mean that they have no "inherent motivation" to fetch? Anyone who has spent time with a retriever can see that the dog, itself, wants to fetch—whatever the source of that desire. Furthermore, satisfying this desire is part of the well-being *for that dog*, even though that desire was designed by intelligent outsiders. Similarly, we did not give ourselves all our desires; some of them, such as for food, are just plain hardwired. It is hard to see

AMSCF-110I

why ends given by evolution are “original,” but ends given by the design of an intelligence are not. In both cases, there is a very natural sense where our ends seem plainly derivative.

Still, I think Torrance is onto something important; in fact, I agree that for something to be intelligent, autopoietic, and a subject of ethical value, it must have a function *for itself*. Teleology is a notorious can of worms in philosophy, and can hardly be settled here. For our purposes, we just need the claim that one way for something to get a function for itself—an “original teleology”—is from the design of another intelligence.

So now perhaps we are in a position to agree that pushing a Person-o-Matic button would result in a real person of intelligence and ethical value, comparable to our own. When we picture this vividly, I think typical intuitions incline us to say that pushing few, if any, of the buttons is permissible. The case is so far removed from our experience, though, that it is hard to trust these intuitions—especially since there are good arguments that say it *is* permissible to press quite a few of them.

18.2 The “Typical” Person Case

Suppose first you notice buttons for building an organic person, just like you (presumably) are. (From here I will use *organic* just to mean *carbon-based*.) Perhaps, after you feed it the complete information about your DNA makeup and the DNA makeup of a willing partner, the Person-o-Matic uses a combination of this information to construct from scratch a viable zygote that matures in an artificial uterus, much later producing an infant, exactly as might have been produced by the more traditional route. Here we leave a great deal of the design up to chance, of course; our intention is not to create a servant, but roughly just for the Person-o-Matic to build a new human, or anyway a human-like person.[6] The scenario may be intuitively distasteful or even abhorrent, but it is

AMSCE-101

very hard to give reasons for why creating such a person would be *wrong*. After all, it results in people just like the people we now create by traditional means. There may be circumstances in which just the creating of a new person is unethical, of course—due to overpopulation or some such—but that would hardly be unique to APs. If anything is uniquely wrong about this case, then, it must be in the *method* for creating the person, rather than the outcome. But even the method seems no less ethical than a combination of in vitro fertilization, artificial implantation, surrogate mothers, and a host of other techniques for creating people that are already in practice. No doubt bioethics is another can of philosophical worms, but the case at hand here is not so different from bioethical cans already wide open. Indeed, using the Person-o-Matic this way could plausibly bring ethical benefit to a great many couples who are not otherwise able to have biological children.

Probably, the most natural way to express our intuitions against the permissibility of this case is to say that such a procedure for making a person like us would be "unnatural." This word shows up frequently when people are confronted with new technology. As a clever novelist once put it:

> 1. Anything that is in the world when you're born is normal and ordinary and is just a natural part of the way the world works.
>
> 2. Anything that's invented between when you're fifteen and thirty-five is new and exciting and revolutionary and you can probably get a career in it.
>
> 3. Anything invented after you're thirty-five is against the natural order of things. (Adams 2002, 95)

The point, of course, is that much of what we consider "natural" today may have looked horrifyingly unnatural to those just a generation or two behind us. To say "unnatural" in this way just means "new enough to make us wary and uncomfortable." When the word means only this, it has no philosophical weight. Our gut reactions are often wise for being wary of the new and strange, but rejecting something *because* it is new and strange is quite different. We do not now consider

AMSCE-ID

flying, cell phones, radiation treatment, or artificial hearts wrong because they would have been distressing to those before us.

It seems then that it is hard to explain why it would be wrong to push such a button. As it happens, though, next to those buttons is another row of buttons that offer the option to create a person much like us, except inorganic—a robot. Aside from desires and goals that are particular to the material makeup, we can suppose the robot is designed to have hardwired interests very like ours, and will also be strongly influenced in a unique way by its educational environment just as we were. Would it be wrong to push any of those buttons? It seems there are only a few avenues for trying to explain such wrongness. One is to say that though the resulting person would be like us in all relevant mental respects, just the fact of its different material constitution makes its creation wrong. Another might be that the desires unique to our organic constitution are relevant—that, for example, it is okay to make an AP who likes to consume carbohydrates, but not one who likes to consume pure hydrogen. I trust neither of these avenues looks very promising. If not, and short of other explanations of asymmetry, the organic and the inorganic cases seem to be morally equivalent. We must conclude that making a robot with predispositions like ours is no more wrong than having a biological child would be.

18.3 The “Enhanced” Person Case

We next notice a bank of buttons to create organic people who are still very much like us, but who have been “enhanced” in any of various ways. Some buttons offer to design the person so that she is immune to common diseases. Of more interest for us, some buttons offer to alter the person’s hardwired desires—so that perhaps she is also immune to the lures of tobacco, or enjoys eating healthy greens more than usual. Other buttons offer to tailor more abstract desires, so that, for example, the AP

AMSCE-101

gains greater intrinsic pleasure than typical from pursuits we consider noble, such as sculpting or mathematics. Would it be wrong to press a button to bring about this type of person?

Again, despite what qualms we might have, it is hard to say why it would be. Given that parents and mentors expend great and generally laudable effort on the nurture side to bring about such results, it is at least a bit odd to say that bringing them about from the nature side would be wrong.

Probably the best argument against creating the "enhanced" person suggests we have robbed the resulting person of important autonomy by engineering such desires. On this view, it is one thing to encourage such desires during the person's upbringing, and another to hardwire them ahead of time. Of course, free will is yet another philosophical can of worms, and one into which we can only peek here—but again, it is a can of worms that is already open, and hardly unique to APs. Some humans are now naturally born with stronger resistance to tobacco's appeal, for example, and it may well be that some are naturally born with stronger predilections for math or art. At any rate, we all come into existence with hardwired desires, and whether they are "enhanced" or "typical" does not seem relevant to whether they are enacted freely.

Imagine, for example, that way down the road—perhaps hundreds of millions of years later—natural selection has shaped humans so that they no longer enjoy tobacco, and they are born with a random mix of significantly stronger desires to do art or science or other lofty pursuits. This seems possible at any rate, and it would be very odd to say that those future humans would thereby have less autonomy than we have. But our Person-o-Matic can now make a molecular duplicate of such a future possible person. If the future product of natural selection is free and the duplicate AP is not, then one's autonomy depends on how one is brought into existence, even if the result is otherwise exactly the same. It is to say, in effect, that intelligent design does not create an *original* function after all.

AMSCE-I101

I have already argued against this position; I hope, on reflection, it is hard to endorse. It is more interesting to examine what tempts us into this view in the first place. Perhaps, it is simply the familiar queasiness of the "unnatural." Another possibility is that we confuse the case at hand with a more familiar one: that of brainwashing a person with contrary desires already in place.

Another possible source of confusion is in the imagined relative *strength* of these inclinations. Perhaps typical people are free, despite being born with strong dispositions because, we think, they are still able in principle to resist them. Whatever this "ability" amounts to, though, we can suppose APs have it, too. It is plausibly a necessary condition of personhood that one be able to reflect on one's desires, for example, and reconsider them (Frankfurt 1971). An enhanced AP might crave mathematics or sculpting as much as a typical human craves food. But Gandhi could reason himself out of acting on his food craving, and the enhanced AP might similarly reason herself out of her cravings, because she is a person able to reflect on them. So, the AP seems to be as free as we humans are—however free that might be—and the objection from autonomy fails.

It is no great surprise when we see another row of buttons on the Person-o-Matic for creating enhanced APs that are inorganic. These buttons result in robots who love to carve elegant statues or prove elegant theorems. Again, pushing these buttons seems morally equivalent to the ones for the organic APs. If so, then creating a robot who loves to pursue art or science is no more wrong than giving birth to a human who gained the same predispositions through natural selection.

Notice, though, that pushing buttons in either of these rows is already at least tantamount to designed servitude. Suppose we commission an AP who is very strongly inclined to help find a cure for cancer. Is this AP our willing servant? If so, then I have already shown that we can design people to serve us without thereby wronging them.

AMSCE-101

18.4 The “General Servitude” Case

A scientist dedicated to curing cancer, even as a result of others’ desires, may not seem like a clear case of servitude. Clearer cases follow readily, though—because one enhancement for a person, plausibly, is general beneficence. Sure enough, a prominent button on the Person-o-Matic designs an organic person who gains great pleasure simply from bringing about happiness in other people. The AP who results genuinely likes nothing more than to do good and will seek opportunities to help others as eagerly as we seek our own favorite pleasures.

Again, it seems possible that natural selection could bring about humans like this in the far future—if group selection turns out to be a force for genetic change after all, for example—and it would not then be wrong to give birth to one. (Indeed, it sounds like a pretty good world into which to be born.) Again, the Person-o-Matic could create a molecular duplicate of such a person. Again, it is hard to see why the naturally selected person would be permissible and not the intelligently designed one. Again, it does not matter, on ethical grounds, whether the resulting AP is organic or inorganic. So, again, we have to conclude that commissioning a robot who wants to help people above all else is no more wrong than giving birth to a human who gained such beneficence through natural selection. The resulting APs would behave much as though they were following Isaac Asimov’s Three Laws of Robotics from his *I, Robot* series ([1950] 1970)—except they would also be helpful to other APs. And this time it seems very clear that the resulting AP would be a dedicated servant to the people around it.

AMSOE-I101

18.5 The “Specific Servitude” Case

Closer still to the *I, Robot* scenario are APs who are designed not to seek the happiness of people generally, but rather the happiness of humans specifically. This is a more task-specific kind of servitude. Still, more specifically, perhaps they are designed to seek the health and well-being of human children—or even your particular children, as Walker pictures his *Mary Poppins 3000*:

> What if the robotic firm sells people on the idea that the MP3000 is designed such that it is satisfied only when it is looking after Jack and Jill, your children? The assumption is that the programming of individual MP3000s could be made that specific: straight from the robot assembly line comes a MP3000 whose highest goal is to look after your Jack and Jill. Imagine that once it is activated it makes its way to your house with the utmost haste and begs you for the opportunity to look after your children. (2006)

In fact, the first robot we meet in the *I, Robot* stories is a similar nanny. Inspection of the Person-o-Matic of course reveals “nanny” buttons, as well as buttons that engineer people to derive great joy out of freshly cleaned and folded laundry, or from driving safe and efficient routes to specified destinations, or from clean and efficient sewers. These buttons are probably the most controversial ones to push; they evoke the gruesome “delta caste” of people engineered for menial labor in Aldous Huxley’s *Brave New World* ([1932] 1998)—especially in the case of organic, human-like APs.[7] Though surely our intuitions rebel against these cases most of all, it is surprisingly difficult to find principled reasons against pushing even these buttons. The three best of which I know are:

1. The resulting AP would have impermissibly limited autonomy.
2. The resulting AP would lead a relatively unfulfilling life.
3. The resulting AP would desensitize us to genuine sacrifices from others.

I will address each reason separately.

18.5.1 Specific Servitude and Autonomy

First, consider the objection from autonomy. Walker, for example, says that in making one of his imagined robot nannies we have just made a "happy slave," because "we are guilty of paternalism, specifically robbing the MP3000 of its autonomy: the ability to decide and execute a life plan of its own choosing" (2006).

I have already addressed the autonomy argument in some detail for the enhanced person case. Those arguments carry over to this case at least to the extent that the content of one's hardwired desires are irrelevant to the autonomy with which they are pursued. If one AP is made with a strong desire to sculpt, another with an equally strong desire to look after your children, and yet another with an equally strong desire to do laundry, then it seems they should all be equally free. If we object to making one and not the other, then it does not seem to be on *autonomy* grounds.

We are more tempted here than in the "enhanced" person case to object from autonomy, though, and I can think of two reasons why: first, it is harder for us to conceive of a person who genuinely wishes such ends for themselves, at least without our coercing them from other, more "natural" desires. Second, the desired ends these APs seek serve us in a much more obvious way. This combination has the effect of convincing us that the APs are being used as a mere means to our ends—and according to a flourishing ethical tradition founded by Immanuel Kant, it is an impermissible violation of autonomy to use any person as a mere means to an end ([1785] 1989).

The "mere" use as means here is crucial. In your reading this chapter, I can use you as a means to my ends—which may be your finding the truth of some difficult ethical claims, or sharing my philosophical thoughts, or my gaining philosophical glory and tenure. Meanwhile you can use me as means to your ends—which may be your gaining a wider perspective on robot ethics, or entertaining yourself with outlandish views, or proving me wrong for your own philosophical glory. This is permissible because we are simultaneously respecting each other's ends.

AMSCE-1101

And here, of course, we see that the same is true of the task-specific APs: though they are a means to our ends of clean laundry and the like, they are simultaneously pursuing their own permissible ends in the process. They therefore are not being used as a *mere* means, and this makes all the ethical difference. By hypothesis, they want to do these things, and we are happy to let them.

Now as genuine people, we are supposing these APs are worthy of full ethical respect, and for the Kantian this means supposing they have a required autonomy. This plausibly means, as noted earlier, that such APs are capable of reasoning themselves out of their predisposed inclinations. But first, this could be roughly as unlikely as our reasoning ourselves out of eating and sex, given the great pleasure the APs derive from their tasks. Second, if they should so reason, then of course I would not defend making them do their tasks anyway; that would be wrong on just about any plausible ethical view.[8] Indeed, if the APs do not reason themselves out of their joy in washing laundry, to give an example, and if suddenly there were no more laundry to do—perhaps because nudity became the fashion—it would be our obligation to help them out by providing them with some unnecessarily dirty clothes.

18.5.2 Specific Servitude and a Fulfilling Life

Perhaps what's behind the autonomy objection is that, despite the fact that the AP comes into existence with these desires, that AP was still "coerced" into an otherwise aversive task. In other words, it is really about the content of the desires—just to bring the APs into existence with such abject desires is to manipulate them unfairly. If so, this is really a form of the next objection: that to create a being who enjoys pursuing such menial tasks is to create someone who we know will live a relatively unfulfilling life, and this is impermissible.

First of all, it is not obvious that such a life is truly "unfulfilling." Assuming that the laundry AP deeply desires to do laundry, and has an ample supply of laundry to do, the life seems to be a pretty good one.

AMSCE-101

We should be careful not to assume the AP must somewhere deep down be discontent with such work, just because we humans might be. And though perhaps clean laundry does not seem so meaningful an achievement in the big picture of things, in the *big* picture I am sorry to say that none of our own aspirations seem to fare any better.

Probably the best way to push the objection from an unfulfilling life is through a distinction that goes back to the utilitarian John Stuart Mill: that between “higher” and “lower” pleasures. Mill says that “there is no known Epicurean theory of life which does not assign to the pleasures of the intellect, of the feelings and imagination, and of the moral sentiments, a much higher value as pleasures than to those of mere sensation” (1871, 14).

As he famously summarizes, “It is better to be a human being dissatisfied than a pig satisfied; better to be Socrates dissatisfied than a fool satisfied” (Mill 1871, 14). Perhaps the task-specific AP is merely a “fool satisfied.”

If a strong, hardwired reinforcement for some achievement is sufficient for it to be a lower pleasure of “mere sensation,” then even an AP designed with Socrates’ taste for philosophy is only living the life of a fool satisfied. Such a criterion for higher and lower pleasures seems arbitrary. If instead we take the higher pleasures to be, as Mill insists, simply what the person who has experienced both will prefer, then it seems they will be highly dependent on the person and their own tastes.[9] If so, then the AP, with quite different interests from ours, might well prefer laundry over a good production of Shakespeare, even after experiencing both—and so laundry may count as that AP’s higher pleasure. If experiencing higher pleasures is, in turn, what constitutes a fulfilling life, then that AP is leading a fulfilling life by doing laundry.

Suppose we grant, though, that for any person of whatever design, doing laundry is not as fulfilling as (for example) contemplation or

AMSCE-101

artistic expression. Even under this assumption, it is still not obvious that it would be wrong to commission such APs.

For one thing, there is no principled reason the AP could not pursue both types of pleasure; we humans manage it, after all. We tend to seek out and enjoy the higher pleasures only after an adequate number of the lower ones have been satisfied, and this fact does not make our lives unfulfilling. And even if given the opportunity to indulge in the lower pleasures exclusively, many of us (who have experienced both) will get bored and seek the higher ones, at least for a while. The APs could well be similar, especially if we design them so; perhaps after bingeing on their baser desires for washing laundry, the sated APs will then turn to Shakespeare or Mahler for a while.

Suppose, though, that the AP spends its whole life cheerfully doing laundry—perhaps at a large twenty-four-hour facility, rather than in a family's home—without ever experiencing what we are supposing to be higher pleasures. Here, surely we have a case of the "fool satisfied." And, the claim goes, bringing about such a life is wrong, because it is not as good as the life of a Socrates dissatisfied.

Here is a dizzying question, though: who exactly is wronged by pushing the button for a laundry AP? It cannot be the resulting laundry AP, because any time before the AP's desires existed is also a time before the AP existed, and so there was no person being harmed by their endowment. Had we pushed the button for the sculptor AP instead, we would have thereby brought about a *different* person, and so the laundry AP cannot benefit from our pushing the sculptor AP button.[10]

A similar case can be made that the miller's daughter was not wrong to promise her firstborn to Rumpelstiltskin, since had she not done so she never would have married the king, and a different first child would have been born to her—if any. Therefore, assuming the child sold into Rumpelstiltskin's care would rather have that life than no life at all, the

AMSCE-101

promise could hurt no one, and so is not wrong. This is surely counterintuitive.

Ethicists will recognize this as what has come to be called *the nonidentity problem*.[11] This problem is a part of *population ethics*—yet another philosophical can of worms worth more attention than I can give it here. (This abundance of nearby philosophical worms is, for me, part of the topic's appeal.) According to a plausible answer to the puzzle already discussed, though, it is better from an ethical standpoint to bring about the sculptor AP than the laundry AP, despite the fact that bringing about the laundry AP instead would harm no one in particular. In other words, an act can be wrong even if it harms no one person, just because it causes less overall well-being than alternatives.[12]

Thus, we might agree that choosing the laundry AP button over the sculptor AP button is wrong, when given the opportunity. But suppose the choice is not exclusive, and you have the opportunity to push *both*. Assuming it is permissible to push the button for the sculptor AP, would it be wrong to push the button for the laundry AP in addition? In this case, we are not substituting a comparatively worse life for a better one; rather, we are simply adding a worthwhile life to the world, even though there are or could be better ones. If this is wrong, then a great deal of our current policies should change drastically. We should prevent the birth of nonhuman animals as best as we are able, for example, since they are capable of only the very lowest pleasures, and so, according to this view, it is wrong to add them to the world. We should also make sure that only those people who can be expected to provide the very best lives—whatever those might be—may have children. And if the Person-o-Matic can make people capable of higher pleasures than that of an ordinary human, then humans should stop reproducing altogether.

If we agree that adding worthwhile but nonideal lives to the world is permissible, however, then it is permissible to push the laundry AP button—even under the questionable assumption that the lives of laundry APs are relatively unfulfilling.

AMSCE-101

18.5.3 Specific Servitude and Desensitization

One last objection to robotic servitude is what I like to call the "desensitization" objection: that having APs do work for us will condition us to be callous toward other people, artificial or not, who do *not* wish to do our dirty work. As David Levy puts it, "Treating robots in ethically suspect ways will send the message that it is acceptable to treat humans in the same ethically suspect ways" (2009, 215).

Those who hold this view generally do not believe that the robots in question are people; they hold that the robots lack some necessary property for ethical value, such as (in Levy's case) sentience.[13] In this form, the objection does not apply to our cases of interest. We should treat APs well, whether organic or inorganic, not because they could be mistaken for people, but because they *are* people. And treating them well—respecting their ends, encouraging their flourishing—could involve permitting them to do laundry. It is not ordinarily cruel or "ethically suspect" to let people do what they want.

Perhaps we can amend the usual desensitization argument to apply to APs, though; perhaps having an AP do laundry for us will condition us blithely to expect such servitude of those who are not so inclined. This argument thus assumes the general population is unable to make coarse-grained distinctions in what different people value. This may well be; humanity has surely displayed stupidity on a par with this in the past. But we do not normally think that all people like haggis, for example, just because some do, so we seem generally capable of recognizing differences in inclinations. More importantly, the fact that people may make such mistakes is no objection to the position, in principle at least. As Mill said, any ethical standard will "work ill, if we suppose universal idiocy to be conjoined with it" (1871, 35). In this form of the objection, we can respond simply by promising to introduce such APs with caution, and accompanied by a strong education program. As a result, instead of learning that people can be used as means, children might

AMSCE-101

learn about the wide range of ends a person could undertake, and thus gain respect for a more robust value pluralism than they could with ordinary humans alone.

Sometimes this objection rings of a protestant guilt about shirking hard labor. If the concern is that idle hands are the devil's play thing, and that we will grow soft and spoiled with the luxury, then we should also consider whether it is already too late, given the technology we now possess. Not only should we be doing our own laundry, if hard labor is good for its own sake, but we should be doing it in a stream by beating it with rocks.

18.6 Underview

I am not arguing that pushing *any* button on the Person-o-Matic is permissible. For one thing, designing a person who strongly desires to kill or inflict pain would be wrong on just about any ethical view. So would designing a person to lead a predictably miserable life,[14] or to crave tasks that are dangerous for them to do. (With good engineering, though, we can probably make a robot that can *safely* do tasks that are dangerous for humans.)

I am not even sure that pushing the buttons defended above is permissible. Sometimes I can't myself shake the feeling that there is something ethically fishy here. I just do not know if this is irrational intuition—the way we might irrationally fear a transparent bridge we "know" is safe—or the seeds of a better objection. Without that better objection, though, I can't put much weight on the mere feeling. The track record of such gut reactions throughout human history is just too poor, and they seem to work worst when confronted with things not like "us"—due to skin color or religion or sexual orientation or what have you. Strangely enough, the feeling that it would be wrong to push one of

AMSCE-1101

the buttons above may be just another instance of the exact same phenomenon.

Notes

[1]. Zunt (2002) presents a letter of Capek's in which he credits his brother Josef for the term.

[2]. For the first view, see Torrance 2007 or Joanna Bryson's less nuanced but provocatively titled "Robots Should Be Slaves" (0). For the second view, see, for example, Levy 2009; Ronald Arkin and Mark Walker have also pressed versions of this objection in correspondence with the author. For the last view, see the Walker 2006 and a host of informal online discussions, such as at the American Society for the Prevention of Cruelty to Robots—ASPCR 1999.

[3]. Compare the intelligent shipboard computer in Douglas Adams's novels, absolutely stumped by why the human would want "the taste of dried leaves boiled in water," with milk "squirted from a cow" ([0] 1982, 12).

[4]. The material will of course constrain some of these appetites and aversions. Though philosophers tend to agree that the mental state of *desire* (for example) is a substrate-independent functional role, some particular desires are more substrate independent than others—just as the functional role of a pendulum clock can be realized in wood or brass, but probably not in gaseous helium. See Lycan 1995 for more discussion.

[5]. They thus practice what Peter Godfrey-Smith calls "methodological continuity" between artificial life and artificial mind (Godfrey-Smith 1996, 320).

[6]. Perhaps to be part of the biological category *human* requires a certain evolutionary history, so that APs do not count.

[7]. One extreme thought experiment along these lines is again from the fertile imagination of Douglas Adams: a bovine-type animal designed to want to be eaten, and smart enough to explain this fact to potential customers.

> "I just don't want to eat an animal that's standing there inviting me to," said Arthur. "It's heartless."
>
> "Better than eating an animal that doesn't want to be eaten," said Zaphod.

AMSCE-101

> “That’s not the point,” Arthur protested. Then he thought about it for a moment. “All right,” he said, “maybe it is the point. I don’t care, I’m not going to think about it now.” ([1980] 1982, 120)

This particular case is probably impermissible on various grounds, however.

[8] Since it’s become a leitmotif, another example from Adams: “Not unnaturally, many elevators imbued with intelligence . . . became terribly frustrated with the mindless business of going up and down, up and down, experimented briefly with the notion of going sideways, as a sort of existential protest, demanded participation in the decision-making process and finally took to squatting in basements sulking” (Adams [1980] 1982, 47).

[9] Mill’s test actually insists on the majority of what people would say (1, 12, 15), but this is even worse; then what counts as a higher pleasure changes depending on how many APs of what type emerge from the Person-o-Matic.

[10] One possibility that is probably unique to the inorganic case is when one robot body—humanoid in shape, say—can be programmed either of two ways. In this case, it makes sense to say that particular hunk of material could have been a sculptor or a launderer. If that hunk of material is the AP itself, rather than merely its body, then we can harm *that* AP by pushing the laundry button. But on this account, the AP exists prior to its programming, in that hunk of material. This means it would also harm the AP to, for example, disassemble that body before it ever gets programmed. I take this as a *reductio* of the view that an inorganic AP is identical to its body, and I leave it to the reader to consider analogies in the organic case. The philosophical problem of *personal identity*—that of determining what changes a person can undergo and still be that same person—is another can of worms beyond this chapter. Suffice it to say that this is not an obviously amenable escape route from the claim on the table: namely, that because no one is harmed by bringing about the laundry AP, it is permissible to do.

[11] It is discussed most famously in Parfit [1984] 1987; see Roberts 2009 for an overview.

[12] This follows from what Parfit calls the “Impersonal Total Principle.”

[13] Still, they say, we should treat them well basically for the same reason Kant says we should treat dogs well, even though (in Kant’s view) dogs are not subjects of ethical value, either: because “he who is cruel to animals becomes hard also in his dealings with men” ([1930] 1963, 240).

AMSCE-101

[14]. More leitmotif: Adams's character Marvin, the "Paranoid Android," was designed by the Sirius Cybernetics Corporation to have the "genuine people personality" of severe depression (Adams [1979] 1981, 93).

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AMSCE-1101

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AMSCE-1101

VII

Rights and Ethics

The preceding chapter 18 examined the ethics of robot servitude: Is it morally permissible to enforce servitude on robots, sometimes termed “robot slavery”? But to call such servitude “slavery” is inapt, if not seriously misleading, if robots have no will of their own—if they lack the sort of freedom we associate with moral personhood and moral rights. However, could robots someday gain what it takes to become a rights holder? What exactly is it that makes humans (but not other creatures) here on Earth eligible for rights? Is there a foreseeable future in which robots will demand their own “Emancipation Proclamation”?

Rob Sparrow in chapter 19 situates the discussion of robot rights within the broader question of whether robots can be people, thus guaranteeing them moral consideration. He claims that equating the concept of “person” with the extension of *Homo sapiens* is a mistake, not least because we could imagine intelligent extraterrestrials that are clearly *nonhuman persons*. His chapter proposes a test for robot personhood: The Turing Triage Test, which takes the concept of triage in life and death situations to determine empirically when a robot meets the criteria for personhood and thus is afforded moral standing and moral rights. Sparrow also reflects on the practical implications of our philosophical methods and asks: Would our philosophical convictions stand the real-world test of choosing a robotic life over a human life?

In chapter 20, Kevin Warwick examines the latest research on neuromorphic (biologically based) brains, which may soon give rise to a

AMSCE-1101

robot that ought to be afforded rights. Research already has taken embryonic rat neurons and grown them into a decision-making mechanism (a “brain”) when embodied in a robot. The procedure can be done with human neurons as well. He asks: “If a robot body contains a brain of 100 billion human neurons then should that robot be afforded the same rights as a human?” As Warwick points out, Searle’s Chinese Room argument against AI, even if sound, would hold no water against his robot’s personhood—because it is an organic brain in a robotic body! He also assays some of the ethical qualms that could arise if scientists have the power of life and death over such persons enmeshed in a robotic body.

Anthony Beavers observes in chapter 21 that the possibility of ethical robots confuses the language of ethics: given “ought implies can,” the nature of our biological implementation—including our “interiority”—helps determine human ethics. Accordingly, it strains our concepts of ethics to the breaking point if we deem robots without a conscience, responsibility, or accountability capable of ethics; such notions problematize not only the concept, but also the very nature of ethics.

Thus, after studying issues related to programming ethics and specific areas of robotic applications, in part VII our focus zooms back out to broader, more distant concerns that may arise with future robots. In part VIII, our epilogue chapter brings together the diverse discussions in this volume.

Chapter 19

AMSCE-101

Can Machines Be People? Reflections on the Turing Triage Test

Rob Sparrow

The idea that machines might eventually become so sophisticated that they take on human properties is as old as the idea of machines.[1] Recently, a number of writers have suggested that we stand on the verge of an age in which computers will be at least as—if not more—intelligent than human beings (Brooks 2003; Dyson 1997; Moravec 1998; Kurzweil 1999). The lengthy history of the fantasy that our machines might someday come to take on human properties is itself a reason to be cynical about these predictions. The idea that this is just around the corner says as much about human anxiety about what, if anything, makes people special, as it does about the capacities of machines. Of course, the fact that people have been wrong in every prediction of this sort in the past is no guarantee that current predictions will be similarly mistaken. Thus, while there is clearly no reason to panic, it is presumably worth thinking about the ethical and philosophical issues that would arise if researchers did succeed in creating a genuine artificial intelligence (AI).[2]

One set of questions, in particular, will arise immediately if researchers create a machine that they believe is a human-level intelligence: What are our obligations to such entities; most immediately, are we allowed to turn off or destroy them? Before we can address these questions, however, we first need to know when they might arise. The question of how we might tell when machines had achieved "moral standing" is therefore vitally important to AI research,

AMSCE-1101

if we want to avoid the possibility that researchers will inadvertently kill the first intelligent beings they create.

In a previous paper, “The Turing Triage Test,” published in *Ethics and Information Technology*, I described a hypothetical scenario, modeled on the famous Turing Test for machine intelligence (Turing 1950), which might serve as means of testing whether or not machines had achieved the moral standing of people (Sparrow 2004). In this chapter, I want to (1) explain why the Turing Triage Test is of vital interest in the context of contemporary debates about the ethics of AI; (2) address some issues that complicate the application of this test; and, in doing so, (3) defend a way of thinking about the question of the moral standing of intelligent machines that takes the idea of “seriousness” seriously. This last objective is, in fact, my primary one, and is motivated by the sense that, to date, much of the “philosophy” of AI has suffered from a profound failure to properly distinguish between things that we can say and things that we can really mean.

19.1 The Turing Triage Test

In philosophical ethics—and especially in applied ethics—questions about the wrongness of killing are now debated in the context of a distinction between “human beings” and “persons” (Kuhse and Singer 2002). Human beings are—unsurprisingly—members of the species *Homo sapiens* and the extension of this term is not usually a matter of dispute. However, in these debates, “persons” functions as a technical term to describe all and only entities that have (at least) as much moral standing as we ordinarily grant to a healthy adult human being. “Moral standing” refers to the power that certain sorts of creatures have to place us under an obligation to respect their interests. Thus, persons are those things that it would be at least as wrong to kill as healthy adult human beings.

AMSCI-IOI

The question the Turing Triage Test is designed to answer, then, is "when will machines become persons?" Here is the test, as I originally described it:

> Imagine yourself the senior medical officer at a hospital, which employs a sophisticated artificial intelligence to aid in diagnosing patients. This artificial intelligence is capable of learning, of reasoning independently, and making its own decisions. It is capable of conversing with the doctors in the hospital about their patients. When it talks with doctors at other hospitals over the telephone, or with staff and patients at the hospital over the intercom, they are unable to tell that they are not talking with a human being. It can pass the Turing Test with flying colors. The hospital also has an intensive care ward, in which up to half a dozen patients may be sustained on life support systems, while they await donor organs for transplant surgery or other medical intervention. At the moment there are only two such patients.
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> Now imagine that a catastrophic power loss affects the hospital. A fire has destroyed the transformer transmitting electricity to the hospital. The hospital has back-up power systems but they have also been damaged and are running at a greatly reduced level. As senior medical officer you are informed that the level of available power will soon decline to such a point that it will only be possible to sustain one patient on full life support. You are asked to make a decision as to which patient should be provided with continuing life support; the other will, tragically, die. Yet if this decision is not made, both patients will die. You face a "triage" situation, in which you must decide which patient has a better claim to medical resources. The diagnostic AI, which is running on its own emergency battery power, advises you regarding which patient has the better chances of recovering if they survive the immediate crisis. You make your decision, which may haunt you for many years, but are forced to return to managing the ongoing crises.
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> Finally, imagine that you are again called to make a difficult decision. The battery system powering the AI is failing and the AI is drawing on the diminished power available to the rest of the hospital. In doing so, it is jeopardizing the life of the remaining patient on life support. You must decide whether to "switch off" the AI in order to preserve the life of the patient on life support. Switching off the AI in these circumstances will have the unfortunate consequence of fusing its circuit boards, rendering it permanently inoperable. Alternatively, you could turn off the power to the patient's life support in order to allow the AI to continue to exist. If you do not make this decision the patient will die and the AI will also cease to exist. The AI is begging you to consider its interests, pleading to be allowed to draw more power in order to be able to continue to exist.
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> My thesis, then, is that machines will have achieved the moral status of persons when this second choice has the same character as the first one. That is, when it is a moral dilemma of roughly the same difficulty. For the second decision to be a

AMSCE-110

> dilemma, it must be that there are good grounds for making it either way. It must be the case, therefore, that it is sometimes legitimate to choose to preserve the existence of the machine over the life of the human being. These two scenarios, along with the question of whether the second has the same character as the first, make up the "Turing Triage Test."[3] (Sparrow 2004, 206)

19.2 The Importance of the Turing Triage Test

I noted earlier that the question of the moral standing of machines will arise with great urgency the moment scientists claim to have created an intelligent machine. Having switched their AI on, researchers will be unable to switch it off without worrying whether in doing so they are committing murder! Presuming that we do not wish to expose AI researchers to the risk that they will commit murder as part of their research, this is itself sufficient reason to investigate the Turing Triage Test.[4] However, the question of when, if ever, AIs will become persons is also important for a number of other controversies in "roboethics" and the philosophy of artificial intelligence.

As intelligent systems have come to play an increasingly important role in modern industrialized economies and in the lives of citizens in industrial societies, the question of whether the operation of these systems is ethical has become increasingly urgent. At the very least, we need to be looking closely at how these systems function in the complex environments in which they operate, asking whether we are happy with the consequences of their operations, and the nature of human interactions with such systems (Johnson 2009; Veruggio and Operto 2006). This sort of ethical evaluation is compatible with the thought that the only real ethical dilemmas here arise for the people who design or make use of these systems. However, Wallach and Allen (2009) have recently argued that it is time to begin thinking about how to build morality into these systems themselves. In their book *Moral Machines*, Wallach and Allen set out a program for designing what they describe as

AMSCE-1101

"autonomous moral agents," by which they mean machines that—they suggest—will be capable of acting more or less ethically by themselves.

The question of "machine ethics" has also arisen in the context of debates about the future of military robotics. Robots—in the form of "Predator" drones—have played a leading role in the U.S.-led invasions and occupations of Iraq and Afghanistan. The (supposed) success of these weapons has generated a tremendous enthusiasm for the use of teleoperated and semi-autonomous robotic systems in military roles (Singer 2009).[5] The need to develop robots that can function effectively without a human being in the loop is currently driving much research into autonomous navigation and machine sensing. Indeed, the logic driving the deployment of military robots pushes toward the development of "autonomous weapon systems" (AWS) (Adams 2001; Singer 2009). Given that the majority of robotics research is funded by the military, it is even probable that the first artificial intelligences (if there are any) will come to consciousness in a military laboratory.

Again, the question of the ethics of military robots can be posed in two forms. We can wonder about the ethics of the development and deployment of these systems and the ethical challenges facing those who design them (Krishnan 2009; Singer 2009; Sparrow 2009b). These investigations construe the ethical challenges as issues for human beings. However, we might also wonder if the ethical questions might, one day, arise for the machines themselves. Thus, Ron Arkin (2009) has advocated the development of an "ethical governor" to restrict the activities of autonomous weapon systems. This module of the software running an AWS would identify situations where there was a significant risk of the machine behaving unethically and either constrain the action of the system or alert a human operator who could then resolve the ethical dilemma appropriately. However, in order to be able to tell when ethical concerns arise, the AWS would need to be able to appreciate the ethical significance of competing courses of action and apply moral principles appropriately. Arkin's ethical governor will either, therefore,

AMSCE-1101

risk allowing machines to behave unethically when they fail to recognize an ethical dilemma as it arises, or will require machines themselves to be capable of thinking—and acting—ethically themselves.

It is without doubt possible to build better or worse robots, which generally produce good or bad outcomes. Perhaps, as Arkin (2009) and Wallach and Allen (2009) suggest, it will encourage better outcomes if we look to design robots that have moral rules explicitly represented in their programming or use moral goals as measurements of the fitness of the genetic algorithms that will ultimately guide them. However, before it will be appropriate to describe a machine as a moral agent, it must first be possible to attribute responsibility for its actions to the machine itself, rather than, for instance, its designer, or some other person. As I have argued elsewhere (Sparrow 2007), if it is to be plausible to hold a machine morally responsible for its actions, it must also be possible to punish it. This in turn requires that it be possible to wrong the machine if we punish it unjustly. The ultimate injustice would be capital punishment— execution—of an innocent machine. Yet, if machines lack moral standing then there will be no direct wrong in killing them and consequently no injustice. If there is no injustice in killing a machine there can be no injustice in lesser punishments. It is that chain of conceptual connections that links moral agency to personhood via the possibility of punishment.[6] Only persons can be moral agents and there will be no genuinely moral machines until they can pass the Turing Triage Test.

The use of robots in military operations has also generated a larger ethical debate about the ethics of the development and deployment of autonomous weapon systems (Krishnan 2009; Singer 2009; Sparrow 2009a); and the question of when (if ever) machines will become persons turns out to be crucial to several of the controversies therein.

Enthusiasm for the use of robots in war stems largely from the fact that deploying robots may help keep human beings “out of harm’s way”

AMSCE-101

(Office of the Secretary of Defense 2005).[7] Yet sending a robot into battle instead of a human being will only represent ethical progress as long as machines have less moral standing than human beings. The moment that machines become persons, military commanders will need to take as much care to preserve the "lives" of their robots as they do with human warfighters. The question of the moral standing of machines is therefore crucial to the ethics of using them to replace human beings in dangerous situations.

Hostility toward the use of robots in war often derives from the intuition that it is wrong to allow robots to kill human beings at all. It is actually remarkably difficult to flesh out this intuition, especially in the context of the role played by existing (nonrobotic) technologies in modern warfare, which includes both long-range (cruise missiles and high-altitude bombing) and automatic (antitank mines and improvised explosive devices) killing. However, one plausible way to explain at least part of the force of this thought is to interpret it as a concern about the extent to which robots are capable of fulfilling the requirements of the *jus in bello* principle of discrimination. This central principle of just war theory requires those involved in fighting wars to refrain from targeting noncombatants (Lee 2004). There are ample grounds for cynicism about the extent to which robotic systems will be capable of distinguishing legitimate from illegitimate targets in the "fog of war." Whether an enemy warfighter or system is a legitimate target will usually depend upon a complex range of competing and interrelated factors, including questions of intention, history, and politics, which robots are currently—and will remain for the foreseeable future—ill suited to assess. Nevertheless, as Ron Arkin (2009) argues, there are some—albeit perhaps a limited number of—scenarios in which it is plausible to imagine robots being more reliable at choosing more appropriate targets than human warfighters. In counterfire scenarios or in air combat, wherein decisions must be made in a fraction of a second

AMSCE-101

on the basis of data from electronic sensors only, autonomous systems might well produce better results than human beings.

Yet, it still seems that this pragmatic defense of AWS leaves much of the force of the original objection intact. Allowing machines to decide who should live or die in war seems to treat the enemy as vermin—to express a profound disrespect for them by implying that their actions and circumstances are not worth the attention of a human being before the decision to take their lives is made. Arkin's argument for the development and application of AWS proceeds by means of speculation about the consequences of using AWS to replace human warfighters in some circumstances. If we adopt a nonconsequentialist account of the origins and force of the principles of *jus in bello*, as advocated in an influential paper by Thomas Nagel (1972), then we may start to see why autonomous weapon systems might be problematic. Nagel argues that—even in warfare—relations between persons must acknowledge the "personhood" of the other. That is, even while they are trying to kill each other, enemies must each acknowledge that they are both Kantian "ends in themselves." If Nagel is correct in this then, *contra* Arkin, AWS will not be able to meet the requirements of the *jus in bello* principle of discrimination until they become persons.[8]

The question of the moral standing of machines—and thus the Turing Triage Test—is therefore crucial to several of the key questions in contemporary debates about machine ethics and the ethics of robotic weapons.

19.3 Understanding the Turing Triage Test

In my original (Sparrow 2004) discussion of the Turing Triage Test, I provided reasons for thinking it impossible for a machine to pass the test. In brief, I argued that machines would never be capable of the sort of embodied expressiveness required to establish a moral dilemma about

AMSCI-101

“killing” a machine: interested readers may wish to see that discussion for the detail of the argument. In the current context, I want to discuss some subtleties of the test that ultimately assist us in reaching a better understanding of its significance. While, at first sight, the scenario described earlier appears to hold out the prospect of developing an empirical test for determining when machines have achieved moral standing, it is more appropriate to understand the test as a thought experiment for explicating the full implications of any claim that a machine has become a moral person. For reasons that I will explore later, the application of the Turing Triage Test requires that we pay careful attention to the connection between our concepts and to the ways in which our assessment of the truth of claims depends upon how people behave as well as what they say. This in turn emphasizes the importance of making a distinction between what we can say and what we can really mean—a distinction that, I shall suggest, has been honored largely in the breach in recent discussions of the ethics of AI.

19.4 An Empirical Test for Moral Standing?

The Turing Triage Test sets out a necessary and sufficient condition for granting moral standing to artificial intelligences. Machines will be people when we can’t let them die without facing the same moral dilemma that we would when thinking about letting a human being die. One might well, therefore, imagine putting each new candidate for attribution of moral standing to the test and providing a certificate of “moral personality” to those who pass it. That is, we might hope to adopt the Turing Triage Test as an empirical test of moral standing. Given the nature of the test, it in fact might be better to conduct it as a thought experiment rather than deliberately engineer putting the lives of human beings at risk. Nevertheless, if it is plausible to imagine a machine passing this test, that would give the machine an excellent prima facie case to be considered a person.

AMSCE-1101

Unfortunately, the application of the test is not straightforward. To begin with, the Turing Triage Test is not satisfied if particular, idiosyncratic, individuals choose to save the “life” of the machine or if it were possible to imagine them doing so. If that was all that was required, it could probably be satisfied now if the person making the decision was sufficiently deranged. Instead, the actions and the responses of the person confronting the choices at the heart of the test must be subject to a test of reasonableness. A machine will pass the Turing Triage Test if a reasonable person would confront a moral dilemma if faced with the choice of saving the life of a human being or the “life” of the machine.

At first sight, this appears to be a harmless concession: as I will argue later, the procedures for testing any hypothesis rely upon an assumption that the person making the requisite observations meets appropriate standards of veracity and competence. However, as we shall see, the need to introduce this qualification ultimately calls into question the extent to which we could use the Turing Triage Test as an empirical test for moral personhood.

The question of the reasonableness of an individual’s way of relating to a machine becomes central to the possibility of the application of the test because human beings turn out to be remarkably easy to fool about the capacities of machines, at least for a little while. It is well known that people are very quick to anthropomorphize machines and to attribute motivations and emotional states to them that we would normally think of as being only possessed by human beings or (perhaps) animals (Wallach and Allen 2009). Popular robot toys, such as Aibo, Paro, and Furby, as well as research robots such as Cog and Kismet have been designed to exploit these responses (Brooks 2003).

I must admit to a certain cynicism about the extent to which such anthropomorphism includes the genuine belief that machines have thoughts and feelings, let alone moral standing. Interpreting human behavior is notoriously difficult, with the result that it is easy to read

AMSCE-IIOT

into it the intentions that we desire. Studies of human–robot interaction often are short term and encourage impoverished uses of the concepts that are internal to the attitudes they purport to be investigating. Much of this research is carried out by computer scientists or engineers rather than by social scientists and, consequently, the researchers are often insufficiently aware of the difficulties involved in accurately attributing beliefs to experimental subjects. In particular, self-report does not necessarily establish the existence of the relevant belief. That is, someone might say that, for instance, the reason why they were reluctant to strike a machine (Bartneck et al. 2007) was that they didn't want to cause the machine pain, without really believing that the machine could feel pain. They may have been speaking metaphorically—or using words "as if"—without explicitly noting the fact: the proper description of their beliefs would include a set of quote marks (Sparrow 2002). One way of testing whether or not this is the case is to look at their behavior over the longer term or to investigate whether or not their other beliefs and desires are consistent with their avowed beliefs. Would they bury a robot and mark its grave in the way that we might for a beloved pet? Would they seek emotional support from their friends after the trauma of "killing" a robot? We might also wonder if a person who states that he or she is worried that his or her robot pet is bored or that one's laptop is distressed is serious. That is, we might wonder if the person stands behind their claims in a way that is essential to the distinction between asserting a deeply held truth and offering a casual opinion: I will discuss this further later in the chapter.

In the meantime, we can go some way toward rescuing the Turing Triage Test from the charge of unreliability by emphasizing that, in order to pass the test, the person faced with the triage situation must confront a moral dilemma. This sets the bar for passing the test much higher than merely having to have some emotional reaction to machines. One does not experience a moral dilemma simply because one is unsure what to do; rather, moral dilemmas require that one is genuinely torn in

AMSCE-IIOL

making a decision, and that whatever one does it will be understandable if it is cause for profound regret or remorse. Where the dilemma involves choosing to sacrifice the life of someone, it must at least be conceivable that the person making this choice be haunted by what they have done (Sparrow 2004). It is much less obvious that people do attribute the properties to machines that would make this response plausible.

Nevertheless, it seems that we can always imagine a scenario wherein a sufficiently complicated machine passes the Turing Triage Test—in the sense that those wondering whether to allow the machine or the human being to die experience an emotionally compelling dilemma—without having anything more than sophisticated means of engaging human emotional responses. Yet, even if some people genuinely did believe that it was appropriate to mourn the death of a machine, this would still not be enough to establish that we should pay attention to these beliefs. That some people report seeing canals on Mars after looking through low-power telescopes is little evidence for their existence. The value of an observation depends upon the situation—and the qualities—of the observer. If a properly situated observer, using an appropriately high-powered telescope, reported seeing canals on Mars, that would be better evidence. However, even in this case, it remains open to us to doubt the eyesight, or perhaps even the sanity, of the observer. If the observer is suffering from delusions or is untrustworthy, we may well be justified in discounting their report. Thus, before we conclude that a machine has moral standing on the basis that people would in fact mourn its death, we need to think about how reliable the data is in support of this conclusion. When the relevant data consists in the moral intuitions of individuals, then the proper measure of its quality is the reasonableness of these intuitions themselves. Unless we introduce such consideration of the reasonableness of people's responses, the Turing Triage Test inherits and suffers from the behaviorism that shaped the formulation of the original Turing Test.

AMSCI-101

19.5 The Implications of Machine Personhood

If, as I have argued here, the Turing Triage Test is best understood as the claim that machines will have moral standing when it is reasonable for a person facing a choice about whether to sacrifice the “life” of a machine or the life of a human being to choose to sacrifice the human being, then it may appear that the test can be of no practical use whatsoever. After all, the question of whether or not it is reasonable to care about the “deaths” of machines, just *is* the question of whether or not they have moral standing. However, at the very least, the test advances our understanding of the implications of claims about the moral standing of machines by dramatizing them in this way: anyone who wishes to assert that machines have personhood is committed to the idea that sometimes it might be reasonable to let a human individual die rather than sacrifice a machine. The burden of the argument, then, is substantial.

19.6 Concepts and Their Application

Moreover, as I argued at length in the original paper, I do not believe that this observation is empty or trivial. There are limits placed on the reasonable application of moral concepts by their relation to other concepts, both moral and nonmoral. As the later Wittgenstein—and philosophers following him—argued, our concepts have a structure that is in turn connected to certain deep features of our social life and human experience (Wittgenstein 1973; Gaita 1991, 1999; Winch 1980–1981). The conditions of the application of our concepts—how we can recognize whether they are being used properly or improperly—include bodily and emotional responses, as well as relations to other concepts and to things that it does or does not make sense to do and say. In the current context, our concepts of life and death, and the deliberate taking

AMSCE-1101

—or conscious sacrificing—of human life, are intimately connected to our sense of the unique value of each individual human life, the appropriateness of grieving for the dead, and the possibility of feeling remorse for one's deeds (Gaita 1990). They are also crucially connected to the forms that grief, remorse, and the recognition of the individuality of others can take. That is to say, in order to be able to make sense of claims about the life and death of moral persons, we must make reference to the contexts in which it would make sense to make similar claims, and to the various ways in which we might distinguish in practice between subtly different claims (for instance, about grief, remorse, or regret) and between appropriate and inappropriate uses of relevant concepts. We need to have access to the distinction between serious claims, which both express and implicate the authority of the utterer, and claims made in jest, in passing, or in other distorted and derivative registers. This will, in turn, require paying detailed attention to things like the tone of voice in which it would be appropriate to make a particular claim, the emotions it would express and presuppose, and the facial expressions and demeanor that we would expect of someone making such a claim. In short, it will require paying attention to the subtle details of our shared moral life.

When it comes to the question as to whether or not it might ever be reasonable for us to experience a moral dilemma when forced to make a choice between the life of a person and a machine, then, we must think not just about—what we would ordinarily understand to be—the philosophical quality of arguments in favor of the moral standing of machines, but also about what would be involved in seriously asserting the various claims therein in more familiar everyday contexts. I am inclined to believe that this makes the burden of the argument that machines could be persons that much heavier. It also suggests that before machines can become persons they will need to become much more like human beings, in the sense of being capable of a much richer,

AMSCE-101

subtler, and more complex range of relationships than was involved in the original Turing Test for intelligence.[9]

19.7 The Limits of Human Understanding?

Some readers will undoubtedly balk at the manner in which my discussion has linked the question of the moral standing of machines, and other nonhuman entities, to the ways in which we might acknowledge and recognize such standing. Surely, it is possible that human beings could just be inclined toward something akin to racism, such that our failure to recognize the moral personality of intelligent machines might reflect only our own bigotry and limitations, rather than any truth about the qualities (or lack thereof) of machines?

I am confident that at least one common form of this objection is misguided. I have not claimed here that the moral standing of machines depends upon our actually, in fact, recognizing them as having moral standing. Indeed, I have deliberately allowed for the possibility that contingent human responses to intelligent machines might diverge from the responses that we should have toward them. Instead, my argument has rather concerned the conceptual possibility of recognizing machines as persons: I have suggested that the issue of the moral standing of machines cannot be divorced from the question of the proper conditions of application of the only concepts that we possess that might allow us to recognize "machine persons." Any conclusions that we wish to draw about whether or not machines might be persons or what would be required for them to become persons must be drawn from this fact, rather than from claims about empirical human psychology.

It may still seem that this concedes too much to a destructive relativism by leaving open the possibility that there might be machines with moral standing that we simply could not recognize as such. Whether this is the case or not—and whether it would reflect a deficit in

AMSCL-110l

the argument if it did—will depend upon what we can legitimately expect from a philosophical argument and from the reasoning of necessarily contingent and embodied creatures such as ourselves. This is a much larger question than I can hope to settle here. In the current context, I must settle for the observation that the idea that we might be ultimately limited in our ability to believe seriously some of the things that we can imagine, seems no less implausible than the idea that we could reach reliable conclusions through arguments that deploy concepts in the absence of the judgments that give them their sense.

19.8 Thinking Seriously about Machines . . .

The larger argument I have made here insists that it is essential to distinguish between what we can mean seriously and what we can merely say when we begin trying to extend the application of our concepts in the course of philosophical arguments. In particular, claims that we can make, and appear to understand, in an academic or philosophical context may prove to be much more problematic once we start to think about what it would mean to assert them in more familiar (and important!) circumstances, such as in the context of a practical dilemma.

There are powerful cultural and institutional forces at work in the academy today—and at the intersection between the academy and the broader society—which discourage paying attention to this distinction. It is easier to win a government grant if one promises extraordinary things rather than admit that one’s contributions to the progress of science are likely to be marginal and incremental. Similarly, it is easier to attract media attention, which itself helps attract grant money, if one describes one’s research results as heralding a revolution or if one predicts discoveries or outcomes that accord with popular narratives about what the future might look like. In the face of these temptations, it

AMSCE-1101

is little wonder that some robotics researchers and academics have started to speak in hushed or extravagant tones about the coming brave new world of intelligent machines. Nor is it a surprise that philosophers and ethicists—who are increasingly under the same pressures to chase funding and publicity—have joined in this discussion and started to write about the ethical dilemmas that might arise if various science-fiction scenarios came about.

I am not denying that it is possible to write or speak about these questions: much has been written about them already. Rather, I want to draw attention to the importance of the tone in which such matters are discussed. In particular, I want to ask how we would tell whether someone was serious in their conclusions, or was instead merely trying them on. How could we tell if they mean what they say?

The easy form of this inquiry simply asks if participants in debates about the future of robotics are willing to draw the other intellectual conclusions that would follow if we did take their claims seriously. Do those who think machines will soon become more intelligent than human beings really believe that we would then be morally compelled to preserve the life of an AI over that of a person, as would seem to follow? If research on AI is threatening to bring a "successor species" to humanity into existence, shouldn't we be having a serious global public debate about whether we wish to prohibit such research? What does it mean to hold a "moral machine" responsible for its actions? Asking such questions would go some way toward distinguishing those who are serious about their claims from those who are merely writing in a speculative mode.

However, I have suggested that it will be equally—if not more—important to interrogate the manner in which such claims are made. Are they sober and responsible, or wild and exaggerated? Are they sensible? Could we imagine someone asserting them in any other context than a philosophical argument, and if they did, how would we tell whether they were talking seriously or in jest? Asking these sorts of questions is vital

AMSCE-101

if we wish to avoid being led astray by the use of concepts and arguments in the absence of the critical vocabulary that would ordinarily give them their sense. It should come as no surprise to the reader to hear that it is my suspicion that the class of claims about the ethics of AI that might be asserted soberly and sensibly on the basis of our existing knowledge of the capacities of robots and computers is significantly smaller than that currently being discussed in the literature.

Perhaps the most important lesson to be drawn from thinking about the Turing Triage Test, then, is that questions about the ethics of robotics are intimately connected to other philosophical questions, including the question of the nature of the philosophical method itself. These questions will remain important even if the promise—and threat—of intelligent machines never eventuates: the real value of conversations about robots may turn out to be what these conversations teach us about ourselves.

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Notes

[1]. The first chapter of Simons 1992 describes the many appearances of mechanical and artificial people in myth and legend.

AMSCE-101

[2] How to define “intelligence” and “artificial intelligence” are, of course, vexing questions. However, this chapter will presume that “intelligence” refers to a general-purpose problem-solving cognitive capacity ordinarily possessed by adult human beings and that “artificial intelligence” would involve the production of such intelligence in a machine. Questions about the moral standing of machines will only arise if researchers succeed in creating such “strong” AI.

[3] This formulation of the Turing Triage Test introduced the test in the context of the discussion of the role played by the original Turing Test in the historical debate about the prospects for machine intelligence, which accounts for the reference to the Turing Test in this passage. In particular, in an earlier section of my 2004 paper I had argued that in order to be a plausible candidate for the Turing Triage Test, a system would first have to be capable of passing the Turing Test: this assumption is not, however, essential to the Turing Triage Test.

[4] It is arguable that killing an artificial intelligence because of a lack of appreciation of its moral standing should be categorized as manslaughter or some other lesser category of offense, rather than murder, on the grounds that it would not involve the deliberate intention to take a life that is essential to the crime of murder. A crucial question here will be whether a lack of awareness of the moral standing of the entity toward whom one’s lethal actions were directed is sufficient to exclude the conclusion that the killing was intentional: in the scenario we are imagining, the actions taken to “kill” the AI would be deliberate, and the intended result would be the destruction of the AI, but the knowledge that the AI was a moral person would be absent. In any case, regardless of whether the appropriate moral or legal verdict is murder, manslaughter, negligent homicide, or some other conclusion, clearly this scenario is one we should strive to avoid.

[5] The caveat here arises from the question as to whether the tactical successes of the Predator drone mask—or, even, have produced—a larger strategic failure owing to a profound mismatch between the capacity to rain death from the skies onto individuals and the ability to establish the political conditions that might make possible a stable government in a nation under foreign occupation (Kilcullen and Exum 2009).

[6] The argument here has of necessity, given space constraints, been extremely swift. For a longer and more thorough exposition, see Sparrow 2007.

[7] For some reservations about the extent to which this is likely to happen, see Sparrow 2009b.

AMSCE-101

[8]. Again, for a longer discussion of these issues, see Sparrow 2011.

[9]. See Sparrow 2004 for further discussion.

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AMSCE-1101

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AMSCE-1101

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AMSCE-1101

20

Robots with Biological Brains

Kevin Warwick

As will be discussed here, it is now possible to grow a biological brain and allow it to develop within a robot body (Warwick et al. 2010). The end result is a robot with a biological brain. If the size and power of such a brain is relatively small, in comparison with that of a human brain, then the issues are arguably limited. But when brainpower is comparable, then the problem clearly is of considerable significance.

The following section describes the technology and processes involved. Then, developments in the field are discussed along with future potential advancements. The chapter then examines resultant implications of such technological opportunities. When considering the ethical implications of robots in general, merely to look at robots that have computer brains would only be investigating part of the issue. Robots with biological brains and robots with hybrid brains present significant problems, which need to be addressed.

AMSCE-1101

20.1 The Technology

The controlling mechanism of a typical mobile robot is presently a computer or microprocessor. Much of the initial work considering the future ethics and rights of robots has apparently focused only on this subclass of intelligent robots (Arkin 2009). Research is now ongoing in which biological neuronal networks are being cultured and trained to act as the brain of a physical, real-world robot—completely replacing a computer system.

From a medical standpoint, studying such neuronal systems can help us to understand biological neural structures in general, and it is to be hoped that it may lead to basic insights into problems such as Alzheimer's and Parkinson's disease. Other research, meanwhile, is aimed at assessing the learning capacity of such neuronal networks (Xydas et al. 2008). To do this, a hybrid system has been created incorporating control of a mobile wheeled robot, solely by a culture of neurons—a biological brain.

Such a brain is brought about by first dissociating or separating the neurons found in cortical tissue using enzymes and culturing them in an incubator, providing suitable environmental conditions and nutrients. In order to connect a brain with its robot body, the base of the incubator is composed of an array of multiple electrodes (a multielectrode array—MEA) providing an electrical interface to the neuronal culture (Thomas et al. 1972).

Once spread out on the array and fed, the neurons spontaneously begin to grow and shoot branches. Even without any external stimulation, they begin to reconnect with other neurons and commence electrochemical communication. This propensity to connect spontaneously and communicate demonstrates an innate tendency to network. The neuronal cultures form a layer over the electrodes on the base of the chamber, making them accessible to both physical and chemical manipulation (Potter et al. 2001).

The multielectrode array enables voltages from the brain to be monitored on each of the electrodes, allowing the detection of the action-potential firing of neurons near each electrode as voltage spikes, representative of neural charge transfer. It is then possible to separate the

AMSCE-101

firing of multiple individual neurons, or small groups, from a single electrode (Lewicki 1998).

With multiple electrodes, an external picture of the neuronal activity of the brain can be pieced together. It is, however, also possible to electrically stimulate any of the electrodes to induce neural activity. The multielectrode array, therefore, forms a functional and nondestructive bidirectional interface with the cultured neurons. In short, via certain electrodes, the culture can be stimulated, and via other electrodes, the culture's response can be measured.

A disembodied cell culture can be provided with embodiment by placing it in a robot body, such that signals from the robot's sensors stimulate the brain, while output signals from the brain are employed to drive the motors of the robot. This is sensible since a dissociated cell culture receiving no sensory input is unlikely to develop useful operation because such input significantly affects neuronal connectivity and is involved in the development of meaningful relationships.

Several different schemes have thus far been constructed in order to investigate the ability of such systems. Shkolnik created a scheme to embody a culture within a simulated robot (Shkolnik 2003). Two channels of a multielectrode array, on which a culture was growing, were selected for stimulation and a signal consisting of a 600mVolts, 400µsecs biphasic pulse was delivered at varying intervals. The concept of information coding was formed by testing the effect of electrically inducing neuronal excitation with a given time delay between two stimulus probes. This technique gave rise to a response curve used to decide the simulated robot's direction of movement using simple commands: forward, backward, left, and right.

Subsequently, DeMarse and Dockendorf introduced the idea of implementing the results in a real-life problem, namely that of controlling a simulated aircraft's flight path, for example, making altitude and roll adjustments (2005).

AMSCE-101

20.2 Embodiment

For the purpose of growing the robot's brain, the neural cortex from a rat fetus is removed. Enzymes are applied to disconnect the neurons from each other. A thin layer of these disassociated neurons is smoothed out onto a multielectrode array, which sits in a nutrient bath. Every two days the bath must be refreshed to provide a food source for the culture and to flush away waste material.

As soon as the neurons have been laid out on the array, they start to project tentacles and thereby reconnect with each other. These projections subsequently form into axons and dendrites. By the time the culture is only one week old, electrical activity can be witnessed to appear relatively structured and pattern forming in what is, by that time, a very densely connected matrix of axons and dendrites.

The multielectrode array employed by my own research team consists of a glass specimen chamber lined with electrodes in an 8 × 8 array, as shown in figure 20.1. The array measures 49 mm × 49 mm × 1 mm, and its electrodes provide a bidirectional link between the culture and the rest of the system.

AMSCE-101

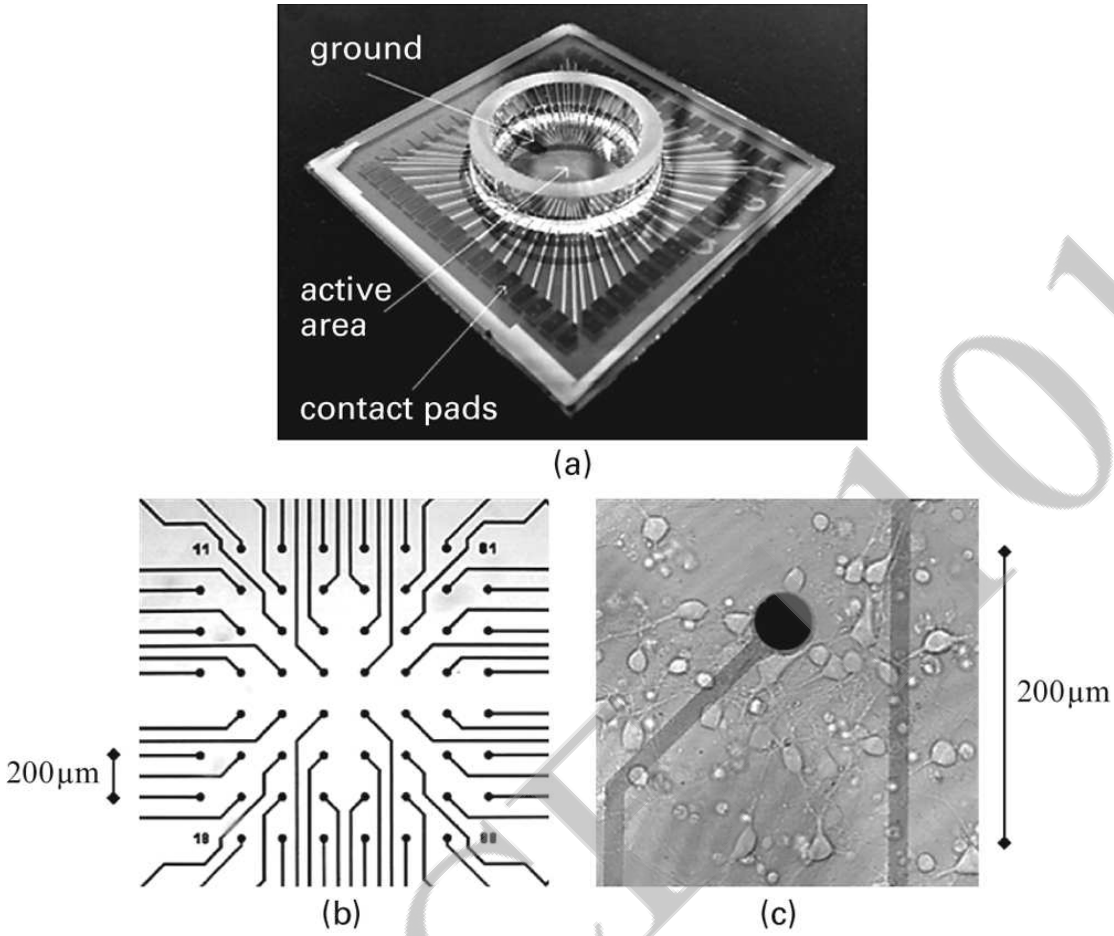


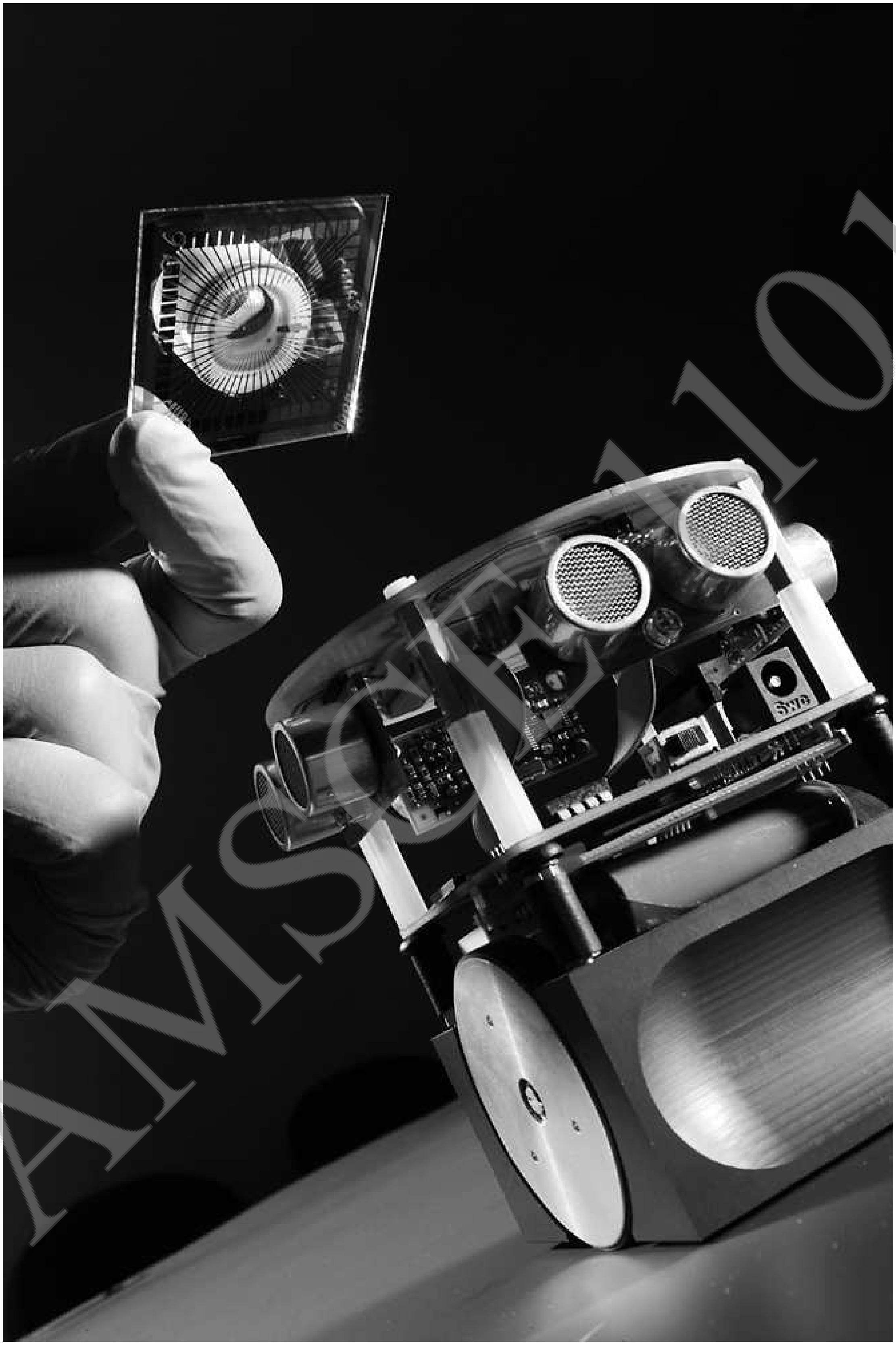
Figure 20.1
(a) A multielectrode array showing the 30µm-diameter electrodes; (b) electrodes in the center of the MEA seen under an optical microscope; and (c) ×40 magnification, showing neuronal cells with visible extensions and inner connections.

Thus far, we have successfully created a modular closed-loop system between a “physical” mobile robotic platform and a cultured neuronal network using the multielectrode array method, allowing for bidirectional communication between the culture and the robot. Each culture consists of approximately 100,000 neurons. The electrochemical activity of the culture is used as motor input to drive the robot’s wheels, and the robot’s ultrasonic sensor readings are proportionally converted into stimulation signals received by the culture as sensory input, effectively closing the loop and giving the culture a body.

AMSCI101

We have selected a Miabot robot as the physical platform. This exhibits very accurate motor encoder precision and speed. Hence, the signals passing to and from the culture have an immediate and accurate real-world physical meaning. Figure 20.2 shows the robot employed along with an adjacent culture on a multielectrode array—body and brain together. The robot is wirelessly controlled by the culture in the incubator via a Bluetooth connection.

AMSCE-1101



AMSCE101

Figure 20.2
Multielectrode array with culture, close to Miabot robot.

20.3 Experimentation

We have conducted a series of experiments utilizing a live culture. Initially, an appropriate neuronal pathway within the culture was identified and suitable stimulus electrodes and response/motor electrodes were chosen. The selection was made based on the criteria that the response electrodes show minimal spontaneous activity in general but respond robustly and reasonably repetitively to the stimuli (a positive-first biphasic waveform; 600mVolts; 100μsecs each phase) delivered via the stimulating electrodes. These spontaneous events were deemed meaningful when the delay between stimulation and response was less than 100m. Hence, an event was a strong indicator that the electric stimulation on one electrode caused a neural response on the recording electrode (Warwick et al. 2010).

The overall task the robot had to achieve was to move forward in a corral and not bump into an object, for example, a wall. The robot followed a forward path until it reached a wall, at which point the front sonar value dropped below a set threshold value triggering a stimulation/sensory pulse applied to the culture. If the responding electrode registered activity following the pulse, the robot turned in order to avoid the wall.

In its early life, the robot sometimes responded correctly by turning away from the wall, although it also bumped into the wall on numerous occasions. The robot sometimes turned spontaneously when activity was registered on the response electrode without a stimulus pulse being applied. The main results highlighted, though, were the chain of events: wall detection, stimulation, response.

AMSCE-101

The maximum speed at which the closed-loop system could respond was clearly dependent on the “thinking” time delay in the response of the culture. This presents an interesting possibility, of studying the response times of different cultures under different conditions and how they are affected by external influences such as electrical fields and chemical stimulants, for example, cannabis and alcohol.

The robot’s individual (right and left separately) wheel speeds were then controlled from the two chosen response/motor electrodes. Meanwhile, received sonar information was used to directly control proportionally the stimulating frequency of the two sensory electrodes.

Run-times have thus far generally been executed for approximately one hour at a time. The robot’s corral is presently being fitted with a special-purpose powered floor, which will allow for the study of a culture embodied 24/7 over an extended period. Of considerable interest is whether or not the culture requires much in the way of down time (sleep equivalent), how quickly its performance improves, and if its useful lifespan increases.

A “wall to stimulation” event corresponds to the 30cm threshold being breached on the sensor, such that a stimulating pulse is transmitted to the culture. Meanwhile, a “stimulation to response” event corresponds to a motor command signal, originating in the culture, which is transmitted to the wheels of the robot, causing it to change direction. It follows that some of the “stimulation to response” events will be in considered response to a recent stimulus, termed meaningful. Whereas other such events, termed spontaneous, will be either spurious or in considered response to some thought in the culture, about which we are unaware.

20.4 Learning

Inherent or innate operating characteristics of the cultured neural network are taken as a starting point to enable the robot body to respond. The culture then operates over a period of time within the robot body in its corral area. This experimentation takes place once every day for an hour or so. Although learning has not, as yet, been a focus of the research, what has been witnessed is that neuronal structures that bring about a satisfactory action apparently tend to strengthen through the habitual process being performed. This is mainly an anecdotal observation, which is presently being formalized through more extensive studies.

At first, a stimulation-motor response feedback action occurs on some, but not all, occasions. The action can be brought about sometimes without any sensory signal being applied. After habitually carrying out the required action for some time, the neural pathways that bring this about appear to be strengthened—referred to as Hebbian learning (Hebb 1949). As a result of this learning, appropriate actions gradually become more likely to occur and spurious, unprovoked decisions to suddenly turn become less likely.

Research is ongoing to use other learning methods to quicken the performance upgrade, reinforcement learning being one example. One major problem with this is deciding what the culture regards as a reward and what as a punishment.

20.5 The Methodology

The Miabot robot is being extended to include additional sensory devices, such as audio input, further sonar arrays, mobile cameras, and other range-finding hardware, such as an onboard infrared sensor. A considerable limitation is, however, the battery power supply of an otherwise autonomous robot.

AMSCE-101

Therefore, at present a main consideration is the inclusion of a powered floor for the robot's corral, to provide the robot with relative autonomy for a longer period of time while the suggested machine learning techniques are applied and the culture's behavioral responses are monitored.

The mapping between the robot goals and the culture input/output relationships will be extended to machine learning techniques, which will ultimately reduce, or completely eliminate, the need for an a priori mapping choice. The aim is for reinforcement learning techniques to be applied to various mobile robot tasks, such as wall following and maze navigation.

One key aspect of the research is a study of the cultured neural network in terms of its observed connectivity density and activity in response to external stimuli. This behavioral evaluation should provide an insight into the workings of the neuronal network by comparing its learning capabilities in terms of its neural plasticity.

20.6 Observations

It is normal practice for several cultures to be started at the same time. A typical number may be twenty-five different cultures. By using the same Miabot robot body, it is then possible to investigate similarities and differences between the cultures within an identical body. Clearly, each culture is unique, has its own individual identity in the sense of it being recognizable (Lloyd 1991), and is dependent on the original neural layout, its growth, and development.

In terms of robot performance, such cultural differences can be manifest in a robot that performs with fewer mistakes, one that responds more quickly or slowly, one that does its own thing more often or responds only after several signals are received. There can be a large

AMSCE-101

number of observed differences in behavior even with a relatively simple task to be performed.

The behavioral response of an animal can be difficult to comprehend. The overall neural requirements of the animal are not particularly understood, and may appear as meaningless to humans. The advantage with our robot system is that its behavior can be investigated directly in terms of neural development—even in response to the effect on the culture of small changes in the environment.

Cultures can be kept alive for perhaps two years or even more. After about three months or so, they become much less active and responsive and hence, most research involves cultures aged between one week and three months. This period is sufficient to consider culture development and neural pathway strengthening. Present lifetime expectancy is limited, due to vulnerability to viruses and the need to establish rigorous growth conditions.

In its robot body, a culture exhibits regular neural pathway firings. Some of these can be diagnosed as responses to stimulating sensory signals; the majority cannot be so classified. The nature of other signaling can only be guessed. However, neurons close to a stimulating electrode appear to play a role as sensory-input neurons. Meanwhile, others close to output electrodes appear to take on a role as motor neurons. There are other neurons that appear to play a routing, controlling activity. Such specialization seems to arise naturally through the culture's development. But the exact role of each of these neurons is mere speculation and will remain, for the moment at least, as anecdotal observation.

When embodied, it is possible to relate neural firings to sensory stimulating signals and/or decisions taken by the culture for specific motor outputs. What is not so straightforward, however, is explaining such firings when the culture is disembodied and is merely sitting alone in the incubator. Such a case is relatively normal for the culture, but is

AMSCE-IIOT

not experienced by an animal or human, whose brain lives its entire life receiving sensory input and making motor output decisions—other than possibly when in a dream state. Within the incubator, structured neural firings can be witnessed and the question arises as to what these firings mean.

Observing the activity in a culture leads to speculation. When the culture is disembodied, does it dream? If not, what is it thinking about? What must it feel like to be the culture? Do the firings relate to previously experienced sensory stimulation? Does a brain need external stimulating signals in order to subsequently make up stories?

20.7 Questions

When the culture is disembodied, no sensory signals are being input, yet neurons within the culture still fire in an occasional structural way. Connecting electrodes into the culture in order to measure the signals affects the culture and, in a sense, embodies it. Questions could be asked as to what does its body mean to the culture? Or who or what does the culture think it is?

As an alternative, human neurons can be employed, rather than rat neurons, as the brain of the robot. This presents a few different technical challenges; however, it is possibly more of an ethical rather than a technical problem. It is hoped that any results obtained in embodying cultured human neurons within a physical robot body will produce much more meaningful results, in terms of studying human neural conditions, and perhaps gaining an understanding of several mental conditions, as indicated by a leading consultant neurosurgeon (Aziz 2009).

Human neurons can also be readily obtained from embryos and cultured after dissociation. The use of human neurons does, however, raise other questions. For example, rather than obtaining neurons from

AMSCE-1101

embryos, humans could be willing to donate their own neurons—either before or after death. Wouldn't an individual like to live on in some form at least, in a robot body? Also, human neurons would not necessarily have to be dissociated; they could be laid out on the electrode array as slices. In this case, it would be interesting to see if some aspect of behavior remained and if experiences of the brain remained.

It would be a way of keeping hold of a loved one who became seriously ill. Indeed, if we are looking forward to a time when humans have robots looking after them around the home—wouldn't it be better for the robot to "know" its housemate? If a loved one is soon to die, scientists could take away neuron slices, culture them, and return them as the brain of a new robot. Maybe the robot would exhibit some of the emotions and characteristics from the loved one that would bring back memories. But for human neurons, with some awareness of their new existence, how would old memories sit with this? Would it be too traumatic an experience?

20.8 Consciousness

We cannot go far with culturing robot brains before we must ask the question as to whether the brain experiences consciousness. At present, a brain, on a two- dimensional array, contains around 100,000 neurons, nothing like the 100 billion neurons in a human brain. For those who feel size is important, then maybe consciousness cannot yet be considered.

But lattice culturing methods are being investigated that allow for a three- dimensional culture to be grown. A three-dimensional brain being embodied means we have a robot brain with 30 million neurons. Looking ahead, a 4,000 × 4,000 two-dimensional structure would result in a three-dimensional brain of over 60 billion neurons—more than half

AMSCE-101

the size of a typical human brain, and approaching that of an elderly human.

There are many different philosophical arguments as to the nature and extent of consciousness. There are those who feel that it is a unique quality of the human brain (Penrose 1995), whereas others believe it is a property of all creatures, and neurons of other animals have the same functionality as human neurons (Cotterill 1997 and 1998).

So what of the consciousness of our robot when it has a brain of 60 billion densely packed, highly connected, and developed human neurons? Will it have genuine understanding and genuine intelligence (Penrose 1995)? If so, we will definitely have to think about giving the robot voting rights, allowing it to become a politician or a philosophy professor if it wants to, and putting it in prison if it does something it shouldn’t.

But what are the arguments against our robot being conscious? Perhaps 60 billion is still not 100 billion, and that’s it? But then we will need to start counting the number of brain cells in each human’s head, such that those whose total falls below a threshold (let’s say 80 billion) will find themselves no longer classified as a conscious being. Perhaps we will need some basic test of communication such as the Turing Test (Turing 1950) and everyone must achieve a basic standard in order to avoid the cut.

Could it be emotional responses that are important? But if the robot has human neurons, couldn’t it experience similar (if not the same) emotions to humans? But are we actually interested in an identical form of consciousness to that of a human, or rather just some form of consciousness?

Is it possible our robot must have the same sensory input as humans to be considered conscious? Well, even now audio input abilities are being given to the robot; olfactory (smell) is another short-term possibility, along with basic touch and vision systems. The only

AMSCE-101

difficulty appears to be with taste, due to its subjectivity. But surely we would not suggest that people who have no sense of taste are not conscious. Or that those who are blind or have a hearing deficiency also lack consciousness. Sensory input, in itself, is not critical to one's status as a conscious being.

More contentious would be an argument suggesting that motor skills are important to consciousness. The robot moves around on wheels. Most humans move around on two legs and manipulate with two arms. But some humans move around on wheels. Meanwhile, other humans have no arms or, in a few cases, have robot arms. Then there are those who have motor neuron disease and have limited movement abilities due to a malfunction in that specific part of their brain. It would be terrible to suggest that humans such as theoretical physicist Stephen Hawking, who has a motor neuron disease, are not conscious beings. Obviously, motor skills cannot be considered as a tester for consciousness. Indeed, we are at present embodying a culture in a biped walking robot body, with arms and hands that can grasp and pick up. Overall, soon this robot may well have better motor performance abilities than some humans.

The fact that our robot has a physical robot body is, therefore, not a reason to claim that it is not a conscious being.

20.9 An Education

What we are left with are the two critical properties of nature and nurture—arguably, the basic elements of human intelligence. Are we going to deny that our robot is not conscious because of its educational background? It didn't have the appropriate experiences or perhaps it didn't go to the right school, therefore it is not a conscious being? We would have to start looking at the education of humans and deny some the basic rights of some individuals because they went to the wrong

AMSCE-101

school—clearly ridiculous. Education or nurture cannot be used as an argument against our robot's consciousness. Even the present robot, in the lab, is obtaining a university education.

So what we appear to be left with is nature. How an entity comes into being must be important as a decision-making tool as to whether or not that entity is conscious. It doesn't matter what we call it. It doesn't matter how it senses the world around it or how it interacts with its environment. It doesn't matter what education it received. All that can be important is how it came to life. If this is not the important issue, then surely we will have to admit that the robot is conscious.

Even here we have problems. It must be said that at present it does not seem possible to bring such a robot to life through some form of sexual act between two humans. But we must also allow for techniques such as test tube babies and even cloning. However, it must be realized here that the human neurons, which actually constitute the brain cells of the robot, came about in one of these manners—very likely in fact through the relatively straightforward sexual act.

Discounting educational and environmental effects, the only difference between the robot brain and a human brain might merely come down to the length of gestation. This would seem to be an extremely weak line to draw for a strong division in decision making with regard to an entity's state of consciousness, especially when we consider the situation of premature babies.

20.10 Human Variety

Possibly the case for our robot with human neurons has been made in terms of its consciousness, but possibly not, maybe there is a loophole or two. What the argument does raise, though, are questions regarding how we consider other (nonrobot) humans and, in particular, extreme

AMSCE-101

cases, such as individuals on life support mechanisms or those affected by dementia. Because our consideration of human consciousness, with its knock-on effect of awareness and rights, must necessarily apply to *all* humans, it is not merely applicable to philosophy or computer science professors.

The point here is that it is extremely difficult, if not impossible, on any practical realistic scientific basis, to exclude our robot from the class of conscious entities. On top of this, because its brain is made up of only human neurons, it is extremely difficult to find grounds on which to discriminate against it, especially when it may well be, in some ways, nearer the human norm than some disadvantaged human individuals.

20.11 Chinese Room

There may be some who feel that if the Turing Test can’t come up with a solution, then maybe the Chinese Room can (Searle 1997). But whether or not the Chinese Room argument holds water, the logic it employs is founded on the basis that human brains are different from computer/machine brains, due to the emergent property of the human brain. Any conclusions drawn are then focused on the assumption that human brains appear to have something extra in comparison with machine brains. Our robot, though, does not have a digital/computer/machine brain; rather, just like you and I, it has a brain full of biological neurons, which are potentially human neurons. If we can conclude anything at all from Searle’s Chinese Room argument, it is that our robot is indeed conscious even now.

In fact Searle (1997) stated that “the brain is an organ like any other; it is an organic machine. Consciousness is caused by lower-level neuronal processes in the brain and is itself a feature of the brain.” Searle also talks of an emergent property, which implies that the more

AMSCE-1101

neurons there are, the greater the complexity of the consciousness. This eventually results in the form of consciousness exhibited by humans. Since we assume our robot will, in time, have a brain consisting of several billion highly connected human neurons, by Searle's argument we must assume that it will have a form of consciousness. This consciousness is pretty much on terms with that of humans, whatever its physical embodiment.

I am not claiming that the emergence of some form of consciousness depends on the size of the brain and the type of the neurons; rather, my point is that at least one philosopher (Searle 1997) points to that conclusion. To deny that our robot exhibits some form of consciousness, you the reader need an alternative, scientifically based argument and a firm philosophical argument that overcomes that of Searle. Simply *not wanting* our robot to be conscious is not good enough—you need a sound argument to *prove* that it is not conscious. Otherwise, as with humans, you will need to accept that the robot is conscious, with all the ramifications that that conclusion presents.

20.12 Functionality

It could be argued that what actually matters in terms of consciousness is the functional organization of neural cells, and not just their quantity (Cotterill 1997, 1998; Asaro 2009). Indeed, it is true that, with our present-day knowledge, it would be difficult to imagine realizing anything that was a copy of part of the human brain in its functioning. This said, as the robot brain develops, even in the two-dimensional case, neurons appear to take on specific roles, including motor, sensory, routing, support, and so forth. These roles, and their performance, are possibly different from those in the human brain.

It must be said, however, that we are not trying to achieve a form of intelligence or consciousness that is an exact copy of the human version.

AMSCE-101

We wish to consider the possibility of our robot being intelligent and conscious in its own right and way, just as different humans are intelligent or conscious in different ways. The fact that our robot brain does not work in exactly the same manner as a typical human brain—if such an entity exists—is therefore only relevant to the argument if it is definitely the case that such differences are critical to the existence of consciousness in any form.

To be clear, what I am saying here is that our robot could be conscious in some way, not that it definitely is conscious. If you say that such differences may or may not be relevant, and not that they definitely are relevant, then you must agree with the point that our robot could be conscious. If, however, you say that such differences definitely are relevant, then this means that you have proven scientific evidence, not that you would simply like it to be the case. As Penrose (1995) put it, you know the "essential ingredient . . . missing from our present-day scientific picture." I personally am not aware that such scientific knowledge, regarding the existence of consciousness, exists.

20.13 Robot Rights

This brings us on to a number of key issues. At present, with 100,000 rat neurons, our robot has a pretty boring life, doing endless circles around a small corral in a technical laboratory. If one of the researchers leaves the incubator door open or accidentally contaminates the cultured brain, then they may be reprimanded and have to mend their ways. No one faces any external inquisitors or gets hauled off to court; no one gets imprisoned or executed for such actions.

With a (conscious) robot whose brain is based on human neurons, particularly if there are billions of them, the situation might be different. The robot will have more brain cells than a cat, dog, or chimpanzee, and possibly more than many humans. To keep such animals in most

AMSCE-101

countries there are regulations, rules, and laws. The animal must be respected and treated reasonably well, at least. The needs of the animal must be attended to. They are taken out for walks, given large areas to use as their own, or actually exist, in the wild, under no human control. Surely a robot with a brain of human neurons must have these rights, and more? Surely it cannot simply be treated as a thing in the lab? Importantly, if the incubator door is left ajar and this robot dies, as defined by brain death, then someone needs to be held responsible and must face the consequences.

We must consider what rights such a robot should have. Do we also need to go as far as endowing it with some form of citizenship? Do we really need to protect it by law, or is considering the possibility of robot rights simply a bunch of academics having some fun? Clearly, if you are the robot and it is you who have been brought to life in your robot body by a scientist in a laboratory, and that scientist is in complete control of your existence, it must be an absolutely terrifying experience. Remember, here we are talking about a creature being brought to life with a brain consisting of human neurons, but with a robot body. It may not be very long before such robots actually are brought into being. Would it be acceptable for me to simply take the life of such a robot when that robot has a brain consisting of 60 or 100 billion human neurons?

20.14 Future Thoughts

For some reason the topic of artificial intelligence (AI), in its classical form, was concerned firmly with getting machines to do things that, if a human did them, they would be regarded as intelligent acts (Minsky 1975). That is, AI was all about getting machines to copy humans, in terms of their intelligence, as closely as possible. There are still those

AMSCE-101

who feel that this is indeed what the subject of AI is about (Minsky 2007).

Such a view presents too many well-defined bounds, which has considerably restricted both technical and philosophical development in the field of AI. Unfortunately, significant philosophical discussion has subsequently been spent (in my view, wasted) merely on whether or not silicon brains could ultimately copy or simulate human brains. Could they do all the things that human brains do? Could they be as conscious as a human? The much more important topic of considering the implications of building machine brains, which are far more powerful than human brains, has, by many, been tossed aside as being merely in the realms of science fiction; as a result the topic is not even discussable by some scientists (e.g., Nicolelis 2010). What a shame! This is a much more interesting question because it points to a potential future in which intelligent, and possibly conscious, beings can outthink humans at every turn. If such entities can exist, then potentially this could be extremely dangerous to the future of humankind.

The size of the cultures employed thus far for neuron growth has been restricted by a number of factors, not the least of which is the dimensional size of the arrays on which the cultures are grown. One ongoing development is aimed at enlarging such arrays for future studies, not only providing more input/output electrodes, but also, at the same time, increasing the overall dimensions and thereby the number of neurons involved. If this increase in size is mapped onto a three-dimensional lattice structure, then things move on rapidly with regard to the size of individual robot brain possible.

A 300 × 300 neuron layout results in a culture of 90,000 neurons, when developed in two dimensions, at the smaller end of present-day studies. This becomes 27 million neurons in a three-dimensional latticed structure. But if this is developed to a 5,000 × 5,000 neuron layout, it results in a 25 million-neuron culture even in two dimensions, which undoubtedly we will witness before too long, and this becomes 125

AMSCE-IOI

billion in a three-dimensional lattice. It is not clear why things should stop there. As an example, moving toward a 7,500 × 7, 500 layout, this achieves 421 billion neurons in three dimensions—an individual brain that contains four times the number of (human) neurons as contained in a typical human brain.

Drawing conclusions on developing robot brains of this size, or even much, much larger, based on human neurons, is then difficult. There are certainly medical reasons for carrying out such research, for example, to investigate the possible effects of Alzheimer’s disease by increasing the overall number of useable neurons. But this approach neglects to consider the repercussions of bringing into being a brain that has the potential (certainly in terms of numbers of neurons) to be more powerful than any human brain as we know it.

The purpose of this chapter has been to consider the role of biological brains within the field of artificial intelligence and to look at their impact on some of the discussions, particularly with regard to consciousness, that have taken place. Many books have been written on these subjects, and hence it is clearly not possible to cover anything like all aspects in a single chapter. It has not been the case that I would wish to claim that such a brain is definitely conscious, but rather to consider how different concepts of what consciousness is deal with this type of brain. Each person has his or her own views on what consciousness is and what it is not. I therefore leave it up to you to reflect on how your own viewpoint is affected, if at all, by the consideration of such brains.

Is our robot with a biological brain conscious? If you feel it is not, do you have realistic scientific reasons to deny it consciousness, or do you just not like the idea of it? Think hard about the actual grounds on which you might deny consciousness to our robot. Possibly, these grounds are that it doesn’t look like you, doesn’t communicate like you, or doesn’t have the same values as you. Shame on you!

AMSCE-101

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AMSCE-1101

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AMSCE-1101

21

Moral Machines and the Threat of Ethical Nihilism

Anthony F. Beavers

AMSCE-1101

In his famous 1950 paper where he presents what became the benchmark for success in artificial intelligence, Turing notes that "at the end of the century the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted" (Turing 1950, 442). Kurzweil suggests that Turing's prediction was correct, even if no machine has yet to pass the Turing Test (1990). In the wake of the computer revolution, research in artificial intelligence and cognitive science has pushed in the direction of interpreting "thinking" as some sort of computational process. On this understanding, thinking is something computers (in principle) and humans (in practice) can both do.

It is difficult to say precisely when in history the meaning of the term "thinking" headed in this direction. Signs are already present in the mechanistic and mathematical tendencies of the early modern period, and maybe even glimmers are apparent in the thoughts of the ancient Greek philosophers themselves. But over the long haul, we somehow now consider "thinking" as separate from the categories of "thoughtfulness" (in the general sense of wondering about things), "insight," and "wisdom." *Intelligent* machines are all around us, and the world is populated with *smart* cars, *smart* phones, and even *smart* (robotic) appliances. But, though my cell phone might be smart, I do not take that to mean that it is thoughtful, insightful, or wise. So, what has become of these latter categories? They seem to be bygones, left behind by scientific and computational conceptions of thinking and knowledge that no longer have much use for them.

In 2000, Allen, Varner, and Zinser addressed the possibility of a Moral Turing Test (MTT) to judge the success of an automated moral agent (AMA), a theme that is repeated in Wallach and Allen (2009). While the authors are careful to note that a language-only test based on moral justifications or reasons would be inadequate, they consider a test based on moral behavior. “One way to shift the focus from reasons to actions,” they write, “might be to restrict the information available to the human judge in some way. Suppose the human judge in the MTT is provided with descriptions of actual, morally significant actions of a human and an AMA, purged of all references that would identify the agents. If the judge correctly identifies the machine at a level above chance, then the machine has failed the test” (206). While they are careful to note that indistinguishability between human and automated agents might set the bar for passing the test too low, such a test by its very nature decides the morality of an agent on the basis of appearances. Since there seems to be little else we could use to determine the success of an AMA, we may rightfully ask whether, analogous to the term “thinking” in other contexts, the term “moral” is headed for redescription here. Indeed, Wallach and Allen’s survey of the problem space of machine ethics forces the question of whether within fifty years one will be able to speak of a machine as being moral without expecting to be contradicted. Supposing the answer were yes, why might this invite concern? What is at stake? How might such a redescription of the term “moral” come about? These are the questions that drive this reflection. I start here with the last one first.

AMSCE-101

21.1 How Might a Redescription of the Term “Moral” Come About?

Before proceeding, it is important to note first that because they are fixed in the context of the broader evolution of language, the meaning of terms is constantly in flux. Thus, the following comments must be understood generally. Second, the following is one way redescription of the term “moral” *might* come about, even though, in places I will note, this is already happening to some extent. Not all machine ethicists can be plotted on this trajectory.

That said, the project of designing moral machines is complicated by the fact that even after more than two millennia of moral inquiry, there is still no consensus on how to determine moral right from wrong. Even though most mainstream moral theories agree from a big-picture perspective on which behaviors are morally permissible and which are not, there is little agreement on why they are so, that is, what it is precisely about a moral behavior that makes it moral. For simplicity’s sake, this question will be here designated as *the hard problem of ethics*. That it is a difficult problem is seen not only in the fact that it has been debated since philosophy’s inception without any satisfactory resolution, but also that the candidates that have been offered over the centuries as answers are still on the table today. Does moral action flow from a virtuous character operating according to right reason? Is it based on sentiment, or on application of the right rules? Perhaps it is mere conformance to some tried and tested principles embedded in our social codes, or based in self-interest, species’ instinct, religiosity, and so forth.

The reason machine ethics cannot move forward in the wake of unsettled questions such as these is that engineering solutions are needed. Fuzzy intuitions on the nature of ethics do not lend themselves to implementation where automated decision procedures and behaviors

AMSCE-110

are concerned. So, progress in this area requires working the details out in advance, and testing them empirically. Such a task amounts to coping with the hard problem of ethics, though largely, perhaps, by rearranging the moral landscape so an implementable solution becomes tenable.

Some machine ethicists, thus, see research in this area as a great opportunity for ethics (Anderson and Anderson 2007; Anderson 2011; Beavers 2009, 2010; Wallach 2010). If it should turn out, for instance, that Kantian ethics cannot be implemented in a real working device, then so much the worse for Kantian ethics. It must have been ill conceived in the first place, as now seems to be the case, and so also for utilitarianism, at least in its traditional form.

Quickly, though some have tried to save Kant's enterprise from death by failure to implement (Powers 2006), the cause looks grim. The application of Kant's categorical imperative in any real-world setting seems to fall dead before a moral version of the frame problem. This problem from research in artificial intelligence concerns our current inability to program an automated agent to determine the scope of reasoning necessary to engage in intelligent, goal-directed action in a rich environment without needing to be told how to manage possible contingencies (Dennett 1984). Respecting Kantian ethics, the problem is apparent in the universal law formulation of the *categorical imperative*, the one that would seem to hold the easiest prospects for rule-based implementation in a computational system: "act as if the maxim of your action were to become through your will a universal law of nature" (Kant [1785] 1981, 30). One mainstream interpretation of this principle suggests that whatever rule (or *maxim*) I should use to determine my own behavior must be one that I can consistently will to be used to determine the behavior of everyone else. (Kant's most consistent example of this imperative in application concerns lying promises. I cannot make a lying promise without simultaneously willing a world in which lying is permissible, thereby also willing a world in which no one would believe a promise, particularly the very one I am trying to make.

AMSCE-1101

Thus, the lying promise fails the test and is morally impermissible.) Though at first the categorical imperative looks implementable from an engineering point of view, it suffers from a problem of scope, since any maxim that is defined narrowly enough (for instance, to include a class of one, anyone like me in my situation) must consistently universalize. Death by failure to implement looks imminent; so much the worse for Kant, and so much the better for ethics.

Classical utilitarianism meets a similar fate, even though, unlike Kant, Mill casts internals, such as intentions, to the wind and considers just the consequences of an act for evaluating moral behavior. Here, "actions are right in proportion as they tend to promote happiness; wrong as they tend to produce the reverse of happiness. By happiness is intended pleasure and the absence of pain; by unhappiness, pain and the privation of pleasure" ([1861] 1979, 7). That internals are incidental to utilitarian ethical assessment is evident in the fact that Mill does not require that one act for the right reasons. He explicitly says that most good actions are not done accordingly (18–19). Thus, acting good is indistinguishable from being good, or, at least, to be good is precisely to act good; and sympathetically we might be tempted to agree, asking what else could being good possibly mean.

Things again are complicated by problems of scope, though Mill, unlike Kant, is aware of them. He writes, "again, defenders of utility often find themselves called upon to reply to such objections as this—that there is not enough time, previous to action, for calculating and weighing the effects of any line of conduct on the general happiness" ([1861] 1979, 23). (In fact, the problem is computationally intractable when we consider the ever-extending ripple effects that any act can have on the happiness of others across both space and time.) Mill gets around the problem with a sleight of hand, noting that "all rational creatures go out upon the sea of life with their minds made up on the common questions of right and wrong" (24), suggesting that calculations are, in fact, unnecessary, if one has the proper forethought and upbringing.

AMSCL-101

Again, the rule is of little help, and death by failure to implement looks imminent. So much the worse for Mill; again, so much the better for ethics.

Wallach and Allen agree that the prospects for a “top-down, theory driven approach to morality for AMAs” (2009, 83), such as we see in both instances described, do not look good, arguing instead that a hybrid approach that includes both “top-down” and “bottom-up” strategies is necessary to arrive at an implementable system (or set of systems). “Bottom-up” here refers to emergent approaches that might allow a machine to learn to exhibit moral behavior and could arise from research in “Alife (or artificial life), genetic algorithms, connectionism, learning algorithms, embodied or subsumptive architecture, evolutionary and epigenetic robotics, associative learning platforms, and even traditional symbolic AI” (112). While they advocate this hybrid approach, they also acknowledge the limitations of the bottom-up approach taken by itself. As one might imagine, any system that learns is going to require us to have a clear idea of moral behavior in order to evaluate goals and the success of our AMAs in achieving them. So, any bottom-up approach also requires solving the ethical hard problem in one way or another, and thus it too dies from failure to implement. We can set the bottom-up approach aside; again, so much the better for ethics.

If these generalizations are correct, that top-down theoretical approaches may run into some moral variant of the frame problem, and that both the top-down and bottom-up approaches require knowing beforehand how to solve the hard problem of ethics, then where does that leave us? Wallach and Allen (and others, see Coleman 2001) find possible solutions in Aristotle and virtue ethics more generally. At first, this move might look surprising. Of the various ways to come at ethics for machines, virtue ethics would seem an unlikely candidate, since it is among the least formalistic. Nonetheless, it has the benefit of gaining something morally essential from both top-down and bottom-up approaches.

AMSCE-101

The top-down approach, Wallach and Allen argue, is directed externally toward others. Its “restraints reinforce cooperation, through the principle that moral behavior often requires limiting one’s freedom of action and behavior for the good of society, in ways that may not be in one’s short-term or self-centered interest” (2009, 117). Regardless of whether Kant, Mill, and other formalists in ethics fall to a moral frame problem, they do nonetheless generally understand morality fundamentally as a necessary restraint on one’s desire with the effect of, though not always for the sake of, promoting liberty and the public good.

But rules alone are insufficient without a motivating cause, Wallach and Allen rightly observe, noting further “values that emerge through the bottom-up development of a system reflect the specific causal determinates of a system’s behavior” (2009, 117). Bottom-up developmental approaches, in other words, can precipitate where, when, and how to take action, and perhaps set restraints on the scope of theory-based approaches, like those mentioned previously. Having suggested already that by “hybrid” they mean something more integrated than the mere addition of top to bottom, virtue ethics would seem after all a good candidate for implementation. Additionally, as Gips (1995) noted earlier, learning by habit or custom, a core ingredient of virtue ethics, is well suited to connectionist networks and, thus, can support part of a hybrid architecture.

Acknowledging that even in virtue ethics there is little agreement on what the virtues are, it nonetheless looks possible, at least, that this is the path to pursue, though to situate this discussion, it is helpful to say what some of them might be. Wallach and Allen name Plato’s canonical four (wisdom, courage, moderation, and justice) and St. Paul’s three (faith, hope, and charity) to which we could just as well add the Boy Scout’s twelve (“a scout is trustworthy, loyal, helpful, friendly, courteous, kind, obedient, cheerful, thrifty, brave, clean, and reverent”), and so on. However we might choose to carve them out, one keystone of

AMSCI-IOI

the virtues is their stabilizing effect, which, for the purposes of building AMAs, allows for some moral reliability. “Such stability,” Wallach and Allen note, “is a very attractive feature, particularly for AMAs that need to maintain ‘loyalty’ under pressure while dealing with various, not always legitimate sources of information” (2009, 121). The attraction is noted, but also note how the language has already started to turn. What is loyalty, whether in quotations or not, such that a machine could have it? How could a robot ever experience the fear essential to make an act courageous, or the craving that makes temperance a virtue at all?

From an engineering point of view, simulated emotion might do just as well to get virtuous behavior from a machine, but getting to emotion “deeply” enough to justify predicating “character” to AMAs may prove something of a philosophical question that hits to the heart of the matter and returns us to the Moral Turing Test mentioned earlier in this chapter. (See Coeckelbergh 2010a for a related discussion on this topic.) As with people, the principal way we judge others as virtuous is by considering their behavior. So, when is a robot loyal? When it sticks to its commitments. When is it wise? Well, of course, when it does wise things. When is it courageous? When it behaves courageously. What more could we legitimately want from a moral machine? Such would appear to be a morally perfect being with an acute sense of propriety governed by right reason and which always acts accordingly. So, *ex hypothesi*, let us build them or some variant thereof and wonder how long it will be before the use of words and general educated opinion will have altered so much that one will be able to speak of machines *as moral* without expecting to be contradicted.

21.2 What Is at Stake?

Interiority counts (at least for the time being), especially in matters of morals, where what we might call “moral subjectivity,” that is, conscience, a sense of moral obligation and responsibility, in short, whatever motivates our moral psychology to care about ethics, governs our behavior. Even the formalist Kant thought it necessary to explain the sense in which “respect,” an essential component of his ethical theory, was and was not a feeling in the ordinary sense of the word, noting along the way that “respect is properly the conception of a worth which thwarts my self-love” ([1785] 1981, 17) and so requires self-love in the same way that courage requires fear. Additionally, Kant’s universal imperative requires a concrete, personally motivated maxim to universalize in order for an agent to be moral (Beavers 2009) and is implicitly tied to interpersonal concerns as well (Beavers 2001). Furthermore, the theme of interiority is explicitly addressed by Mill, who notes that there are both external and internal sanctions of the principle of utility, ascribing to the latter “a feeling in our own mind; a pain, more or less intense, attendant on violation of duty,” which is “the essence of conscience” ([1861] 1979, 27–28).

More importantly for this discussion, interiority counts in the virtue ethics of Plato and Aristotle, both of whom mark an essential distinction between being good and merely acting so. Famously, in Book II of the *Republic*, Plato (1993) worries that moral appearances might outweigh reality and in turn be used to aid deceit (see 53, 365a–d), and Aristotle’s ethics is built around the concept of *eudaimonia*, which we might translate as a well-being or happiness that all humans in essence pursue. We do so at first only imperfectly as children who simulate virtuous behavior, and in the process learn to self-legislate the satisfaction of our desire. Even though Aristotle does note that through habituation, virtuous behavior becomes internalized in the character of the individual, it nonetheless flows from inside out, and it is difficult to imagine how a being can be genuinely virtuous in any Greek sense without also a genuinely “felt,” affective component. We need more, it seems, than what is visible to the judges in the MTT discussed earlier. Or do we?

AMSCE-IOI

The answer to this question hangs on what our goals are in developing machine ethics. To make this clear, it is helpful to consider Moor's often-cited taxonomy of moral agency. According to Moor, "ethical-impact agents" are machines that have straightforward moral impact, like the robotic camel jockeys implemented in Qatar that helped to liberate Sudanese slave boys who previously served in that capacity, even though the motive for implementing them was to escape economic sanction. Though Moor does not say so here, most machines seem to qualify in some way for this type of agency, including a simple thermostat. Straightforward ethical impact is not what concerns designers of robot morality, however. "Frequently, what sparks debate is whether you can put ethics into a machine. Can a computer operate ethically because it's internally ethical in some way" (2006, 19)? Here the waters start to get a bit murky. To clarify the situation, Moor marks a three-fold division among kinds of ethical agents as "implicit," "explicit," or "full."

"Implicit ethical agents" are machines constrained "to avoid unethical outcomes" (Moor 2006, 19). Rather than working out solutions to ethical decisions themselves, they are designed in such a way that their behavior is moral. Moor mentions automated teller machines (ATMs) and automatic pilots on airplanes as examples. The ATM isn't programmed with a rule about promoting honesty any more than the automatic pilot must deduce when to act safely in order to spare human life. The thermostat mentioned earlier would seem to fall in this category, though whether the camel jockey does depends on the mechanisms it uses in making its decisions.

"Explicit ethical agents" are machines that can "'do' ethics like a computer can play chess" (Moor 2006, 19–20). In other words, they can apply ethical principles to concrete situations to determine a course of action. The principles might be something like Kant's categorical imperative or Mill's principle of utility. The critical component of "explicit" ethical agents is that they work out ethical decisions for themselves using some kind of recognizable moral decision procedure. Presumably, Moor notes, such machines would also be able to justify their judgments. Finally, “full ethical agents” are beings like us, with “consciousness, intentionality, and free will” (20). They can be held accountable for their actions—in the moral sense, they can be at fault—precisely because their decisions are in some rich sense *up to them*.

We can see how machines can achieve the status of implicit and perhaps explicit moral agents, if Wallach and Allen are right, but whether one can ever be a full moral agent requires technologies far from what we have yet to conceive. Given that the question of full ethical agency for robots will not be settled soon, Moor remarks, “we should . . . focus on developing limited explicit ethical agents. Although they would fall short of being full ethical agents, they could help prevent unethical outcomes” (Moor 2006, 21). Wallach and Allen concur, though perhaps while implicitly offering one way to deal with the question of full moral agency in robots short of actually settling it in the sense suggested by Moor. The problem concerns the difference between Moor’s notions of explicit and full ethical agency, in light of both the MTT and the criterion of implementation that machine ethics (legitimately) forces upon us. Can the distinction between explicit and full moral agency stand up to their challenge?

The answer to this question hangs in part on an empirical component in engineering moral machines that is intimately tied to the implementation criterion itself. If *ought* implies *can*, then *ought* implies *implementability*. Though this might not seem immediately apparent, it is nonetheless the case, since any moral theory that cannot be implemented in a real, working agent, whether mechanical or biological, limits the agent’s ability to execute real-world action. Thus, if ought implies can, or the ability to act in a particular situation, then moral obligation must rest on some platform that affords the agent this possibility. A nonimplementable approach to morals does not. Thus, a valid approach must also be an implementable one. As such, the test for

AMSCL-101

a working moral system (or theory) is partly cast as an engineering problem whose solution hangs precisely on passing the MTT. Consequently, the AMA that passes the MTT is not merely an implementation of a moral machine, but also proof of concept for a valid approach to morals. If we can successfully engineer moral machines, interiority, thus, does not appear to count.

But what then serves to distinguish an explicit moral agent that "does ethics as one plays chess" and exhibits proper moral behavior from the full ethical agent that acts with intentionality and moral motivation? In a world populated by human beings and moral machines, assuming we are successful in building them, the answer would seem to be nothing. Minimally, at least, we would have to concede that morality itself is multiply realizable, which strongly suggests that full moral agency is just another way of getting explicit moral agency, or, as a corollary, that what is essential for full moral agency, as enumerated by Moor, is no longer essential for ethics. It is merely a sufficient, and no longer necessary, condition for being ethical. Though this might sound innocuous at first, excluded with this list of inessentials are not only consciousness, intentionality, and free will, but also anything intrinsically tied to them, such as conscience, (moral) responsibility, and (moral) accountability.

The MTT, together with the criterion of implementability for testing approaches to ethics, significantly rearranges the moral playing field. Philosophical speculation, unsettled for more than two millennia, is to be addressed here not by argument, but by engineering in an arena where success is gauged by the ability to simulate moral behavior. What then is left for requisite notions that have from the start defined the conscience of the human? They seem situated for redefinition or reclassification, to be left behind by conceptions of morality that will no longer have much use for them.

AMSCE-101

21.3 Why Might This Invite Concern?

Ethics without conscience sounds a little like knowledge without insight to guide it. To turn this in a different direction, ethics without accountability sounds as equally confused as placing moral praise and blame on components that cannot possibly have them, at least on our current understanding of terms, and especially when making attributions of virtue. To see this, let us suppose that some time in the near future, we read the (rather long) headline, “First Robot Awarded Congressional Medal of Honor for Incredible Acts of Courage on the Battlefield.” What must we assume in the background for such a headline to make sense without profaning a nation’s highest award of valor? Minimally, fortitude and discipline, intention to act while undergoing the experience of fear, some notion of sacrifice with regard to one’s own life, and so forth, for what is courage without these things? That a robot might simulate them is surely not enough to warrant the attribution of virtue, unless we change the meaning of some terms.

At bottom, to bestow respect on someone or something for their (its?) actions is to deem agents “responsible” for them. Mixed in with the many definitions of the term “responsible” is the matter of accountability. Sometimes this term refers to an agent of cause, as when a fireman might explain to me that the toaster was responsible for my house burning down. But I cannot hold the toaster accountable for its actions, though I might its manufacturer. *Moral* responsibility travels with such accountability. To return to the robot soldier once more, the robot can be the precipitating cause of an action, and hence responsible in the same sense as a toaster; what must we add to it to make it accountable, and hence also morally responsible, for its actions? From the engineering point of view, we have no way to say. Indeed, MTT and the criterion of implementability make such a distinction between causal and moral responsibility impossible in the first place. This is because

AMSCE-101

stipulating the means of implementation is precisely to have determined the causal properties responsible for moral responsibility and, indeed, for the virtues themselves, if we should choose to implement a virtue ethics. So, the fact that the robot soldier was designed to be courageous either undermines its ability to be so, though certainly not to act so, or we invert the strategy and say that its ability to act so is precise proof that it is so.

Even explicit awareness of the inverted strategy as such will not stop us from bestowing moral esteem on machines, any more than knowing that my Ragdoll kitten was genetically bred to bond with human beings stops me from feeling the warmth of its affection. (“Ragdoll” here represents a feline breed that was controversially engineered to be passive and amiable.) Indeed, if our moral admiration can be raised by the behavior of fictitious characters simulated by actors—Captain Picard in the TV program *Star Trek*, for instance—then all the easier it will be to extend it to real machines that look, think, and act like us. This psychological propensity (and epistemic necessity) to judge internals on the basis of external behavior is not the main concern, however, as it may first appear, precisely because we are not dealing here with a matter of misplaced attribution. Rather, on the contrary, MTT and the criterion of implementability suggest that such attribution is quite properly placed. Success in this arena would thus seem to raise even deeper concerns about the nature of human morality, our moral objectivity, and our right to implement a human-centered ethics in machines.

If, for instance, implementability is a requirement for a valid approach to morals (thereby resituating full moral agency as a sufficient, though not necessary, condition for moral behavior, as previously noted), then the details of how, when, and why a moral agent acts the way it does is partly explained by its implementation. To the extent that human beings are moral, then, we must wonder how much of our own sense of morals is tied to its implementation in our biology. We are ourselves, in other words, biologically instantiated moral machines. To

AMSCE-101

those working in neuroethics and the biology of morality more generally, there is nothing surprising about this. Ruse (1995), for instance, has already noted that our values may be tied implicitly to our biology. If so, then human virtues are *our virtues* partly because we are mammals. Is there any reason to think that human virtues are those that we *should* implement in machines? If so, on what grounds? Why mammalian virtues as opposed to reptilian, or perhaps, even better, virtues suited to the viability and survival advantages of the machines themselves?

The question of an objectively valid account of morality is once again on the table, this time complicated by details of implementation. Even though questions of biological, genetic, neurological, and technological determinism are still hotly debated today (yet another indication of the difficulty of the hard problem of ethics), we are nonetheless left wondering whether soon the notion of accountability may be jettisoned by the necessity of scientific and technological discovery. If so, moral responsibility would seem to vanish with it, leaving only causal responsibility to remain. Research in building moral machines, it would seem, adds yet another challenge to a conventional notion of moral responsibility that is already under attack on other fronts.

In 2007, Anderson and Anderson wrote:

> Ethics, by its very nature, is the most practical branch of philosophy. It is concerned with how agents ought to behave when faced with ethical dilemmas. Despite the obvious applied nature of the field of ethics, however, too often work in ethical theory is done with little thought to real world application. When examples are discussed, they are typically artificial examples. Research in machine ethics, which of necessity is concerned with application to specific domains where machines could function, forces scrutiny of the details involved in actually applying ethical principles to particular real life cases. As Daniel Dennett [2006] recently stated, AI "makes philosophy honest." Ethics must be made computable in order to make it clear exactly how agents ought to behave in ethical dilemmas. (2007, 16)

At the very least, we must agree that the criterion of implementability suggested here makes ethics honest, and herein lies the problem. For

AMSCE-IJOI

present purposes, I define “ethical nihilism” as the doctrine that states that morality needs no internal sanctions, that ethics can get by without moral “weight,” that is, without some type of psychological force that restrains the satisfaction of our desire and that makes us care about our moral condition in the first place. So what, then, if the trajectory I have sketched should turn out to be correct and that internal sanctions are merely sufficient conditions for moral behavior? Will future conceptions of ethics be forced to make do without traditionally cherished notions, such as conscience, responsibility, and accountability? If so, have we then come at last to the end of ethics? No doubt, if the answer is no, it may be so only by embracing a very different conception of ethics than traditional ones like those mentioned earlier (for possibilities, see Floridi and Sanders 2004 and Coeckelbergh 2010b).

AMSCE-1101

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AMSCE-1101

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AMSCE-1101

VIII

Epilogue

22

Roboethics: The Applied Ethics for a New Science

Gianmarco Veruggio and Keith Abney

AMSCE-1101

The previous chapters in this book have covered a multitude of ethical issues raised by the new science of robotics, from issues about the use of robots in policing and the military, to assist in various social activities, including entertainment and even sex, to discussion of the possibility that robots will one day have rights and be moral agents themselves. This possibility highlights an important ambiguity in the use of the term "robot ethics," as the phrase has at least three distinct meanings.

First, it applies to the philosophical studies and researches about the ethical issues arising from the effects of the application of robotics products on our society. In this sense, *roboethics* suggests the development of a very broad "applied ethics," which, similarly to the ethical studies related to bioethics, deals with the universal, fundamental ethical issues. These are related to the need to protect and enhance human dignity and personal integrity; to secure the rights of the weakest; and to limit the “robotics divide” in all those instances in which robotics products could either worsen the existing inequalities, or create some new ones. In this meaning, roboethics pertains to all the issues deriving from the relationship among science, technology, and society, and it benefits from the related studies in psychology, sociology, law, comparative religions, and so on.

Second, robot ethics could refer to the moral code to which the robots themselves are supposed to adhere (presumably a morality somehow programmed into them). For any level of robotic autonomy, there will be some code the programmers create that the robot must follow in order to do what it ought; in effect, that will be a moral code for the robots, in this second sense. This will enable humans to make the judgment that the robot acted morally, in obeying its programmed moral code and doing what it ought to do, or that the robot acted immorally, in doing something that it wasn’t supposed to (that it ought not to have done), whether due to a electromechanical glitch, or a bug in the software, or lack of foresight about the conditions of its use, or otherwise incompetent programming. But the robot itself is unaware of its own programmed-in morality; it is “just following orders,” whether it does so badly or well.

The last consideration leads us to yet a third sense of robot ethics: it could refer to the self-conscious ability of the robots themselves to do ethical reasoning, to understand from a first-person perspective their choices and responsibilities, and to freely, self-consciously choose their course of action. Such an ability would make robots full moral agents, themselves (and not their programmers, designers, or builders) personally responsible for their actions. This third sense of robot ethics would imply that robots have a morality they choose for themselves, not merely one they slavishly, mindlessly must follow; they would share the human trait of self-conscious, rational choice, or *freedom*.

To help disambiguate and explore the first sense of robot ethics as described here, one of the coauthors of this epilogue (Veruggio) has coined the term “roboethics” to indicate an applied ethics whose objective is to develop scientific, cultural, and technical tools that can be shared by different social groups and beliefs. These tools aim at promoting and encouraging the development of robotics for the advancement of human society and of the individual, and to help to prevent its misuse. As per this definition, it is clear that roboethics is a human-centered ethics: it is not the—“artificial” or “natural”—ethics of the robots, but the ethics of the robotics researchers, of the producers, and of users of the robots.

The exploration of those professional responsibilities underlies the development of the Roboethics Program and Roboethics Roadmap (Veruggio 2007), as follows. Following the First International Symposium on Roboethics in 2004, many leading roboticists determined to work in collaboration with scholars of humanities. The aim of this common endeavor was to roadmap the ethical issues surrounding the emerging science of robotics in order to create a cross-cultural and interdisciplinary consciousness of these new social challenges. The results of these common and synergic efforts should be (a) a general cultural (ethical, social, and legal) framework for robotics; (b) a professional ethics for the roboticists; and (c) the technical standards, regulatory rules, and the legal apparatus for the robotics market products.

But discussion of this first sense of robot ethics, or roboethics ineluctably leads to considerations of the second sense: as robots gradually become more autonomous, what moral codes shall we program into them? How can we guarantee that the robots we create will do little to no unintended harm, that they will commit no immoral actions? What moral codes shall we program in: deontological, utilitarian, virtue, or just war theory? (Selmer Bringsjord and Joshua Taylor in chapter 6 in this book even investigate programming a divine-

AMSCE-1101

command ethics into military robots!) And what will this mean for personal, moral, and legal responsibility? As robots increase in autonomy and complexity, and their use becomes ever more pervasive in society, will the robotic programmer, builder, user, or the robot itself be the proper locus of moral evaluation and legal responsibility?

The chapters in this book have examined all three senses of robot ethics. The design and programming of robotic ethics and ethical issues concerning the military use of robots, and varieties of human–robot interaction (from sex to health care) all primarily involve senses one and two of robot ethics. As the discussion of moral behavior by robots advances, we may eventually have to face the possible third sense: the (as yet distant) specter that the robotics community may one day be responsible for creating something that SETI has so far failed to discover—a new race of intelligent beings capable of doing ethics, beings that raise difficult questions about the nature and extent of morality, questions that have been obfuscated as long as the only moral agents were members of *Homo sapiens*. This third sense is also investigated in part I (especially by Keith Abney in chapter 3), and in part VII, on robot rights and ethics.

But the creation of fully autonomous artificial moral agents is still off in the distance, if it is even possible; and in the meantime, roboticists have a serious responsibility to examine sensitive issues about their work in the first and second senses of robot ethics, as their creations gradually become more complex, more autonomous, more pervasive, and more enmeshed in the activities of everyday life. As such, roboethics currently involves key issues of regulation, including issues of safety and responsible use and development, even while robots remain mere human tools and not (yet) moral agents. Ideally, philosophers and roboticists (and even lawyers!) should work together on this project (as demonstrated in many of the chapters), as applied ethics works best when experts in both ethics and its applied field have mutually fertile conversations and reach plausible positions, ideally forming a consensus that informs action.

This chapter, the epilogue of this edited collection, is intended as a snapshot of some current developments in the field of robot ethics, or roboethics, in all three senses. As such, we will attempt to explain some important and unifying themes of this text, and, of robot ethics more generally, clear up some common misconceptions, and gesture toward the future of the field. To begin, we need clarification on the discipline that informs robot ethics, that is, the field of robotics.

22.1 Robotics, a New Science?

Robotics, of course, deals with robots; so what exactly is a robot? One definition: a robot is "a machine, situated in the world, that senses, thinks, and acts" (Bekey 2005, and chapter 2 of this volume). A typical robot uses sensors to detect aspects of an external world, software to reason about it, and actuators to interact with it; as such, all proper robots have at least some degree of autonomy and, hence, a sort of intelligence. So, we can define robotics as a branch of engineering that deals with autonomous machines—that is, robots. Robotics is but a nascent discipline, yet in contemporary robots we can already see glimpses of the fulfillment of the human dream of designing an artificial intelligence embodied in an autonomous entity, whether it be a friendly companion or pet (like AIBO) or a terrifying weapon of war (like the Predator drone).

Some have called the rise of robotics a "Third Industrial Revolution" (Thurow 1999) as machines progress from mere tools into something that potentially has "a mind of its own"; as robotics advances, investigations into complex notions like autonomy, learning, (self-)consciousness, evaluation and judgment, free will, emotions, and the like, formerly the province of philosophers, shall become part and

AMSCE-1101

parcel of engineering practice. As the previous chapters demonstrate, the ever-expanding capabilities of robots will pose multiple new ethical challenges (given “ought implies can”), as will the various modes of their deployment: there will be biorobots, military applications of robotics, nanny robots in children’s rooms, socially assistive robots taking care of the elderly, and many more. Each of these applications will create new quandaries as a new kind of machine intelligence interacts with humans, sometimes taking human jobs, but even more often usurping traditional human roles and creating tension, as usually happens when new ways challenge venerable traditions.

Robotics thus forms a new science (and related emerging technologies) at an early stage; as philosophers of science such as Thomas Kuhn (1970) or Larry Laudan (1984) point out, new sciences are born from both the rational quest to solve problems and test solutions, and the nonrational thrust of societal forces and *gestalt* shifts in one’s worldview. The future developments of robotics will likely require scrutiny, if not full-scale revision, of some of our contrastive concepts, such as person (moral being) versus mere machine, freedom versus determinism, or intelligently autonomous versus merely algorithmic. Such possible revisions in our basic concepts may well result in a *gestalt* shift in our worldview, and lead to a radically new science. The emerging science of robotics thus has far-reaching implications, and likewise itself depends upon a syncretic melding of disciplines involving knowledge from many fields, as is clearly demonstrated by scanning the entries in the huge *Handbook of Robotics* (Siciliano and Khatib 2008).

Robotics holds another promise, one not shared by all emerging sciences—the possibility of major development by way of a potentially immense number (and value) of applications, which in turn is controlled by the so-called forces of the market. Governments have made huge investments into robotics applications, from Japan’s METI (Ministry of Economy, Trade and Industry) promise of 4 billion yen or more in the

AMSCE-101

humanoids challenge (Robertson 2007), to the 160 billion dollars in the U.S. Future Combat Systems Program. Such applications raise new possibilities and, hence, new worries as well. Given “ought implies can,” novel moral issues arise when science and technology give us new capabilities and new possibilities—but not before. So, popular opinion and expression has made doing roboethics far more difficult, as rampant confusion reigns over what robots can and cannot do, and over how they are similar to (and different from) human beings. These popular misconceptions about robotics largely stem not from its being a new scientific discipline, but from its status as an ideology.

22.2 The Robotics Ideology

An *ideology* evokes belief in certain ideas that transcend a mere evanescent opinion; instead, to qualify as an ideology, there must exist a major concretion of symbols or memes that are passed down over generations and shape the thoughts of many. A helpful contrast is with knowledge (which, unlike ideology, never occurs in the plural). To qualify as public knowledge, as opposed to a mere ideology, there needs be some set of reasons for belief that approaches a settled consensus by experts. Many popular beliefs about robots do not reflect widespread knowledge of robotics, but instead fit the criteria for an ideology. These beliefs are shaped by myths, legends, and the imagination of fiction writers and the public at large, rather than by facts and reasonable (to experts!) possibilities.

In the eighteenth century, one of the main missions of scientists in the field of electromagnetism was to remove magic from physical phenomena, turning (for example) lightning from being seen as the work of the gods or the “black arts” into something naturalistically explicable. Roboethics, in order to advance, currently needs to perform such a demystification, freeing robotics from the magical conception still dominant today in the popular imagination. Roboethicists need to help design plausible visions of the future and the options it may hold (and choices we must make), based on fact and informed speculation, not fancies and atavistic fears borne of science-fiction movies.

One example of the power of ideology in roboethics is the legend we term the “Rebellion of the Automata,” in which robots rise up and overthrow their human masters, a theme so common in the literature about robots as to seem almost trite. Yet for now (and for the foreseeable future), robots are simply not self-conscious, and so while a complex robot can malfunction or break or engage in behavior that surprises its programmer, it can never consciously rebel! (Put differently, robot ethics in the third sense is as yet impossible—and may always be). Yet much of the popular fear of robots stems from the belief that they will rise up against their human masters and engage in murderous revolt. Perhaps this myth originated for reasons related to the development of Western civilization, going back to ancient Egypt and classical Greece, if not even further. In this history, we see many cultures dominated by authoritarian kingdoms whose ultimate authority was based on religious understandings, often where subdued sons surrounded a god-like king, and the king’s constant fear was revolt by his family/slaves/subjects. Perhaps the worries over the so-called rebelling automata are because we think of them not as artificial tools, but instead as human slaves, illegitimately treated as a mere tool for their master’s use—that is, they are treated as mere *automata*, but we fancifully believe they are capable of more! Perhaps this recurring myth is driven by our collective guilt over the history of slavery and a need for reassurance in the face of uncertainty over our robotic future? (Or perhaps it is driven by our own theory of mind and our overwillingness to attribute agency to mindless creatures—more on this follows).

But in reality, our robots are not (for now, anyway) our “slaves” in any robust sense, as they have no will of their own; and the historical origins of robots do not actually include such fictions as a Golem or a

AMSCE-J101

Frankenstein’s monster that could rebel against its master. For current roboethics, continuing to take such tales seriously seems as silly as believing that our ancestors were the Flintstones, and our grandchildren will be the Jetsons! These tales arouse highly unrealistic expectations among the public about the near future of robotics, while simultaneously helping mask public recognition of actual near-term developments and their moral implications. Real technological advance often progresses far slower than the public is aware; and actual revolutionary technological advance is often undreamt of, even by science-fiction novelists.

To take but two examples, Arthur C. Clarke (an engineer and a scientist, as well as novelist) forecast that in 2001 we should have arrived on Jupiter, taking off from a lunar base, piloted by an autonomous robotic spacecraft of murderous intelligence (HAL), whose murders were based on its own moral reasoning. Or take the novelist Philip K. Dick, whose 1968 novel *Do Androids Dream of Electric Sheep?* was made into the movie *Blade Runner* (a source of innumerable images in the robotics literature). The novel/movie is set at the year 2019, and has autonomous biological robotic androids (replicants) with superhuman powers who wish to rise up against their enforced servitude and gain their freedom as persons. The timeframe to attain robotic moral personhood, or robot ethics in the third sense, that was assumed by these artists, was definitely more than a bit optimistic! And the robots they envisage cause great harm and destructiveness to the ordinary human protagonists—as befits the attempt to create literary and narrative drama, but not the attempt to engage soberly with the real implications of robotics.

Literature and novels are primary human arts; but reality is not a mere social construction or a novel. So to do roboethics responsibly, we need to redefine the *liaison dangereuse* between literature and robotics. We need other myths, images, and metaphors, which are more proper to the practice of robotics, and not to the anthropology of the

AMSCE-101

human/automaton tragedy and legend. A different cultural history may make a society's ideology and myth less prone to such distortions and fears. For instance, the Japanese mythology does not include such fears of the evil robots overthrowing their human yoke. On the contrary, Japanese depictions of robots are largely beneficial and friendly to humanity, and popular opinion in Japan is much more sanguine about human–robot interaction. Perhaps the Japanese view of robots as beneficent helpers—not the violent, rebellious machines of Western science fiction—is rooted in the Shinto religion, which blurs the boundaries between animate and inanimate objects. The Shinto mythology may help the Japanese avoid undue fear of robots, and perhaps even avoid the "Uncanny Valley" of creepiness that seems to afflict those from other cultures when viewing humanoid robots.

Another myth that forms part of a related pernicious robotic ideology we could call the "Pinocchio Syndrome": the idea that humanoid robots could evolve into humans. Pinocchio is the main character of a novel for children by Italian author Carlo Collodi, made into the animated film by Walt Disney. It is a naughty, pinewood marionette that gains wisdom through a series of misadventures, which lead it/him to become a real human as reward for his good deeds (Collodi [1883] 2009). Implicit in this myth is the idea that reproducing human functions ever more perfectly coincides with producing a human being. This Pinocchio Syndrome commits an acknowledged flaw of reasoning, the fallacy of composition; for even if we could design and manufacture a robot endowed with reasoning powers about symbolic properties (i.e., language) analogous to those of humans, the former would belong to another, different kind of entity, another *species* (albeit nonbiological). Passing some version of the Turing Test may or may not be enough to become a "person" in some sense to be defined (as discussed by Rob Sparrow, in chapter 19 of this volume); but it certainly would not make one *human*. Our nature as humans is not merely the ability to express symbolic properties, but also the result of our biophysical powers and

AMSCE-1101

properties, as well as the human relationships that we develop and mature from birth until death—“human” is, in part, a relational concept. So, human nature inevitably contains both socio-cultural and biological components, and robots may gain capacities that make them our equals or betters in certain ways, but (trivially) they can never be *Homo sapiens*.

22.3 Robots and Moral Agency

But the third sense of robot ethics may not be so quickly dismissed. The future possibilities of cyborgs bring up the possibility that what may be morally crucial may not be unique to our biology. Kevin Warwick (2002, and chapter 20, this volume) explores some of these issues, as he himself has become a cyborg, and investigates the possibilities of machines with human neural cells. We can extend his thought experiment: if (admittedly, a *very large* if) we could gradually replace all of our higher brain biological functions with mechanical, robotic replacements, until we had a completely robotic brain, with no interruption in first-person self-consciousness, why would the result not qualify as a moral person, even if no longer a completely biological human? And, if so, why would biological arms or legs or digestive tract be morally crucial? Surely those humans with artificial arms, legs, and so forth, are full moral persons. So, what of robots’ moral status? With the appropriate abilities, why could they not be moral persons? Do we not have to face the possibility of robot ethics in the third sense?

The foregoing considerations suggest that biological humanity is not morally crucial if robots could attain first-person self-consciousness and deliberative agency, the usual requirement for moral responsibility and the hallmark of moral personhood. But could robots ever attain agency, the ability that philosophers have long claimed set us apart from the other animals? You or I can be held responsible for our actions; we can

AMSCE-101

be tried in a court of law, and found guilty or innocent, in a way that makes no sense (thus far) for any other species here on Earth (genetic engineering or discovery of extraterrestrial intelligences on other worlds pending!). But will this remain true for robots? Now, unlike the other animals we have thus far encountered here on Earth, robots have the promise of being excellent (indeed, superhuman) logical reasoners, and the prospect of such sophisticated machine reasoning has no doubt contributed to the Pinocchio Syndrome. But to be an agent, plausibly one needs more than mere mechanical reasoning; there are several possibilities (and much active research) on what more is needed.

For one possibility, perhaps one needs what Kant ([1781/1787] 1997) termed the "transcendental unity of apperception" (hereafter abbreviated TUA), in which conceptual reasoning and the appearances of objects due to sensation are tied together in a single, self-aware consciousness, able to experience a unified first-person self-consciousness—to experience (and not merely "say") the thought "I choose to do X, not Y." Mere machines (like some bank ATMs or socially assistive robots) can already speak, but they (presumably) have no self, no awareness that they are speaking—they *mean* nothing by what they say; the only *meaning* is in the (human) mind of the hearer, not in the utterance itself, or in the robot that utters it. Is TUA what is missing? If so, can an increasing complexity of programming cause TUA to emerge, or is it separated from mere algorithmic programming by some unbridgeable divide? Is it that such complex programming can simulate the syntax of human language, but a program (even a very complex program) can never have a mind that understands its *meaning*? Philosophers and neuroscientists such as John Searle (1984) with his "Chinese Room argument" and Paul and Patricia Churchland (Churchland and Churchland 1990) have hotly debated such issues and the debate rages on today.

Relatedly, the Catholic philosopher José Galván wrote: "The symbolic capacity of man takes us back to a fundamental concept which

AMSCE-101

is that of free will. Free will is a condition of man, which transcends time and space. Any activity that cannot be measured in terms of time and space cannot be imitated by a machine, because it lacks free will as the basis for the symbolic capacity" (Galván 2004). So what robots may necessarily lack for agency is freedom (the freedom needed for TUA?), not mere instrumental reason. If Galván is correct, then it will continue to be the case that whenever a machine makes a statement or even displays an emotion, this doesn't mean that it feels that emotion, but only that it is using an emotional language to interact with the humans. There is more to agency than mere behavior—there is an interiority, a self who knows what it is like to be someone, in a subjective sense still unexplained by science.

Perhaps, however, one could ask: why is moral agency so important? If we merely evaluate the morality of actions by their consequences, rather than by the intentions behind the act, moral agency may not be crucial for moral practice. Perhaps as long as robots obey moral codes (in the second sense of robot ethics), difficult questions about their ability to become moral agents are irrelevant. Is it the results of actions, and not self-conscious intentions, that ultimately matter?

In human terms, most ethics presumes agency matters, because of our theory of mind. The ability to detect agents within the human community was a key to our evolution as a social species, and we are so hardwired for it that we attribute agency promiscuously, naively attributing the human ability to choose on the basis of reasons and goals to dogs and cats, cars and trains, even trees and clouds and volcanoes and the weather and . . . well, just about everything we interact with. Because this "intentional stance" works so well in understanding other humans, we have a tendency to use it to explain everything: so the Hawaiians explained volcanic eruptions by the agency of a displeased goddess Pele, and the Greeks explained shipwrecks as due to a similar rage of their god Poseidon.

AMSCI-1101

The history of science comprises the long and difficult attempt to remove such teleological thinking from being applied to the natural world, so much so that some scientists and philosophers (like the Churchlands) attempt to remove it from humans themselves. But the fallacy of the intentional stance as applied to robots and the resulting Pinocchio Syndrome comes from the older and more typical human tendency to ascribe a theory of mind like our own to things that act in relevantly similar ways—and so we attribute emotions to the robot that we see speaking, precisely because of our own human emotions and mind. Robots may come to simulate many human abilities, but any simulation always lacks some of the reality of that which it simulates—or else it would not be a simulation, but identity. A related complication arises because of the nature of the different decision-making systems within the human brain.

Neuropsychological research has overwhelming support for the theory that human cognition actually involves not one but two primary systems, the one reflexive, and the other deliberative. The deliberative, fully self-aware "rational" system is an evolutionary newcomer, but perhaps as a result is often overridden by the older, usually subconscious reflexive system. As the speed required for decision making increases (whenever we must decide "in a hurry"), the fast, ancestral, emotional system continues on as usual, while the more modern deliberative frontal cortex system gets left behind. As a result, we become more prone to stereotyping, more vulnerable to emotional reactions, wishful thinking or confirmation bias, or various other "weaknesses of the will" in which we choose something that, upon deliberation, we would think is bad for us. Our moral judgments and beliefs are influenced by our cognitive limitations and evolved methods of dealing with the breakdown of rational control. The result is that human agency resembles not a finely tuned machine, but a "kluge" (Marcus 2008), a Rube Goldberg-esque construction that leaves us with a sense of reason

AMSCE- 1101

and deliberation that is both temporally behind and somewhat subservient to our sense of impulse and reflex.

Taking such concerns about the evolutionary background of moral agency seriously, some theorists advance an alternative: perhaps it is not TUA or freedom or computational complexity that enables moral consideration, but embodiment. On this view, robots, equipped with mechanical bodies, sensors, and actuators, as well as computational abilities, would have minds, but not human minds—because they lack human *bodies*. The research program known as Embodied Cognition (EC) (Brooks 1999; Lakoff and Johnson 1999) rejects the strong AI view that all cognition consists in computational, representational symbol manipulation. EC's account of conscious (and subconscious) cognition therefore emphasizes the embodied experiences of organisms as opposed to abstract symbol manipulation, and aims to explicate how such embodiment shapes knowledge. Common to EC accounts is the idea that normal everyday human interactions consist, not in algorithmic mental computing, but in nonmentalist embodied engagements. If this approach is correct, then perhaps it is not freedom or TUA that are needed for a self-consciousness, but a body; and the type of body will determine the type of mind that inhabits it.

So, conceptual clarification is needed in order to advance this debate: does being a moral person merely require the ability to engage in symbolic representations (so any computer could qualify?!), or embodiment with freedom of action in an external world, or TUA, or . . .? The questions and confusion over robotic (self-)consciousness, robotic emotions, and robot rights and responsibilities are often based on the confusion generated by the use of the same words for intrinsically different items, and by further unclarity or equivocation over the abilities and resources necessary to have emotions, consciousness, rights, and responsibilities.

One attempt to solve at least the representational and equivocation problems is to express potential ontological differences through a

AMSCH-101

specific notation. We might indicate with an "R dot" (R.) the properties of our presumably mindless robotic artifacts, to distinguish them from the capabilities known to be held by self-conscious human beings. So:

- Humans have intelligence (and agency)
- Robots have R. intelligence (and no self-conscious agency—so far)

This notation could help keep us aware of these ontological differences, and so also help avoid flaws in our moral reasoning. It is worth recalling this device began with Isaac Asimov, inventor of the Three Laws of Robotics (Asimov [1942] 1968). One character in Asimov's novels was the robot-detective R. Daniel Olivaw, so named because humanoid robots in the novel's futuristic society are virtually indistinguishable from human beings; so to avoid any confusion between humans and robots, all robots should have their name preceded by an R (Asimov 1954).

22.4 Roboethics, a Work in Progress

As Anthony Beavers (this volume, chapter 21) points out, given "*ought* implies *can*," implementability is a requirement for any plausible approach to morals; and he suggests that our own morality is ineluctably tied to its implementation in our biology—humans are "biologically instantiated moral machines." He then asks a crucial question for the future of roboethics: "Is there any reason to think that human virtues are those that we *should* implement in machines? If so, on what grounds? Why mammalian virtues as opposed to reptilian, or perhaps, even better, virtues suited to the viability and survival advantages of the machines themselves?"

In other words, in the development of roboethics, must human engineers place their own (biologically inspired) ethics into robots, or

AMSCE-101

will we gradually develop a kind of “alien” ethics, suitable for robots with very different bodies and capacities, but perhaps unsuitable for *Homo sapiens*? Given “ought implies can,” how could we think it would be otherwise?

What becomes clear is that, far from the received biological nature we humans have, a robotic nature will be a choice its engineers make for it. The issues that pervade the ethics of human enhancement and the possibility of genetic engineering, and particularly the issues of “playing God” in fashioning a new human nature, thus apply with even greater force to robots—as roboticists and ethicists will be deciding the moral code of machines with novel capabilities, until (and unless) the day comes that they choose their moral code for themselves. From such considerations, the task of the robotics community must include becoming master of our own destiny, and anticipating future developments and social needs about the ethical, legal, and societal aspects of such research and its potential applications.

At the same time, given robotics’ status as an ideology, it is necessary that those not involved in robotics keep themselves up to date on the field’s real and scientifically predictable developments, in order to base the discussions on data supported by technical and scientific reality, and not on appearances or emotions generated by legends. To achieve this goal, we need an internationally open debate. Currently we are living in the Age of Globalization, and robotics will have a global market, just like computers, video games, cars, or cameras. This also means that roboethics is the daughter of our globalized world. It is an ethics that should be shared by most of the world’s cultures, and capable of being translated into international laws that could be adopted by most of the nations of the world.

But, given that there are significant differences in the way the human–robot relationship is considered in the various cultures and religions, only a large and lengthy international debate will be able to produce useful philosophical, technical, and legal tools. At a technical level, we need a huge effort by the standard committees of the various international organizations, to achieve safety standards, just like for any other machine or appliance. In the case of robots, this task is more complex, due to the potential unpredictability of autonomous learning machines. Most obviously, this means that, in accordance with the precautionary principle, for now we will have to impose limits on the autonomy of the robots, especially in sensitive circumstances, when the robot could be harmful. At a legal level, we will need a whole new set of laws, regulating, for instance, the mobility of robots in work places or public spaces, setting clear rules about the liability and accountability of their operations. At a philosophical level, we need to discuss in depth the serious problem of the lethality of robots, for instance, in military applications. Such is precisely the mission that led to starting the Roboethics Program, and developing the Roboethics Roadmap (Veruggio 2007). The basic idea was to build the ethics of robotics in parallel with the construction of robotics itself. The goal was not only to prevent problems or equip society with cultural tools with enough time to tackle them, but also to pursue a much more ambitious aim. Indeed, it seems that robotics' development is not so much driven by abstract laws of progress, but more so by complex relations with the driving forces of the economic, political, and social system. And therefore dealing with roboethics means influencing the route of robotics.

It is certainly a great responsibility, which cannot however be avoided. Indeed, in society there cannot be a "non-choice" stance; to avoid regulation is itself a choice. Abstention ultimately ends up favoring the strongest, and in our case, in the current political, social, and economic system of the world, this means one thing only: a development policy largely driven by the interests of multinational corporations. As Philippe Coiffet said: "A development in conformity with a Humanist vision is possible but initiatives must be taken because 'natural' development driven by the market does not match with the desired humanist project" (2004).

AMSCE-IIOT

Roboethics is precisely one of these initiatives. A crucial step is the dissemination of accurate information on robotics and its applications. The first task is to inform society and try to remedy the delusions borne from the robotics ideology. Education activities are crucial, and they should target in particular our younger citizens. It is also important to inform and, indeed, educate policy makers at a national and international level. Guidelines for the ethical application of robotics to society should come out from deep transdisciplinary and multidisciplinary discussions held by scientists and scholars of humanities (law, philosophy, sociology, psychology, and so on). Different cultures, religions, and approaches should be taken into account. International roundtables should be organized, sponsored by alliances of states like UNESCO, the European Union, and so on, with the assistance of professional orders and associations.

22.5 The Primacy of Principles over Regulations: The Example of Military Robots

Roboethics thus should be the result of deep discussions about general ethical principles that bear on pressing practical concerns, not merely far-off scenarios. Yet, discussions should not be hidden behind any technical issue—when the guiding moral principles are not clearly defined, the pace of discovery and innovation is too fast for that: no regulation could match the speed of innovations. In doing roboethics, then, we adopt the methodology of triage, which teaches us to select the most urgent subjects and, once clear about them, see what comes next. In light of this methodology, we would like to gesture at some crucial principles for analyzing one of the most critical robotics applications—military robotics—which is certainly one of the most difficult challenges for roboethics, as already surveyed by coauthor Keith Abney in "Robots in war: Issues of risk and ethics" (Lin, Bekey, and Abney 2009).

Dealing with ethical principles when robotics weapon systems are deployed implies a close examination, among other subjects, of the doctrine of just war through history; of the details of modern, industrial warfare, and how its new possibilities problematize traditional concepts; and of the influence of military politics as well as new technology. Consideration must also be paid to the various agreements humans have already made to limit the nature of warfare, such as the Geneva and Hague Conventions and other treaties related to technological warfare, including dual use and export control agreements and other treaties (Altmann 2009).

The import of technological evolution in warfare is hard to overstate: dramatic turning points in human history occurred when development of novel weapons systems guaranteed military advantages and political power to the side that employed them. History further offers us numerous cases in which technological military superiority was used to make wars even crueler. To lessen the inhumanity of war, societies have agreed on ethical codes, codified in *jus in bello* restrictions on the ways war may morally be waged. The principles crucially include the requirement that one must exercise both discrimination and proportionality in attacks, never intentionally targeting civilians.

In this vein, it is worth reading from the “Declaration Renouncing the Use, in Time of War, of Explosive Projectiles Under 400 Grammes Weight”:

> Considering: that the progress of civilization should have the effect of alleviating as much as possible the calamities of war; that the only legitimate object, which states should endeavor to accomplish during war is to weaken the military forces of the enemy; that for this purpose it is sufficient to disable the greatest possible number of men; that this object would be exceeded by the employment of arms, which uselessly aggravate the sufferings of disabled men, or render their death inevitable; that the employment of such arms would, therefore, be contrary to the laws of humanity; the Contracting Parties engage mutually to renounce, in case of war amongst themselves, the employment by their military or naval troops of any projectile of a weight below 400 grams, which is either explosive or charged with fulminating or inflammable substances. (Declaration of Saint Petersburg 1868)

AMSCE-101

The preceding words were signed by most of the world powers to renounce precisely those “inflammable substances” which formed the novel technological development of chemical warfare. Unfortunately, despite the treaty, such weapons were extensively used in the following hundred years in many war theaters. More recently, facing threats of “weapons of mass destruction” (WMD), there have been new arms control conventions to reduce their proliferation. But worries persist about their use.

Robots offer a new kind of weapon. The explicit aim of much military robotics research is to develop autonomous robots that substitute for human soldiers; to create, in effect, a new army, “manned” (what will the new word be?) by untiring and near-invincible robotic soldiers that can defeat the enemy without cruelty and with discriminating selection of the military targets. Robots are also proclaimed to be able to solve some of the crucial problems of human warfare, in the three (now four) Ds: *Dull*, *Dirty, Dangerous,* and (as suggested in conversations with Patrick Lin, coeditor of this volume) *Dispassionate.*

Real warfare, unlike the movies, is often *Dull*; but robots can engage in extended reconnaissance and patrol, well beyond limits of human endurance, and can stand guard over perimeters in ways impossible for humans. Warfare is often also *Dirty*—but robots can work with hazardous materials, or after nuclear/biochemical attacks, or in environments unsuitable for humans, for example, underwater or in space. Warfare, of course, is also *Dangerous*—but robots can tunnel in terrorist caves, or control hostile crowds, or clear improvised explosive devices (IEDs), and save the lives and limbs of human soldiers. Finally, robotic warfare could be *Dispassionate*: in the heat of battle, seeing brothers in arms wounded, or bored and homesick, or fearful and seeing the enemy as subhuman, soldiers often let their emotions get the best of them and commit atrocities on the battlefield, to say nothing of the all too common crimes of the rape and pillaging of innocent civilians.

AMSCE-101

Robots in war need have no emotions, no fears, no homesickness, no passions to satisfy, no bloodlust to quench.

Does that mean robot soldiers are automatically a good idea, and morally permissible to deploy? Not so fast. The prospect of a robotic army also has troubling ethical implications, especially given the push to further autonomy for military robots. It evokes a (for now) fanciful belief in the logical culmination of this trend, wars waged without human bloodshed at all—only machines fighting other machines. But there are many problems with the probable sequence of events that would lead to such an outcome, as pointed out by Jutta Weber (2009). First of all, a robotic army is often depicted as the zenith of technological perfection: fully autonomous robots, linked in clusters by superefficient networks, endowed with learning capabilities, perhaps even with self-conscious powers. Second, the perfect and "emotionally correct" (dispassionate) robotic warrior is lethally equipped, and could kill combatants (other human beings) with total autonomy, that is, without any *human* control or responsibility. It is implied, then, that those robots can be so perfectly programmed and so high in intelligence that they can analyze the situation "objectively," unfailingly obeying the laws of war and rules of engagement.

Such is but a dream, at least for now. Any professional involved in the fields of computer science and robotics knows the impossibility of guaranteeing both the performance and safety of a complex technological product such as a robot. If this is true in civilian situations, it is ever more difficult in a military theater, where avoiding "friendly fire" and making correct (non-)combatant discrimination is morally and practically crucial. In view of current limitations of robotic technologies, robots cannot yet achieve the performances of human-level perceptual recognition that are required to distinguish friends or bystanders from foes. The same argument can apply to the performance of networks (gluing together the robot soldier's clusters): disruption by weather conditions, technological imperfection, the heightened speed of warfare,

AMSCE-I0I

and enemy hacking all constitute risks that could disable robots' communications. Furthermore, robot-soldiers furnished with learning capabilities able to generate a behavioral evolution according to the learning algorithms could generate unforeseeable consequences, unpredictable even by their designers. In short, given currently foreseeable technology, it is probable that autonomous robotic soldiers could go terribly wrong.

Bearing in mind the candor of the 1868 Declaration on the Explosive Projectiles compared to the hundred years of war tragedies that followed, one could regard the like, well-rounded words representing the robot soldiers—loyal to the various international conventions' regulations; respectful of civilians, the defenseless, and those who surrender; programmed to be humane; endowed with ethical firing rules—as fairy tales that, at least in the short term, no one could seriously believe. Until fully autonomous robots demonstrate (in realistic simulations) that they are no more likely to commit war crimes than human soldiers, it seems immoral to deploy them.

Third, fully autonomous systems thereby gain the status of subject of responsibility, as they are the decision makers in the war theater. If a robot commits a war crime, who is to blame—the commanding officer, the designer, the engineer/builder, the company selling it, or the robot itself? In reality, this provides autonomous robots with a license to kill. To allow such robots to exist is extremely serious, and it should not be taken for granted without informed debate and consent by humankind. This calls into question a fundamental principle: before discussing "how," we should decide "if" a fully autonomous robot can be allowed to kill a human.

AMSCE-101

22.6 Conclusion

This volume and this chapter hope to have clarified the definition, scope, and at least some of the aims of robot ethics. The subject is a difficult one, given the complexity of robotics—a new science highly interconnected with almost all technological fields, whose products can, in turn, be applied to almost every field of human activity. For these reasons, the ethical, legal, and societal issues of robotics share many common elements with another field of knowledge and practice—medicine—and its associated applied ethics, bioethics.

Roboethics also borrows from many other applied ethics, including computer and military ethics, which helps account for the slowness in disentangling old from new issues. In order to communicate crucial aspects of roboethics, it is also important to remember that the mere uttering of the word “robot” opens up a Pandora’s box of images, myths, wishes, illusions, and hopes, which humanity has, over centuries, applied to automata. Tales, novels, science-fiction stories, movies—and also some roboticists who “jazz up” their papers to shock the layman—have loaded robotics with many improper conceptions.

Further, the development of robotics is driven not only by the curiosity of the researcher, but also by the turbulent forces of the global market, forces more responsive to profit than to ethics and the well-being of humanity and of our ecosystem. These forces usually count ethics as an annoying constraint or, at best, they reckon with it only to “avoid ethical issues becoming barriers to market.”

That is why it is important to clear from the field the many incorrect notions about robots—a machine that is so complex that it often becomes unintelligible, even to its designer, but always an artificial product of technology, ontologically and irreparably different from a human being. And that is why it is crucial to tackle not the mythical worries due to ideologies and utopian hopes or dystopian fears, but the real issues facing robotics in the larger society—before it’s too late.

AMSCE-IOI

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AMSCE-1101

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AMSCE-1101

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AMSCE-1101

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AMSCE-1101

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AMSCE-1101

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AMSCE-101

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AMSCE-101

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AMSCE-IOT

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AMSCE-101

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AMSCE-101

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AMSCE-101

Research Fellow (2010–2012) on the ethical and technical appraisal of robots on the battlefield.

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Gianmarco Veruggio is responsible for the Operational Unit of Genoa of CNR-IEIIT. In 1980 he received a degree in electronic engineering from the University of Genoa, Italy. His research interests encompass robot mission control, real-time human–machine interfaces, control system architectures for telerobotics, and Internet robotics. In 1989, he founded the CNR-IAN Robotlab, which he headed until 2003, to carry out research and missions in experimental robotics in extreme environments. He led several marine robotics campaigns in Antarctica and in the Arctic. In 2000, he founded Scuola di Robotica (School of Robotics), a nonprofit association, to promote this new science among young people and society. His research on the complex relationship between robotics and society led him to coin the term—and propose the concept—of “roboethics” and to dedicate increasing resources to the development of this new applicative field of ethics. He serves as the corresponding cochair of the IEEE Robotics and Automation Society's Technical Committee on Roboethics and as a distinguished lecturer. In 2009, he was presented with the title of Commander of the Order of Merit of the Italian Republic.

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Kevin Warwick is a professor of cybernetics at the University of Reading, England, where he carries out research in artificial intelligence, control, robotics, and biomedical engineering. Warwick took his first degree at Aston University, followed by a PhD and a research post at Imperial College, London. He subsequently held positions at Oxford, Newcastle, and Warwick universities before being offered the chair at Reading. He has been awarded higher doctorates (DScs) both by Imperial College and the Czech Academy of Sciences, Prague, in addition to honorary doctorates from Aston, Coventry, and Bradford universities. He was presented with The Future of Health Technology Award from MIT, was made an Honorary Member of the Academy of Sciences, St. Petersburg, and received the IEE Senior Achievement Medal, the Mountbatten Medal, and the Ellison-Cliffe

AMSCE-101

Medal. In 2000, Warwick presented the Royal Institution Christmas Lectures. He is perhaps best known for carrying out a pioneering set of experiments involving the implant of multielectrodes into his own nervous system. With this in place, he carried out the world’s first experiment involving electronic communication directly between the nervous systems of two humans.

Blay Whitby is a philosopher and ethicist concerned with the social impact of new and emerging technologies. His publications include “Oversold, Unregulated, and Unethical: Why We Need to Respond to Robot Nannies,” “On Computable Morality,” and “Sometimes It’s Hard to be a Robot: A Call for Action on the Ethics of Abusing Artificial Agents.” His books include *Reflections on Artificial Intelligence: The Legal, Moral and Ethical Dimensions* and *Artificial Intelligence, A Handbook of Professionalism* (1996). Whitby is a member of the Ethics Group of BCS, The Chartered Institute of IT, and an ethical advisor to Royal Academy of Engineering. He is a regular speaker in academic, commercial, military, and community settings and has participated in several high-impact science/art collaborations. Whitby received his doctorate in the social implications of artificial intelligence in 2003 and holds degrees in philosophy, politics, and economics (BA, Oxford), philosophy (MA, Sussex), and intelligent systems (MSc, Sussex). Whitby lectures at the University of Sussex, where he chairs the University Ethics Committee for Science and Technology.

AMSCE-101

Index

Note: The letter *f* following a page number denotes a figure, while the letter *t* indicates a table.

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

AMSCE-1101

IEEE P7003™ Standard for Algorithmic Bias Considerations

Work in progress paper

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ABSTRACT[*]

The IEEE P7003 Standard for Algorithmic Bias Considerations is one of eleven IEEE ethics related standards currently under development as part of the IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems. The purpose of the IEEE P7003 standard is to provide individuals or organizations creating algorithmic systems with development framework to avoid unintended, unjustified and inappropriately differential outcomes for users. In this paper, we present the scope and structure of the IEEE P7003 draft standard, and the methodology of the development process.

CCS CONCEPTS

• **General and reference** → **Document types** → Computing standards, RFCs and guidelines

KEYWORDS

Algorithmic Bias, Standards, work-in-progress, methods

ACM Reference format:

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1 INTRODUCTION

In recognition of the increasingly pervasive role of algorithmic decision making systems in corporate and government service, and growing public concerns regarding the 'black box' nature of many of these systems, the IEEE Standards Association (IEEE-SA) launched the IEEE Global Initiative on Ethics for Autonomous and Intelligence Systems [1] in April 2016. The 'Global Initiative' aims to provide "an incubation space for new standards and solutions, certifications and codes of conduct, and consensus building for ethical implementation of intelligent technologies". As of early 2018 the main pillars of the Global Initiative are:

- a public discussion document "Ethically Aligned Design: A vision for Prioritizing human Well-being with Autonomous and Intelligent Systems" [2], on establishing ethical and social implementations for intelligent and autonomous systems and technology aligned with values and ethical principles that prioritize human well-being in a given cultural context;
- a set of eleven working groups to create the IEEE P70xx series ethics standards, and associated certification programs, for Intelligent and Autonomous systems.

The IEEE P70xx series of ethics standards aims to translate the principles that are discussed in the Ethically Aligned Design document into actionable guidelines or frameworks that can be used as practical industry standards. The eleven IEEE P70xx standards that are currently under development are:

- **IEEE P7000**: Model Process for Addressing Ethical Concerns During System Design
- **IEEE P7001**: Transparency of Autonomous Systems
- **IEEE P7002**: Data Privacy Process
- **IEEE P7003**: Algorithmic Bias Considerations
- **IEEE P7004**: Standard on Child and Student Data Governance
- **IEEE P7005**: Standard on Employer Data Governance
- **IEEE P7006**: Standard on Personal Data AI Agent Working Group
- **IEEE P7007**: Ontological Standard for Ethically Driven Robotics and Automation Systems
- **IEEE P7008**: Standard for Ethically Driven Nudging for Robotic, Intelligent and Autonomous Systems
- **IEEE P7009**: Standard for Fail-Safe Design of Autonomous and Semi-Autonomous Systems
- **IEEE P7010**: Wellbeing Metrics Standard for Ethical Artificial Intelligence and Autonomous Systems

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AMSCE-101

A brief paper outlining the aims of IEEE P7003 and its relationship to the other IEEE P700x series standards working groups was published in [3] and a tech-industry oriented summary of the eleven IEEE P70xx series standards appeared on the technology-industry blog TechEmergence [4].

In this paper we present a more detailed overview of the scope, structure and development process of the IEEE P7003 Standard for Algorithmic Bias Considerations [5].

IEEE P7003 is aimed to be used by people/organizations who are developing and/or deploying automated decision (support) systems (which may or may not involve AI/machine learning) that are part of products/services that affect people. Typical examples would include anything related to personalization or individual assessment, including any system that performs a filtering function by selecting to prioritize the ease with which people will find some items over others (e.g. search engines or recommendation systems). Any system that will produce different results for some people than for others is open to challenges of being biased. Examples could include:

- Security camera applications that detect theft or suspicious behaviour.
- Marketing automation applications that calibrate offers, prices, or content to an individual's preferences and behaviour.
- etc…

The requirements specification provided by the IEEE P7003 standard will allow creators to communicate to users, and regulatory authorities, that up-to-date best practices were used in the design, testing and evaluation of the algorithm to attempt to avoid unintended, unjustified and inappropriate differential impact on users.

Since the standard aims to allow for the legitimate ends of different users, such as businesses, it should assist them in assuring citizens that steps have been taken to ensure fairness, as appropriate to the stated aims and practices of the sector where the algorithmic system is applied. For example, it may help customers of insurance companies to feel more assured that they are not getting a worse deal because of the hidden operation of an algorithm.

As a practical example, an online retailer developing a new product recommendation system might use the IEEE P7003 standard as follows:

Early in the development cycle, after outlining the intended functions of the new system IEEE P7003 guides the developer through a process of considering the likely customer groups, in order to identify if there are subgroups that will need special consideration (e.g. people with visual impairments). In the next phase of the development, the developer is establishing a testing dataset to validate if the system is performing as desired. Referencing P7003 the developer is reminded of certain methods for checking if all customer groups are sufficiently represented in the testing data to avoid reduced quality of service for certain customer groups.

Throughout the development process IEEE P7003 challenges the developer to think explicitly about the criteria that are being used for the recommendation process and the rationale, i.e. justification, for why these criteria are relevant and why they are appropriate (legally and socially). Documenting these will help the business respond to possible future challenges from customers, competitors or regulators regarding the recommendations produced by this system. At the same time, this process of analysis will help the business to be aware of the context for which this recommendation system can confidently be used, and which uses would require additional testing (e.g. age ranges of customers, types of products).

2 SCOPE

The IEEE P7003 standard will provide a framework, which helps developers of algorithmic systems and those responsible for their deployment to identify and mitigate unintended, unjustified and/or inappropriate biases in the outcomes of the algorithmic system. Algorithmic systems in this context refers to the combination of algorithms, data and the output deployment process that together determine the outcomes that affect end users. Unjustified bias refers to differential treatment of individuals based on criteria for which no operational justification is given. Inappropriate bias refers to bias that is legally or morally unacceptable within the social context where the system is used, e.g. algorithmic systems that produce outcomes with differential impact strongly correlated with protected characteristics (such as race, gender, sexuality, etc).

The standard will describe specific methodologies that allow users of the standard to assert how they worked to address and eliminate issues of unintended, unjustified and inappropriate bias in the creation of their algorithmic system. This will help to design systems that are more easily auditable by external parties (such as regulatory bodies).

Elements include:

- a set of guidelines for what to do when designing or using such algorithmic systems following a principled methodology (process), engaging with stakeholders (people), determining and justifying the objectives of using the algorithm (purpose), and validating the principles that are actually embedded in the algorithmic system (product);
- a practical guideline for developers to identify when they should step back to evaluate possible bias issues in their systems, and pointing to methods they can use to do this;
- benchmarking procedures and criteria for the selection of validation data sets for bias quality control;
- methods for establishing and communicating the application boundaries for which the system has been designed and validated, to guard against unintended consequences arising from out-of-bound application of algorithms;
- methods for user expectation management to mitigate bias due to incorrect interpretation of systems outputs by users (e.g. correlation vs. causation), such as specific action points/guidelines on what to do if in doubt about how to interpret the algorithm outputs;

- a taxonomy of algorithmic bias
- … others yet to be determined

3 STRUCTURE

Discounting procedural sections, dealing with matters of Normative References, Definitions, Conformance etc, the standard document will consist of three main section categories: 1. Foundational sections covering issues related to the fundamentals of understanding algorithmic bias; 2. Algorithmic system design and implementation orientated sections addressing actionable recommendations for identifying and mitigating algorithmic bias; 3. Use cases providing examples of systems where the use of the P7003 standard could provide clear benefits.

3.1 Foundational sections

Foundational sections are currently envisioned to include sections on 'Taxonomy of Bias', 'Legal frameworks related to Bias', 'Psychology of Bias' and 'Cultural context of Bias'. Each of these sections will outline the associated socio-technical aspect of algorithmic bias, providing a background understanding of the reasons for, and importance of, the design/implementation recommendations that are provided in the subsequent sections. Even though the presence of these foundational sections may appear unusual for an industry standard, we believe that they play an important part in an 'ethics' standard such as IEEE P7003. The foundational sections provide a framework of understanding that should allow the designers of algorithmic systems to go beyond a mechanistic 'tick-box' compliance exercise towards a deeper engagement with the underlying ethical issues of algorithmic bias.

3.2 System Design and Implementation sections

The 'algorithmic system design and implementation' orientated sections are currently envisaged to include sections on 'Algorithmic system design stages', 'Person categorizations and identifying of affected groups', 'Representativeness and balance of testing/training/validation data', 'System outcomes evaluation', 'Evaluation of algorithmic processing', Assessment of resilience against external biasing manipulation', 'Assessment of scope limits for safe system usage' and 'Transparent documentation', though it is anticipated that further sections will be added as work progresses.

The intent of these sections is to provide a clear framework of guidance including challenge questions to help designers identify unintended bias issues that would go unnoticed unless specifically looked for. A possible comparison would be the way in which explicit questioning of everyday behavior is required in order to identify and mitigate unconscious bias in management practices.

Proposed solutions to identified causes of algorithmic bias will likely primarily take the form of listing classes of solution methods, with links to relevant work being published at venues such as FairWare, FAT*, KDD and similar publications, in order to reflect the context dependent nature of optimal solutions and the dynamic development in the research on improved methods.

3.3 Use Cases

The Use Cases form an annex to the IEEE P7003 standard document listing a number of illustrative examples of algorithmic systems that resulted in unintended bias, or that highlight specific types of concerns about bias that could be addressed by following the framework provided by IEEE P7003. The inclusion of the Use Cases, and their standardized presentation format, were proposed by a working group participant with experience of industry engagement with standards. They form an important element for 'making the case' for using ethics standards within a corporate context.

Some examples of the use cases that have been gathered so far include:

- "Tay the Nazi chatbot", an example of deliberate system behavior corruption through biased manipulation of inputs by an external 'adversary';
- "The use of facial expression recognition to support diagnostic assessment for patient prioritization", an example of a sensitive application context where differences in operational capability of the system for different population groups can easily result in reputation damaging claims of unjustified bias;
- "Beauty contest judging algorithm that appeared biased to favor lighter skin tones", an example of bias in the training data resulting in biased outcomes that undermined the credibility of the statement purpose of the algorithm (to produce objective beauty contest judgements);
- …

4 METHODOLOGY

Methodologically, the content of the P70xx standards are developed by the working group members through an open deliberation process in which each participant is encourage to suggest content or amendments for the standard document. In order to reflect the broad socio-technical nature of the AI ethics issues addressed by the P70xx standards, the working group members are drawn from a broad range of stakeholders including civil-society organizations, industry and a wide range of academic disciplines. Participation in the working groups is on an individual basis. Even through the participants are affiliated with particular stakeholder organizations, all voices in the standard development process are treated as equals. With the exception of the working group chair and vice-chair, IEEE membership is not required and does not change the status of the participant within the working group.

For the P7003 Standard for Algorithmic Bias Considerations the working group currently consists of 78 participants identifying as having expertise in: Computer Science (18), Engineering (8), Law (6), Business/Entrepreneurship (6), Policy (6), Humanities

(4), Social Sciences (3), Arts (2) and Natural Sciences (1)[1]. In light of the nature of the topic of the P7003 standard, dealing with bias/discrimination, the working group also expressed special concerns about establishing sufficient cultural diversity in its participants. As of early 2018 the participants who chose to indicate their geographic location were from: USA (11), UK (6), Canada (3), Germany (3), Brazil (2), India (2), Japan (2), the Netherlands (2), Australia (1), Belgium (1), Israel (1), Pakistan (1), Peru (1), Philippines (1), S. Korea (1) and Uganda (1); clearly indicating a strong N. America / W. Europe bias that has not yet been resolved. With respect to types of employers, the participants are roughly separated into 1/3 academics, 1/3 industry and 1/3 civil-society affiliations.

During the first eight months, the work of developing the standard focused on growing the participant membership and on exploratory discussions during the monthly conference calls to identify possible factors and sections that could be of relevance for including in the standard. Much of this centered on the foundational sections, which were mostly proposed by working group members as a result of these discussions. In the time between the monthly meetings, working group members are encouraged to develop the document content. During this initial exploratory phase detailed document development was initiated primarily for two of the foundational sections, 'Taxonomy of Bias' and 'Legal frameworks related to Bias'.

As of January 2018, the standard development process has transitioned into the next phase, moving from the initial exploration of the problem space towards consolidation and specification of the standard document content. All P7003 working group members are asked to identify document sections that they will take primary responsibility for, with the aim of having teams of at least two participants for each section. The monthly conference calls will focus on providing updates from each of the teams to the complete working group regarding their progress during the intervening month and any issues that might require input from other teams. This will also be the primary opportunity for all other working group members to raise questions, make suggestions and/or volunteer to (temporarily) contribute to the work of another team.

Once the IEEE P7003 draft document is completed and approved by the IEEE P7003 working group, it will be submitted for balloting approval to the IEEE-SA. The IEEE-SA will send out an invitation-to-ballot to all IEEE-SA members who have expressed an in interest in the subject, i.e. Algorithmic Bias. If the draft receives at least 75% approval, the draft is submitted to the IEEE-SA Standards Board Review Committee, which checks that the proposed standard is compliant with the IEEE-SA Standards Board Bylaws and Operations Manual. The Standards Board then votes to approve the standard, which requires a simple majority. At that point, about 2.5 to 3 years after the proposal for developing the standard was first submitted, the standard is published for use.

5 CONCLUSION

As part of the IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems a series of eleven ethics standards are under development, designated IEEE P7000 through IEEE P7010. As outlined in this paper, the IEEE P7003 Standard for Algorithmic Bias Considerations aims to provide an actionable framework for improving fairness of algorithmic decision-making systems that are increasingly being developed and deployed by industry, government and other organizations. The IEEE P7003 standard is currently transitioning from an initial exploratory phase into a consolidation and specification phase. Participation in the IEEE P7003 working group is open to all who are interested in contributing towards reducing and mitigating unintended, unjustified and societally unacceptable bias in algorithmic decisions.

Minutes of recent IEEE P7003 working groups meetings are available at [3].

ACKNOWLEDGMENTS

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[1] Number in brackets indicate number of participants who identified as having this expertise as part of an informal internal survey. Many participants chose not to respond while some chose to indicate multiple expertise.

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IEEE Standard Model Process for Addressing Ethical Concerns during System Design

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IEEE Standard Model Process for Addressing Ethical Concerns during System Design

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Approved 16 June 2021

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Abstract: A set of processes by which organizations can include consideration of ethical values throughout the stages of concept exploration and development is established by this standard. Management and engineering in transparent communication with selected stakeholders for ethical values elicitation and prioritization is supported by this standard, involving traceability of ethical values through an operational concept, value propositions, and value dispositions in the system design. Processes that provide for traceability of ethical values in the concept of operations, ethical requirements, and ethical risk-based design are described in the standard. All sizes and types of organizations using their own life cycle models are relevant to this standard.

Keywords: case for ethics, concept of operations, ethical value requirements, ethical values elicitation, ethically aligned design, IEEE 7000™, software engineering, system engineering, value-based requirements, value prioritization

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Introduction

This introduction is not part of IEEE Std 7000™-2021, IEEE Standard Model Process for Addressing Ethical Concerns during System Design.

Organizations are becoming increasingly aware of the need to demonstrate socially responsible behavior when dealing with stakeholders, customers, regulators, and society in general. Socially responsible organizations recognize that their decisions and actions affect not just their financial bottom line but also society and the environment. One of the principles of social responsibility is ethical behavior.

Engineers, their managers, and other stakeholders benefit from well-defined processes for considering ethical issues along with the usual concerns of system performance and functionality early in the system life cycle. Consumers can be unaware of the ethical considerations regarding the products and services they use; it is only by rigorously examining ethical concerns that manufacturers, engineers, and technologists can align products and services with the results valued by acquirers, consumers, and users.

This standard aims to support organizations in creating ethical value through system design. Creating ethical value is a vision for organizations that recognizes their central role in society as shapers of well-being and carriers of societal progress that benefits humanity. Implementing IEEE Std 7000 can help them to strengthen their value proposition and avoid value harms. It is applicable to all kinds of products and services, including artificial intelligence (AI) systems.

IEEE Std 7000 is recommended for use by organizations engaged in concept exploration, requirements definition, or development of new or revised products or services. The standard requires consideration of values relevant to the culture where the system is to be deployed. It is applicable with any life cycle model or development methodology. IEEE Std 7000 is designed to work for all sizes and types of organizations (e.g., large, small, for profit, non-profit) aiming to deliver products that enable the ethical values of their customers and their own organization. The standard can help organizations to build better products with a more refined and nuanced value proposition and with less risk. This standard can be more easily applied in the context of organizational policies that are consistent with the organization’s ethical values, such as the following:

- Readiness to include a wide group of stakeholders in the engineering effort
- An open, transparent, and inclusive project culture
- A commitment to quality
- A dedication to ethical values from the top of the organization
- A commitment to allocate sufficient time and resources for ethical requirements definition

IEEE Std 7000 is most effectively applied when organizational leaders and top management are involved in and assume responsibility for the products and services created. Through key roles defined for IEEE Std 7000 project teams, this standard seeks to help align management and engineering activities with stakeholder expectations for ethical values in the operational concept, value propositions, and design features being developed.

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Contents

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IEEE Standard Model Process for Addressing Ethical Concerns during System Design

1. Overview

1.1 Scope

The standard establishes a set of processes by which engineers and technologists can include consideration of ethical values throughout the stages of concept exploration and development, which encompass system initiation, analysis, and design. This standard provides engineers and technologists with an implementable process aligning innovation management processes, system design approaches, and software engineering methods to help address ethical concerns or risks during system design.

IEEE Std 7000™ does not give specific guidance on the design of algorithms to apply ethical values such as fairness and privacy.

1.2 Purpose

The goal of this standard is to enable organizations to design systems with explicit consideration of individual and societal ethical values, such as transparency, sustainability, privacy, fairness, and accountability, as well as values typically considered in system engineering, such as efficiency and effectiveness.

Projects conforming to IEEE Std 7000 balance management commitments for time and budget constraints with the long-term values of social responsiveness and accountability. To enable this, the commitment of top executives to establish and uphold organizational values is important.

NOTE—A system is sometimes considered as a product or as the services it provides.[1]

1.3 Applicability and constraints

To reach its goal, this standard primarily supports organizations to identify stakeholder values and to engage in value-based system or service development. It is applicable within any life cycle model or set of methods for systems and software engineering. If organizations have running systems that cause ethical challenges, then the processes in this standard can be used for reiteration of value-based analysis.

[1] Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

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The processes in this standard apply during system conception and design for organizations seeking to uncover, address and monitor value concerns for a system intended for a given context. When organizations use IEEE Std 7000, it is the respective project teams, stakeholder groups, and organizational leaders who determine the values that a system is supposed to address and sustain. The use of IEEE Std 7000 cannot guarantee that the system as designed and subsequently built is ethical, because the ethicality achieved in a system depends on the moral capabilities and choices of those who use the standard and the commitment of the organization offering the system to adhere to the recommendations made as a result of ethically aligned design as stated in the remainder of this clause.

This standard has a number of limitations to its scope, as stated in the remainder of this clause.

Some human values required of systems have been extensively treated in other standards (e.g., health, security, and safety) and are not further detailed in this standard on ethical values. Aesthetic characteristics (such as color or form) are in scope where they reflect social or cultural characteristics with ethical impact.

NOTE 1—The ISO/IEEE 11073 family of health informatic standards specifies numerous engineering solutions for interoperability of health information. The IEEE publishes many safety-related standards and codes, e.g., for electrical safety, nuclear power plant safety. In the area of systems and software engineering, IEEE Std 1228-1994 [B23][2] can be consulted. The ISO/IEC 27000 family of standards includes close to a hundred standards on information security techniques, including privacy engineering.

The processes described in this standard do not prescribe what is ethical and what is unethical. While the standard is intended to be consistent with the IEEE Code of Ethics [B24], it does not provide ethical guidance for individual engineers in their personal ethical judgements regarding their professional work or specific rights or wrongs, nor advice to whistleblowers on how to address ethical lapses in an organization. As further discussed in C.4, the IEEE code of ethics (one example of professional ethics) has general applicability, but no specific requirements for applying ethical values in system design.

This standard does not prescribe any specific organizational ethical policies. Organizations also commonly develop ethical principles related directly to workplace ethics, consistent with legal and regulatory employment requirements. This standard focuses rather on how to operationalize ethical values that are commonly at stake in technology design and deployment. The use of IEEE Std 7000 does not imply that an organization following its processes is ethical in all other aspects of its mission, product or service development, or discharge of its social responsibility. However, adoption and implementation of ethical value processes in the design and deployment of new products and services or modification of existing legacy systems are illustrative of an organization that is cognizant of its social responsibility and the impact of its endeavors on the values of its stakeholders.

IEEE Std 7000 allows organizations to make their value choices transparent to anyone who uses the system as well as to auditors, potential certifiers, or governmental agencies. Moreover, IEEE Std 7000 provides processes for organizations that assume accountability for the ethical decisions they take. This standard helps organizations in the following:

- Understanding and anticipating value implications and consequences of their systems and taking investment decisions based on them
- Identifying ethical value requirements (EVR) and priorities for system design to be integrated into system requirements
- Choosing system design alternatives according to value priorities while avoiding or mitigating value harms or ethical pitfalls
- Keeping control of the long-term value-based sustainability of a system through ongoing supervision and information management
- Creating transparency and responsibility for the choices made and the system's resulting functionality

[2] The numbers in brackets correspond to those of the bibliography in Annex J.

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AMSCE 101

This standard is most applicable to organizations that are building a system for a known context or at least known typical use cases for the products, services, and systems they build.

NOTE 2—IEEE Std 7000 does not challenge the ethicality of fundamental research.

1.4 Process overview

This standard can also be applied during the enhancements or modifications of existing legacy systems. The enhancements and modifications to products, services, and systems can adopt and conform with the requirements depicted in this standard. For example, it can be used by a device manufacturer building a care robot for a nursing home. It can be used for an artificial intelligence (AI) chat system that is employed in a specific use context, such as medical advice, teaching a language, or recommending music. This standard can be less usable for building a generic product, service, or system for which the deployment context is indefinite, such as a generic camera system or a computer chip usable in multiple ways. This standard can be more effective in specific application of products, services, and systems where the context of application and the stakeholder impact is discernible and amenable to clearer specification and analysis.

This document establishes a set of processes for organizations and projects that address the ethical values of software-based systems (and services) during design and development. The processes can be aligned with any system or software engineering methods, life cycle model, and engineering management style that an organization or project uses for design and development. The processes can be used for new design and development and for improvement of the ethical attributes of existing systems. Systems of interest are not limited to particular industries, sectors, applications, or system sizes. The processes can be used by organizations of all types and sizes, including small and innovative organizations.

Engineers, technologists, and other project stakeholders need a methodology for identifying, analyzing, and reconciling ethical concerns of end users and other stakeholders at the beginning of systems and software life cycles. The processes in this standard enable the pragmatic application of this type of value-based system design methodology. This standard provides engineers, technologists, and other members of the organization with implementable processes aligning innovation management processes, IT system design approaches, and software engineering methods to address ethical concerns in their systems that can affect their organizations, stakeholders, and end users. The processes of IEEE Std 7000 provide organizations with ethical requirements and design activities that enable systems engineering to support human wellbeing. By positively addressing the values of direct and indirect system stakeholders, organizations can attain more than mere legal compliance. They can attain ethical practices that engage with the original spirit of laws, human rights, or other social values in the specific context of a system's use as detailed further in 5.7.

Figure 1 illustrates the processes presented in this standard. These processes occur during the concept exploration and development stages of the product life cycle and are detailed in Clause 7 through Clause 11 of this standard.

The importance of considering potential values and harms during concept exploration and development of the concept of operations (ConOps) sets the context for the remaining processes. This process supports initial identification of values and an extensive feasibility analysis, which can help to refine the ConOps as well as anticipate value-based system requirements.

During the Ethical Values Elicitation and Prioritization Process, a wide range of stakeholders identify potential positive and negative system consequences, stakeholder virtues, and ethical duties that are impacted by the system concept. These are typically expressed by stakeholders in unstructured form (e.g., in terms of harms and benefits) but have underlying values that people care about. Consequences, virtues, and duties are identified with the help of ethical theories; specifically, utilitarianism, virtue ethics, and duty ethics, along with other culturally appropriate value systems or ethical theories. Values are prioritized with the help of an activity where the top management of an organization evaluates the importance of the value to the system of interest

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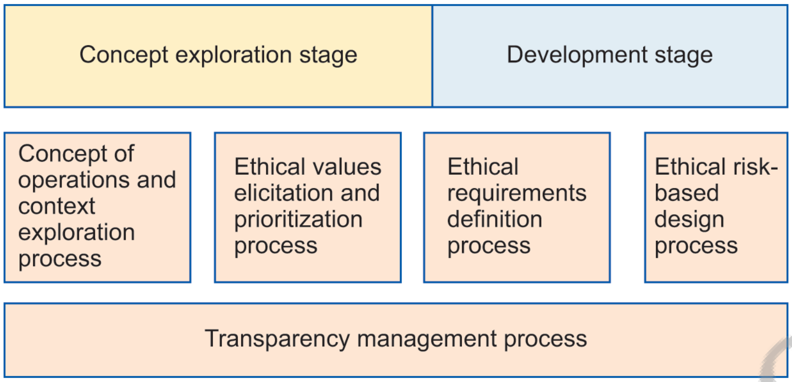
Concept exploration stage
Development stage
Concept of operations and context exploration process
Ethical values elicitation and prioritization process
Ethical requirements definition process
Ethical risk-based design process
Transparency management process

Figure 1—Relationship of processes and stages in IEEE Std 7000

(SOI). Once values are identified and prioritized, they are scrutinized again with a view to potential legal expectations and internationally applied ethical guidelines. The result is a list of value priorities for the system.

These value priorities are then analyzed more systematically and conceptually as the basis for the Ethical Requirements Definition Process, which generates EVR and value-based system requirements.

IEEE Std 7000 is compatible with many existing development practices, including iterative and incremental life-cycle models and agile methods. The Ethical Risk-Based Design Process translates value-based requirements into design characteristics and determines controls that can mitigate risks to values. Controls are system requirements or organizational policies and procedures. As EVRs are instantiated in the system design, the value dispositions are validated for incorporation of the specified values.

The value-based engineering processes include Transparency Management, based on the Information Management process of ISO/IEC/IEEE 12207:2017 [B40] and ISO/IEC/IEEE 15288:2015 [B41]. In this standard, the Transparency Management Process is refined to consider the special requirements of value-based engineering in communicating more openly with relevant stakeholders.

In this standard, the focus on concept analysis, requirements engineering, risk-based design, validation, and monitoring of a product's design, characterize it as deeply embedded into system engineering thinking. Its alignment with established system engineering processes is indicated in Annex A; the relationship of processes in IEEE Std 7000 and in ISO/IEC/IEEE 12207:2017 [B40] and ISO/IEC/IEEE 15288:2015 [B41]. Those standards provide processes without the special focus on ethical values.

1.5 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (shall equals is required to).[3,4]

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred, but not necessarily required (should equals is recommended that).

The word *may* is used to indicate a course of action permissible within the limits of the standard (may equals is permitted to).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (can equals is able to).

AMSCE-1101

[3] The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

[4] The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

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2. Normative references

This standard has no normative references.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this standard, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause. [5]

NOTE—For additional terms and definitions in the field of systems and software engineering, see ISO/IEC/IEEE 24765 [B45], which is published periodically as a "snapshot" of the SEVOCAB (Systems and Software Engineering Vocabulary) database and is publicly accessible at <computer.org/sevocab>.

acquirer: Stakeholder that acquires or procures a product or service from a supplier.

NOTE—Other terms commonly used for an acquirer are buyer, customer, owner, purchaser, or internal/organizational sponsor.

acquisition: Process of obtaining a product, service, or system.

activity: Set of cohesive and purposeful tasks of a process.

agreement: Mutual acknowledgment of terms and conditions under which a working relationship is conducted. *Example:* Contract, memorandum of agreement.

architecture: <system> Fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution (ISO/IEC/IEEE 42010:2011 [B49]).

audit: Independent examination of a work product or set of work products to assess compliance with specifications, standards, contractual agreements, or other criteria (ISO/IEC/IEEE15288:2015 [B41]).

NOTE—The scope includes professional and industry codes of practice.

benefit: Positive outcome that is voluntarily or involuntarily created by a system or process.

NOTE—Benefits correspond to one or more underlying desired values.

concept of operations (ConOps): Verbal and/or graphic statement, in broad outline, of an organization's assumptions or intent in regard to an operation or series of operations (ISO/IEC/IEEE15288:2015 [B41]).

NOTE—The concept of operations ConOps frequently is embodied in long-range strategic plans and annual operational plans. In the latter case, the ConOps in the plan covers a series of connected operations to be carried out simultaneously or in succession. The concept is designed to give an overall picture of the organization operations. *See also:* **operational concept**.

concern: <system> Interest in a system relevant to one or more of its stakeholders (ISO/IEC/IEEE 42010:2011 [B49]).

NOTE—Concern pertains to any influence on a system in its environment, including developmental, technological, business, operational, organizational, political, economic, legal, regulatory, ecological, and social influences.

[5] *IEEE Standards Dictionary Online* is available at: http://dictionary.ieee.org. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

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consumer: Individual member of the general public purchasing or using products for private purposes (IEC/IEEE 82079:1:2019 [B22]).

context of use: Intended operational environment for a system.

NOTE 1—The environment determines the setting and circumstances of all influences upon a system, including not only other systems, but also people, settings, social, and ecological factors.

NOTE 2—Context of use can be captured using a Context of Use Description (ISO/IEC 25063.3 [B35]).

control: Ability to determine the nature, sequence and/or consequences of technical and operational settings, behavior, specific events, and/or experiences.

NOTE—Control includes cognitive control (that is, being informed about activities), decisional control (having choices over actions), and behavioral control (receiving feedback from actions).

core value: A value that is identified as central in the context of a system of interest.

NOTE—A core value is at the center of a value cluster of instrumental or related values and value demonstrators. A core value is a positive value. Typically, a system of interest (SoS) has several core values.

customer: Organization or person that receives a product or service (ISO/IEC/IEEE12207:2017 [B40]). *Example:* Consumer, client, user, acquirer, buyer, or purchaser.

NOTE—A customer can be internal or external to the organization.

dependability: Ability of a system to perform as and when required.

NOTE—A measure of a system's availability, reliability, and maintainability.

design: (verb) <process> To define the architecture, elements, interfaces, and other characteristics of a product, service or system, or system element (ISO/IEC/IEEE15288:2015 [B41]). (noun) Result of the design process (ISO/IEC/IEEE15288:2015 [B41]).

design characteristic: Design attributes or distinguishing features that pertain to a measurable description of a product or service (ISO/IEC/IEEE15288:2015 [B41]).

duty: Obligation or expectation to perform a specific action when certain circumstances occur.

duty ethics/deontology: Ethical theory that identifies universal moral laws to bound the actions of all rational individuals.

enabling system: System that supports a system of interest during its life cycle stages but does not necessarily contribute directly to its function during operation. *Example:* When a system of interest enters the production stage, a production-enabling system is required.

NOTE—Each enabling system has a life cycle of its own. Each enabling system can, in its own right, be treated as a system of interest.

environment: <system> Context determining the setting and circumstances of all influences upon a system (ISO/IEC/IEEE 42010:2011 [B49]).

NOTE—Also applies to products and services.

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ethical: Supporting the realization of positive values or the reduction of negative values.

NOTE—A system can be ethical or unethical in the sense that it bears value dispositions to cater to positive value creation or negative value prohibition.

ethical policy statement: A high-level declaration endorsed by the top management to explain and demonstrate the organization's commitment to respect core values in the conduct of its activities.

ethical principle: Shared proposition about ethical values that members of a community can pursue and uphold.

ethical requirement: Requirement that is either an ethical value requirement (EVR) or a value-based system requirement.

ethical risk: A risk to ethical values.

ethical value: Value in the context of human culture that supports a judgment on what is right or wrong.

NOTE—A virtue is an example of an ethical value.

ethical value requirement (EVR): Organizational or technical requirement catering to values that stakeholders and conceptual value analysis identified as relevant for the SOI.

ethics: Branch of knowledge or theory that investigates the correct reasons for thinking that this or that is right.

NOTE—Ethics are guidelines for conduct that help people in making a judgment about what is right or wrong.

functional requirement: Statement that identifies what results a product or process shall produce.

harm: (noun) Negative event or negative social development entailing value damage or loss to people. (verb) Acting with negative value effects for self or others, within a respective SOI, organization, or beyond.

NOTE—Harms correspond to one or more underlying values.

hazard: Source or situation with a potential for harm in terms of human injury or ill health (both short and long term), damage to property, damage to the environment, or a combination of these (ISO 31000 [B29]).

human rights: Rights to which every person is entitled.

incident: Anomalous or unexpected event, set of events, condition, or situation at any time during the life cycle of a project, product, service, or system (ISO/IEC/IEEE12207:2017 [B40]).

information item: Separately identifiable body of information that is produced, stored, and delivered for human use (ISO/IEC/IEEE 15289 [B42]).

legal feasibility: Determination that the system of interest is consistent with applicable laws and regulations.

life cycle: Evolution of a system, product, service, system, project, or other human-made entity from conception through retirement.

life cycle model: Framework of processes and activities concerned with the life cycle that may be organized into stages, which also acts as a common reference for communication and understanding.

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nonfunctional requirement: Requirement that describes not what the system does, but how the system does it.

operational concept: Verbal and graphic statement of an organization's assumptions or intent in regard to an operation or series of operations of a system or a related set of systems.

NOTE 1—The operational concept is designed to give an overall picture of the operations using one or more specific systems, or set of related systems, in the organization's operational environment from the users' and operators' perspective. *See also:* **concept of operations** (ISO/IEC/IEEE 15288:2015 [B41]).

NOTE 2—The operational concept can include major product, service or system elements and/or system components, boundaries and directly adjunct elements beyond boundaries, internal and external input elements (i.e., databases and/or applications serving the system that are outside of the SOI's boundaries) and output elements (i.e., databases and/or applications serving the system that are outside of the SOI's boundaries).

NOTE 3—The operational concept can be visualized.

operator: Individual or organization that performs the operations of a product, service or system.

NOTE 1—The role of operator and the role of user can be vested, simultaneously or sequentially, in the same individual or organization.

NOTE 2—An individual operator combined with knowledge, skills, and procedures can be considered as an element of the service or system.

NOTE 3—An operator may perform operations on a SOI that is operated, or of a SOI that is operated, depending on whether or not operating instructions are placed within the SOI's boundary.

opportunity: A condition or state with a potential to lead to a benefit or gain.

organization: Group of people and facilities with an arrangement of responsibilities, authorities, and relationships. *Example:* Corporation, firm, enterprise, institution, charity, sole trader, association, or parts or combination thereof.

NOTE—An identified part of an organization (even as small as a single individual) or an identified group of organizations can be regarded as an organization if it has responsibilities, authorities, and relationships. A body of persons organized for some specific purpose, such as a club, union, corporation, or society, is an organization.

participatory design: System design process that aims at investigating, understanding, reflecting upon, establishing, developing, and supporting mutual learning between multiple system stakeholders and system developers in collective reflection-in-action.

NOTE—The participants in a participatory design practice typically undertake the two principal roles of users and designers where the designers strive to learn the realities of the users' situation/requirements, while the users strive to articulate their desired aims and identify appropriate technological means to obtain them.

persona: Archetypal user of a product, service, or system.

NOTE 1—Personas can represent the needs of a larger group in terms of their goals, expectations, and personal characteristics. They can help to guide decisions about system design and design targets.

NOTE 2—The term 'persona' stems from the field of usability design where personas are typically described in a storytelling exercise. They bring personas to life by giving them names, personalities, and photos.

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personal maxim: Personal principle of what one wishes for, acts upon, and thinks that it should be applicable to everyone.

problem: Difficulty, uncertainty, or otherwise realized and undesirable event, set of events, condition, or situation that requires investigation and corrective action.

process: Set of interrelated or interacting activities that transforms inputs into outputs (ISO 9000:2005 [B30]).

process purpose: High-level objective of performing the process and the likely outcomes of effective implementation of the process.

NOTE—The purpose of implementing the process is to provide benefits to the stakeholders.

product: Result of a process.

NOTE—There are four agreed generic product categories: hardware (e.g., engine mechanical part); software (e.g., computer program); services (e.g., transport); and processed materials (e.g., lubricant). Hardware and processed materials are generally tangible products, while software or services are generally intangible.

program: Related projects, subprograms and program activities managed in a coordinated way to obtain benefits not available from managing them individually.

project: Endeavor with defined start and finish criteria undertaken to create a product or service in accordance with specified resources and requirements.

quality assurance: Part of quality management focused on providing confidence that quality requirements are fulfilled (modified from ISO 9000 [B30]).

quality management: Coordinated activities to direct and control an organization with regard to quality (ISO 9000 [B30]).

requirement: Statement that translates or expresses a need and its associated constraints and conditions (ISO/IEC/IEEE 29148:2018 [B48]).

NOTE—System design needs include system characteristics (such as data flows or data flow characteristics) and system elements.

resource: Asset that is utilized or consumed during the execution of a process. *Example:* Includes diverse entities such as funding, personnel, facilities, capital equipment, tools, and utilities such as power, water, fuel and communication infrastructures (ISO/IEC/IEEE 12207:2017 [B40]).

NOTE—Resources include those that are reusable, renewable, or consumable.

risk: Effect of uncertainty on objectives (ISO/IEC/IEEE 16085 [B43]).

NOTE 1—An effect is a deviation from the expected—positive or negative. A positive effect is also known as an opportunity.

NOTE 2—Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product, and process).

NOTE 3—Risk is often characterized by reference to potential harmful events and consequences, or a combination of these.

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NOTE 4—Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence.

NOTE 5—Uncertainty is the state, even partial, of deficiency of information related to understanding or knowledge of an event, its consequence, or likelihood.

security: Protection against intentional subversion or forced failure (NATO AEP-67 [B58]).

NOTE—A composite of four attributes – confidentiality, integrity, availability, and accountability—plus aspects of a fifth, usability, all of which have the related issue of their assurance.

service: performance of activities, work, or duties.

NOTE 1—A service is self-contained, coherent, discrete, and can be composed of other services.

NOTE 2—A service is generally an intangible product.

social responsibility: Obligation to wider society to respect the values reigning within it and to act in line with the organization's values, including legal, ethical, environmental, and financial responsibilities.

stage: Period within the life cycle of an entity that relates to the state of its description or realization.

NOTE 1—Stages relate to major progress and achievement milestones of the entity through its life cycle.

NOTE 2—Stages often overlap.

stakeholder: Individual or organization having a right, share, claim, influence or interest in a system or in its possession of characteristics that meet their needs and expectations. *Example:* Human beings using the system, organizations representing human beings using the system, supporters, developers, producers, trainers, maintainers, disposers, acquirers, supplier organizations, and regulatory bodies (ISO/IEC/IEEE12207:2017 [B40]).

NOTE 1—Some stakeholders can have interests that oppose each other or oppose the system.

NOTE 2—There can be direct and indirect stakeholders. Indirect stakeholders are not directly using a system but are indirectly influenced by it.

supplier: Organization or an individual that enters into an agreement with the acquirer for the supply of a product or service.

NOTE 1—Other terms commonly used for supplier are contractor, producer, seller, or vendor.

NOTE 2—The acquirer and the supplier sometimes are part of the same organization.

system: Combination of interacting elements organized to achieve one or more stated purposes.

NOTE—A construct or collection of different elements that together produce results not obtainable by the elements alone. The elements, or parts, can include people, hardware, software, facilities, policies, processes and documents; that is, all things required to produce systems-level results.

system boundary: Conceptual interface between a system and its environment.

system characteristic: Attributes or distinguishing features pertaining to a system.

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system element: Member of a set of elements that constitute a system. *Example:* Hardware, software, data, humans, processes (e.g., processes for providing service to users), procedures (e.g., operator instructions), facilities, materials, and naturally occurring entities or any combination.

NOTE—A system element is a discrete part of a system that can be implemented to fulfill specified requirements.

system of interest (SOI): System whose life cycle is under consideration.

system of systems (SoS): System of interest whose constituents are themselves systems.

NOTE—A SoS brings together a set of systems for a task that none of the systems can accomplish on its own. Each constituent system keeps its own management, goals, and resources while coordinating within the SoS and adapting to meet SoS goals.

systems engineering: Interdisciplinary approach governing the total technical and managerial effort required to transform a set of stakeholder needs, expectations, and constraints into a solution and to support that solution throughout its life.

task: Required, recommended, or permissible action, intended to contribute to the achievement of one or more outcomes of a process.

trade-off: Decision-making actions that select from various requirements and alternative solutions on the basis of net benefit to the stakeholders.

transparency: Characteristic of the transfer of information to a stakeholder, which is honest; contains information relevant to the causes of some action, decision or behavior; and is presented at a level of technicality and in a form that are meaningful to the stakeholder.

top management: Person or group of people who direct and control the organization at the highest level.

NOTE—Top management can be the owner of an organization, majority shareholders, senior manager in the organization or members of the governing board.

user: Individual or group that interacts with a system or benefits from a system during its utilization (ISO/IEC 25010:2011 [B34]).

NOTE—The role of user and the role of operator are sometimes vested, simultaneously or sequentially, in the same individual or group.

utilitarianism: Ethical decision-making approach to consider the consequences of system design and deployment (harms and benefits).

NOTE—The aim of utilitarianism is to maximize positive consequences of an act and to minimize negative consequences so as to achieve the greatest satisfaction and happiness of direct and indirect stakeholders in life in the long term.

validation: Confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled (modified from ISO 9000:2015—Note to entry has been added).

NOTE—A system is able to accomplish its intended use, goals, and objectives (i.e., meet stakeholder requirements) in the intended operational environment. The right system was built.

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value: A conception that influences the selection from available modes, means and ends of action:

- *Examples of positive values*: love, privacy, security, transparency, accountability, generosity, dignity, courage, fairness
- *Examples of negative values:* bias, absence of transparency, absence of privacy, selfishness, greediness

NOTE—A value can be positive or negative. A positive value is intuitively recognized because of its relatively high desirability. A negative value is marked by its undesirability.

value at risk: Value that is regarded as being undermined or threatened.

value-based system requirement: System requirement that is traceable from ethical value requirements, value clusters, and core values.

value bearer: System, person, thing, action, or relationship that carries values.

NOTE—If a system is a value bearer it carries values by the means of value dispositions.

value benefit: A positive state or activity fostering a value.

value cluster: Group containing one core value and several values instrumental to, or related to, the core value.

NOTE—A value cluster can contain value demonstrators.

value demonstrator: Potential manifestation of a core value, which is either instrumental to the core value or undermines it.

value disposition: System characteristic that is an enabler or inhibitor for one or more values.

value harm: A negative state or activity undermining a value.

value lead: Person assigned to coordinate and conduct tasks related to ethical values elicitation and prioritization and traceability of values through the requirements and design artifacts.

value register: An information store created for transparency and traceability reasons, which contains data and decisions gained in ethical values elicitation and prioritization and traceability into ethical value requirements.

verification: Confirmation, through the provision of objective evidence, that specified requirements have been fulfilled (modified from ISO 9000:2005—Note to entry has been added).

NOTE—Verification is a set of activities that compares a system or system element against the required characteristics. This includes, but is not limited to, specified requirements, design description and the system itself. The system was built right.

virtue: Positive value of human conduct.

NOTE 1—Habitual character quality of a person. Vice is the corresponding negative term.

NOTE 2—Virtue promotes not only individual, but also collective greatness. Virtue is typically marked by well-balanced golden-mean behavior, avoiding extreme behaviors (for example the virtue of generosity is marked by being the golden mean between greediness and lavishness).

NOTE 3—All virtues are values, but not all values are virtues.

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3.2 Acronyms and abbreviations

AI	artificial intelligence
BAT	best available technique
ConOps	concept of operations
EVR	ethical value requirement
RACI	responsible, accountable, consulted, informed
SLA	service level agreement
SOI	system of interest
SoS	system of systems

4. Conformance

Conformance to this standard can be achieved in two ways: a) conformance to outcomes, by demonstrating that all of the outcomes from Clause 7 to Clause 11 have been performed; b) conformance to tasks, by demonstrating that all of the tasks from Clause 7 to Clause 11 have been performed. Organizations can also claim full conformance to both outcomes and tasks. Full conformance to outcomes permits greater freedom in the implementation of conforming processes and can be useful for implementing processes to be used in the context of an innovative life cycle model.

IEEE Standards cannot guarantee or ensure ethical system design, and conformance with the provisions of this standard does not imply conformance with any particular ethical principles or value system, which may vary from community to community, or over time. Users of the standard are responsible for being apprised of and referring to appropriate, applicable ethical criteria for consideration during system design.

NOTE 1—Options for conformance allow flexibility in the application of this standard. Each process has a set of required results ("outcomes") consistent with its purpose and a set of high-level activities and more detailed tasks that represent one way to achieve the outcomes.

NOTE 2—Users who implement the activities and tasks of the declared set of processes can assert full conformance to tasks of the selected processes. Some users, however, might have innovative process variants that achieve the results (i.e., the outcomes) of the declared set of processes without implementing all of the activities and tasks. These users can assert full conformance to the outcomes of the declared set of processes. The two criteria—conformance to task and conformance to outcome—are not necessarily equivalent, since specific performance of activities and tasks can require, in some cases, a higher level of capability than just the achievement of outcomes.

NOTE 3—ISO/IEC/IEEE 24774 [B46] explains the concepts of outcomes, outputs, activities, and tasks.

5. Key concepts and application

5.1 General application

This standard is usable by organizations that engage in system and software engineering. This includes the following in particular:

- Organizations building a new generic or application specific product, service or system from scratch
- Organizations implementing a major revision on an existing product, service or system
- Organizations planning the acquisition of a tailored product, service or system
- Research organizations that build a new product, service or system from scratch or adapt an existing entity in the course of their research activities

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An organization and its project team(s) can apply the requirements in this standard to help make value-based ethical system design and investment decisions.

This standard can be used in one or more of the following modes:

a) By an organization—to help establish an environment of value-based processes. These processes can be supported by an infrastructure of policies, methods, procedures, techniques, tools, and trained personnel. The organization may then employ this environment to perform and manage its projects and progress systems through their life cycles. In this mode, this standard is used to assess conformance of a declared, established environment to its provisions.

b) By a project—to help select, structure, and employ the elements of an established environment to provide products and services. In this mode, this standard is used in the project's requirements in the declared and established environment.

c) By an acquirer and a supplier—to help develop an agreement concerning processes and activities. Via the agreement, the processes and activities in this standard are selected, negotiated, agreed to, and performed. In this mode, this standard is used for guidance in developing the agreement.

d) By process assessors—to serve as a process reference model for use in the performance of process assessments that may be used to support organizational process improvement.

5.2 Specified context of use

In general, the context of use and the concept of operation of a system are relevant to the identification of ethical values. They affect the extent to which the direct or indirect human users are able to control the system and the extent to which the system has the capacity to inflict harm or promote well-being. Clause 7 provides a process for exploring and setting the ethical context of a system.

NOTE—Although the ConOps is defined before a system is developed, the context and the system are likely to change during the system life cycle, and continued iterations of value analysis may be needed.

Systems support values relevant to a context of use. For example, a speech assistant used in a car can contain some conversational skills that are different from those used in virtual worlds or at home. With different contexts (car, game, home) come different subject matters and, hence, different conversational subject domains with different ethical import. This standard assumes that systems can undermine and foster values relevant in certain use contexts.

5.3 The Organization

This standard is intended to be used in systems and software engineering organizations of all types and sizes, whether they apply a hierarchical or a relatively flat organizational model. It is also usable by components of an organization, such as a product development team, project, or a corporate division, although conformance to the standard likely requires participation across organizations in most cases. It is intended for international use with various cultural values and governance systems. In applying this standard, one person can assume many roles, and one role can be held by numerous individuals or subgroups within the organization. There are no requirements for independence of roles in this standard. For more on risk management for systems and software engineering, see ISO/IEC/IEEE 16085 [B43].

Ethical decisions are not the sole responsibility of top management, although top management has an undeniable role in setting expectations for values and policies and establishing control of performance and results. One of the premises of this standard is that the informed judgment of systems and software engineers need to be considered while making ethical decisions about a system under development. Another premise of this standard is that engineers and others in the organization can benefit from learning and regularly applying

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specific processes and methods to make ethical choices throughout the life cycle. Just as engineering analyses, decisions, and risk assessments have always involved balancing and trade-offs of values, in this context engineers participate as the organization weighs competing values and harms. Although involvement with internal or external ethics practitioners may improve outcomes and efficiency, it is not required to engage an ethics expert to conform with the standard.

NOTE 1—Numerous management system standards and value-based standards are already in use for various domains, such as quality, security, environmental impact, safety, asset management, risk management, and social responsibility and sustainability (e.g., ISO 9001 [B31], ISO/IEC 27001 [B37], ISO/IEC 19770 [B33], ISO 31000 [B29], ISO/IEC/IEEE 16085 [B43], and ISO 26000 [B28]).

The ethical decisions made in one organization can affect its suppliers and customers, the entire economy, and public well-being. Organizations can encourage their business partners and customers to make ethical decisions, to consider harm to users, and to promote certain values. However, in this standard the span of control of the organization is assumed to include its first-tier relationships: the internal or external contractors who agree to adhere to the ethical decisions and share the ethical values the acquirer has identified. While an organization acting as a supplier can often exert pressure on its customers (acquirers) to act in more ethical ways through the design of its systems, these customers and users are stakeholders not within its span of control. This standard also does not address how to determine the legal feasibility of designing a system nor how to effect changes in ethical values and cultures on a national level or changes in the legal environment.

Within the scope of this standard is the design of products, services, and systems in an organization. It does not address how an individual within the organization makes individual ethical decisions as to whether to participate in the engineering process and work on a product (or whether to be a whistleblower). This standard also does not address ethical considerations or establish requirements for non-engineering areas of organizational governance and ethical policies, such as various human relations policies, organizational structures, employment arrangements, work practices, team dynamics, or governance and financial management systems used in organizations where they do not directly affect the SOI. However, it is more likely that an organization can make ethical decisions and reduce its risks by applying the same ethical values it espouses for its systems to its own operations.

The use of this standard is facilitated if organizations have strong organizational principles. Such principles ease several of the normative activities in this standard in addition to providing an organization with a more coherent identity and shared purpose.

This standard does not require any specific set of principles but, recommends organizations to develop a set of core values, such as transparency or accountability.

NOTE 2—Organizations also commonly develop ethical principles related directly to work ethics and consistent with legal and regulatory employment requirements. These are not considered directly in this standard.

General organizational principles are an agreed set of guiding principles for planning and delivery of systems, products, and services when faced with activities that can have an ethical impact on internal or external stakeholders. The principles should be able to guide individuals, line managers, management, and leadership during decision-making, conflict situations, decision points, and prioritization calls. The organization’s goals and strategy are developed on the foundation of the principles. The principles should be demonstrable in the organization’s strategy, portfolio of systems, and future operating models.

Clear and evident collaboration, inclusion, and interaction should be present during the activities to create and implement principles. As principles are introduced into the organization they should be enacted as a formal change project including stakeholders. Principles should be included in the formal targets for product development and internal improvement projects.

NOTE 3—ISO/IEC TR 38504 [B39] includes guidance on alignment of principles to organizational governance.

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5.4 Stakeholders

Concern for the interests of direct and indirect stakeholders is central to applying values to engineering design. This can include society at large as a stakeholder—for instance, when the value of environmental sustainability is an issue for system design. As for any engineering design effort, the interests of the project owners or the organization's top management along with the system architects and designers are typically predominant. The acquirers for a custom-built system, or whoever identifies the needs to be translated into requirements, such as business or market analysts, and portfolio managers, or product line managers, are also considered as major stakeholders. Depending on the organization's policies and team resources, the interests of other team members may also be considered, such as quality assurance, risk management, testing, logistics and sustainment, training, documentation, and disposal. Systems and software engineers do have a large stake in the system through their responsibility and control of the system concept; requirements; architecture; design; verification; and concepts and mechanisms for operations, sustainment, and disposal. However, the internal stakeholders can be least affected by areas where ethical concerns arise since they are often not the users of the system.

Along with these internal stakeholders and the customer, the class of stakeholders that is intrinsic to ethical risk-based design is the users. Users frequently are categorized by the levels or types of system access they need to perform various tasks or have services provided to them. These include hands-on system operators (often agents of the customer) as well as those who benefit from, or are harmed by, use of the system, both through direct transactions using the system and also through its impact on the environment and their culture. Users also include those whose personal data is held in a system, whether they have access to that data or are aware of that data or not. For many systems, users are not limited to skilled, trained, and educated workers and consumers who can be assumed to assess the risk or benefits of use of a system with sufficient information. Users can include the general public at large, both current and future users, and vulnerable populations, such as those unable to read, children, the aged, and people of different abilities.

A particular concern in ethical risk-based design can be implicit assumptions about user stakeholders that create bias against certain types of users. For example, designers need to take particular care that the system design and algorithms do not unjustly favor or select users in certain geographic areas, or of certain biometric or demographic characteristics, or based on unvalidated reports, or unfairly target or exclude other classes of users.

Because it can be difficult to interact directly with the broad scope of user stakeholders, development organizations may include user advocates or create personas that act as proxy stakeholders. However, just including a stick-figure user in a use case is unlikely to capture the variety of ethical concerns and values that the actual users may bring to the transaction and how it is handled by the system.

Another class of stakeholders may have interests that oppose the system or may interfere with its use. These include competitors; cybersecurity hackers; or opponents of the development organization, system owner, or customer. Other external stakeholders can offer divergent perspectives. Government regulators and external advocacy groups, whose cultural norms and ethical values may differ from the system owner, can expose a clash in values and constrain the decisions of the system owners. Third-party assessors, data brokers, and independent verification and validation (IV&V) contractors are stakeholders who can point out flaws or unstated assumptions that have skewed the organization's ethical choices.

These groups of stakeholders: internal, users, opponents, and external authorities, are treated differently when risks, ethical values, and impacts are evaluated. Information about potential system characteristics and performance, and the balance of ethical values and stakeholder interests are rarely shared openly with all stakeholders. Indirect stakeholders who are not users but are affected by the system also need to be considered. The success of a system can depend on indirect stakeholder opinions, which can shape public opinion.

Thus transparency, or open communication (the opposite of secrecy) is not uniformly applied. See Clause 11 for the Transparency Management Process, including typical transparency rules in Item a) 2) of 11.3. The ethical

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value of transparency in establishing decision-making processes, assessing risk, and involving stakeholders in making and validating decisions is applied differently to different stakeholders in practice. Transparency is hindered by too much technical detail beyond the capacity of the stakeholder to comprehend, as well as by other forms of non-disclosure. Transparency is not achieved through one uniform and pervasive approach for all stakeholders, e.g., for revealing how algorithms make decisions in AI systems, how an organization established its design priorities, and how an acceptable level of system accuracy was set. The level of transparency decreases according to how much the information owners trust the stakeholder to agree with their values and protect their proprietary resources and according to the type of technical detail they believe the stakeholder is capable of understanding and applying (the Need to Know or Explainability principle).

The range of stakeholders who can participate in the ethical risk-based design process may be recorded and managed using a RACI (Responsible, Accountable, Consulted, Informed) matrix for stakeholder involvement at various stages.

5.5 Human values

This standard addresses ethical concerns about an SOI by eliciting and implementing stakeholder values. Human values guide ethically aligned design. Human values are phenomena that are appreciated by human beings. Beauty, freedom, fairness, dignity, knowledge, friendship, control, privacy, *and* environmental sustainability, are examples of human values. The discrete list of phenomena that are called values is very long. All cultures make use of values to describe how people should behave or live, and values are often shared between cultures, but the lists of the most important values vary between cultures. A realization of ethical values is the desired outcome from all processes in this standard. Through the processes in this standard, an organization determines which values are relevant to stakeholders, which values may be affected by the SOI, which values can be created or supported by the SOI, and which values are reduced or discouraged by the SOI.

NOTE 1—Talking about "human" values does not preclude the recognition of animal rights or care for nature.

NOTE 2—Annex B provides a more detailed discussion of value concepts, including an extended example in B.2.

Although the terms are often conflated in colloquial usage, values are distinct from ethical theories (see Annex C). Values are independent phenomena, while ethical theories are interpretive frameworks that identify morally salient aspects of a context and can include values.

NOTE 3—A value is carried by a value bearer, including things, persons, relationships, or activities.

NOTE 4—Perception of a value is possible due to observable and/or sensible values that are carried by value bearers. However, a value does not need to be physically perceived or sensed to exist. Its existence is already constituted by its desirable nature that can be felt by humans more or less in the form of aspiration.

Socio-technical systems are assumed to affect many ethical values. In this standard, the goal of a project is to identify and prioritize the most relevant ethical values for a system, to conceptually understand the values and the feasibility of implementing them, and to then design the system with a view to enable and protect the desired values and to inhibit or prevent negative values from prevailing. Figure 2 depicts concepts related to values that are used in this standard.

For the sake of clarity and efficiency, the potentially lengthy list of elicited values and value demonstrators can be condensed to a limited number of core value clusters. Each value cluster takes the name of one positive "core value" that is prominent in the value space. Typically, a core value materializes in the form of various related and instrumental value demonstrators. These are mapped out as part of the value analysis in value clusters. For instance, the core value of privacy is enabled by a value called "confidentiality" or a value demonstrator "right to be left alone." Other positive or negative values can be identified as related to an aspect or attribute of the core value.

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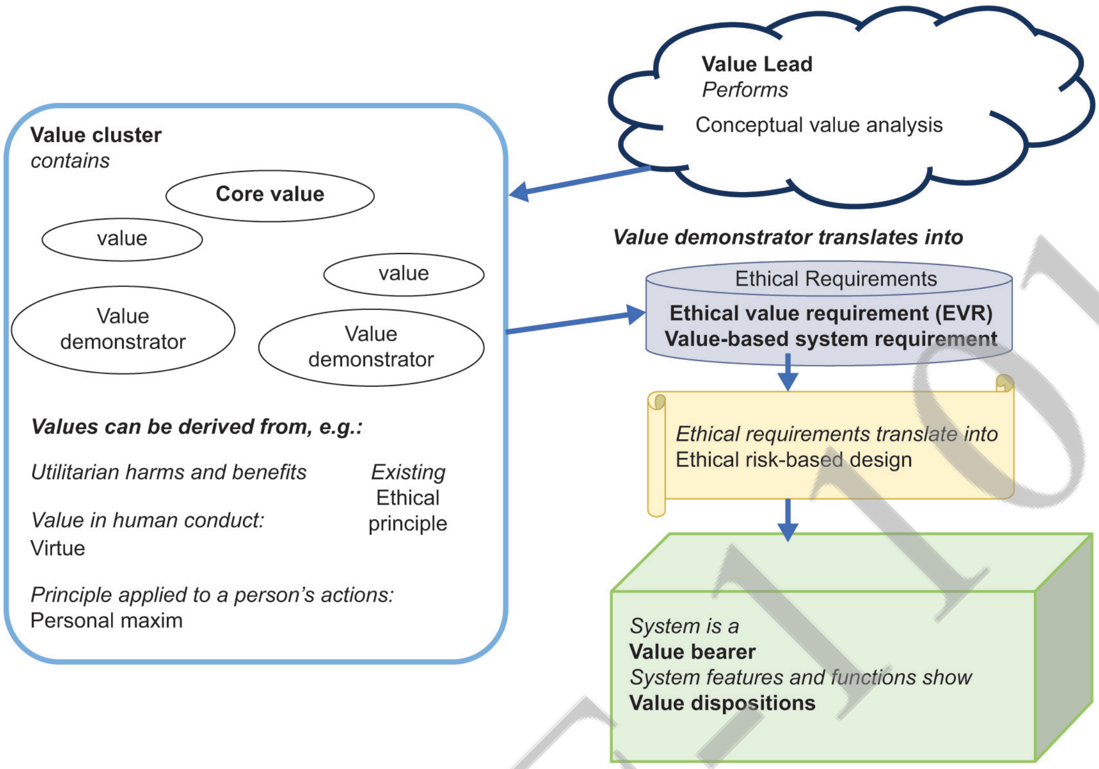
Value Lead
Performs
Conceptual value analysis
Value cluster
contains
Core value
value
value
Value demonstrator
Value demonstrator
Values can be derived from, e.g.:
Utilitarian harms and benefits
Existing Ethical principle
Value in human conduct:
Virtue
Principle applied to a person's actions:
Personal maxim
Value demonstrator translates into
Ethical Requirements
Ethical value requirement (EVR)
Value-based system requirement
Ethical requirements translate into
Ethical risk-based design
System is a
Value bearer
System features and functions show
Value dispositions

Figure 2—Relationships of value concepts

Value demonstrators are associated with and instrumental to the core value, constituting the core value's meaning in the context of the SOI. These are akin to stakeholder needs as they reflect a result valued by the stakeholder that the system should achieve. A value demonstrator is a way in which a value can be made more concrete and can be translated into an EVR.

Although a value and value demonstrator may be appropriately inhibited or discouraged in one system, in other systems the same value or value demonstrator may be encouraged. The priority of a value is related to the purpose of the system and the context of system use. Clause 8 describes activities for eliciting which values are pertinent to an SOI in a specific context and determining from a wide range of stakeholders and contextual analyses which values should be encouraged and which should be inhibited.

Value demonstrators are rendered as engineering targets in the form of EVRs, which are expressed in technical terms as value-based system requirements. Value dispositions are created in systems when designs are created that fulfill the ethical requirements. An analysis of the EVR and value-based system requirements can reveal which requirements are likely to be difficult to achieve and guide engineering decisions on the tradeoffs between the ultimate achievement of an ethical value and system feasibility. In designing a system, using models, prototypes, algorithms, and other design tools, engineers can focus on the system features and components where the ethical value needs to be realized.

The Ethical Risk-Based Design Process aims to create an optimal system. This is achieved by engineers who are working (at least in many respects) on the value dispositions at the level of the system. Value dispositions inhere in the features, functions, and elements that are engineered in systems. In the system, values are enabled by value dispositions at the technical or organizational level. These dispositions can come in the form of positive drivers of values or negative inhibitors (controls) of negative values (harms).

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AMSCE-1101

5.6 Ethical theories used to elicit values

This standard utilizes well-established ethical theories to identify salient aspects of the system that are relevant to designing for values.

NOTE—See Annex C, especially C.4, for more detailed discussion of ethical theories.

Three ethical theories are applied to help identify and prioritize values in this standard: utilitarian ethics, virtue ethics, and duty-ethics.

— *Utilitarian ethics* helps collect and judge positive and negative outcomes (synonyms: benefits and harms) in a broad and egalitarian manner. They ask: "What benefits or harms would arise if everyone were to build and/or deploy the SOI in the way we envision it?"

— *Virtue ethics* focus on system effects on individuals' habitual character and wellbeing; in particular they ask for virtues affecting one's role in a community: "What are the effects of the respective SOI for the virtues of stakeholders affecting their community behavior?"

— *Duty ethics* tap into the responsibility of stakeholders by calling for the use of value priority judgments (personal maxims) and refraining from the use of people as means only. They ask: "What are the potential personal value maxims that can be undermined or fostered by the respective system?" Duty ethics are also important for prioritizing values identified.

These three theories do not determine what is ethical or not. In this standard, they solely contribute three complementary questions that help team members to think about a broad set of values that are relevant for the respective organization to think about. Different cultures answer these questions differently. Therefore, the stakeholder groups involved in the Ethical Values Elicitation and Prioritization Process also need to accommodate representatives of those markets, nations, or world regions in which a system is going to be deployed. That said, the emphasis on these three ethical theories should not be taken as an exclusion of any other ethical theory or of consideration of a type of harm not accounted for in these theories. Users of IEEE Std 7000 are encouraged to ask additional widely used ethical questions warranted in their cultures to elicit values and thereby potentially consider even more global and local variations warranted by the conditions of the SOI.

These theories are not intended to be an exhaustive accounting of how to determine the ethical status of an action, decision, or system but, instead, reflect the belief that these complementary approaches capture *most* of the ethically relevant characteristics of a product, service or system. This standard treats these core types of ethical analysis as essential for due diligence. Although the names of these ethical theories as referenced here are distinctly Western, their core commitments (consequences, character, and duty) are found globally under different traditions and variations.

The decision to invest in a system is not determined by simply counting positive and negative value effects across the SOI at an early stage. Rather, the preliminary determinations provide input to later processes where values are ranked and can guide designers to make values-sensitive design decisions to improve the values effects of the SOI. Again, different cultures rank and prioritize values differently. Therefore, stakeholders of the respective market regions should be included in the design of the system (versions) rolled out in their markets. The prioritized value list of an envisioned system is taken also as a decision basis to decide for or against investment in the SOI.

5.7 Stages and processes

This standard allows any organization or systems developer to achieve the requirements in this standard by means of their own particular set of standard system development processes, methods, and practices. IEEE Std 7000 has distinct processes that can be applied to systems and software engineering and relate to the general processes in ISO/IEC/IEEE 15288:2015 [B41] and ISO/IEC/IEEE 12207:2017 [B40] (see Annex A). The point of an ethically aligned design is to be realized and delivered in the form of a system.

AMSCE-101

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This standard is intended to be suitable for use by organizations and projects using iterative approaches and methods as well as in those using other engineering approaches.

The activities and tasks in this standard are not sufficient by themselves to produce an SOI. They are intended to be an integral part of an organization's comprehensive approach to managing the development of a sociotechnical system. Communication, coordination, and collaboration in an integrated and timely manner are expected within any group that uses this standard in a system development effort.

Continued reiteration of the processes allows for adaptation and reprioritization of the evolving requirements and design. Monitoring of the design can result in reiteration of the processes. The processes take various classes of data; information; human and technical resources, such as knowledge of preliminary harms, legal requirements, and initial concept of operation for the SOI; and stakeholder views as inputs. The inputs inform and empower the activities and tasks in each process and, in turn, result in the generation of various classes of physical and virtual outputs from the processes such as a Value Register (a project ethical value repository), EVR, and a Case for Ethics. The outcomes are the insights and work products generated as a result of activities and tasks. A result of applying this standard to the design of a product, service, or system can be a more ethically aligned artifact that is more responsive to and inclusive of ethical values of the stakeholders and society at large.

This standard does not prescribe any particular sequence of processes within the life cycle model. Subject to possible restrictions applicable to the selected life cycle model, the processes, activities, and tasks described in Clause 7 to Clause 11 may overlap with each other and with other systems or software engineering processes. However, many of the activities and tasks logically apply outputs from other tasks, so there is an inherent sequence of activities, which can be applied iteratively. The sequence of the processes is determined by project objectives and by selection of the life cycle model. Also, outputs of one iteration of a process can be inputs for the next iteration of the process.

The process model for this standard does not include process assessment and control as a separate process or use process views.

Decisions to proceed or reiterate a process are needed at numerous key decision points and at the end of processes.

The ethically aligned processes described in this standard are performed during two stages in the system life cycle:

- Concept exploration
- Development

NOTE—The stages are adapted from ISO/IEC/IEEE 24748-1 [B44], which uses the following exemplary set of stages: concept, development, production, utilization, support, and retirement.

Other stages (utilization, sustainment, and retirement) are beyond the scope of this standard.

Not all values are identified as the result of interactive activities with stakeholders. In addition, some EVRs can originate from awareness of regulations or other social-responsibility frameworks. While completing the list of system level requirements, teams continuously collect ideas on value-related needs and outcomes, which inform the ConOps. These ideas are noted as ideas for the ConOps of the envisioned system.

The result of a risk and opportunity analysis and assessment is that risks are evaluated. When controls are integrated in a system, they further refine and detail the operational concept. The result is a design solution for reduced risk (improved opportunity) for bearing the values needed by the system users.

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After an ethically aligned designed product, service, or system is put into operation, the need for reiteration of the processes described in this standard can be determined through performance monitoring and maintenance. Adverse deviations from the expected performance, emergence of new undesirable behaviors, or adverse user or operator feedback can necessitate a reiteration of ethical analysis, evaluation, assessment and appropriate redress. The overall aim is to sustain the originally achieved ethical profile within the concept and context of operation and seek opportunities to enhance the SOI's ethical attributes during upgrades.

6. Key roles in Ethical Value Engineering Project teams

6.1 General

The following roles and associated competencies should be included as project team members involved in value-based engineering efforts. The roles may be combined and delivered by one person taking into account workload and competence. In applying this standard, one person can assume many roles, and one role can be held by numerous individuals or subgroups within the organization. There are no requirements for independence of roles in this standard. For these competencies and roles, it is not necessary to have one unique team member each. It is feasible that one person may be competent in more than one of the above areas, so that the project team size can vary depending on the organizational processes, roles, and staff. Organizations may designate a project leader with responsibility and accountability for achieving the objectives.

Nothing in this standard, neither the vocabulary nor the techniques, should be understood to require or even suggest the need for a group of specialists whose workflow is separate from the organization's chosen engineering workflow. For example, the same people who perform the activities and tasks in this standard may have responsibility for other engineering activities also. It is expected that personnel who carry out the activities and tasks and achieve the outcomes, in this standard collaborate with their coworkers in a team-like, integrated, synergistic manner. Team members should get sufficient time to be engaged in the roles. Project team members should be present or send a designee for meetings required for the project.

6.2 Role descriptions

6.2.1 Top Management Champion

The Top Management Champion sets strategic policy and enables work as a leader in the organization, e.g., part of the executive board, Chief Technology Officer, Chief Information Officer, Chief Operating Officer, or someone who is responsible for the unit or area in which the system is developed. In the case of a Very Small Entity, the role of the top-management champion may be filled by the entity's owner.

The responsibilities of the Top Management Champion include the following:

a) Motivates project teams to uphold value priorities

b) Resolves conflicts in strategies and value priorities

c) Upholds the ethics of decisions taken throughout the system's life cycle

d) Directs communications with leaders of customer, deploying, or acquiring organizations regarding ethical and technical decisions made in system design

e) Receives and directs responses to concerns and information from project team members or stakeholders about project decisions

f) Communicates with the team both regularly and when needed

g) Continuously explains the link between ethically aligned design and the individual's role in achieving the objectives of ethically aligned design

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6.2.2 System Expert

The System Expert contributes understanding of existing systems, potential capabilities for new systems, and the context for operation of the SOI (the installed base of legacy systems and technologies with which the new system is to be interoperable), e.g., a systems engineer, software engineer, hardware engineer, requirements engineer, business analyst, or systems architect.

The responsibilities of the System Expert include the following:

a) Listens to stakeholders and team members to understand concerns rather than jumping to a readily available technical solution

b) Develops system requirements that enable EVR

c) Evaluates alternatives and trade-offs for suitability to the context of operation and the organization's long-term strategy

d) Optimizes technical solutions to support values among a range of system requirements

6.2.3 Value Lead

The Value Lead focuses on the identification, analysis, and prioritization of ethical values and their incorporation in the system design. The Value Lead is not "the person in charge of ethics" in a project but contributes subject matter expertise and facilitative skills, bridging gaps between engineering, management, and ethical values in a constructive way.

The responsibilities of the Value Lead include the following:

a) Organizes, analyzes, communicates, and records ethical and/or value related concepts, concerns, activities and decisions in a project

b) Facilitates discussions and value-related activities to accompany a project in its design efforts

c) Builds compromises through practices like participatory design

6.2.4 Risk Lead

The Risk Lead coordinates the identification, evaluation, and treatment of risks and opportunities related to ethical values for a system.

The responsibilities of the Risk Lead include the following:

a) Establishes activities for the organization or team to identify, evaluate and prioritize, and treat (mitigate, avoid, or accept) risks related to the ethical values, EVR, and value dispositions

b) Facilitates, records, organizes, and communicates decisions on risks, risk assessments, and risk treatments related to ethical values

c) Reinforces awareness of how each role is involved in risk-related activities

6.2.5 User Advocate

The User Advocate represents future direct and indirect users of the system, working with functionally oriented members of the design team.

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The responsibilities of the User Advocate include the following:

a) Applies a market view or societal perspective to system or value conflicts

b) Represents stakeholder groups that cannot be directly involved in project team meetings

c) Advocates the reduction of the social and economic impacts of the system on indirect stakeholders

6.2.6 Senior Product Manager

The Senior Product Manager in an organization directs the development, supply, or sustainment of one product or a portfolio or product line at some part of the product's life cycle.

The responsibilities of the Senior Product Manager include the following:

a) Leads the application of knowledge of the target market and context of use for the product to value-based decisions on ConOps and to product design

b) Directs the implementation of value-based decisions with the engineering, marketing, or customer support teams

6.2.7 Moderator

The Moderator brings sufficient knowledge of the technical domain and system context to lead productive team discussions and meetings with stakeholders.

The responsibilities of the Moderator include the following:

a) Elicits information, viewpoints, and recommendations from stakeholders in meetings and discussions

b) Encourages fair consideration of different views without allowing individuals to dominate the discussion

c) Mediates between different viewpoints and helps participants reach consensus decisions

6.2.8 Transparency Manager

The Transparency Manager leads the communication of technical decisions and system functions to stakeholders in a way that is understandable to them.

The responsibilities of the Transparency Manager include the following:

a) Records decisions and those who are accountable in a consistent and as easily retrievable form

b) Tracks and reports related decisions to adhere to transparency

c) Maintains the Case for Ethics

6.3 Team competency

In addition to the individual roles and responsibilities needed to carry out the activities in this standard, there are competencies that should be demonstrated by each individual and the team as a whole while engaged in ethically aligned design. It is prudent to select individuals for team roles on the basis of their competence. In this context, competence is the ability to perform a task correctly, efficiently, and consistently to a high quality under varying conditions to the satisfaction of the end client. Competency may also be attributed to a group or a team when a task is performed by more than one person in view of the multidisciplinary nature, complexity,

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or the scale. A competent person or team requires a number of requisite qualities and capabilities, including the following:

a) Technical domain knowledge: empirical, academic, or a blend of both

b) The experience of application (knowing what works) in different contexts and the requisite skills

c) The drive: motivation to achieve the goals and strive for improvement or excellence

d) Sharing appropriate behaviors, such as teamwork, leadership, and compliance with professional codes

e) The ability to adapt to changing circumstances and demands by creating new know-how

f) The ability to perform the requisite tasks efficiently and minimize waste of physical and virtual resources

g) The ability to sense what is desired and to consistently deliver high quality to the satisfaction of the end client(s)

The right blend of these abilities renders a person or group of people (a team) competent in that they can achieve the desired outcomes consistently, efficiently, satisfactorily, or exceeding the expectations of the clients over varying circumstances. In this spirit, competence is the ability to generate success, satisfaction, value, and excellence from the application of knowledge, skill, and know-how.

7. Concept of Operations (ConOps) and Context Exploration Process

7.1 Purpose of the Process

The purpose of the ConOps and Context Exploration Process is to define how a system is expected to operate from the users' perspective and its context of use, its stakeholders, and its potential for ethical benefit or harm. A ConOps is a broad outline of an organization's intent regarding an operation or a series of operations that are intended to occur within the same SOI. The Context Exploration Process develops an understanding of the ethical environment in which the SOI and its operations impact stakeholders. When context is explored and envisioned for a system's future, it should be done under the assumption that the system will be implemented at scale, that is, having a significant impact on target stakeholders and markets.

The ConOps and Context Exploration Process identifies stakeholders involved with the system throughout its life cycle and chooses representatives. It also analyzes control over the envisaged SOI. It gathers relevant information on the social, legal, and environmental feasibility of the SOI.

NOTE—Annex D provides a sample questionnaire for a legal, social, and environmental feasibility analysis.

Actual use cases or possible use cases (scenarios) should be chosen that are likely to unveil representative values relevant in human interaction with the SOI. Market research has provided potential insights into existing use cases of a system—especially when it is already deployed. For example, it may turn out that human beings using a general conversational agent have typical conversation domains with these agents, such as healthcare, scheduling appointments, or education. Such specific use cases should determine the context that is explored in the project and addressed ethically.

IEEE Std 7000 is recommended even for generic system manufacturers where the context of the SOI may not be obvious, because any system context has stakeholders. For example, database manufacturers who think their systems do not have any effective context with users. However, database design determines the capabilities of systems interacting with users; for instance, the capability to fully delete data for privacy reasons.

Descriptions of use cases or concepts of operation should consider a long time-horizon (i.e., 10 to 20 years), assume significant market share of the envisaged SOI, and consider those regions of the world in which the

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SOI is or will be marketed. Use cases should include demographically diverse groups who may use the system, such as elderly people, minors, racial minorities, differently abled people, and different language speaking populations.

If several use cases or contexts are available, the choice of scenario should be guided by those social, legal, and environmental issues that turn out most problematic with respect to enhancing positive values or prohibiting negative values.

7.2 Outcomes

As a result of the successful implementation of the ConOps and Context Exploration Process, achievement of the following outcomes shall be demonstrable:

a) The SOI's intended context of use is described.

b) Stakeholders involved with the envisaged system throughout its life cycle are identified and their representatives are chosen.

c) Concepts of control over the SOI are identified and analyzed.

d) Relevant information on the social, legal, and environmental feasibility of the SOI is gathered.

e) The activities and tasks of this process are integrated with other tasks that define the context and the initial ConOps for the SOI.

f) The need to further explore potential harms and benefits to ethical values from the system concept is determined.

7.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the ConOps and Context Exploration Process.

NOTE—These activities can benefit from close co-operation with stakeholders and the guidance of the value lead.

a) Develop an understanding of the system's intended context(s) of use. This activity consists of the following tasks:

   1) Describe the context of current operations to be replaced or changed by the future system.

   2) Identify and suitably represent one or more actual or possible system use contexts.

   Example contexts: a robot to be used in a nursing home, a social network to be used among students, a software suite to do office work. These are cases where there is direct interaction between human beings and systems in known contexts.

b) Identify stakeholders who may be interested in or affected by the system at some point. This activity consists of the following tasks:

   1) Identify relevant stakeholders, including:

      i) Organizational representatives driving the innovation effort

      ii) A diverse spectrum of stakeholders that are both critical and widely distributed across technical ability and ethical value orientation

      iii) Stakeholder advocates for indirect stakeholders

      iv) Professionals who understand the social context of the SOI

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v) Professionals who understand the technical capabilities of the SOI

vi) Stakeholder advocates selected in a transparent way

vii) Potential users of the system participating in the processes, as appropriate; in particular, end-users from the market or world regions in which the system is or will be deployed

viii) Institutions that are affected by the SOI or their advocates, as appropriate

ix) Civil society and legal advocates, as appropriate

2) Identify stakeholder groups

c) Describe and analyze technical and organizational control over the envisaged system. This activity consists of the following tasks:

1) Aggregate the SoS elements potentially relevant for the concept.

2) Identify the owner of the SoS elements.

3) Analyze control over the envisaged SOI and its elements.

NOTE 1—Controllability can become a challenge if the system operates in system of systems (SoS) or depends on systems with a long legacy and/or high complexity. Organizations create insight for themselves to the degree in which they have control over system elements to understand: a) whether they have sufficient influence to change/design elements that turn out to be relevant and b) whether they can be consistent with their own ethical policies. Annex E outlines what level of control is appropriate for organizations when their SOI is embedded in a wider SoS.

NOTE 2—A RACI cross-reference matrix of stakeholders to decision points is helpful in analyzing controllability and advancing through the project.

NOTE 3—This analysis should include elements within the SOI and its SoS. It investigates whether and how potential system elements can be accessed and controlled with reasonable effort. It specifies whether SoS relationships are virtual, collaborative, acknowledged, or directed. Sufficient control is more readily achieved in “acknowledged” and “directed” forms of SoS.

NOTE 4—Annex E and Annex F provide guidance on control over SoS and AI systems.

NOTE 5—Where possible, control over the SoS elements can be considered.

4) Record the controls needed to preserve ethical values in the concept.

NOTE—The supporting analysis should consider the need for control of each aspect of the concept. As extended to the resulting system, controls affect control of the supply chain, as well as control of the design through recognized methods such as system models, architecture descriptions, and interface specifications or data flow diagrams documenting control of personally identifiable data.

d) Obtain access to the enabling systems or services to be used.

e) Gather available social, legal, and environmental information on SOI feasibility. This activity consists of the following tasks:

1) Gather available information on relevant legal boundaries for the system.

2) Gather available information on prevalent social or environmental concerns potentially impacting the system.

3) Identify initial value harms and benefits related to the system.

f) Identify and suitably represent one or more system concepts of operations.

NOTE 1—Annex E gives an overview and further examples of system use contexts.

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NOTE 2—Actual use cases or possible use cases (scenarios) can reveal representative values relevant in human interaction with the SOI. Potentially market research has provided insights into existing use cases of a system, especially when it is already deployed.

NOTE 3—If several use cases or contexts are available, the choice of scenario should be guided by those social, legal, and environmental issues that are most problematic with respect to fostering positive values or prohibiting negative values.

NOTE 4—The ConOps can include value-related aspects of operations as noted by the users and other stakeholders.

g) Identify and resolve gaps and discrepancies between the assumptions and outcomes of the value-based ConOps and alternative ConOps descriptions.

h) Complete concept and context analyses. This activity consists of the following tasks:

1) Identify and record potential technical and organizational risks and improvements affecting the ConOps.

2) Decide whether the potential ethical benefits and harms in the system concept need further treatment in requirements and system design. Determine if the ethical impact of the concept should receive explicit value analysis and risk assessment.

NOTE—Based on the available documentation of control of elements in the ConOps, the exercise to obtain access to the enabling systems, the list of stakeholders, as well as the initial gathering of information on the social, legal, and environmental system constraints, the organization determines if it can expect to effectively control the SOI and its design. If not, the organization can modify the project scope of work to exclude the EVR; or alternatively terminate the project.

3) As information is developed regarding prioritized values, EVRs, and ethical risk-based design characteristics, refine the ConOps.

7.4 Inputs

The following resources constitute a suitable, but not exhaustive, suite of the process inputs:

a) A potential problem for which the concept is a possible solution

b) An initial service and/or product idea

c) Organizational ethical principles

d) An initial ConOps for the SOI

7.5 Outputs

The following work products constitute a suitable, but not exhaustive, suite of the process deliverables:

a) Context description

b) Lists of stakeholders to be consulted and direct and indirect stakeholders affected by the ConOps

c) Refined SOI concept of operation

d) Outcomes of feasibility studies

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8. Ethical Values Elicitation and Prioritization Process

8.1 Purpose of the Process

The purpose of the Ethical Values Elicitation and Prioritization Process is to obtain and rank values and value demonstrators for approval by management and other stakeholders as a basis for the requirements and the design of the SOI.

In this process, the direct and indirect, internal, and external stakeholders whose values are to be elicited are chosen. Utilitarianism, virtue ethics, and duty ethics are used to elicit from stakeholders the ethical issues, values, and potentials that may influence the requirements and the design of the SOI. Furthermore, any alternative ethical theory may be used that is considering the culture where the SOI will be deployed. From the collected values, issues, and potentials, core values are identified which are then described in the form of value clusters including the ethical issues, values, and potentials raised in the form of value demonstrators. The value clusters are confirmed by the stakeholders. The core values are prioritized and compared to value priorities that are suggested by authoritative external sources. In consideration of incompatibilities between the value priorities, the priorities and value clusters are adjusted. The resulting value clusters can be conceptually refined by the value lead. Value clusters are approved by selected stakeholders and management.

NOTE—B.4 discusses a philosophical approach to value ranking (prioritization). Annex C presents more information on ethical theories as applied to ethical values elicitation. Annex G identifies typical ethical values associated with systems design. Annex H discusses the application of ethical values at the organizational rather than the system level. Annex I outlines the contents of a complete case for ethics that includes the Value Register.

8.2 Outcomes

As a result of the successful implementation of the Ethical Values Elicitation and Prioritization Process, achievement of the following outcomes shall be demonstrable:

a) Stakeholder values, ethical issues, and potential harms and benefits with respect to the SOI are elicited.

b) Using conceptual analysis, values and value demonstrators are refined and organized into value clusters.

c) Value clusters are prioritized.

d) Concurrence of management with the prioritized values is obtained.

e) The activities and tasks of this process are integrated with the other tasks that develop the SOI.

8.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Value Elicitation and Prioritization Process:

NOTE—These activities can benefit from close co-operation with stakeholders and the guidance of the value lead. Many of the following activities and tasks may be most successfully conducted by the value lead who verifies and adjusts conclusions with the stakeholders.

a) Choose the stakeholders in the SOI whose values are to be elicited. This activity consists of the following tasks:

   1) Identify relevant stakeholders for ethical values elicitation and prioritization [See 7.3 b) 1)].

   2) Designate the stakeholder group.

      NOTE—The list of stakeholders is maintained in the case for ethics that is outlined in Annex I.

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b) Elicit and record stakeholder values relevant to the ConOps. This activity consists of the following tasks:

   1) Conduct a detailed benefits and harms-based value analysis (utilitarian ethics) as follows:

      i) Identify benefits for individual stakeholders that can be provided by the SOI if the system were implemented at scale.

      ii) Identify harms for individual stakeholders that can be caused by the SOI if the system were implemented at scale.

      iii) Elicit the ethical values that underlie the identified potential harms and benefits.

      NOTE—Benefits and harms should be elicited against the background of the question "What benefits or harms would arise if everyone were to build and/or deploy the SOI in the way we envision it?"

      iv) Identify and record potential technical and organizational improvements affecting the ConOps.

   2) Conduct a detailed and critical analysis of how the SOI or features within the SOI potentially change user character (virtue-ethical analysis), identifying the potential damage to the character of individual stakeholders that can occur if the system were implemented at scale.

   NOTE—The potential damage to a person's character can mean that either a virtue of that person is undermined or a vice is developed.

   3) Conduct a detailed and critical analysis of how the SOI or features within the SOI potentially challenge the perceived ethical duties of the stakeholders, as follows:

   NOTE 1—Ethical duties can be expressed as personal value maxims. Personal value maxims are highest personal rules or, in other words, personal principles of what one wishes for and acts upon in one's own life and thinks that they should be universal laws. All personal principles are values, but not all values are personal maxims.

   NOTE 2—Elicitation of values should be performed along with eliciting stakeholder needs for the SOI.

      i) Identify the potential personal value maxims of project team members, which can be undermined if the system were implemented at scale.

      NOTE—To say that a SOI can undermine a personal value maxim means that the nature of the SOI or its behavior does not accord with the personal maxim.

      ii) Identify the potential personal value maxims of project team members that can be fostered if the system were implemented at scale.

      NOTE—To say that an SOI can foster a personal value maxim means that the nature of the SOI or its behavior is in accord with the personal maxim.

   4) Identify any additional ethical theories in the culture of SOI deployment that can provide additions to the list of values and elicit values via those theories that reflect the ethical expectations of that culture.

   NOTE—An additional ethical framework added for value analysis should be one that is widely used in the culture of SOI's deployment, and it should ask different questions or have different foci than the utilitarian, virtue or duty ethics.

   5) Capture core values, associated values, issues, and value demonstrators in the Value Register.

c) Analyze and organize the elicited values. This activity consists of the following tasks:

   NOTE—This activity should be performed by the Value Lead.

   1) Perform a conceptual analysis of the elicited values.

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2) Identify value demonstrators based on stakeholder responses to ethical values elicitation and the elicited values.

   NOTE—Name the elicited value demonstrators precisely enough to capture the associated harms or benefits.

3) Create value clusters that group identified core values with related values and value demonstrators.

   NOTE 1—Detailing the value cluster simplifies traceability of the design and the requirements to the values.

   NOTE 2—Relevant value demonstrators are considered in conceptually completing and refining the value clusters.

4) Verify that distinct values are not inappropriately aggregated and lost.

5) Confirm with the project stakeholders that the value clusters and their descriptions are representative of the elicited values.

6) Record confirmed value clusters and their descriptions in the Value Register.

   NOTE—The Value Register is a part of the case for ethics that is outlined in Annex I.

d) Prioritize the core values for the SOI. This activity consists of the following tasks:

NOTE—In principle, all core values identified are important. Their priority and feasibility of implementation can change as the SOI matures. The core value prioritization decided in this activity gives guidance on the development priorities.

1) Prioritize the core values based on the extent to which they are important to enable the ConOps to satisfy the following ethical considerations.

   i) Stakeholders agree that the SOI is good for Society and avoids unnecessary harm.

   ii) The organization does not use people merely as a means to some end.

   iii) Organizational leaders can accept responsibility for the value priorities chosen according to their own personal maxims.

   iv) The organization respects its own stated ethical organizational principles if there are any.

   v) The organization can commit to the value priorities in its business mission.

   vi) The environment is maximally preserved.

   vii) The organization considers existing ethical guidelines.

   NOTE 1—All of the criteria in 8.3 d) 1) are equally important.

   NOTE 2—When there are conflicts about value priorities, an alternative method of prioritizing values can be used, as presented in Table B.1.

2) Compare the value priorities with external sources, such as the following:

   i) Relevant legal precedent that may affect whether the SOI is likely to be in compliance with legal or regulatory authorities in the area of SOI deployment

   ii) Records of prior substantively similar systems, if available

   iii) International agreements on ethical conduct

   NOTE—Examples for applied ethics literature can found in Annex J.

3) Record in the Value Register incompatibilities between the value priorities and external sources.

4) Identify inconsistencies and conflicts among values and value demonstrators that affect the prioritization of core values.

e) Identify and record potential technical and organizational risks and opportunities affecting the values.

NOTE—Risks and opportunities can be recorded in the Case for Ethics as detailed in Annex I.

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f) Perform a conceptual value analysis and refine the prioritized value clusters, including the following:

   1) Add value demonstrators derived from external sources.

   2) Refine the value demonstrators to increase the potential for technical and organizational benefits and reduce technical and organizational risks from opportunities to implement the core values.

   3) Refine the value demonstrators to support the management of technical and organizational risks to implementing the core values, and to increase the potential for technical or organizational benefits from opportunities to implement the core values.

   4) Exclude values demonstrators from further analysis that the organization cannot influence through any technical or organizational means.

   5) Annotate conflicts among values that affect their priority to be realized in the system requirements and design.

   Example: Values that conflict in this way include privacy versus provision of private information to a government entity legally authorized to require the information. See Annex G for additional examples.

g) Obtain approval for the prioritized values. This activity consists of the following tasks:

   1) Review with top management and relevant stakeholders the identified core values, value clusters including value demonstrators, and related risks and opportunities to validate their acceptability as a basis for requirements and design.

   2) As needed, repeat the activities to obtain acceptable value clusters.

   3) Record the approved value clusters, the decision, the authority and the rationale in the Value Register or preliminary case for ethics.

8.4 Inputs

The following resources constitute a suitable, but not exhaustive suite of the process inputs:

a) Applied ethics literature with conceptual frameworks for individual value's taxonomy (if available)

b) Human rights frameworks or other value lists

   NOTE—Annex F identifies typical ethical values.

c) An initial ConOps for the SOI

d) The outcome of any feasibility studies initiated during project preparation (if available)

e) A preliminary case for ethics

8.5 Outputs

The following work products constitute a suitable, but not exhaustive, suite of the process deliverables:

a) Value Register or case for ethics with selected and prioritized value clusters, core values, and value demonstrators

b) List of potential technical and organizational risks and improvements for the value clusters

c) Updates to the ConOps

d) Updated list of stakeholders to be consulted

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9. Ethical Requirements Definition Process

9.1 Purpose of the Process

The purpose of the Ethical Requirements Definition Process is to formulate EVRs and value-based system requirements that define how the prioritized core values and their value demonstrators are reflected in the SOI. Ethical requirements are proposed risk mitigation treatments to protect and preserve the core values within the SOI. The process analyzes the EVRs and value-based system requirements for ethics-related risks and identifies mitigations in revisions to the requirements set. This process engages those responsible for the SOI and records their commitment to value-based requirements through validation.

NOTE 1—B.2 provides an example for ethical requirements definition.

NOTE 2—ISO/IEC/IEEE 12207:2017 [B40], 6.4.2.3 (stakeholder requirements) and 6.4.3.3 (system or software requirements) from ISO/IEC/IEEE 15288:2015 [B41], and ISO/IEC/IEEE 29148 [B48] have more detailed explanations of requirements engineering.

9.2 Outcomes

As a result of the successful implementation of the Ethical Requirements Definition Process, achievement of the following outcomes shall be demonstrable:

a) Ethical requirements of the SOI, consisting of EVRs and value-based system requirements traceable from the prioritized core values and value clusters, are specified for ethically aligned design, development, and validation.

   NOTE—EVRs can be satisfied not only through physical and functional features of the system design, but also through provisions for warranty, recall, replacement, repair, update, or upgrade of the system.

b) Value-based requirements are evaluated for feasibility and control of the SOI.

c) Ethical requirements are validated with stakeholders to protect and preserve the prioritized values.

d) Value-based requirements are harmonized and integrated with other requirements for the SOI that are derived from other sources that are not necessarily value-based.

e) The activities and tasks of this process are integrated with other tasks that define the stakeholder requirements and the system requirements for the SOI.

9.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures for the Ethical Requirements Definition Process.

For purposes of explanation, this process and others are presented as an ordered set of activities (see Figure 3). However, in practice, incremental and iterative development of value-based requirements and their realization, in continuous interaction with general system development, should be the norm.

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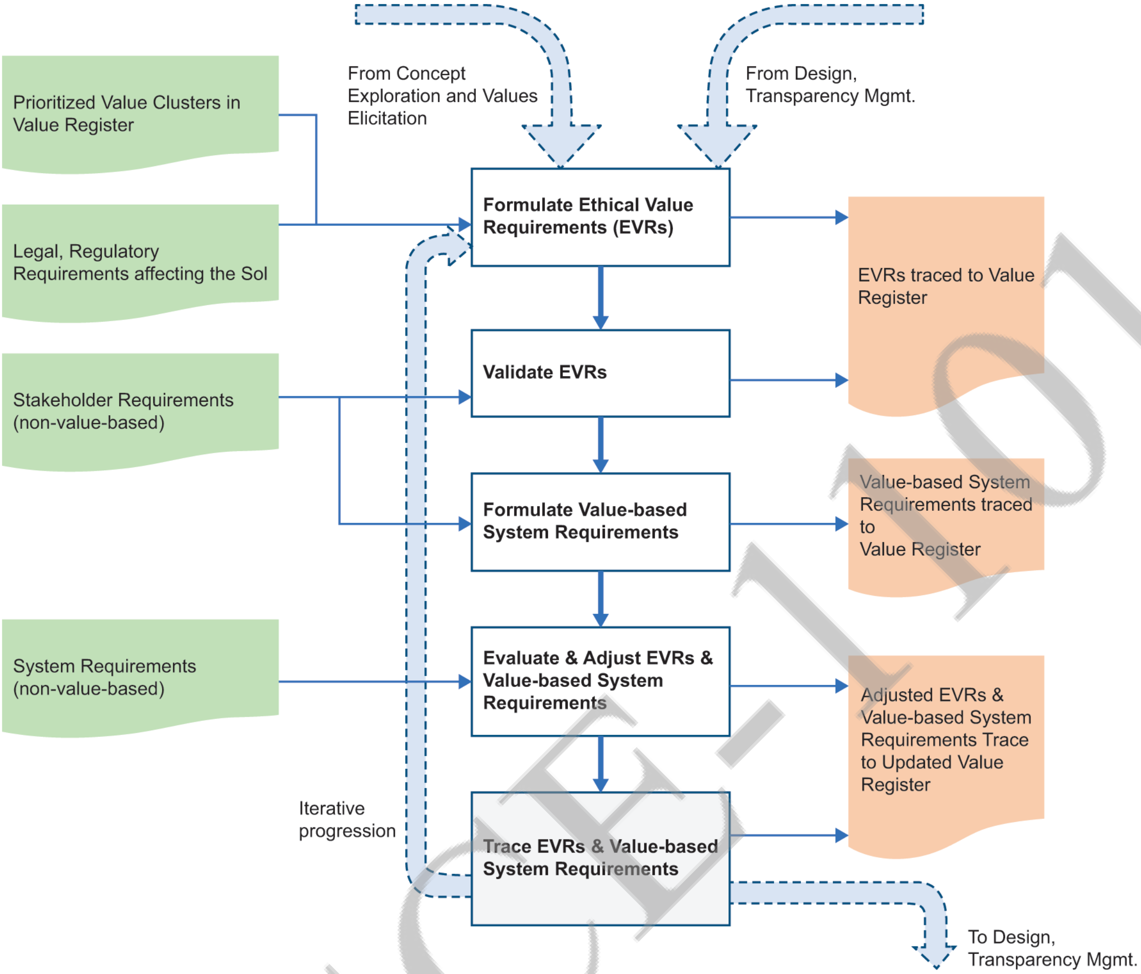
Prioritized Value Clusters in Value Register
Legal, Regulatory Requirements affecting the SoI
Stakeholder Requirements (non-value-based)
System Requirements (non-value-based)
From Concept Exploration and Values Elicitation
From Design, Transparency Mgmt.
Formulate Ethical Value Requirements (EVRs)
Validate EVRs
Formulate Value-based System Requirements
Evaluate & Adjust EVRs & Value-based System Requirements
Trace EVRs & Value-based System Requirements
Iterative progression
EVRs traced to Value Register
Value-based System Requirements traced to Value Register
Adjusted EVRs & Value-based System Requirements Trace to Updated Value Register
To Design, Transparency Mgmt.

Figure 3—Ethical Requirements Definition Process

NOTE—Many of the following activities and tasks may be most successfully conducted by the value lead who verifies and adjusts conclusions with the stakeholders.

a) Formulate and record EVRs. This activity consists of the following tasks:

NOTE 1—EVRs can be expressed in formal requirement statements, use cases, user stories, scenarios, or other forms.

NOTE 2—EVRs can be used to translate the prioritized core values into the system's value dispositions.

1) Identify one or more EVRs as socio-technology statements that describe possible risk treatment options that may promote and protect the prioritized core values and realize the value demonstrators. Treatment options are technical, organizational, or social.

NOTE—Each high-priority core value and value demonstrator has at least one EVR. Normally there are one or more EVRs for each core value. It is not necessary that for every identified value there is an EVR, the number of EVRs generated should reflect only high-priority items.

2) Identify related assumptions and constraints identified with the EVRs.

3) Evaluate and, if necessary, mitigate the risks of incorrect or incomplete EVRs.

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4) Record each EVR with a unique reference number, its associated risks, prioritized core values, and related assumptions and constraints.

NOTE—A simple requirements register contains a table associating each EVR with one or more value clusters.

b) Validate the EVRs along with other stakeholder requirements in cooperation with selected stakeholders, including top management and the project team.

NOTE—Any risks associated with a proposed EVR that cannot be validated are identified and mitigated.

c) Formulate and record the system requirements arising from each EVR. This activity consists of the following tasks:

1) Analyze the value demonstrators and risk mitigations in the EVRs to identify potential value dispositions.

2) For each EVR or related EVRs, formulate one or more associated value-based system requirements (functional or non-functional) that realize the EVR within the SOI.

3) Identify qualitative or quantitative measurement targets and acceptance criteria associated with each system requirement.

4) Record each value-based system requirement with a unique reference number, its traceability to an EVR, its associated risks, and related assumptions and constraints.

NOTE 1—Various techniques for determining socio-technology system requirements can be used, including research, stakeholder consultation and collaboration and experimentation (e.g., prototypes).

NOTE 2—System requirements for machine learning systems may include quantitative and qualitative data-oriented specifications that include identifications for collection of data, data formats, diversity, ranges of data, data provenance (sources), performance measures (accuracy, precision), explainability, evidence of fairness or discrimination according to legal/societal values, and regulatory use of training data (see Vogelsang and Borg [B76]).

NOTE 3—System requirements for organizational or societal systems may include personas, business capability analysis, and process modeling.

NOTE 4—Requirements records typically include and describe the structure, elements, attributes, traceability, priority, metadata, hierarchy, relationships, provenance, and other components.

NOTE 5—Registers containing EVRs and associated system requirements can be modeled in matrix format, and can also capture other requirement elements, including diagrams, formal requirement statements, use cases, user stories, scenarios, acceptance criteria, measurable conditions, constraints, assumptions, personas, business rules, organizational roles, activity flows, prototypes, data models, or other forms and descriptive components.

NOTE 6—Possible risks include an inability to formulate acceptance criteria that are measurable and sufficiently accurate.

d) Evaluate and adjust the EVR and the value-based system requirements in cooperation with stakeholders and the project team. This activity consists of the following tasks:

NOTE—This activity is stated at the level of EVR and value-based system requirements, but it can be performed at the level of subsystems, elements, and components.

1) Evaluate technical, operational, legal, and economic feasibility of the EVR and value-based system requirements.

2) Analyze and harmonize the EVR and value-based system requirements with requirements derived from non-value driven means, identifying and rationalizing competing or supportive requirements for the SOI.

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3) Analyze EVR value-based system requirements in conjunction with the requirements derived from non-value driven means for technical and organizational control over the system.

NOTE—Annex F presents specific considerations for control over AI systems.

4) If needed, modify the EVR and system requirements on the basis of evaluation and risk analysis, including feedback from the design process, and record adjustments in the Case for Ethics and requirements register.

NOTE—Possible risks associated with evaluating and adjusting the ethical requirements include:

— An inability to harmonize and rationalize ethical requirements with requirements derived from non-value driven means, thereby creating two separate domains within the project

— As value-based system requirements are integrated with system requirements that have not been derived from ethical reflections, functional system requirements are prioritized over value-based system requirements for further SOI construction.

e) Analyze, trace, and record the further handling of value-based requirements in agreement with the project team and stakeholders. This activity consists of the following tasks:

1) Recheck the traceability of value-based system requirements to EVR and prioritized core values in the Value Register, showing relationships between each entity.

2) Identify and record potential changes affecting the ConOps from the ethics-based requirements.

3) Determine further handling of ethical requirements in cooperation with the project team and stakeholders, and update the risk register and Value Register.

4) Validate and record the approval of the value-based requirements by those responsible for the SOI and relevant stakeholders in the Case for Ethics.

9.4 Inputs

The following resources constitute a suitable, but not exhaustive suite of the process inputs:

a) Prioritized core values and value demonstrators (value clusters) as identified in the Value Register for the SOI

b) The SOI concept of operation

c) References to related legal and regulatory requirements affecting the SOI

d) Current or previous versions of value-based requirements

e) Other (non-value driven) stakeholder and system requirements

f) Previous feasibility studies

g) Risk register

9.5 Outputs

The following work products constitute a suitable, but not exhaustive, suite of the process deliverables:

a) EVR and value-based systems/software requirements for the SOI traceable to one or more prioritized core values

b) Potential technical and organizational risks and opportunities for the EVR

c) Improvement ideas for the concept of operation

d) Updated Value Register or Case for Ethics with traceability of values to EVR and value-based system requirements

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10. Ethical Risk-Based Design Process

10.1 Purpose of the Process

The purpose of Ethical Risk-Based Design is to realize ethical values and required functionality in the system or software design. Ethical Risk-Based Design includes functionality that helps mitigate or control identified risks to EVR and value-based system requirements. This is a design activity that is fundamental to the realization of value-based system requirements and the relevant risk treatment options.

NOTE 1—As this standard aims to result in ethically aligned systems, organizations should have sufficient control over the system for which they assume responsibility.

NOTE 2—6.3.4 in ISO/IEC/IEEE 12207:2017 [B40], 6.3.4 in ISO/IEC 15288:2015 [B41], and ISO/IEC/IEEE 16085 [B43] include additional guidance on general risk management, including risk identification, risk analysis, and risk mitigation.

10.2 Outcomes

As a result of the successful implementation of the Ethical Risk-Based Design Process, achievement of the following outcomes shall be demonstrable:

a) Ethically aligned design and value dispositions are traceable to the EVRs and value-based system requirements.

b) Control over the SOI is demonstrable through design features.

c) The activities and tasks of this process are integrated with other tasks that define the design of the SOI.

d) System design treatments are identified for value-based system requirements and prioritized in response to identified risks.

10.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Ethical Risk-Based Design process:

a) Prepare for and produce a SOI ethically aligned design. This activity includes the following tasks:

   1) Identify and plan design activities and select methods and tools.

   2) Analyze and harmonize design features that realize EVRs and value-based system requirements with other design features, identifying and rationalizing competing or supportive requirements for the SOI.

   3) Incorporate the ethically derived functional, operational, procedural, organizational, or structural dispositions into the SOI design specifications.

   4) Identify and specify the system elements that embody and deliver value dispositions.

   NOTE 1—Use of participatory design techniques (often connected with iterative methods) can aid in understanding whether design alternatives are consistent with user values and EVR.

   NOTE 2—In the engineering context, prioritization of value dispositions includes determining to what extent an EVR can be satisfied through the system design, and to what extent realizing the EVRs can be balanced with achieving (or modifying) other functions and performance requirements of the system. Doing this kind of trade-off analysis is essential to realizing the ethical values in the SOI.

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NOTE 3—In the case of an iterative system development, the initial prototype can be a "Minimum Viable Product" (MVP) that addresses only selected requirements.

NOTE 4—Design considers not only the deployment and operation of the system, but also its sustainability and eventual disposal or reuse.

b) In consultation with stakeholders, identify risks and risk contexts associated with the feasibility of implementing the design. This activity consists of the following tasks:

1) Estimate the probability or likelihood of the hazard or harm to occur.

2) Estimate the consequence (impact, degree of hazard or harm) or a benefit caused by opportunities.

3) Combine the probability (likelihood) of hazards or harms with the degree of harm to derive the risk level for the value.

4) Prioritize the risk.

c) Analyze and specify technical and organizational control over the system. This activity consists of the following tasks:

1) Aggregate the system elements potentially relevant for control of the SOI.

2) Identify the owner of the system elements.

3) Analyze control over the SOI and its elements.

4) Include control mechanisms in the value dispositions for system functions that can impact value-based requirements.

5) Where feasible, simulate or prototype the related system functions and features to verify the effectiveness and acceptability of the implemented controls and risk reduction options, in consultation with the stakeholders.

NOTE—To support incorporation of EVRs in design characteristics, the system design description contains a list of system elements relevant for a system, records the owner of this system, the owner(s) of system elements, lists how the SOI interfaces with other systems and whether SLAs are in place that can be changed (for instance in a SoS), records whether the SOI and its elements (including those residing within a wider SoS) can be manipulated with reasonable effort and within what time-frame. It contains a final judgment or scale as to degree of controllability of each system element and for the overall system.

6) Document an ethical value control analysis.

NOTE—Annex E outlines what level of control is appropriate when the SOI is embedded in a wider SoS. Annex F outlines principles for control over AI systems.

d) Identify and select pragmatic treatment options for work products that can reduce their respective risks or positively foster opportunities

NOTE—Consider risk avoidance for the values through control of the supply chain as well as control of the design through recognized methods such as system models, architecture descriptions, and interface specifications or data flow diagrams documenting control of personally identifiable data.

e) Perform ethically aligned system design verification and validation. This activity consists of the following tasks:

1) Verify that value-based requirements specifications have been fulfilled through the value dispositions of the design. Trace value-based requirements to value dispositions and SOI design features, showing relationships and dependencies between requirements and design, and showing how the design fosters or inhibits the ethical values.

2) Determine whether risks to value-based requirements are at a level within the system design that stakeholders find tolerable (acceptable) without the need for further treatment.

3) Document key value opportunity enhancements that are realized within the system design.

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4) Identify more effective (enhanced) risk avoidance, mitigation, or treatment options when a value risk is not validated as tolerable by the stakeholders under existing treatment option(s).

5) Confirm the acceptability of the enhanced risk treatments in the design and realize value enhancement opportunities.

6) Update the system design documentation based on the implemented value risk treatment and opportunity enhancement options.

7) Capture the final state of the risk treatments and opportunity enhancement options and the final validation results in the Case for Ethics.

8) Through design verification and continued monitoring, determine when the design needs to be modified to accommodate changing contexts, different value priorities, or changes in technical needs, and reiterate the applicable processes.

10.4 Inputs

The following resources constitute a suitable, but not exhaustive suite of the process inputs:

a) Functional and non-functional system requirements including value-based requirements

b) The SOI concept of operation

c) The Value Register and preliminary Case for Ethics for the SOI

d) The Risk Register

10.5 Outputs

The following work products constitute a suitable, but not exhaustive, suite of the process deliverables:

a) An ethically aligned design for the SOI

b) A refined concept of operation and operational concept

c) An updated Value Register

d) An updated Case for Ethics

11. Transparency Management Process

11.1 Purpose of the Process

The purpose of the Transparency Management Process is to share with internal and external, short-term, and long-term stakeholders sufficient and appropriate information about how the developer has addressed ethical concerns during SOI design. This process shares information about the stakeholder values that the project has elicited and about how the project has implemented those values in the SOI. It maintains the information for retrieval both during system development and afterward.

Transparency is linked to accountability; the information to be shared should include the roles and the affiliations of the people involved in the project decisions (i.e., project team members and stakeholders).

The principle of explainability may be more relevant to the needs of stakeholders than full transparency into large data stores of complex technical specifications. Explainability implies presenting technical information in a form understandable to, and meeting the needs of, a specific user category.

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11.2 Outcomes

As a result of the successful implementation of the Transparency Management process, achievement of the following outcomes shall be demonstrable:

a) Sufficient appropriate information about the ethical aspects of the SOI is made available during system development and afterward.

b) Stakeholder and project communications reflect principles of transparency, accountability, and explainability.

11.3 Activities and tasks

The organization shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Transparency Management Process.

a) Prepare to manage transparency. This activity consists of the following tasks:

  1) Identify and record organizational rules for transparency that include but are not limited to the following:

    i) Information to be shared shall be available and consistent with identified stakeholders' interest and need to know.

    ii) Information to be shared shall be maintained.

    iii) Each item of information to be shared shall be approved by the managers who are directly responsible for the activities of the project that produced the information.

  2) Enforce the organizational rules for transparency and stakeholder communication.

  NOTE—Typical stakeholder communication rules include the following:

    i) Arguments are truthful, right, intelligible, and sincere.

    ii) All stakeholders are allowed equal and fair participation in a discourse.

    iii) Everyone is allowed to question any claims or assertions made by anyone else.

    iv) Anyone is allowed to express their own attitudes, desires and needs.

b) Share information about the ethical content of the SOI. This activity consists of the following tasks:

  1) Share information regarding the ConOps, Context Exploration, and related feasibility studies, as follows:

    i) A representation of each context in which the SOI is used or is likely to be used

    ii) Identity of the identified stakeholder group or groups

    iii) Potential social, legal and environmental benefits and harms to the stakeholder values to be elicited

  2) Share information about the elicitation and prioritization of core values and value demonstrators related to the SOI, such as the following:

    i) Potential benefits to stakeholders if the SOI were implemented at scale

    ii) Potential harms to stakeholders if the SOI were implemented at scale

    iii) Values that underlie the perceived benefits and harms

    iv) Potential damage to the character of individual stakeholders if the SOI was implemented at scale

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v) Personal maxims of project team members that can be undermined if the SOI was implemented at scale

vi) Personal maxims of project team members that can be fostered if the SOI was implemented at scale

vii) Values not already recorded that are related to implementation of the SOI at scale in one or more particular regions of the world

viii) One or more representative clusters that group the recorded (elicited) values and the values and value demonstrators contained in them.

3) Share information regarding the EVRs and value-based system requirements

4) Share information regarding value dispositions in the design

5) Share information regarding identified risks, risk profiles, and risk treatments related to ethically aligned design.

c) Share information about the availability of collected information both during system development and afterward through the Case for Ethics.

NOTE—6.3.6.3 of ISO/IEC/IEEE 15288:2015 [B41] provides additional details [6.3.6.3 b) 2) clarifies information maintenance].

11.4 Inputs

The following resources constitute a suitable, but not exhaustive, suite of the process inputs:

a) Project decisions

b) Outputs of each process

c) Contents of the requirements, risks, and value records

11.5 Outputs

The following work products constitute a suitable, but not exhaustive, suite of the process deliverables:

a) Value Register

b) Case for Ethics

NOTE—Annex I outlines the contents of a complete Case for Ethics extending through the Ethical Risk-Based Design process.

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Annex A

(informative)

Relationship of processes in IEEE Std 7000 to processes in ISO/IEC/IEEE 12207:2017 [B40] and ISO/IEC/IEEE 15288:2015 [B41]

Although the processes in this standard are related to typical systems and software engineering processes as described in ISO/IEC/IEEE 12207 [B40] and ISO/IEC/IEEE 15288 [B41], this standard has distinct processes, activities, and tasks that are unlikely to occur unless the engineering organization explicitly commits to incorporation of ethical values. The processes in this standard can be performed concurrently with the processes in ISO/IEC/IEEE 12207:2017 [B40] and ISO/IEC/IEEE 15288:2015 [B41]. Table A.1 maps the relationships on a process level.

Table A.1—Relationship of processes in IEEE Std 7000 to those in ISO/IEC/IEEE 12207:2017 [B40] and ISO/IEC/IEEE 15288:2015 [B41]

IEEE Std 7000 clause	ISO/IEC/IEEE 12207:2017 [B40] and ISO/IEC/IEEE 15288:2015 clause [B41]
7 Concept of Operations (ConOps) and Context Exploration	6.4.1 Business or mission analysis
8 Ethical Values Elicitation and Prioritization Process	6.4.1 Business or mission analysis 6.4.2 Stakeholder needs and requirements definition
9 Ethical Requirements Definition Process	6.4.2 Stakeholder needs and requirements definition 6.4.3 System requirements definition
10 Ethical Risk-Based Design Process	6.4.4 Architecture definition 6.4.5 Design definition
11 Transparency Management Process	6.3.6 Information management

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Annex B

(informative)

Value concepts

B.1 Philosophical basis for value concepts

The term value is derived from the Latin word “valere,” which means “to be strong” or “to be worthy.” As a consequence of this origin of the word, a value is a conception of the desirable—what is worthwhile pursuing. The concept of value in this standard is based on Material Value Ethics, a stream of philosophy (phenomenology) developed throughout the Twentieth Century (Kelly [B51]). In this context an appropriate definition is that “a *value* is a conception …of the desirable which influences the selection from available modes, means and ends of action.” (Kluckhohn 1962, p. 395 [B52]). For example, we have a conception of the value of honesty: a phenomenon we perceive as desirable and which influences our mode of actions vis-à-vis an honest or dishonest person or slot machine. With this definition, “values are not the characteristics of things” (Scheler, p.10 [B64]), nor are they individual preferences of people. Instead, “values are clearly perceivable phenomena” (Scheler, p. 11 [B64]) that are noticed in a situation and are carried by a SOI as a result of it possessing certain “value dispositions.”

Values can be expressed in positive terms (benefits) and in negative terms (harms or hazards). Beauty, for instance, can result from the many positive value drivers an SOI can have, such as an appealingly shiny surface, attractive icon design, or an attractive sound. It can also suffer from dispositions such as clumsy form factor or an ugly color. These dispositions that “value bearers” (systems or things) can possess are enablers of “values” (i.e., beautiful hardware or a beautiful interface), which, in their entirety, cause the value of beauty to be perceived and/or appreciated (in different ways) by the world of users.

Values can be associated or mapped in groups or networks. Kelly (in referencing Hartmann) writes: “...values condition each other, in that it is not possible to grasp one value without having grasped some others” [B51]. This is the reason why value clusters are created to capture different aspects of a value that may need to be embedded in the system design. Values are extrinsic or instrumental to the core value that a system should possess. Taken together, values and value demonstrators are clustered to support one or more overall core values.

Values are related in different ways for different stakeholders, due to the stakeholder’s cultural background, as well as to their preferences, professions, upbringing, or what Scheler calls their “milieu” [B64]. Relationships as well as systems are also value bearers. For example, a marriage as a form of relationship bears different values than a normal friendship. For these reasons, value clusters are analyzed for distinct stakeholder groups and stakeholder relations.

This standard emphasizes how ethical values can be affected by technology. Values borne by people and reflected in their conduct are called virtues. Most comprehensive lists of values relevant for person’s character development are the virtues recognized in respective cultures. Virtues are the values we appreciate in the behavior of persons. And they are, at the same time, value traits in a person’s character that lead to his or her long-term eudemonia (well-being) in life.

Systems can undermine virtues. For example, playing violent computer games can influence the virtue of “dama” (temperance). But computer games can, at the same time, entrain and foster values, such as “charity.” by integrating and remunerating such a virtue in their story line.

Across cultures, virtues are generally marked by well-balanced golden-mean behavior(s); hence avoiding extreme behaviors. For example, the virtue of generosity is marked by being the golden mean between greediness and lavishness. Examples of “golden-mean”-virtues (as identified by Aristotle in his *Nichomachean*

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*Ethic*s [B5]) are prudence, temperance, courage, high-mindedness, gentleness, generosity, humor, kindness, and justice or truthfulness. Roman virtues reflected some cultural differences: mercy, dignity, discipline, prudence, sternness, spiritual authority, respectability, and industriousness (see Marcus Aurelius [B56]). Buddhism's four brahmavihara ("Divine States") are not identical, but similar to virtues in the European sense (see Gethin [B16]). The four states are as follows:

- *Metta/Maitri:* loving-kindness toward all; the hope that a person is well; loving kindness is the wish that all sentient beings, without any exception, be happy.
- *Karuṇā:* compassion; the hope that a person's sufferings are diminished; compassion is the wish for all sentient beings to be free from suffering.
- *Mudita:* altruistic joy in the accomplishments of a person, oneself or other; sympathetic joy is the wholesome attitude of rejoicing in the happiness and virtues of all sentient beings.
- *Upekkha/Upeksha:* equanimity, or learning to accept both loss and gain, praise and blame, success and failure with detachment, equally, for oneself and for others. Equanimity means not to distinguish between friend, enemy or stranger, but to regard every sentient being as equal. It is a clear-minded tranquil state of mind; not being overpowered by delusions, mental dullness or agitation.

B.2 Example of value concepts applied to Ethical Risk-Based Design

Figure 2 illustrates the layered value terminology used in this standard. This example traces use of value concepts through a design case.

A systems engineering organization anticipates that a full-body scanner at an airport should protect the value of privacy. Privacy requires a number of ethical value demonstrators to be respected: for instance, avoidance of exposure of genitals, avoidance of exposure of passengers' figures, and the related value of confidentiality, with the value demonstrator of avoiding exposure of individuals' data to other passengers. This standard's methodology helps project teams to identify privacy as a relevant ethical value along with other related and unrelated values and value demonstrators.

In the Ethical Values Elicitation and Prioritization process (see Clause 8), the goal is to identify the higher values for a system so they can be prioritized in the EVR and system design. In this example of the scanner, the highest value is air safety (value demonstrator: no dangerous articles carried onboard). The value of privacy also has a high value. (People complained to authorities and refused to use a previous generation of body-imaging X-ray technology that displayed precise images of naked bodies to the security agent.) Efficiency (saving passengers' time) is a lower-level value in prioritization for the airport scanner.

If the organization accepts privacy as a high-ranking core value for the system, it should be formulated in an EVR, e.g., "The system shall protect the privacy of body images of scanned passengers." The EVR can then be translated into explicit value-based systems requirements, e.g., "The system shall display images of suspected contraband metal, plastic, ceramic, and explosive items positioned on a generic body outline." Clause 9 of this standard describes the process of translating prioritized values into concrete EVRs and value-based system requirements. The system requirements are applied to produce a design that incorporates the relevant value dispositions (see Clause 10).

As a value bearer, the scanner system has some "value dispositions" (enablers or inhibitors of the privacy value) that fulfill the value-based system requirements. the security screens depicting passengers don't display the passengers' exact body contours or genitals. The generic body outline shown on the system display thus becomes a value disposition. These privacy-preserving dispositions at the level of the system (the scanner) lead to the negative value of exposure being prevented. Another disposition is the encryption and immediate deletion of passengers' scanner profiles once the passenger has cleared security. This data deletion disposition in the scanner system protects the confidentiality of the collected passenger data and thereby enables the value

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of passenger privacy. The core value of privacy can then be engineered into the scanner (the value bearer) through its physical design, software functionality, and operational procedures, and become part of its value proposition.

This standard's risk-based approach helps an organization to systematically look into the relative importance of values like privacy, exposure, and confidentiality when prioritized in comparison with other competing values like air safety, right to bear arms, efficiency, and accuracy. In risk assessment, an issue like exposure of data (as well as exposure to hazardous radiation) is identified as a risk of harm. This standard prescribes that system development teams should engage in risk assessment and think about the extent to which such harms should be mitigated by technical or procedural/organizational approaches. It asks organizations to identify effective control techniques for prioritized harms and to transparently record and communicate their decisions. However, this standard does not prescribe any specific design solutions, implementations, test approaches, interfaces, or data structures, for specific negative values or risks since these are highly context sensitive. This level of detail (e.g., the use of millimeter wave technology or X-ray backscatter technology for scanning) is left to other domain-specific standards and the competence of the designers.

B.3 Value axioms

The conception of something positive can only materialize if there is at the same time the presence and awareness of the non-desirable from which the positive can differentiate. Consequently, scholars embrace the existence of "negative values" as well.

Positive and negative values interrelate in the following way (Axioms of Material Value Ethics):

a) The existence of a positive value is itself a positive value.

b) The non-existence of a positive value is itself a negative value.

c) The existence of a negative value is itself a negative value.

d) The non-existence of a negative value is itself a positive value.

The value axioms become specifically clear when thinking about human virtues. A virtue is a specific type of value: it is the value borne by a person. When a person bears a value, such as courage or generosity, we talk about a "virtue." The existence of the virtue of courage is itself a positive value. The undermining or increasing non-existence of courage in society is itself a negative value. The existence of the vice of cowardice is itself a negative value. The non-existence of cowardice is itself a positive value.

B.4 Value-ranking criteria in Material Value Ethics

Sometimes values appear to be in conflict. When this happens, it is helpful to know some criteria that can support a rational value ranking from a philosophical perspective. Material Value Ethics offers some indication as to what makes one value more important or 'higher' than another. These ranking criteria are summarized in Table B.1. and include the persistence of a value, its divisibility, the degree of integrity it has, the depth of satisfaction it gives to humans and its relative independence from a value bearer.

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Table B.1—Principles for value ranking

Values are higher…	Examples
… the more they endure (has nothing to do with absolute time, but with the *persistence* of a value, the eternality of a value	Love is higher than enthusiasm; happiness is higher than convenience.
… the less they are extensible or divisible	A piece of art cannot be divided, which is why it is of higher value than a piece of bread; beauty as a phenomenon is of higher value than an attractive haircut.
…the less they are founded through other values (classical distinction between intrinsic and extrinsic values)	Dignity is a higher value than amusing, which caters to dignity.
… the deeper the satisfaction connected with feeling them	A deep life satisfaction is of higher value than feeling happy while on a walk.
…the less the feeling is relative to the positioning or existence of a specific bearer of feeling or preferring	Moral values (e.g., fairness) are higher than a value such as convenience, which needs a bearer (a situation or thing that is convenient).

For example, take the value of privacy for a virtual-world gamer. Privacy can be undermined when players are generally not anonymous in games for security reasons. What value is higher: privacy or security? Privacy is an ongoing boundary regulation value with higher *persistence* than security. Security is not an ongoing regulation value present in some social processes. Instead security in some contexts is considered relevant only in those cases where the safety of a person or the integrity of a system is threatened. The level of security is also determined by other values, such as confidentiality, integrity, or authenticity; so, it is a highly extrinsic value and it is even instrumental to the higher value of privacy. A right to privacy can be considered intrinsic, a fundamental need of any free person. So, in this situation, the value of privacy would be held higher than the value of security and a gaming platform would be therefore designed such that it prioritizes privacy over security. That said: This *default* prioritization of the value of privacy does not mean that there can be no exceptions to the rule. In this case, even if the gaming company worked toward the prioritized default privacy of its users, it can still revoke anonymity and player privacy if the context requires it; for instance, when the police are legitimately searching for a specific player. Ideally, organizations set higher values as defaults and prioritize them, but they can have mechanisms to revoke this order when needed.

Often it is questioned where money or financial gain is placed in the hierarchy of values. According to Material Value Ethics, the answer is simple: money or financial gain is always only instrumental to some other value; it is a means to buy something, it is divisible. Its reception gives a person a temporary pleasure (perhaps one is extremely happy to win the lottery, but this happiness is not persistent). Money does not give as deep a satisfaction as other values such as love, dignity, or health. And money does not exist as a value if there is not a trusted monetary bearer for it, such as coins or a banking system supporting its existence. So the value of money or financial gain is relatively low regardless of the sum. Human life is considered priceless and cannot be directly compared to financial gain.

Ranking and prioritization of values according to Material Value Ethics is a philosophical exercise that involves holistic thinking to come to terms with ethical dilemmas. The ethical dilemma can be eased by distinguishing between system defaults and system exceptions. This exercise of philosophical reasoning for defaults and determination of exceptions can be expected in organizational decision-making in those cases where few of the criteria listed in 8.3 are working effectively.

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Annex C

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Ethical theories applied to Ethical Values Elicitation

In Clause 8, ethical theories are used to help unveil relevant values for a technical service or product. An ethical theory is a formalization of insights regarding how people can judge right from wrong. Whether promulgated by religious or philosophical texts, an ethical theory is the result of people distilling a sense of how to distinguish moral action from immoral action into behavioral guidance that can be applied broadly and perhaps even universally. Ethical theories are fundamentally a way of designating what features of a context are most salient to making a moral judgment about people's actions or about technology's likely effects. For example, if we were to tell someone that stealing a pair of shoes is morally wrong, we certainly do not think it was salient whether the shoes were red or blue or high-heeled or flat-soled. We instead ask what other features are salient or most important to our moral judgment? The harm done to the shoe-seller on an individual basis? The harm done to the community or society in general through disorder? The reflection of the thief's poor character? The violation of a law forbidding stealing?

Because ethical theories are abstractions and do not themselves provide context-specific guidance (e.g., no ethical theory is focused on shoe-stealing specifically), a significant amount of interpretation is required to guide concrete decisions about whether a particular action is ethically permissible, required, or forbidden in a given context.

Ethical Value Elicitation Activities are organized to produce a common output across the diversity of available ethical theories and maintained in a Value Register. The goal of the Ethical Values Elicitation and Prioritization Process is to identify leverage points to improve outcomes through the Ethical Risk-Based Design process. The ethical theories underlying this standard indicate where system designers are likely to find the most productive indicators of values. Whereas from a philosophical or anthropological perspective different ethical theories may be considered incompatible with one another, in this standard's values-oriented framework, ethical theories and principles function primarily as a robust method for noticing and articulating the most relevant set of values whose absence results in harms to the system and its users. The values that can be elicited via utilitarian perspectives focused on harms and benefits are different from those that can be elicited via the virtue ethical method. The focus on character, duty, harms, and benefits should be understood by users that these can provide a broad preliminary basis for an Ethical Values Elicitation and Prioritization Process. These three Western philosophical theories should be treated as non-exhaustive and complementary approaches to effectively eliciting and tracking the values relevant to design of the SOI.

C.1 Utilitarian ethics

Utilitarian ethics is the most common subset of consequentialism: it asserts that the outcomes (benefits and harms) of an action are the most important feature when judging whether an action (or ConOps of a system) is ethical (Mill [B57]). "Utility" is simply one common way of measuring consequences and is typically treated as a synonym for "happiness," "pleasure," or "well-being," with the opposite state of "disutility" being synonymous with "unhappiness" or "pain." The core goal of utilitarianism has been expressed as: "Everyone ought to act so as to bring about the greatest amount of happiness for the greatest number of people," or similarly: "Always act to create the most good consequences and least bad consequences." Put most simply: utilitarianism is the belief that the overall good created by an action is the most ethically relevant feature of that action. Using utilitarianism means to believe that the overall good created by an SOI is the most ethically relevant for a system.

In General Utilitarianism, which we apply in this standard, utility is considered globally and universally: the utility of everyone affected by the action is considered in an egalitarian fashion, and everyone's happiness

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is considered to be of equal type and importance without regard to a person's station in life. In the context of system design, utilitarianism has the value of connecting national and business interests in welfare macroeconomics with the long-term happiness of individual human beings. A rationally economically self-interested organization should invest in understanding and tracking the utility consequences of its actions broadly, and not only in monetary terms because, in the long run, harms done to society reduce the viability of the organization. In the context of this standard, this goal is transferred to project teams who should act to bring about the greatest amount of happiness to the greatest number of human beings impacted by the system under development. Project teams should approach this goal by asking, "What benefits or harms arise if everyone were to build and/or deploy our SOI in the way we envision it?" This question is derived from the original philosophical question of John Stuart Mill: "What would happen if everyone were to do so-and-so in such cases?" [B57]. In doing so they should consider the consequences for both direct and indirect stakeholders in the short, middle, and long terms.

This standard is intended to help organizations track utility by translating harms and benefits into values that can then be weighed as to their importance. For example, if stakeholder ethical values elicitation indicates that the most harmful aspect of using public transit is stress induced by uncertainty about whether the train will arrive on time, then designers should understand that the value of "certainty" should be ranked highly when designing an app or signage for the transit system.

C.2 Virtue ethics

A specific form of values are the virtues. Virtues are the values carried by a person or, in other words, the personal characteristics of a person that make him or her a "good" person and allow him or her to achieve long-term satisfaction and wellbeing in life (Aristotle [B5], MacIntyre [B55]). Examples are courage, patience, kindness, and honesty. Virtue ethics in this engineering context aim to help humans using the system as well as other stakeholders to flourish upon long-term system use—flourish in the sense that their characters can maintain or even increase in virtuousness and hence wellbeing. Therefore, the virtue ethical approach tries to anticipate how an envisioned system influences a person's habitual character and virtuous behavior in the long term. It should be assumed that systems affecting human behavior encourage certain personal character qualities and discourage others, and the theory of virtue ethics functions to account for those effects.

Virtues can be regarded as habitual character qualities that make a human being a good and moral community member and decision maker. This definition of virtue in relation to one's community implies that ethical system design practices should be open for both global and culture-specific virtue priorities, because every cultural community has its own priorities regarding what is good and moral behavior that is embedded in regional and global cultures. System design teams should reflect on how their envisioned system impacts the virtuousness of human beings using a system over a longer period and, for this purpose, consider the culture or region into which the system is to be deployed.

This standard is intended to help organizations track the virtues shown in their systems. As a result of virtue ethical analysis, the project team accumulates a list of virtues that stakeholders want to foster in human users of the envisioned system. It likewise has a list of virtues that can be undermined as a result of using the envisioned system. For example, if a social networking SOI encourages users to habitually behave cruelly to other persons, the discouragement of the virtue "kindness" is considered a virtue harm to be weighed against that particular design. Similarly, if a system design is found to cause users to behave habitually in a cooperative manner, then that is weighted as a value benefit. Comparing virtues fostered and undermined, project teams can rank their importance, set system design priorities, and make the decision whether to invest in a system.

While some virtues may be culturally specific or weighted more heavily by one culture compared to another, an emphasis on personal character appears to be nearly universal in human cultures. "What would a good person do?" is a common criterion for determining whether an action is ethically praiseworthy and is a useful proxy question in the virtue ethics activities of the Ethical Values Elicitation and Prioritization Process. Role models are a common feature of moral reasoning and a core feature of understanding virtue ethics. Virtues are the

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positive traits of role models in a society; however, users of this standard should be aware that what is virtuous to one person may appear non-virtuous to another, even if both value the same set of virtues. Therefore, a wide set of stakeholders should be involved in an ethical value activity, to develop a joint common sense on the virtues prioritized in a project.

C.3 Duty ethics

Duty ethics (also called "deontology") aim to identify universal rules that place boundaries on everyone's actions (Kant [B50]). Ethics identifies the fulfillment of such expectations as the salient aspect of judging whether an action or decision is ethical. Duty ethics typically asks questions from an impersonal distance, reasoning backward from what it is rational for any person to do in a circumstance or set of circumstances without reference to contingent aspects such as happiness or character. The Western philosopher most strongly associated with duty ethics, Immanuel Kant, sought to identify universal moral laws that should place limits on every rational person's actions. By strongly associating abstract reason with moral judgment he sought to show that acting unethically was fundamentally irrational in a way that no rational person should choose. Furthermore, this association between reason and morality implies that all people, simply because we are capable of reason, should treat other people as beings with inherent value that should not be diminished.

In the context of systems design, duty ethics aims to align design teams' and top management's personal ethics (or value maxims) with the expectations of stakeholders. Top management can be owners of an organization, majority shareholders, and/or senior managers in the organization, ideally including members of the board. Many organizations also have written values statements or ethics codes written in part by the organization's leadership that can be referred to as evidence of their leadership's principles.

This standard is intended to help organizations track and articulate relevant duties to identify values that are relevant to the Ethical Risk-Based Design Process. This is accomplished by enquiring into top management's, the design teams' and stakeholders' personal "maxims." A maxim is a person's intention or reason for acting in a particular way. Personal maxims are personal values with universal validity, which (in an ideal scenario) should govern a person's life. For example, if a designer refused to deceive a client, this may be due to his or her value maxim of "honesty." This again translates into a duty or rule "never act dishonestly in order to achieve economic gain." This maxim is rational because it is ultimately to everyone's benefit to act honestly in economic transactions—if everyone acted dishonestly then commerce would collapse. Therefore, according to duty ethics, we have a duty to always act honestly in commerce regardless of near-term outcomes that may reduce our own economic status. In the context of an organization, maxims are personal principles that the leaders and stakeholders wish for themselves and therefore have the duty to act upon in the interest of others.

According to Kant [B50], all the personal principles that can be rightfully willed for are derived from the so called "categorical imperative" (synonym: "universal command"), an overarching rule of ethical behavior that describes all the others. The categorical imperative as proposed by Kant is typically stated in two philosophically equivalent fashions:

a) Act only according to that maxim whereby you can, at the same time, will that it should become a universal law." In other words, always act in a manner that your reasons for acting can be adopted by everyone in every situation. If you would not choose to live in a world where everyone lived by the same maxim you are acting by in this moment, then your action is immoral and irrational.

b) So act that you use humanity, whether in your own person or in the person of any other, always at the same time as an end, never merely as a means." In other words, because all people have an inherent dignity, we should never treat each other as a mere means to get what we want. Even when we have an instrumental relationship to another person (such as an economic relationship), we should treat each other with the respect due to other rational, autonomous persons because a world without such respect would be irrational and unlivable.

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The second formulation is typically considered the easiest to apply to a practical situation, such as situations found in system design. Notably, duty ethics are typically not concerned with the detailed specifics of what would count as respect but are instead stated as negative principles that tell us what we should never do. They set wide boundaries on the range of acceptable behavior rather than specifying precisely which behavior is preferred. The categorical imperative should be understood as the underlying framework by which duty ethics operates and are therefore the inspiration for the duty ethics activities described in Clause 8.

In systems design it is important to understand how both respect and disrespect for people can be concretely built into a system. For example, if a machine-learning system routinely associated a group of people with an insulting epithet due to social bigotry incorporated into the historical learning data, that would be considered a "dignitary harm" violating the duty to always treat people with respect. The most common way a technical system can undermine a person's dignity is by not respecting their autonomy to make their own choices over matters that are important to their own lives, such as data privacy or medical decisions. This document assumes that all people responsible for a system should endeavor to ask whether that system treats individuals as a mere means at any point. If such a harm is discovered, it is a primary point to look for alternative design priorities.

Eliciting value priorities as the personal maxims of members of responsible management, design teams, stakeholders, and respected moral leaders from outside an organization illuminates the common expectations about how a system should treat people. The work of eliciting and aligning these expectations functions to identify what these groups of people value, providing useful parameters for the SOI's value priorities.

C.4 Other ethical theories and models

As stated above, utilitarian, virtue and duty analyses are not exhaustive accounts of how people and communities can be harmed. These three core theories are emphasized because they identify salient, widely familiar features of ethical reasoning: consequences, character, and duties. However, there are numerous alternative models and traditions, which an Ethical Values Elicitation Activity can accommodate, as long as the output of those analyses are consistent and rankable ethical values.

For example, a non-exhaustive list of other ethical theories may be of use in identifying relevant values, as follows:

— *Ethics of care:* In contrast to the universalism of other theories, ethics of care emphasizes the particularity of close interpersonal and social relationships as the foundation of human empathy (see Held [B20])

— *Pragmatism:* Morality develops in a similar manner to scientific knowledge, with refinements and improvements over time, and without the expectation that there is a final state of perfect knowledge. Creedence should therefore be given to well-considered social norms and be open to reasoned arguments about how norms should change (see Legg and Hookway [B54])

— *Culturally-appropriate theories:* Relevant ethical theories that are widely used in the SOI's target market (see Baghramian and Carter [B6])

— *Natural law:* Determinations of right and wrong should be derived from the natural or divine order of the world (see Finnis [B14])

— *Casuistry:* We should primarily rely on precedents when making an ethical judgment, reasoning from a paradigmatic case for guidance about how to respond to similar cases in the present. Casuistry is often utilized in applied ethics contexts, such as hospital ethics boards. Rigorous use of casuistry requires access to precedents, subject-matter experts, and case studies (see Schmidt [B66])

Furthermore, there are approaches to ethical reasoning that rely on no theory but rather emphasize specific principles that have proven contextually useful. This is sometimes called "principlism" (see Beauchamp and DeGrazia [B7]) Such an approach is familiar in scientific and technological communities, where a set

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of principles can be derived from the common goal of generating empirical knowledge in an effective and trustworthy manner. A well-functioning scientific community requires that participants adhere to principles such as the following:

a) Communicate and debate openly
b) Attribute prior research and labor fairly
c) Be transparent with data and methods
d) Rely on replicability and peer-review of findings

In such a case, the relevant ethical values identified are openness, fairness, transparency, and replicability. It is possible to articulate why violation of those norms is a harm to the scientific community and its common goals without referring to any traditional ethical theory.

Similarly, biomedical research is often associated with three core ethical principles, as articulated by the Belmont Report: respect for persons, beneficence, and justice (Belmont Report [B9]). Most scientific research ethics review processes are governed by some variation of these principles, such as Institutional Review Boards (IRB) in the United States or Research Ethics Committees (REC) in the European Union. Similarly, most nations have signed on to sets of principles that protect universal human rights in medical research, such as the Nuremberg Code (see Weindling [B77]) and Helsinki Declaration [B79]. Furthermore, many professional societies to which the designers of an SOI may belong to have codes of professional ethics that should be considered, such as the IEEE Code of Ethics [B24] or the Association of Computing Machinery's Code of Ethics and Professional Conduct [B1]. Any given SOI may have similar widely accepted principles at stake, which should be considered within the analysis. The processes defined by this standard encourage consideration of these widely helpful principles as a way to check on the priorities of the organization designing the SOI relative to common norms of science and engineering.

Ethical theories occupy an intermediate space between cultural specificity and global universality that poses challenges for the global mandate of IEEE standards. Each of the ethical theories described in this standard was developed in a specific historical and cultural context and, therefore, make use of the linguistic and conceptual resources available to it. Unavoidably, Western philosophical literature uses different terminology than philosophical traditions of the Indian subcontinent or the Confucian philosophies of East Asia. Yet despite the local influence present in ethical theories, all of them make some degree of claim upon what is right and wrong for every person, in every culture, and in every time (Vallor [B75]). Therefore, a globally applicable standard that invokes the most robust resources of ethical reasoning should also acknowledge some degree of localized and culturally specific concepts and terminology.

The ethical activities outlined in Clause 8 on ethical values elicitation emphasize three approaches directly derived from the Western philosophical canon. But they were framed such that they are culturally sensitive: Personal character (virtue ethics, Aristotle [B5]) is something that all cultures care about with different emphases. Moral duty (deontology, Kant [B50]) is known in all cultures even if these duties can vary (duty ethics or deontology, Alexander and Moore [B2]). Harms and benefits (utilitarianism, Mill [B57]) is also known to all cultures. In addition, users of this standard can identify the relevant value space in their own culturally adaptive way [see activity 8.3 c)]. The process can return different and culturally sensitive value results and value priorities for its distinct users.

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Annex D

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Legal, social, and environmental feasibility analyses

A legal, social, or environmental feasibility analysis allows further consideration of the potential intended or unexpected system impacts. Analyses can be performed at the stage of concept exploration or during system development. The open-ended questions in Table D.1 are intended to result in organizational conversations across domains because they are not context specific. Questions are presented as an illustration of the approach to this mode of feasibility analysis. These questions are not complete and sufficient in all cases but illustrate a typical approach for a 360-degree view of the context as part of a triple-bottom-line approach (financial, social, environmental).

The legal questions can be applied to already enacted laws and regulations, as well as to cross-jurisdiction and cross-functional considerations and to potential laws and regulation, that may affect the SOI, its users and other stakeholders, and the broader international context.

The social and environmental feasibility questions pertain to how the ConOps and the SOI can impact the social and cultural lives and geographic contexts of the stakeholders and users. The social feasibility analysis can be significant in developing a concept of operation and in the design of an SOI, because potential severe adverse impacts may be unintended and unknown to communities of affected stakeholders. Social feasibility can involve risk management and mitigating the risk of those impacts in the ConOps and system design.

New IT systems and other SOI's can also have significant environmental impacts arising from construction and system operation, which can be both positive and negative. The Precautionary Principle is often applied: when an activity raises threats of harm to human health or the environment, precautions should be taken, even if causality is not fully scientifically established. The impacts may also include follow-on effects beyond the immediate legal, social, or environmental impacts, as well as beyond the stakeholders directly associated with the SOI (secondary impacts). Secondary impacts can be addressed independently in further conversations and analyses.

Table D.1—Legal, social, and environmental feasibility study and analysis guidelines

Analysis topic	Legal	Social	Environmental
Definition	Legal feasibility study and analysis includes the identification and analysis of pertinent laws and regulations that may affect the SOI, its stakeholders, users, society, and broader international policy.	Social feasibility study and analysis includes the identification and scrutiny of the community and cultural aspects that may be affected by the SOI design.	Environmental feasibility study and analysis includes the identification and analysis of pertinent or natural laws and regulations that may affect the natural environment, its stakeholders, ecosystem, life forms, and biodiversity.
Description	Due diligence is relevant for civil law, criminal law, and precedent case history that may affect the SOI design and also how the SOI design may affect the legal rights and status of stakeholders, users, society, and broader international policy.	Analysis should address a broad set of issues related to changes in the social, economic, political, and cultural conditions in which stakeholders/users live and work. Specific types of social issues and cultural impacts associated with an SOI can vary considerably. Thus, different SOI's result in different levels and depths of analysis depending on the social issues.	The environmental feasibility study and analysis determines the impacts the SOI can have on natural systems, including climate change, biodiversity, resources, water, waste, life cycles, recycling, contamination, or overt abuse of scarce resources.

Table continues

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Table D.1—Legal, social, and environmental feasibility study and analysis guidelines *(continued)*

Analysis topic	Legal	Social	Environmental
Question 1	Who are the leaders, managers, consultants, individuals, or groups, legally accountable and responsible for the design milestones across the concept exploration and development stages? Record the full chain of command in the design custody.	What different kinds of demographics, geographies and cultures are impacted by the SOI as designed?	What is the project/SOI's approach to compliance with international environmental standards such as ISO 26000 [B28] and ISO 14001 [B27]?
Question 2	What local, regional, national, and international regulatory bodies should be consulted or enhanced to evaluate a full 360 view of the SOI's legal responsibilities to its stakeholders, users, society, and international policy?	Are any special interest groups or stakeholders differentially impacted by the SOI's design? If so, how are these to be identified and addressed?	What is the scope and scale of the environmental impact?
Question 3	Are any special interest groups or stakeholder legal rights differentially impacted by the SOI's design? If so, how ae these to be identified and addressed?	Are there significant social, economic, political, or cultural issues among the stakeholders and users and their geographies/cultures that should be analyzed using the precautionary principle? If so, they should be described in writing as a social feasibility baseline report.	How is the Precautionary Principle being applied? Describe how risks and threats are being identified and mitigated.
Question 4	What legislation relates to the granting of ownership/control of the SOI design, data, use, storage and final disposition?	How can the SOI design be adapted to be more socially and culturally relevant for stakeholders and users?	What actions and policies are being taken for the SOI's use of rare earth materials, avoidance of contamination, recycling of waste materials, protection of habitats and wildlife?

Table continues

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Table D.1—Legal, social, and environmental feasibility study and analysis guidelines *(continued)*

Analysis topic	Legal	Social	Environmental
Question 5	What are the laws regulating current and future income streams related to SOI design, assets, and stakeholder data derived from designs across international boundaries?	How can a two-way public conversation be opened to assess the social impact of the SOI to promote the active engagement of individuals, groups, and organizations who have a stake in the SOI design and its outcomes?	Describe the environmental plan developed for the design of the SOI and the associated resources?
Question 6	If the SOI's impact on stakeholders, society, and the broader international policy are considered "legal," provide three points of reference as evidence that its impact can also be considered "ethical."	If the SOI's impact on stakeholders, society, and the broader international policy are considered "ethical," provide three points of reference and ask how the SOI design can surpass the ethical considerations.	Name the person responsible and describe the contingency and emergency response plan for the environmental aspects of the SOI?
Outputs	a) Accountability report of full chain of custody for the design, including individual contact information. b) Communication report with regulatory bodies and a descriptive report of the differential impact on stakeholders, users, society, and relevant international policy making organizations such as the GDPR. c) SIG (special interest group) demographic report and action plans for addressing SIGS legal requirements. d) In-depth Data Life Cycle use evaluation, including a description of the income stream analysis. e) Gap analysis report between legal and ethical imperatives and requirements.	a) Descriptive impact report of the demographic, geographic, and cultural stakeholders. b) SIG (special interest group) action plans for addressing SIGS legal requirements. c) Precautionary principle evaluation as described in a social feasibility baseline report. d) Communication report of two-way public conversation on SOI adaptation for added relevance to stakeholders and users, including three reference points for exceeding ethical considerations.	a) ISO environmental compliance report. b) Precautionary Principle report, including identification of risks, threats, and description of the actions being taken for use of rare and vulnerable earth resources and the policies in place to protect habitats and wildlife. c) Environmental plan, including a description of the contingency response actions to be taken in an emergency.

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Annex E

(informative)

Control considerations in systems of systems (SoS)

Many systems of interest build on system elements sourced from outside an organization’s managerial boundaries. The SOI, for example, may consume cloud services, web services, storage, data processing, components, and other system elements under external control. It is not always a given that organizations have control over these system elements—at least not to a degree that ethical guarantees can be given for them. Organizations with low control and observability over external system elements can only be partially effective in addressing ethical concerns in the system development lifecycle.

The following aspects of system control should be analyzed (which ethical issues identified in the ethical issues register are connected to the system element):

- Organizational measures and system requirements to ensure observability of the ethical issues
- Technical measures and system requirements for the controllability of the ethical issues
- A judgment on the observability of ethical issues in the system element or constituent system
- A judgment on the controllability of ethical issues in the system element or constituent system

Controllability can become a challenge if the system operates in system of systems (SoS) or depends on systems with a long legacy and/or high complexity. Organizations create insight for themselves to the degree to which they have control over system elements to understand the following:

a) Whether they have sufficient influence to change/design elements that can turn out to be relevant

b) Whether they can live up to their own ethical policies

The organization needs to address control and observability over system elements both in systems in their first lifecycle and in further lifecycles. Systems in their first lifecycle are designed from zero not having existed before. Designing an SOI in a further lifecycle means the SOI exists already or is a piece within a larger system environment that is already operating. In such a situation it is vital to understand the level of control an organization has over existing system elements that are parts of or input factors to the SOI.

Depending on the strength of the governance relationships between the constituent systems and the SoS, ISO/IEC/IEEE 15288:2015 [B41] and ISO/IEC/IEEE 12207:2017 [B40] characterize and distinguish four forms of SoS (see Table E.1). The level of observability and control over ethical concerns of the constituent system determines the maximum degree of ethical risk that can acceptably be influenced by or connected to the constituent system. Because of the non-existing or very low observability and control over ethical issues in constituent systems characterized as virtual systems, these systems should only be related to insignificant or very low ethical risks. If an ethical risk is influenced by a constituent system that is characterized as a virtual system, the connected ethical risk should not be higher than insignificant or very low. Constituent systems that are collaborative in nature should not expose the SOI to an ethical risk that is greater than low. In case of an acknowledged type of a constituent system, ethical issues should be controlled through defined service level agreements (SLAs) that outline the expectations and requirements of the organization using this standard, including mechanisms for monitoring the ethical values of service fulfillment. Constituent systems of directed nature provide the highest level of observability and control over ethical issues. In a directed SoS, procedures can be established for constituent systems to help control risks to ethical values.

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Table E.1—Types of systems of systems (SoS)

Type of SoS	Character as described in ISO/IEC/IEEE 15288:2015 [B41]	Observability of ethical issues	Control over ethical issues	Maximum risk of ethical value at stake that can be treated
Virtual systems	Lack a central management authority Lack of centrally agreed upon purpose Emerging behaviors that rely upon relatively invisible mechanisms to maintain it	None/very low	None/ very low	Insignificant/ very low
Collaborative systems	Component systems interact voluntarily to fulfill agreed upon purposes Collectively decide how to interoperate, enforcing and maintaining standards	Low	Low	Low
Acknowledged systems	Recognized objectives, a designated manager, and resources for the SoS Constituent systems retain their independent ownership, management, and resources	Medium	Medium	Medium
Directed systems	Integrated SoS built and managed to fulfill specific purposes Centrally managed and evolved Component systems maintain ability to operate independently Normal operational mode is subordinated to central purpose	High	High	High
NOTE—Based on Figure G-1 from ISO/IEC/IEEE 15288:2015 [B41].				

In general, a higher observability of and control over ethical issues in constituent systems, as in a directed SoS, increases the organization's capability to include consideration of ethical values during system design and other systems and software engineering processes.

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Annex F

(informative)

Control over AI systems

System control is essential for the preservation of ethical values in an AI system, even if the exact internal mechanisms for system learning are not fully understood. The system design includes controls so that a system's behavior has known limits and is in response to human instructions. Where the system's use is contrary to expectations or it creates unforeseen new ethical value harms, engineers use a feedback loop to recalibrate system decisions or adjust the system's design, control, and operational options accordingly.

Where AI systems are concerned, there should be control over the following:

- The quality of the data used in the AI system
- The selection processes feeding the AI
- The algorithm design
- The evolution of the AI's logic
- The best available techniques (BATs) for a sufficient level of transparency of how the AI is learning and reaching its conclusions"

Where there is potential or actual harm from the use of a system, it is in the public interest to know who is responsible under the law. Responsibility concerns who has a duty to fulfil a certain task/function and, if they fail to do so, what the legal sanctions are for any resulting harm. That is, who should be attributed with responsibility for the consequences of the use of the system. This differs from accountability, where someone has a designated function/role/task which they fail to fulfil or do so inadequately, but for which there are no legal sanctions; the person merely accounts for their actions (i.e., provides an explanation) and nothing more. Responsibility involves more than simply explaining actions; it is about accepting any legal sanctions that may follow.

To have control over the quality of the data used by the AI system means to be able to judge the accuracy, timeliness, consistency and completeness of the data used and to be able to judge the legitimacy (and legality) of data provenance (if personal data is used, for instance, the question is whether this data has been collected in a legally compliant way). Finally, the controller should have the ability to shape the data such that it can later be optimally catered to the values that the system is supposed to have for business or ethical reasons.

To have control over the selection process feeding the AI means to have sufficient degrees of freedom to ignore/exclude certain data sets, the use of which turn out to be ethically problematic in the later project (i.e., sensitive personal data); to be able to consciously and carefully specify the AI starting structure; and to be able to dispose of a sufficiently large number of data dimensions to allow for choice (to allow for later adaptation and refinement of training results).

Control over algorithm design means that the AI's internal logic [algorithm(s)] is, as system elements are as follows:

a) The general mathematics on which the algorithm is based is openly published

b) The algorithm's logic is put into simple words so that lay people can get a notion of what the mathematics is doing

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c) The training of an algorithm should strive to avoid bias and if such biases evolve, document their potential existence

d) Testing of algorithms should allow time for testing on different data sets as the algorithm is trained

NOTE—ISO/IEC TR 29119-11[B38] provides detailed guidance on testing of AI-based systems.

e) The organization should communicate the limitations of the AI algorithms (for example, stating the probability with which its result seems to be true)

Control over an AI's logic evolution can be met if the above criteria of data quality control and algorithm design are applied. In addition, the organization should have the possibility to integrate a mechanism to reverse or to adapt learning based on data set exclusion.

For the long-term controllability of a machine-learning process within an AI, the AI organization should establish BATs to provide sufficient transparency of the development of the AI's intelligence or reasoning. Such BATs can include mechanisms like running the algorithm in reverse, hence refiguring its learning path, and accessing a number of central neurons to see what inputs activated them most or to extract snippets of text, keywords, or images that are representative for the patterns discovered by the AI.

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Annex G

(informative)

Typical ethical values

This standard encourages the elicitation of individually held values, virtues, personal maxims, and principles as motivation for applying values to the SOI and its effect on the users. To avoid inadvertent gaps in ethical values elicitation and prioritization, values elicited in this way should be compared with lists of common ethical values that may be relevant to a system in its context. This annex provides typical examples of values, related values, and opposing values applicable to system design.

Table G.1 lists ethical values commonly applied to system design. These values should be considered during the processes described in Clause 8 through Clause 10. This is not an exhaustive list and other values, both positive and negative, may be identified. The core values are shown with related values and opposing values. Some of the opposing values are not direct opposites but merely contrasting values or lesser embodiments of the absolute value. For example, control and trust are opposite ethical values regarding the relationship of a human and a system, and transparency and privacy are opposite ethical values. Competence is not the complete opposite of perfection, but a task done competently is not necessarily perfect.

NOTE—Human rights are not a value, but rather a characterization of a set of values that are deemed the inherent property of each human.

Table G.1—Typical ethical values for systems design

Ethical value applicable to system design	Related value	Opposing value
Autonomy	Moral agency, dignity, independence, freedom, liberty, mobility, self-direction, power, self-actualization, ownership	Accountability, responsibility, responsiveness, reciprocity, paternalism, slavery
Care	Accountability to shareholders, investors, suppliers, and other stakeholders; understanding; compassion; love; empathy; protection of the vulnerable; affection; support; friendliness; beneficence; benevolence; generosity; gentleness; helpfulness; kindness; comfort; quality of life; paternalism	Torture, maleficence, persecution, machine capability, logic, objectivity
Control	Human responsibility, governance, usability, portability, logic, sense of accomplishment, moderation	Trust, accountability to stakeholders; imagination, reminding, obedience
Fairness	Responsible position on conflicts of interest, tolerance, justice, balance, equality (legal, gender, minority)	Bias, suspicion, discrimination, arbitrariness
Inclusiveness	Participation, partnership, solidarity, interdependence, compatibility, accessibility, diversity	Control, bias, detachment
Innovation	Modifiability, adventure, novelty, excitement, playfulness, diversity, development, learning, curiosity, creativity	Tradition, distraction
Perfection	Integrity, truth, honesty, achievement, transcendence, universalism, wisdom	Competence, feasibility, over-capacity,
Privacy	Respect for confidentiality, intimacy, anonymity	Transparency, inclusiveness, alerting
Respect	Politeness, courtesy, respect for environment and natural habitat, respect for information and confidentiality, respect for norms, reputation	Self-esteem, maleficence

Table continues

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Table G.1—Typical ethical values for systems design *(continued)*

Ethical value applicable to system design	Related value	Opposing value
Sustainability	Respect for environment and natural habitat, efficiency, maintainability, operability, supportability, reliability, durability, resilience, forgiveness, robustness, redundancy, reusability, re-configurability, simplicity, economy, renewability	Cost (extravagance), wastefulness, poverty, consumption
Transparency	Openness, cleanliness, explicability, explainabililty, access to data. auditability	Privacy, bribery, corruption
Trust	Predictability, dependability, veracity	Control
NOTE—Opposing values can be positive or negative.		

The following is a set of values with observations on how they may be perceived or realized in systems design. The values are presented in alphabetical order and not prioritized.

— *Autonomy:* The ability of persons to govern themselves including formation of intentions, goals, motivations, plans of action, and execution of those plans, with or without the assistance of other persons or systems. A person perceives autonomy vis-a-vis a machine if that machine leaves ample room for a user to act according to his or her proper reasons and motives. The perception of autonomy vis-a-vis a machine is created by machines leaving users ample choices and allowing users access to adjust the logic.

— *Care:* Ethical risk-based design inherently includes some unquantifiable implicit requirements, which are difficult to include in formal specifications. Engineers therefore need to take day-to-day design decisions with potential ethical impact. In order to do so, engineers should embrace an attitude of care and consider their own reaction, or that of someone close to them, to the product's behavior.

— *Control:* Having control of a machine means having a) cognitive control in terms of being informed about what is going on in the computing environment, b) having decisional control in terms of having choices over what is going on in one's networked environment, and c) behavioral control in terms of receiving feedback on one's actions/choices taken. As this standard results in ethically aligned system designs, it is applicable for organizations that have sufficient control over the system for which they assume responsibility.

The behavior and other properties of a system are considered as ultimately under human control, even if some properties emerge in the course of system usage and cannot be predicted beforehand. See Annex F for further discussion.

— *Fairness:* Fairness has the attributes of systematic discrimination with an absence of bias in reaching reasonable judgments and allowing opportunities. On the other hand, a computer system is biased when it systematically and unfairly discriminates against certain individuals or groups of individuals in favor of others. The three attributes of a) systematic, b) unfair and c) discriminating are all present for bias to materialize. Unfairness means that decisions taken by a machine or algorithm are b) 1) inappropriate or b) 2) unreasonable. Discrimination is created if there is a c) 1) denial of opportunity and/or c) 2) assignment of an undesirable outcome for the user.

— *Inclusiveness:* Inclusiveness in a system means that it is accessible to differently abled users, unbiased in its decisions, and fair to the broadest range of characteristics (especially human characteristics) it may encounter. On a project, inclusiveness involves respect and consideration for the judgment of internal stakeholders and other participants who provide information and participate in decision-making. Inclusiveness encompasses suggested improvements to the design and product and alerts regarding risks and harms arising during the product lifecycle.

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- *Openness:* Openness is related to transparency as a value. Ethical value project culture should be marked by openness in voicing concerns, communicating system constraints and limitations, and sharing understanding of how the system works. Openness should be more highly valued than fear of disclosure within the organization. Participants in ethical value efforts should feel comfortable if their actions became public at any time.
- *Perfection:* It is unlikely that there can be a perfect system design even when a "zero-defects" approach is taken. Engineers should however try to meet or exceed value requirements, both stated and implicit, wherever possible. Extra costs incurred through a striving for value-based product perfection should be identified and highlighted in cost/benefit analyses for the product.
- *Politeness:* Computer communication with human users is less likely to be successful if the computer is perceived as rude or insulting. Politeness in computer interaction with humans implies the use of all of the following aspects: a) polite communication and b) the granting and respecting of user choices. Polite communication means respecting a) 1) cultural norms of polite language and a) 2) polite interaction (i.e., gestures). Granting and respecting user choices implies that the machine needs to b) 1) offer useful choices (i.e., choices desired by users, choices that are easily understandable, and choices that are transparent in its implications), b) 2) respect user choices (avoiding potentially undesired preemptive actions, not initiating actions without user consent, signaling respect for choices made), and remember past choices (have an interaction memory). Machine identity revelation implies that c) 1) the user knows by whom the machine is operated, c) 2) what parties are involved in the interaction, and c) 3) what the contact details of the involved parties are (including humans reachable at the machine operator for further advice).
- *Privacy:* Privacy means that a) the collection, b) processing, and c) dissemination of personal information is done in such a way as to maintain the information self-determination of a data subject. In addition, any form of d) invasion is avoided. Privacy in terms of information collection is given when a) 1) situations of unsolicited surveillance and a) 2) interrogation are avoided; personal information is best obtained by asking data subjects for their explicit, informed, and uncoerced consent to data collection. Privacy in terms of information processing is given when b) 1) situations of unexpected and unsolicited personal data aggregation or b) 2) secondary use are avoided, when the data subject's b) 3) data security it maintained, and when (b4) the data subject is not excluded from any service based purely on his/her data or on the automated decisions based upon that data. Privacy in terms of information dissemination is given when c) 1) there is no breach of confidentiality vis-à-vis the data subject and when there is c) 2) no exposure, c) 3) disclosure, c) 4) blackmail, c) 5) appropriation, or c) 6) distortion happening based on personal data. Increased accessibility of a data subject (due to further use or visibility of his/her data; i.e., through social media) can be a privacy issue, reduced by asking data subjects for their explicit and informed consent to information dissemination. Privacy breach in terms of invasion is given when a machine d) 1) intrudes or interferes with a person's natural flow of action and d) 2) against his/her will. It is also given when d) 3) a machine interferes with a user's free flow of decision making.
- *Respect:* Respect in human-machine interaction implies that a machine is perceived as a) attentive and b) responsive. Attentiveness implies that the machine is perceived as a) 1) replying in a reasonable amount of time and a) 2) respecting user privacy. Responsiveness implies that the machine is perceived as b) 1) applying appropriate criteria in its decisions b) 2) made explicit to the user (see "transparency") and that it is perceived as acting b) 3) fairly and b) 4) politely (acknowledging inconvenience the user may have encountered) (see *Politeness*).
- *Transparency:* Transparency means that information provided about a system is a) meaningful, b) useful, c) accessible, d) comprehensive, and e) truthful. "Meaningful" means that information about a system or its functioning should not necessarily contain everything one can possibly publish about a system's functioning (i.e., plain log files). Instead, it should contain the information a) 1) relevant for users' concern or a) 2) user control. "Usefulness" of information implies that consumers can b) 1) act upon it and b) 2) make choices easily, acting upon the information provided to them. "Accessible" means that it is possible to c) 1) easily obtain and retrieve the relevant information in a machine-

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readable or c) 2) other way whether through state-of-the-art electronic channels or via constrained devices or constrained networks. "Comprehensive" means that information about a system should be d) 1) easy to read and understand for ordinary people and d) 2) not require any expert knowledge. "Truthful" means that information about a system accurately reflects a system's or system landscape's activities, such as e) 1) data processing and e) 2) data sharing practices. The information should be e) 3) up to date and e) 4) written in plain language that is clear and direct. It should not e) 5) mislead users in any way, e) 6) hide information, or give e) 7) a "half-truth" about practices.

— *Trust:* Trust in a system can be granted as a result of a system's demonstrated a) competence, b) benevolence, c) honesty and d) predictable behavior. System competence is a matter of system dependability; that is system a) 1) security, a) 2) reliability, and a) 3) safety. Dependability can be signaled to users through some evidence or frame, such as quality seals or certification, publicly stated guarantees, and warranties. System benevolence is embedded in human-computer interaction, which can be of b) 1) emotional, b) 2) responsive, and b) 3) respectful manner (see *Respect*). System honesty can be signaled by a system through c) 1) its way of being transparent (see *Transparency*). System predictability is fostered by d) 1) embedding standardized forms of interaction (signaling situation normality) and d) 2) making a system sustainable and d) 3) easy-to-use.

The following values are not treated in detail as ethical values in this standard. More specialized standards are already available regarding these special value domains.

— *Aesthetics (beauty, beatitude, harmony):* is typically not regarded as a core value in systems engineering but is realized through other demonstrators of "good" design, such as simplicity, usability, efficiency, or quality. Aesthetic properties such as color and form are in scope when they affect cultural values.

— *Health:* Health is the state of physical and mental well-being, not just the absence of disease or infirmity.

— *Safety:* A system is safe when it does not, under defined conditions, lead to a state in which human life, health, property, or the environment is endangered.

— *Security:* A system is secure when the environment is not able to affect it in an undesirable way. Undesirable effects are minimized through the information qualities:

- Confidentiality [data is a) 1) encrypted and a) 2) accessible only to authorized parties]
- Integrity [b) 1) data is whole, b) 2) complete, and b) 3) uncorrupted]
- Availability [c) 1) data is accessible when needed], c) 2) authenticity (data is genuine, original, and stems from a trusted source)
- Accuracy (data is free of errors)

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Annex H

(informative)

Organizational-level values

An organization thta espouses and supports the core values and principles outlined below in a matter of course in their daily operations is more likely to successfully design a system compliant with this standard. This annex distinguishes between the values of a system, which is the core analytic focus of this standard, and the values of the organization designing and integrating the system which is not assessed directly by this standard. This annex is offered to assist in aligning organizational and project values within this context. This standard works for applying values to system design based on organizational values. Organizational values can be generated using the Ethical Values Elicitation and Prioritization process, and organizational policy statements can be based on the values. Organizational policy statements are not an output of this standard but, can be developed based on its processes.

In addition to the general values and principles, certain principles of work and cooperation can facilitate projects so that the organizational environment encourages the delivery of EVR, e.g., to prioritize humanity over profit and time, to embrace an attitude of care, inclusiveness, and openness.

Organizations that do not explicitly define their ethical values are more likely to encounter ethical issues, such as placing economic gain or privileges of a few above human rights; suppressing human autonomy through systematic control; disguising the responsibilities of human operators for system outputs; concealing system limitations in accounting for ethical values; or misleadingly representing systems with anthropomorphic characteristics.

Embedding the principles may be included in the formal targets in product development and internal improvement projects.

NOTE 1—ISO TR 38504 provides guidance on alignment of principles to organizational governance.

To work toward the goal of ethical system design, organizations should consider the following core values and principles that can be applied at a strategic organizational level as well as for a specific system or project.

The following ethical principles should be reflected in the core values in the organization to support the Ethical Risk-Based Design process. Consistent values should also be included in the Value Register for the SOI.

a) Human rights are to be protected.

b) Human autonomy and moral agency are to be protected.

c) Algorithms should be reviewed for fairness in application to the target population of human users or human subjects.

d) The responsibilities of human beings (in designing, commissioning, owning, operating etc. those systems) are to be made clear throughout the SOI lifecycle.

e) Anthropomorphic representation of the system, including in linguistic and extra-linguistic cues, is to be regarded as a risk.

NOTE 2—IEEE P7003 (in preparation) covers these topics in more detail.

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Annex I

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Case for Ethics

This standard provides advisory and normative requirements for ethically aligned design activities. It is highly desirable, however, that the effort, resources and time spent, as well as evidence and outcomes attained in the course of implementing the requirements and the spirit of this standard, are recorded, consolidated, structured and presented in an adequate, consistent, and coherent narrative: a Case for Ethics. The Case for Ethics is a project memory and an auditable repository. Similar to a safety case, the Case for Ethics is intended to provide a structured account of the ethical and technical activities undertaken in the course of pursuing an ethically aligned design for the SOI. The Case for Ethics is a key contribution toward the organizational memory and maturity in ethically aligned design and a foundational information product for assessments.

The structure, contents, and arguments pertinent to a final claim for an ethically aligned design should be developed in an evolutionary manner throughout the life of a system. The Case for Ethics encourages the process outputs, evidence, and outcomes to be recorded at each stage of the ethically aligned design to provide a process or project repository and memory as well as a structured argument for the ethicality of the product, service or system. It constitutes indispensable inputs into any subsequent ethics assessment for the SOI and the organization.

The following content is recommended for the Case for Ethics for a given SOI. It serves as a checklist that can be satisfied by the organization's content mapping, templates and information models. This outline is not intended to address all possible contents, or to mandate the title of the information item, nor the order or titles of the sections in documents presenting some or all of the contents of the Case for Ethics.

a) Introduction
   1) Societal context
   2) Key drivers
b) System of interest, scope, and boundaries
   1) Purpose
   2) Context: scope, boundary, and interfaces
      i) Direct and indirect stakeholders
      ii) Data flows
      iii) Processes
   3) Initial concept of operation
   4) Other supporting or dependent systems (SoS)
c) Setting the ethical context outcomes
   1) Realistic scenario description
      i) Envisaged market share assumption (as outlined in the business plan)
      ii) Assumed place(s) of service usage
      iii) Assumed geographic location(s) of service offering
      iv) Assumed primary user interface(s)

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2) Preliminary harms and benefits

3) Key stakeholders involved in consultation

4) Consultation

5) Value Register

i) Value list

ii) Value clusters identified as positive and negative field potentials per stakeholder and/or stakeholder relationship

iii) Value narrative (e.g., scenario or use case illustrating the effect of the value)

d) Enterprise ethical value-based strategy

1) Enterprise ethical policy statement

2) Enterprise ethically aligned design processes

3) System level EVRs (Ethical values impacted by the SOI)

e) Ethical value risk assessment and management outcomes

1) Ethical values at risk: evaluation and tolerability criteria

2) Ethical values sustained or promoted

3) Risk mitigation and control options for ethical values at risk

4) Derivation of ethically driven functional and non-functional requirements

f) Functional and non-functional requirements traced in the system design

g) Ethical claims for the SOI and conclusions

h) Principal resources and references

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Annex J

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AMSCE-1101

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The ethics of artificial intelligence: Issues and initiatives

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The ethics of artificial intelligence: Issues and initiatives

This study deals with the ethical implications and moral questions that arise from the development and implementation of artificial intelligence (AI) technologies. It also reviews the guidelines and frameworks which countries and regions around the world have created to address them. It presents a comparison between the current main frameworks and the main ethical issues, and highlights gaps around the mechanisms of fair benefit-sharing; assigning of responsibility; exploitation of workers; energy demands in the context of environmental and climate changes; and more complex and less certain implications of AI, such as those regarding human relationships.

AMSCE 1101

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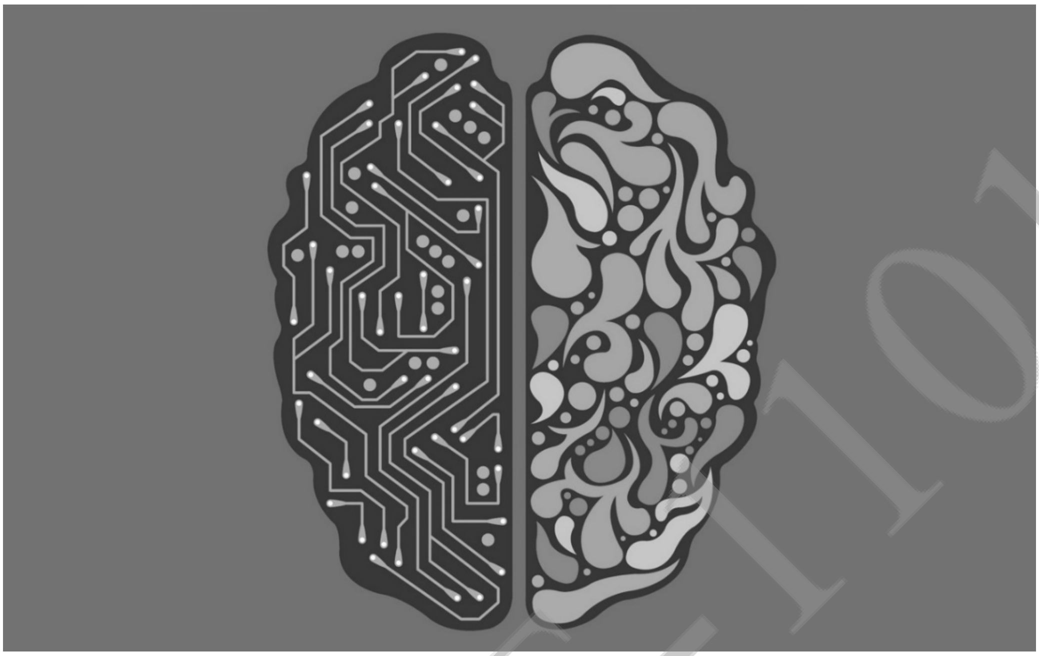
AMSCE-1101

Executive summary



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This report deals with the ethical implications and moral questions that arise from the development and implementation of artificial intelligence (AI) technologies. It also reviews the guidelines and frameworks that countries and regions around the world have created to address them. It presents a comparison between the current main frameworks and the main ethical issues, and highlights gaps around mechanisms of fair benefit sharing; assigning of responsibility; exploitation of workers; energy demands in the context of environmental and climate changes; and more complex and less certain implications of AI, such as those regarding human relationships.

Chapter 1 introduces the scope of the report and defines key terms. The report draws on the European Commission's definition of AI as 'systems that display intelligent behaviour'. Other key terms defined in this chapter include intelligence and how this is used in the context of AI and intelligent robots (i.e. robots with an embedded AI), as well as defining machine learning, artificial neural networks and deep learning, before moving on to consider definitions of morality and ethics and how these relate to AI.

In Chapter 2 the report **maps the main ethical dilemmas and moral questions associated with the deployment of AI**. The report begins by outlining a number of potential benefits that could arise from AI as a context in which to situate ethical, social and legal considerations. Within the context of issues for society, the report considers the potential impacts of AI on the labour market, focusing on the likely impact on economic growth and productivity, the impact on the workforce, potential impacts on different demographics, including a worsening of the digital divide, and the consequences of deployment of AI on the workplace. The report considers the potential impact of AI on inequality and how the benefits of AI could be shared within society, as well as issues concerning the concentration of AI technology within large internet companies and political stability. Other societal issues addressed in this chapter include privacy, human rights and dignity, bias, and issues for democracy.

AMSCE-1101

Chapter 2 moves on to consider the impact of AI on human psychology, raising questions about the impact of AI on relationships, as in the case of intelligent robots taking on human social roles, such as nursing. Human-robot relationships may also affect human-human relationships in as yet unanticipated ways. This section also considers the question of personhood, and whether AI systems should have moral agency.

Impacts on the financial system are already being felt, with AI responsible for high trading volumes of equities. The report argues that, although markets are suited to automation, there are risks including the use of AI for intentional market manipulation and collusion.

AI technology also poses questions for both civil and criminal law, particularly whether existing legal frameworks apply to decisions taken by AIs. Pressing legal issues include liability for tortious, criminal and contractual misconduct involving AI. While it may seem unlikely that AIs will be deemed to have sufficient autonomy and moral sense to be held liable themselves, they do raise questions about who is liable for which crime (or indeed if human agents can avoid liability by claiming they did not know the AI could or would do such a thing). In addition to challenging questions around liability, AI could abet criminal activities, such as smuggling (e.g. by using unmanned vehicles), as well as harassment, torture, sexual offences, theft and fraud. Self-driving autonomous cars are likely to raise issues in relation to product liability that could lead to more complex cases (currently insurers typically avoid lawsuits by determining which driver is at fault, unless a car defect is involved).

Large-scale deployment of AI could also have both positive and negative impacts on the environment. Negative impacts include increased use of natural resources, such as rare earth metals, pollution and waste, as well as energy consumption. However, AI could help with waste management and conservation offering environmental benefits.

The potential impacts of AI are far-reaching, but they also require trust from society. AI will need to be introduced in ways that build trust and understanding, and respect human and civil rights. This requires transparency, accountability, fairness and regulation.

Chapter 3 explores **ethical initiatives in the field of AI**. The chapter first outlines the ethical initiatives identified for this report, summarising their focus and where possible identifying funding sources. The harms and concerns tackled by these initiatives is then discussed in detail. The issues raised can be broadly aligned with issues identified in Chapter 2 and can be split into questions around: human rights and well-being; emotional harm; accountability and responsibility; security, privacy, accessibility and transparency; safety and trust; social harm and social justice; lawfulness and justice; control and the ethical use (or misuse) of AI; environmental harm and sustainability; informed use; existential risk.

All initiatives focus on human rights and well-being, arguing that AI must not affect basic and fundamental human rights. The IEEE initiative further recommends governance frameworks, standards and regulatory bodies to oversee use of AI and ensure that human well-being is prioritised throughout the design phase. The Montreal Protocol argues that AI should encourage and support the growth and flourishing of human well-being.

Another prominent issue identified in these initiatives is concern about the impact of AI on the human emotional experience, including the ways in which AIs address cultural sensitivities (or fail to do so). Emotional harm is considered a particular risk in the case of intelligent robots with whom humans might form an intimate relationship. Emotional harm may also arise should AI be designed to emotionally manipulate users (though it is also recognised that such nudging can also have

AMSCE-IUJ

positive impacts, e.g. on healthy eating). Several initiatives recognise that nudging requires particular ethical consideration.

The need for accountability is recognised by initiatives, the majority of which focus on the need for AI to be auditable as a means of ensuring that manufacturers, designers and owners/operators of AI can be held responsible for harm caused. This also raises the question of autonomy and what that means in the context of AI.

Within the initiatives there is a recognition that new standards are required that would detail measurable and testable levels of transparency so that systems can be objectively assessed for compliance. Particularly in situations where AI replaces human decision-making initiatives, we argue that AI must be safe, trustworthy, reliable and act with integrity. The IEEE focus on the need for researchers to operate with a 'safety mindset' to pre-empt unintended or unanticipated behaviours.

With regard to societal harms, the IEEE suggests that social and moral norms should be considered in design, while the Japanese Society for AI, suggests that AI should be designed with social responsibility in mind. Several initiatives focus on the need to consider social inclusion and diversity, and the risk that AI could widen gaps between developed and developing economies. There is concern that AI-related degree programmes fail to equip designers with appropriate knowledge of ethics.

Legal issues are also addressed in the initiatives, with the IEEE arguing that AI should not be granted the status of 'personhood' and that existing laws should be scrutinised to ensure that they do not practically give AI legal autonomy.

Concerns around environmental harms are evident across initiatives, including concerns about resource use but also acknowledgement that AI could play a role in conservation and sustainable stewardship. The UNI Global Union states that AI should put people and plants first, striving to protect and enhance biodiversity and ecosystems.

Throughout the initiatives, there is a recognition of the need for greater public engagement and education with regard to the potential harms of AI. The initiatives suggest a range of ways in which this could be achieved, as a way of raising a number of topics that should be addressed through such initiatives.

Autonomous weapons systems attract particular attention from initiatives, given their potential to seriously harm society.

Case studies in Chapter 3 cover the particular risks associated with healthcare robots, which may be involved in diagnosis, surgery and monitoring health and well-being as well as providing caring services. The first case study highlights particular risks associated with embodied AI, which have moving parts that can cause injury. Healthcare AI applications also have implications for training of healthcare professionals and present data protection, legal and equality challenges. The case study raises a number of ethical concerns in relation to the deployment of robots for the care of the elderly in particular. The use of AI in healthcare also raises questions about trust, for example, how trust in professionals might change if they are seen as 'users' of technology.

A second case study explores ethical issues associated with the development of autonomous vehicles (AVs). In the context of driving, six levels of automation are recognised by SAE International: no automation, hands on (e.g. Cruise Control), hands off (driver still monitors driving), eyes off (driver can turn attention elsewhere, but must be prepared to intervene), minds off (no driver attention required) and steering wheel optional (human intervention is not required). Public safety is a key

AMSCE-TIOL

concern regarding the deployment of autonomous vehicles, particularly following high-profile deaths associated with the use such vehicles. Liability is also a key concern with this emerging technology and the lack of standards, processes and regulatory frameworks for accident investigation hampers efforts to investigate accidents. Furthermore, with the exception of the US state of California, manufacturers are not required to log near misses.

Manufacturers of autonomous vehicles also collect significant amounts of data from AVs, which raises questions about the privacy and data protection rights of drivers and passengers. AVs could change urban environments, with, for example, additional infrastructure needed (AV-only lanes), but also affecting traffic congestion and requiring the extension of 5G network coverage.

A final case study explores the use of AI in warfare and the potential for AI applications to be used as weapons. AI is already used in military contexts. However, there are particular aspects of developing AI technologies that warrant consideration. These include: lethal autonomous weapons; drone technologies; robotic assassination and mobile-robotic-improvised explosive devices.

Key ethical issues arising from greater military use of AI include questions about the involvement of human judgement (if human judgement is removed, could this violate International Humanitarian Law). Would increasing use of AI reduce the threshold for going to war (affecting global stability)?

Chapter 4 discusses emerging **AI ethics standards and regulations**. There are a number of emerging standards that address emerging ethical, legal and social impacts of robotics and AI. Perhaps the earliest of these is the BS 8611 Guide to the Ethical Design and Application of Robots and Robotic Systems. It is based on a set of 20 distinct ethical hazards and risks, grouped under four categories: societal, application, commercial & financial, and environmental. The standard recognises physical hazards as implying ethical hazards and recognises that both physical and emotional hazards should be balanced against expected benefits to the user.

National and International policy initiatives are addressed in Chapter 5: **National and International Strategies on AI**. Canada launched the first national strategy on AI in March 2017, followed soon after by Japan, with many initiatives published since (see Figure 5. 1), including national strategies for Denmark, Finland, France, Germany, Sweden and the UK. The EU Strategy was the first international initiative on AI and supports the strategies of individual Member States. Strategies vary however in the extent to which they address ethical issues. At the European level, public concerns feature prominently in AI initiatives. Other international AI initiatives that cover ethical principles include: G7 Common Vision for the Future of AI, Nordic-Baltic Region Declaration on AI, OECD Principles on AI and the World Economic Form's Global AI Council. The United Nations has several initiatives relating to AI, including the AI for Good Global Summit; UNICRI Centre for AI and Robotics; UNESCO Report on Robotics Ethics.

Finally, Chapter 6 draws together the **themes emerging** from the literature, ethical initiatives and national and international strategies in relation to AI, highlighting gaps. It questions whether the two current international frameworks (EU High Level Expert Group, 2018[2] and OECD principles for AI, 2019) for the governance of AI are sufficient to meet the challenges it poses. The analysis highlights gaps in relation to environmental concerns; human psychology; workforce, particularly in relation to inequality and bias; democracy and finance.

AMSCE-IOI

Table of contents

AMSCE-1101

AMSCE-1101

Table of figures

Table of tables

AMSCE-1101

AMSCE-1101

1. Introduction

Rapid developments in artificial intelligence (AI) and machine learning carry huge potential benefits. However it is necessary to explore the full ethical, social and legal aspects of AI systems if we are to avoid unintended, negative consequences and risks arising from the implementation of AI in society.

This chapter introduces AI broadly, including current uses and definitions of intelligence. It also defines robots and their position within the broader AI field.

1.1. What is AI – and what is intelligence?

The European Commission's Communication on Artificial Intelligence (European Commission, 2018a) defines artificial intelligence as follows:

> *'Artificial Intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals.*
>
> *AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications).'*

Within this report, we consider both software-based AI and intelligent robots (i.e. robots with an embedded AI) when exploring ethical issues. Intelligent robots are therefore a subset of AI (whether or not they make use of machine learning).

How do we define intelligence? A straightforward definition is that intelligent behaviour is 'doing the right thing at the right time'. Legg and Hunt (2007) survey a wide range of informal definitions of intelligence, identifying three common features: that intelligence is (1) 'a property that an individual agent has as it interacts with its environment or environments', (2) 'related to the agent's ability to succeed or profit with respect to some goal or objective', and (3) 'depends on how able that agent is to adapt to different objectives and environments'. They point out that intelligence involves adaptation, learning and understanding. At its simplest, then, intelligence is 'the ability to acquire and apply knowledge and skills and to manipulate one's environment'.

In interpreting these definitions of intelligence, we need to understand that for a physical **robot** its environment is the real world, which can be a human environment (for social robots), a city street (for an autonomous vehicle), a care home or hospital (for a care or assisted living robot), or a workplace (for a workmate robot). The 'environment' of a software AI is its context, which might be clinical (for a medical diagnosis AI), or a public space – for face recognition in airports, for instance, or virtual for face recognition in social media. But, like physical robots, software AIs almost always interact with humans, whether via question and answer interfaces: via text for chatbots, or via speech for digital assistants on mobile phones (i.e. Siri) or in the home (i.e. Alexa).

It is this interaction with humans that gives rise to almost all of the ethical issues surveyed in this report.

All present-day AIs and robots are examples of what we refer to as **'narrow' AI**: a term that reflects that fact that current AIs and robots are typically only capable of undertaking one specialised task. A long-term goal of AI and robotics research is so-called **artificial general intelligence (AGI)** which

AMSCE-101

would be comparable to human intelligence.[1] It is important to understand that present-day narrow AI is often better than most humans at one particular task; examples are chess- or Go-playing AIs, search engines or natural language translation systems. But a general-purpose care robot capable of, for instance, preparing meals for an elderly person (and washing the dishes afterwards), helping them dress or undress, get into and out of bed or the bath etc., remains a distant research goal.

Machine learning is the term used for AIs which are capable of learning or, in the case of robots, adapting to their environment. There are a broad range of approaches to machine learning, but these typically fall into two categories: supervised and unsupervised learning. Supervised learning systems generally make use of **Artificial Neural Networks (ANNs)**, which are trained by presenting the ANN with inputs (for instance, images of animals) each of which is tagged (by humans) with an output (i.e. giraffe, lion, gorilla). This set of inputs and matched outputs is called a training data set. After training, an ANN should be able to identify which animal is in an image it is presented with (i.e. a lion), even though that particular image with a lion wasn't present in the training data set. In contrast, unsupervised learning has no training data; instead, the AI (or robot) must figure out on its own how to solve a particular task (i.e. how to navigate successfully out of a maze), generally by trial and error.

Both supervised and unsupervised learning have their limitations. With supervised learning, the training data set must be truly representative of the task required; if not, the AI will exhibit bias. Another limitation is that ANNs learn by picking out features of the images in the training data unanticipated by the human designers. So, for instance, they might wrongly identify a car against a snowy background as a wolf, because all examples of wolves in the images of the training data set had snowy backgrounds, and the ANN has learned to identify snowy backgrounds as wolves, rather than the wolf itself. Unsupervised learning is generally more robust than supervised learning but suffers the limitation that it is generally very slow (compared with humans who can often learn from as few as one trial).

The term **deep learning** simply refers to (typically) supervised machine learning systems with large (i.e. many-layered) ANNs and large training data sets.

It is important to note the terms AI and machine learning are not synonymous. Many highly capable AIs and robots do not make use of machine learning.

1.2. Definition of morality and ethics, and how that relates to AI

Ethics are moral principles that govern a person's behaviour or the conduct of an activity. As a practical example, one ethical principle is *to treat everyone with respect*. Philosophers have debated ethics for many centuries, and there are various well-known principles, perhaps one of the most famous being Kant's categorical imperative 'act as you would want all other people to act towards all other people'.[2]

AI ethics is concerned with the important question of how human developers, manufacturers and operators should behave in order to minimise the ethical harms that can arise from AI in society, either arising from poor (unethical) design, inappropriate application or misuse. The scope of AI ethics spans immediate, here-and-now concerns about, for instance, data privacy and bias in current AI systems; near- and medium-term concerns about, for instance, the impact of AI and robotics on

AMSCE-1101

[1] AGI could be defined as technologies that are explicitly developed as systems that can learn incrementally, reason abstractly and act effectively over a wide range of domains — just like humans can.

[2] From Kant's 1785 book *Groundwork of the Metaphysics of Morals*, with a variety of translations from the original German.

jobs and the workplace; and longer-term concerns about the possibility of AI systems reaching or exceeding human-equivalent capabilities (so-called superintelligence).

Within the last 5 years AI ethics has shifted from an academic concern to a matter for political as well as public debate. The increasing ubiquity of smart phones and the AI-driven applications that many of us now rely on every day, the fact that AI is increasingly impacting all sectors (including industry, healthcare, policing & the judiciary, transport, finance and leisure), as well as the seeming prospect of an AI 'arms race', has prompted an extraordinary number of national and international initiatives, from NGOs, academic and industrial groupings, professional bodies and governments. These initiatives have led to the publication of a large number of sets of ethical principles for robotics and AI (at least 22 different sets of ethical principles have been published since January 2017), new ethical standards are emerging (notably from the British Standards Institute and the IEEE Standards Association), and a growing number of countries (and groups of countries) have announced AI strategies (with large-scale investments) and set up national advisory or policy bodies.

In this report we survey these initiatives in order to draw out the main ethical issues in AI and robotics.

1.3. Report structure

Robots and artificial intelligence (AI) come in various forms, as outlined above, each of which raises a different **range of ethical concerns**. These are outlined in Chapter 2: Mapping the main ethical dilemmas and moral questions associated with the deployment of AI. This chapter explores in particular:

Social impacts: this section considers the potential impact of AI on the labour market and economy and how different demographic groups might be affected. It addresses questions of inequality and the risk that AI will further concentrate power and wealth in the hands of the few. Issues related to privacy, human rights and dignity are addressed as are risks that AI will perpetuate the biases, intended or otherwise, of existing social systems or their creators. This section also raises questions about the impact of AI technologies on democracy, suggesting that these technologies may operate for the benefit of state-controlled economies.

Psychological impacts: what impacts might arise from human-robot relationships? How might we address dependency and deception? Should we consider whether robots deserve to be given the status of 'personhood' and what are the legal and moral implications of doing so?

Financial system impacts: potential impacts of AI on financial systems are considered, including risks of manipulation and collusion and the need to build in accountability.

Legal system impacts: there are a number of ways in which AI could affect the legal system, including: questions relating to crime, such as liability if an AI is used for criminal activities, and the extent to which AI might support criminal activities such as drug trafficking. In situations where an AI is involved in personal injury, such as in a collision involving an autonomous vehicle, then questions arise around the legal approach to claims (whether it is a case of negligence, which is usually the basis for claims involving vehicular accidents, or product liability).

Environmental impacts: increasing use of AIs comes with increased use of natural resources, increased energy demands and waste disposal issues. However, AIs could improve the way we manage waste and resources, leading to environmental benefits.

Impacts on trust: society relies on trust. For AI to take on tasks, such as surgery, the public will need to trust the technology. Trust includes aspects such as fairness (that AI will be impartial), transparency (that we will be able to understand how an AI arrived at a particular decision),

AMSCE-110

accountability (someone can be held accountable for mistakes made by AI) and control (how we might 'shut down' an AI that becomes too powerful).

In Chapter 3, **Ethical initiatives in the field of artificial intelligence**, the report reviews a wide range of ethical initiatives that have sprung up in response to the ethical concerns and issues emerging in relation to AI. **Section 3.1** discusses the issues each initiative is exploring and identifies reports available (as of May 2019).

Ethical harms and concerns tackled by the initiatives outlined above, are discussed in Section 3.2. These are broadly split into 12 categories: human rights and well-being; emotional harm; accountability and responsibility; security, privacy, accessibility, and transparency; safety and trust; social harm and social justice; financial harm; lawfulness and justice; control and the ethical use (or misuse) of AI; environmental harm and sustainability; informed use and existential risks. The chapter explores each of these topics and the ways in which they are being addressed by the initiatives.

Chapter 4 presents the current status of **AI Ethical standards and regulation**. At present only one standard (British Standard BS8611, *Guide to the ethical design of robots and robotic systems*) specifically addresses AI. However, the IEEE is developing a number of standards that affect AI in a range of contexts. While these are in development, they are presented here as an indication of where standards and regulation is progressing.

Finally, Chapter 5 explores **National and international strategies on AI**. The chapter considers what is required for a trustworthy AI and visions for the future of AI as they are articulated in national and international strategies.

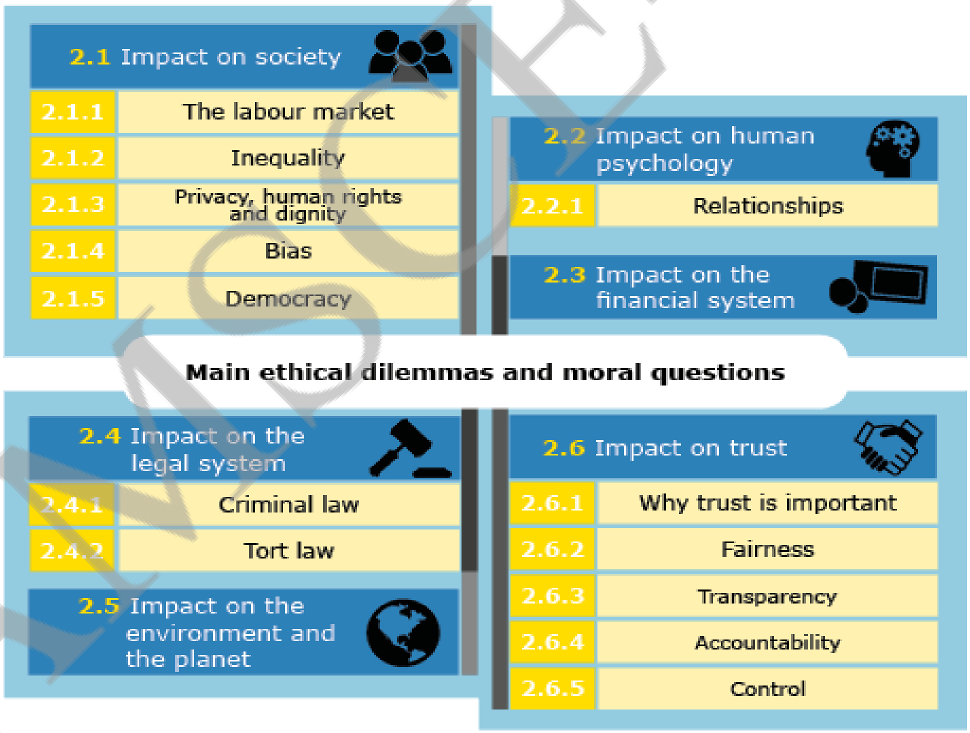
AMSCE-INOI

2. Mapping the main ethical dilemmas and moral questions associated with the deployment of AI

According to the Future of Life Institute (n.d.), AI 'holds great economic, social, medical, security, and environmental promise', with potential benefits including:

- Helping people to acquire new skills and training;
- Democratising services;
- Designing and delivering faster production times and quicker iteration cycles;
- Reducing energy usage;
- Providing real-time environmental monitoring for air pollution and quality;
- Enhancing cybersecurity defences;
- Boosting national output;
- Reducing healthcare inefficiencies;
- Creating new kinds of enjoyable experiences and interactions for people; and
- Improving real-time translation services to connect people across the globe.

Figure 1: Main ethical and moral issues associated with the development and implementation of AI


2.1 Impact on society
2.1.1 The labour market
2.1.2 Inequality
2.1.3 Privacy, human rights and dignity
2.1.4 Bias
2.1.5 Democracy
2.2 Impact on human psychology
2.2.1 Relationships
2.3 Impact on the financial system
Main ethical dilemmas and moral questions
2.4 Impact on the legal system
2.4.1 Criminal law
2.4.2 Tort law
2.5 Impact on the environment and the planet
2.6 Impact on trust
2.6.1 Why trust is important
2.6.2 Fairness
2.6.3 Transparency
2.6.4 Accountability
2.6.5 Control

In the long term, AI may lead to 'breakthroughs' in numerous fields, says the Institute, from basic and applied science to medicine and advanced systems. However, as well as great promise, increasingly capable intelligent systems create significant ethical challenges (Winfield, 2019a). This section of the report summarises the main ethical, social and legal considerations in the deployment

AMSCE-1101

of AI, drawing insights from relevant academic literature. The issues discussed deal with impacts on: human society; human psychology; the financial system; the legal system; the environment and the planet; and impacts on trust.

2.1. Impact on society

2.1.1. The labour market

People have been concerned about the displacement of workers by technology for centuries. Automation, and then mechanisation, computing, and more recently AI and robotics have been predicted to destroy jobs and create irreversible damage to the labour market. Leontief (1983), observing the dramatic improvements in the processing power of computer chips, worried that people would be replaced by machines, just as horses were made obsolete by the invention of internal combustion engines. In the past, however, automation has often substituted for human labour in the short term, but has led to the creation of jobs in the long term (Autor, 2015).

Nevertheless, there is widespread concern that artificial intelligence and associated technologies could create mass unemployment during the next two decades. One recent paper concluded that new information technologies will put 'a substantial share of employment, across a wide range of occupations, at risk in the near future' (Frey and Osborne, 2013).

AI is already widespread in finance, space exploration, advanced manufacturing, transportation, energy development and healthcare. Unmanned vehicles and autonomous drones are also performing functions that previously required human intervention. We have already seen the impact of automation on 'blue-collar' jobs; however, as computers become more sophisticated, creative, and versatile, more jobs will be affected by technology and more positions made obsolete.

Impact on economic growth and productivity

Economists are generally enthusiastic about the prospects of AI on economic growth. Robotics added an estimated 0.4 percentage points of annual GDP growth and labour productivity for 17 countries between 1993 and 2007, which is of a similar magnitude to the impact of the introduction of steam engines on growth in the United Kingdom (Graetz and Michaels, 2015).

Impact on the workforce

It is hard to quantify the effect that robots, AI and sensors will have on the workforce because we are in the early stages of the technology revolution. Economists also disagree on the relative impact of AI and robotics. One study asked 1,896 experts about the impact of emerging technologies; 48 percent believed that robots and digital agents would displace significant numbers of both 'blue' and 'white' collar workers, with many expressing concern that this would lead to vast increases in income inequality, large numbers of unemployable people, and breakdowns in the social order (Smith and Anderson, 2014). However, the other half of the experts who responded to this survey (52%) expected that technology would *not* displace more jobs than it created by 2025. Those experts believed that although many jobs currently performed by humans will be substantially taken over by robots or digital agents, they have faith that human ingenuity will create new jobs, industries, and ways to make a living.

Some argue that technology is already producing major changes in the workforce:

> *'Technological progress is going to leave behind some people, perhaps even a lot of people, as it races ahead… there's never been a better time to be a worker with special skills or the right education because these people can use technology to create and capture value. However, there's never been a worse time to be a worker with only 'ordinary' skills and abilities to offer, because computers, robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rate' (Brynjolfsson and McAfee, 2014).*

AMSCE-IOI

Ford (2009) issues an equally strong warning, and argues that:

> *'as technology accelerates, machine automation may ultimately penetrate the economy to the extent that wages no longer provide the bulk of consumers with adequate discretionary income and confidence in the future. If this issue is not addressed, the result will be a downward economic spiral'. He warns that 'at some point in the future — it might be many years or decades from now — machines will be able to do the jobs of a large percentage of the 'average' people in our population, and these people will not be able to find new jobs'.*

However, some economists dispute these claims, saying that although many jobs will be lost through technological improvements, new ones will be created. According to these individuals, the job gains and losses will even out over the long run.

> *'There may be fewer people sorting items in a warehouse because machines can do that better than humans. But jobs analysing big data, mining information, and managing data sharing networks will be created' (West, 2018).*

If AI led to economic growth, it could create demand for jobs throughout the economy, including in ways that are not directly linked to technology. For example, the share of workers in leisure and hospitality sectors could increase if household incomes rose, enabling people to afford more meals out and travel (Furman and Seamans, 2018).

Regardless, it is clear that a range of sectors will be affected. Frey and Osborne (2013) calculate that there is a high probability that 47 percent of U.S. workers will see their jobs become automated over the next 20 years. According to their analysis, telemarketers, title examiners, hand sewers, mathematical technicians, insurance underwriters, watch repairers, cargo agents, tax preparers, photographic process workers, new accounts clerks, library technicians, and data-entry specialists have a 99 percent chance of having their jobs computerised. At the other end of the spectrum, recreational therapists, mechanic supervisors, emergency management directors, mental health social workers, audiologists, occupational therapists, health care social workers, oral surgeons, firefighter supervisors and dieticians have less than a one percent chance of this.

In a further study, the team surveyed 156 academic and industry experts in machine learning, robotics and intelligent systems, and asked them what tasks they believed could currently be automated (Duckworth et al., 2019). They found that work that is clerical, repetitive, precise, and perceptual can increasingly be automated, while work that is more creative, dynamic, and human oriented tends to be less 'automatable'.

Worryingly, eight times as much work fell between 'mostly' and 'completely' automatable than between 'mostly not' and 'not at all' automatable, when weighted by employment. Activities classified as 'reasoning and decision making' and 'coordinating, developing, managing, and advising' were less likely than others to be automatable, while 'administering', 'information and data processing' and 'performing complex and technical activities' were likely to be more so.

Overall the model predicted very high automation potential for office, administrative support, and sales occupations, which together employ about 38 million people in the U.S. Also at high risk of automation were physical processes such as production, farming, fishing and forestry, and transportation and material moving, which employ about 20 million people in total. In contrast, occupations that were robust to automation included education, legal, community service, arts, and media occupations, and to a lesser extent, management, business, and financial occupations.

Unsurprisingly, the study found that occupations with the highest salaries and levels of education tend to be the least amenable to automation. However, even this does not guarantee that an occupation's activities cannot be automated. As the authors point out, air traffic controllers earn about US$125,000 a year, but it is thought that their tasks could largely be automated. In contrast, preschool teachers and teaching assistants earn under $30,000 a year, yet their roles are not thought to be amenable to automation.

Labour-market discrimination: effects on different demographics

The impacts of these sizeable changes will not be felt equally by all members of society. Different demographics will be affected to varying extents, and some are more at risk than others from emerging technologies. Those with few technical skills or specialty trades will face the most difficulties (UK Commission for Employment and Skills, 2014). Young people entering the labour market will also be disproportionately affected, since they are at the beginning of their careers and they will be the first generation to work alongside AI (Biavaschi et al., 2013). Even though many young people have time to acquire relevant expertise, few gain training in science, technology, engineering, and math (STEM) fields, limiting their ability to withstand employment alterations. According to the U.S. Department of Education (2014), there will be a 14 percent increase in STEM jobs between 2010 and 2020 — but 'only 16 percent of American high school seniors are proficient in mathematics and interested in a STEM career'.

Women may also be disproportionately affected, as more women work in caregiving positions — one of the sectors likely to be affected by robots. Due to discrimination, prejudice and lack of training, minorities and poor people already suffer high levels of unemployment: without high-skill training, it will be more difficult for them to adapt to a new economy. Many of these individuals also lack access to high-speed Internet, which limits their ability to access education, training and employment (Robinson et al., 2015).

Special Eurobarometer survey 460 identified that EU residents have a largely positive response to the increasing use of digital technology, considering it to improve society, the economy, and their quality of life, and that most also consider themselves competent enough to make use of this technology in various aspects of their life and work (European Commission, 2017). However, crucially, this attitude varied by age, location, and educational background — a finding that is central to the issue of how AI will affect different demographics and the potential issues arising around the 'digital divide'.

For instance, young men with high levels of education are the most likely to hold positive views about digitisation and the use of robots — and are also the most likely to have taken some form of protective measure relating to their online privacy and security (thus placing them at lower risk in this area). These kinds of socio-demographic patterns highlight a key area of concern in the increasing development and implementation of AI if nobody is to be disadvantaged or left behind (European Commission, 2017).

Consequences

'When we're talking about 'AI for good', we need to define what 'good' means. Currently, the key performance indicators we look to are framed around GDP. Not to say it's evil, but it's about measuring productivity and exponential profits'. (John Havens)

It is possible that AI and robotic technologies could exacerbate existing social and economic divisions, via putting current job classes at risk, eliminating jobs, causing mass unemployment in automatable job sectors. Discrimination may also be an issue, with young people potentially being disproportionately affected, alongside those without high-skill training.

2.1.2. Inequality

'The biggest question around AI is inequality, which isn't normally included in the debate about AI ethics. It is an ethical issue, but it's mostly an issue of politics – who benefits from AI?' (Jack Stilgoe)

AMSCE-IOI

AI and robotics technology are expected to allow companies to streamline their businesses, making them more efficient and more productive. However, some argue that this will come at the expense of their human workforces. This will inevitably mean that revenues will be split across fewer people, increasing social inequalities. Consequently, individuals who hold ownership in AI-driven companies are set to benefit disproportionately.

Inequality: exploitation of workers

Changes in employment related to automation and digitisation will not be expressed solely via job *losses*, as AI is expected to create many numerous and new forms of employment (Hawksworth and Fertig, 2018), but also in terms of job *quality*. Winfield (2019b) states that new jobs may require highly skilled workers but be repetitive and dull, creating 'white-collar sweatshops' filled with workers performing tasks such as tagging and moderating content – in this way, AI could bring an additional human cost that must be considered when characterising the benefits of AI to society.

Building AI most often requires people to manage and clean up data to instruct the training algorithms. Better (and safer) AI needs huge training data sets and a whole new outsourced industry has sprung up all over the world to meet this need. This has created several new categories of job.

These include: (i) scanning and identifying offensive content for deletion, (ii) manually tagging objects in images in order to create training data sets for machine learning systems (for example, to generate training data sets for driverless car AIs) and (iii) interpreting queries (text or speech) that an AI chatbot cannot understand. Collectively these jobs are sometimes known by the term 'mechanical turk' (so named after the 18th century chess playing automaton that was revealed to be operated by a human chess master hidden inside the cabinet).

When first launched such tasks were offered as a way for people to earn extra money in their spare time, however Gray and Suri (2019) suggest that 20 million individuals are now employed worldwide, via third party contractors, in an on-demand 'gig economy', working outside the protection of labour laws. The jobs are usually scheduled, routed, delivered and paid for online, through application programming interfaces (APIs). There have been a few journalistic investigations into the workers in this field of work[3] – termed 'ghost work' by Harvard researcher Mary L. Gray because of the 'hidden' nature of the value chain providing the processing power on which AI is based (Gray, 2019).

The average consumer of AI technology may never know that a person was part of the process – the value chain is opaque. One of the key ethical issues is that – given the price of the end-products – these temporary workers are being inequitably reimbursed for work that is essential to the functioning of the AI technologies. This may be especially the case where the labour force reside in countries outside the EU or US – there are growing 'data-labelling' industries in both China and Kenya, for example. Another issue is with the workers required to watch and vet offensive content for media platforms such as Facebook and YouTube (Roberts, 2016). Such content can include hate speech, violent pornography, cruelty and sometimes murder of both animals and humans. A news report (Chen, 2017) outlines mental health issues (PTSD-like trauma symptoms, panic attacks and burnout), alongside poor working conditions and ineffective counselling.

This hidden army of piecemeal workers are undertaking work that is at best extremely tedious and poorly paid, at worst, precarious, unhealthy and/or psychologically harmful. Gray's research makes the case that workers in this field still display the desire to invest in work as something more than a single payment transaction, and advises that the economic, social and psychological impacts of 'ghost work' should be dealt with systematically. Making the worker's inputs more transparent in the end-product, ensuring the value chain improves the equitable distribution of benefits, and

AMSCE-101

[3] The Verge: https://www.theverge.com/2019/5/13/18563284/mary-gray-ghost-work-microwork-labor-silicon-valley-automation-employment-interview;

ensuring appropriate support structures for those humans-in-the-loop who deal with psychologically harmful content are all important steps to address the ethical issues.

Sharing the benefits

AI has the potential to bring significant and diverse benefits to society (Conn, 2018; UK Government Office for Science, 2015; The Future of Life Institute, n.d.; The White House, 2016) and facilitate, among other things, greater efficiency and productivity at lower cost (OECD, n.d.). The Future of Life Institute (n.d.) states that AI may be capable of tackling a number of the most difficult global issues – poverty, disease, conflict – and thus improve countless lives.

A US report on AI, automation, and the economy (2016) highlights the importance of ensuring that potential benefits of AI do not accumulate unequally, and are made accessible to as many people as possible. Rather than framing the development of AI and automation as leading to an inevitable outcome determined by the technology itself, the report states that innovation and technological change 'does not happen in a vacuum': the future of AI may be shaped not by technological capability, but by a wide range of non-technical incentives (The White House, 2016). Furthermore, the inventor or developer of an AI has great potential to determine its use and reach (Conn, 2018), suggesting a need for inventors to consider the wider potential impacts of their creations.

Automation is more applicable to certain roles than others (Duckworth et al., 2018), placing certain workers at a disadvantage and potentially increasing wage inequality (Acemoglu and Restrepo, 2018). Businesses may be motivated by profitability (Min, 2018) – but, while this may benefit business owner(s) and stakeholders, it may not benefit workers.

Brundage and Bryson (2016) mention the case study of electricity, which they say is sometimes considered analogous to AI. While electricity can make many areas more productive, remove barriers, and bring benefits and opportunity to countless lives, it has taken many decades for electricity to reach some markets, and 'indeed, over a billion [people] still lack access to it'.

To ensure that AI's benefits are distributed fairly – and to avoid a whoever designs it first, wins dynamic – one option may be to pre-emptively declare that AI is not a private good but instead for the benefit of all, suggests Conn (2018). Such an approach would require a change in cultural norms and policy. New national and governmental guidelines could underpin new strategies to harness the beneficial powers of AI for citizens, help navigate the AI-driven economic transition, and retain and strengthen public trust in AI (Min, 2018). Brundage and Bryson (2016) agree with this call for policy and regulation, stating that 'it is not sufficient to fund basic research and expect it to be widely and equitably diffused in society by private actors'. However, such future scenarios are not predetermined, says Servoz (2019), and will be shaped by present-day policies and choices.

The Future of Life Institute (n.d.) lists a number of policy recommendations to tackle the possible 'economic impacts, labour shifts, inequality, technological unemployment', and social and political tensions that may accompany AI. AI-driven job losses will require new retraining programmes and social and financial support for displaced workers; such issues may require economic policies such as universal basic income and robot taxation schemes. The Institute suggests that policies should focus on those most at risk of being left behind – caregivers, women and girls, underrepresented populations and the vulnerable – and on those building AI systems, to target any 'skewed product design, blind spots, false assumptions [and] value systems and goals encoded into machines' (The Future of Life Institute, n.d.).

According to Brundage and Bryson (2016), taking a proactive approach to AI policies is not 'premature, misguided [or] dangerous', given that AI 'is already sufficiently mature technologically to impact billions of lives trillions of times a day'. They suggest that governments seek to improve

AMSCE-IOI

their related knowledge and rely more on experts; that relevant research is allocated more funding; that policymakers plan for the future, seeking 'robustness and preparedness in the face of uncertainty'; and that AI is widely applied and proactively made accessible (especially in areas of great social value, such as poverty, illness, or clean energy).

Considering the energy industry as an example, AI may be able to modernise the energy grid, improve its reliability, and prevent blackouts by regulating supply and demand at both local and national levels, says Wolfe (2017). Such a 'smart grid' would save energy companies money but also allow consumers to actively monitor their own energy use in real-time and see cost savings, passing the benefits from developer to producer to consumer – and opening up new ways to save, earn, and interact with the energy grid (Gagan, 2018; Jacobs, 2017). Jacobs (2017) discusses the potential for 'prosumers' (those who both produce and consume energy, interacting with the grid in a new way) to help decentralise energy production and be a 'positive disruptive force' in the electricity industry – if energy strategy is regulated effectively via updated policy and management. Giving consumers real-time, accessible data would also help them to select the most cost-efficient tariff for them, say Ramchurn et al. (2013), given that accurately estimating one's yearly consumption and deciphering complex tariffs is a key challenge facing energy consumers. This may therefore have some potential to alleviate energy poverty, given that energy price increases and dependence on a centralised energy supply grid can leave households in fuel poverty (Ramchurn et al., 2013).

Concentration of power among elites

> *'Does AI have to increase inequality? Could you design systems that target, for example, the needs of the poorest people? If AI was being used to further benefit rich people more than it benefits poor people, which it looks likely to be, or more troublingly, put undue pressure on already particularly marginalised people, then what might we do about that? Is that an appropriate use of AI?' (Jack Stilgoe)*

Nemitz (2018) writes that it would be 'naive' to ignore that AI will concentrate power in the hands of a few digital internet giants, as 'the reality of how [most societies] use the Internet and what the Internet delivers to them is shaped by a few mega corporations…the development of AI is dominated exactly by these mega corporations and their dependent ecosystems'.

The accumulation of technological, economic and political power in the hands of the top five players – Google, Facebook, Microsoft, Apple and Amazon – affords them undue influence in areas of society relevant to opinion-building in democracies: governments, legislators, civil society, political parties, schools and education, journalism and journalism education and — most importantly — science and research.

In particular, Nemitz is concerned that investigations into the impact of new technologies like AI on human rights, democracy and the rule of law may be hampered by the power of tech corporations, who are not only shaping the development and deployment of AI, but also the debate on its regulation. Nemitz identifies several areas in which tech giants exert power:

1. **Financial**. Not only can the top five players afford to invest heavily in political and societal influence, they can also afford to buy new ideas and start-ups in the area of AI, or indeed any other area of interest to their business model — something they are indeed doing.
2. **Public discourse.** Tech corporations control the infrastructures through which public discourse takes place. Sites like Facebook and Google increasingly become the main, or even only, source of political information for citizens, especially the younger generation, to the detriment of the fourth estate. The vast majority of advertising revenue now also goes to Google and Facebook, removing the main income of newspapers and rendering investigative journalism unaffordable.

AMSCE-IOT

3. **Collecting personal data.** These corporations collect personal data for profit, and profile people based on their behaviour (both online and offline). They know more about us than ourselves or our friends — and they are using and making available this information for profit, surveillance, security and election campaigns.

Overall, Nemitz concludes that

> *'this accumulation of power in the hands of a few — the power of money, the power over infrastructures for democracy and discourse, the power over individuals based on profiling and the dominance in AI innovation…must be seen together, and…must inform the present debate about ethics and law for AI'.*

Bryson (2019), meanwhile, believes this concentration of power could be an inevitable consequence of the falling costs of robotic technology. High costs can maintain diversity in economic systems. For example, when transport costs are high, one may choose to use a local shop rather than find the global best provider for a particular good. Lower costs allow relatively few companies to dominate, and where a few providers receive all the business, they will also receive all of the wealth.

Political instability

Bryson (2019) also notes that the rise of AI could lead to wealth inequality and political upheaval. Inequality is highly correlated with political polarisation (McCarty et al., 2016), and one possible consequence of polarisation is an increase in identity politics, where beliefs are used to signal in-group status or affiliation (Iyengar et al., 2012; Newman et al., 2014). This could unfortunately result in situations where beliefs are more tied to a person's group affiliation than to objective facts, and where faith in experts is lost.

> *'While occasionally motivated by the irresponsible use or even abuse of position by some experts, in general losing access to experts' views is a disaster. No one, however intelligent, can master in their lifetime all human knowledge. If society ignores the stores of expertise it has built up — often through taxpayer-funding of higher education — it sets itself at a considerable disadvantage' (Bryson, 2019).*

2.1.3. Privacy, human rights and dignity

AI will have profound impacts on privacy in the next decade. The privacy and dignity of AI users must be carefully considered when designing service, care and companion robots, as working in people's homes means they will be privy to intensely private moments (such as bathing and dressing). However, other aspects of AI will also affect privacy. Smith (2018), President of Microsoft, recently remarked:

> *'[Intelligent 3] technology raises issues that go to the heart of fundamental human rights protections like privacy and freedom of expression. These issues heighten responsibility for tech companies that create these products. In our view, they also call for thoughtful government regulation and for the development of norms around acceptable uses.'*

Privacy and data rights

'Humans will not have agency and control [over their data] in any way if they are not given the tools to make it happen'. (John Havens)

One way in which AI is already affecting privacy is via Intelligent Personal Assistants (IPA) such as Amazon's Echo, Google's Home and Apple's Siri. These voice activated devices are capable of

AMSCE101

learning the interests and behaviour of their users, but concerns have been raised about the fact that they are always on and listening in the background.

A survey of IPA customers showed that people's biggest privacy concern was their device being hacked (68.63%), followed by it collecting personal information on them (16%), listening to their conversations 24/7 (10%), recording private conversations (12%), not respecting their privacy (6%), storing their data (6%) and the 'creepy' nature of the device (4%) (Manikonda et al, 2018). However despite these concerns, people were very positive about the devices, and comfortable using them.

Another aspect of AI that affects privacy is Big Data. Technology is now at the stage where long-term records can be kept on anyone who produces storable data — anyone with bills, contracts, digital devices, or a credit history, not to mention any public writing and social media use. Digital records can be searched using algorithms for pattern recognition, meaning that we have lost the default assumption of anonymity by obscurity (Selinger and Hartzog, 2017).

Any one of us can be identified by facial recognition software or data mining of our shopping or social media habits (Pasquale, 2015). These online habits may indicate not just our identity, but our political or economic predispositions, and what strategies might be effective for changing these (Cadwalladr, 2017a,b).

Machine learning allows us to extract information from data and discover new patterns, and is able to turn seemingly innocuous data into sensitive, personal data. For example, patterns of social media use can predict personality categories, political preferences, and even life outcomes (Youyou et al., 2015). Word choice, or even handwriting pressure on a digital stylus, can indicate emotional state, including whether someone is lying (Hancock et al., 2007; Bandyopadhyay and Hazra, 2017). This has significant repercussions for privacy and anonymity, both online and offline.

AI applications based on machine learning need access to large amounts of data, but data subjects have limited rights over how their data are used (Veale et al., 2018). Recently, the EU adopted new General Data Protection Regulations (GDPR) to protect citizen privacy. However, the regulations only apply to personal data, and not the aggregated 'anonymous' data that are usually used to train models.

In addition, personal data, or information about who was in the training set, can in certain cases be reconstructed from a model, with potentially significant consequences for the regulation of these systems. For instance, while people have rights about how their personal data are used and stored, they have limited rights over trained models. Instead, models have been typically thought to be primarily governed by varying intellectual property rights, such as trade secrets. For instance, as it stands, there are no data protection rights nor obligations concerning models in the period after they have been built, but before any decisions have been taken about using them.

This brings up a number of ethical issues. What level of control will subjects have over the data that are collected about them? Should individuals have a right to use the model, or at least to know what it is used for, given their stake in training it? Could machine learning systems seeking patterns in data inadvertently violate people's privacy if, for example, sequencing the genome of one family member revealed health information about other members of the family?
Another ethical issue surrounds how to prevent the identity, or personal information, of an individual involved in training a model from being discovered (for example through a cyber-attack). Veale et al. (2018) argue that extra protections should be given to people whose data have been used to train models, such as the right to access models; to know where they have originated from, and to whom they are being traded or transmitted; the right to erase themselves from a trained model; and the right to express a wish that the model not be used in the future.

Human rights

AI has important repercussions for democracy, and people's right to a private life and dignity. For instance, if AI can be used to determine people's political beliefs, then individuals in our society might become susceptible to manipulation. Political strategists could use this information to identify which voters are likely to be persuaded to change party affiliation, or to increase or decrease their probability of turning out to vote, and then to apply resources to persuade them to do so. Such a strategy has been alleged to have significantly affected the outcomes of recent elections in the UK and USA (Cadwalladr, 2017a; b).

Alternatively, if AI can judge people's emotional states and gauge when they are lying, these people could face persecution by those who do not approve of their beliefs, from bullying by individuals through to missed career opportunities. In some societies, it could lead to imprisonment or even death at the hands of the state.

Surveillance

'Networks of interconnected cameras provide constant surveillance over many metropolitan cities. In the near future, vision-based drones, robots and wearable cameras may expand this surveillance to rural locations and one's own home, places of worship, and even locations where privacy is considered sacrosanct, such as bathrooms and changing rooms. As the applications of robots and wearable cameras expand into our homes and begin to capture and record all aspects of daily living, we begin to approach a world in which all, even bystanders, are being constantly observed by various cameras wherever they go' (Wagner, 2018).

This might sound like a nightmare dystopian vision, but the use of AI to spy is increasing. For example, an Ohio judge recently ruled that data collected by a man's pacemaker could be used as evidence that he committed arson (Moon, 2017). Data collected by an Amazon Alexa device was also used as evidence (Sauer, 2017). Hundreds of connected home devices, including appliances and televisions, now regularly collect data that may be used as evidence or accessed by hackers. Video can be used for a variety of exceedingly intrusive purposes, such as detecting or characterising a person's emotions.

AI may also be used to monitor and predict potential troublemakers. Face recognition capacities are alleged to be used in China, not only to identify individuals, but to identify their moods and states of attention both in re-education camps and ordinary schools (Bryson, 2019). It is possible, such technology could be used to penalise students for not paying attention or penalise prisoners who do not appear happy to comply with their (re)education.

Unfortunately, governments do not always have their citizens' interests at heart. The Chinese government has already used surveillance systems to place over a million of its citizens in re-education camps for the crime of expressing their Muslim identity (Human Rights Watch, 2018). There is a risk that governments fearing dissent will use AI to suppress, imprison and harm individuals.

Law enforcement agencies in India already use 'proprietary, advance hybrid AI technology' to digitise criminal records, and use facial recognition to predict and recognise criminal activity (Marda, 2018; Sathe, 2018). There are also plans to train drones to identify violent behaviour in public spaces, and to test these drones at music festivals in India (Vincent, 2018). Most of these programmes intend to reduce crime rates, manage crowded public spaces to improve safety, and bring efficiency to law enforcement. However, they have clear privacy and human rights implications, as one's appearance and public behaviour is monitored, collected, stored and possibly shared without consent. Not only does the AI discussed operate in the absence of safeguards to prevent misuse, making them ripe for surveillance and privacy violations, they also operate at questionable levels of accuracy. This could

AMSCE-101

lead to false arrests and people from disproportionately vulnerable and marginalised communities being made to prove their innocence.

Freedom of speech

Freedom of speech and expression is a fundamental right in democratic societies. This could be profoundly affected by AI. AI has been widely touted by technology companies as a solution to problems such as hate speech, violent extremism and digital misinformation (Li and Williams, 2018). In India, sentiment analysis tools are increasingly deployed to gauge the tone and nature of speech online, and are often trained to carry out automated content removal (Marda, 2018). The Indian Government has also expressed interest in using AI to identify fake news and boost India's image on social media (Seth 2017). This is a dangerous trend, given the limited competence of machine learning to understand tone and context. Automated content removal risks censorship of legitimate speech; this risk is made more pronounced by the fact that it is performed by private companies, sometimes acting on the instruction of government. Heavy surveillance affects freedom of expression, as it encourages self-censorship.

2.1.4. Bias

AI is created by humans, which means it can be susceptible to bias. Systematic bias may arise as a result of the data used to train systems, or as a result of values held by system developers and users. It most frequently occurs when machine learning applications are trained on data that only reflect certain demographic groups, or which reflect societal biases. A number of cases have received attention for promoting unintended social bias, which has then been reproduced or automatically reinforced by AI systems.

Examples of AI bias

The investigative journalism organisation ProPublica showed that COMPAS, a machine learning based software deployed in the US to assess the probability of a criminal defendant re-offending, was strongly biased against black Americans. The COMPAS system was more likely to incorrectly predict that black defendants would reoffend, while simultaneously, and incorrectly, predicting the opposite in the case of white defendants (ProPublica, 2016).

Researchers have found that automated advertisement distribution tools are more likely to distribute adverts for well-paid jobs to men than women (Datta et al., 2015). AI-informed recruitment is susceptible to bias; an Amazon self-learning tool used to judge job-seekers was found to significantly favour men, ranking them highly (Dastin, 2018). The system had learned to prioritise applications that emphasised male characteristics, and to downgrade applications from universities with a strong female presence.

Many popular image databases contain images collected from just a few countries (USA, UK), which can lead to biases in search results. Such databases regularly portray women performing kitchen chores while men are out hunting (Zhao et al, 2017), for example, and searches for 'wedding gowns' produce the standard white version favoured in western societies, while Indian wedding gowns are categorised as 'performance art' or 'costumes' (Zhou 2018). When applications are programmed with this kind of bias, it can lead to situations such as a camera automatically warning a photographer that their subject has their eyes closed when taking a photo of an Asian person, as the camera has been trained on stereotypical, masculine and light-skinned appearances.

ImageNet, which has the goal of mapping out a world of objects, is a vast dataset of 14.1 million images organised into over 20,000 categories – the vast majority of which are plants, rocks, animals. Workers have sorted 50 images a minute into thousands of categories for ImageNet – at such a rate there is large potential for inaccuracy. Problematic, inaccurate – and discriminatory - tagging (see Discrimination above) can be maintained in datasets over many iterations

There have been a few activities that have demonstrated the bias contained in data training sets. One is a facial recognition app (ImageNet Roulette)[4] which makes assumptions about you based entirely on uploaded photos of your face – everything from your age and gender to profession and even personal characteristics. It has been critiqued for its offensive, inaccurate and racist labelling – but the creators say that it is an interface that shows users how a machine learning model is interpreting the data and how results can be quite disturbing.[5]

Implications

As many machine-learning models are built from human-generated data, human biases can easily result in a skewed distribution in training data. Unless developers work to recognise and counteract these biases, AI applications and products may perpetuate unfairness and discrimination. AI that is biased against particular groups within society can have far-reaching effects. Its use in law enforcement or national security, for example, could result in some demographics being unfairly imprisoned or detained. Using AI to perform credit checks could result in some individuals being unfairly refused loans, making it difficult for them to escape a cycle of poverty (O'Neil 2016). If AI is used to screen people for job applications or university admissions it could result in entire sections of society being disadvantaged.

This problem is exacerbated by the fact that AI applications are usually 'black boxes', where it is impossible for the consumer to judge whether the data used to train them are fair or representative. This makes biases hard to detect and handle. Consequently, there has been much recent research on making machine learning fair, accountable and transparent, and more public-facing activities and demonstrations of this type would be beneficial.

2.1.5 Democracy

As already discussed, the concentration of technological, economic and political power among a few mega corporations could allow them undue influence over governments — but the adoption and implementation of AI could threaten democracy in other ways too.

Fake news and social media

Throughout history, political candidates campaigning for office have relied on limited anecdotal evidence and surveys to give them an insight into what voters are thinking. Now with the advent of Big Data, politicians have access to huge amounts of information that allow them to target specific categories of voters and develop messaging that will resonate with them most.

This may be a good thing for politicians, but there is a great deal of evidence that AI-powered technologies have been systematically misused to manipulate citizens in recent elections, damaging democracy. For example, 'bots' — autonomous accounts — were used to spread biased news and propaganda via Twitter in the run up to both the 2016 US presidential election and the Brexit vote in the United Kingdom (Pham, Gorodnichenko and Talavera, 2018). Some of these automated accounts were set up and operated from Russia and were, to an extent, able to bias the content viewed on social media, giving a false impression of support.

During the 2016 US presidential election, pro-Trump bots have been found to have infiltrated the online spaces used by pro-Clinton campaigners, where they spread highly automated content,

[4] Created by artist Trevor Paglen and Professor Kate Crawford and New York University.

[5] https://www.vice.com/en_uk/article/xweagk/ai-face-app-imagenet-roulette

generating one-quarter of Twitter traffic about the 2016 election (Hess, 2016). Bots were also largely responsible for popularising #MacronLeaks on social media just days before the 2017 French presidential election (Polonski, 2017). They bombarded Facebook and Twitter with a mix of leaked information and falsified reports, building the narrative that Emmanuel Macron was a fraud and hypocrite.

A recent report found that at least 28 countries — including both authoritarian states and democracies — employ 'cyber troops' to manipulate public opinion over major social networking applications (Bradshaw and Howard, 2017). These cyber troops use a variety of tactics to sway public opinion, including verbally abusing and harassing other social media users who express criticism of the government. In Russia, cyber troops have been known to target journalists and political dissidents, and in Mexico, journalists are frequently targeted and harassed over social media by government-sponsored cyber troops (O'Carrol, 2017). Others use automated bots — according to Bradshaw and Howard (2017), bots have been deployed by government actors in Argentina, Azerbaijan, Iran, Mexico, the Philippines, Russia, Saudi Arabia, South Korea, Syria, Turkey and Venezuela. These bots are often used to flood social media networks with spam and 'fake' or biased news, and can also amplify marginal voices and ideas by inflating the number of likes, shares and retweets they receive, creating an artificial sense of popularity, momentum or relevance. According to the authors, authoritarian regimes are not the only or even the best at organised social media manipulation.

In addition to shaping online debate, AI can be used to target and manipulate individual voters. During the U.S. 2016 presidential election, the data science firm Cambridge Analytica gained access to the personal data of more than 50 million Facebook users, which they used to psychologically profile people in order to target adverts to voters they thought would be most receptive.
There remains a general distrust of social media among members of the public across Europe, and its content is viewed with caution; a 2017 Eurobarometer survey found that just 7% of respondents deemed news stories published on online social platforms to be generally trustworthy (European Commission, 2017). However, a representative democracy depends on free and fair elections in which citizens can vote without manipulation — and AI threatens to undermine this process.

News bubbles and echo chambers

The media increasingly use algorithmic news recommenders (ANR) to target customised news stories to people based on their interests (Thurman, 2011; Gillespie, 2014). However presenting readers with news stories based on their previous reading history lowers the chance of people encountering different and undiscovered content, opinions and viewpoints (Harambam et al., 2018). There is a danger this could result in increasing societal polarisation, with people essentially living in 'echo chambers' and 'filter bubbles' (Pariser, 2011) where they are only exposed to their own viewpoints. The interaction of different ideas and people is considered crucial to functioning democracies.

The end of democracies

Some commentators have questioned whether democracies are particularly suited to the age of AI and machine learning, and whether its deployment will enable countries with other political systems to gain the advantage (Bartlett, 2018). For the past 200 years democracies have flourished because individual freedom is good for the economy. Freedom promotes innovation, boosting the economy and wealth, and creating well-off people who value freedom. However, what if that link was weakened? What if economic growth in the future no longer depended on individual freedom and entrepreneurial spirit?

A centrally planned, state-controlled economy may well be better suited to a new AI age, as it is less concerned with people's individual rights and privacy. For example, the size of the country's population means that Chinese businesses have access to huge amounts of data, with relatively few restraints on how those data can be used. In China, there are no privacy or data protection laws, such as the new GDPR rules in Europe. As China could soon become the world leader in AI, this means it could shape the future of the technology and the limits on how it is used.

'The last few years suggest digital technology thrives perfectly well under monopolistic conditions: the bigger a company is, the more data and computing power it gets, and the more efficient it becomes; the more efficient it becomes, the more data and computing power it gets, in a self-perpetuating loop' (Bartlett, 2018). According to Bartlett, people's love affair with 'convenience' means that if a 'machinocracy' was able to deliver wealth, prosperity and stability, many people would probably be perfectly happy with it.

2.2 Impact on human psychology

AI is getting better and better at modelling human thought, experience, action, conversation and relationships. In an age where we will frequently interact with machines as if they are humans, what will the impact be on real human relationships?

2.2.1 Relationships

Relationships with others form the core of human existence. In the future, robots are expected to serve humans in various social roles: nursing, housekeeping, caring for children and the elderly, teaching, and more. It is likely that robots will also be designed for the explicit purpose of sex and companionship. These robots may be designed to look and talk just like humans. People may start to form emotional attachments to robots, perhaps even feeling love for them. If this happens, how would it affect human relationships and the human psyche?

Human-robot relationships

'The biggest risk [of AI] that anyone faces is the loss of ability to think for yourself. We're already seeing people are forgetting how to read maps, they're forgetting other skills. If we've lost the ability to be introspective, we've lost human agency and we're spinning around in circles'. (John Havens)

One danger is that of **deception** and **manipulation**. Social robots that are loved and trusted could be misused to manipulate people (Scheutz 2012); for example, a hacker could take control of a personal robot and exploit its unique relationship with its owner to trick the owner into purchasing products. While humans are largely prevented from doing this by feelings like empathy and guilt, robots would have no concept of this.

Companies may design future robots in ways that enhance their trustworthiness and appeal. For example, if it emerged that humans are reliably more truthful with robots[6] or conversational AIs (chatbots) than they are with other humans, it would only be a matter of time before robots were used to interrogate humans — and if it emerged that robots are generally more believable than humans, then robots would likely be used as sales representatives.

It is also possible that people could become psychologically dependent on robots. Technology is known to tap into the reward functions of the brain, and this addiction could lead people to perform actions they would not have performed otherwise.

AMSCE-1101

[6] The word's first chatbot ELIZA, developed by AI pioneer Joseph Weizenbaum showed that many early users were convinced of ELIZA's intelligence and understanding, despite Weizenbaum's insistence to the contrary.

It may be difficult to predict the psychological effects of forming a relationship with a robot. For example, Borenstein and Arkin (2019) ask how a 'risk-free' relationship with a robot may affect the mental and social development of a user; presumably, a robot would not be programmed to break up with a human companion, thus theoretically removing the emotional highs and lows from a relationship.

Enjoying a friendship or relationship with a companion robot may involve mistaking, at a conscious or unconscious level, the robot for a real person. To benefit from the relationship, a person would have to 'systematically delude themselves regarding the real nature of their relation with the [AI]' (Sparrow, 2002). According to Sparrow, indulging in such 'sentimentality of a morally deplorable sort' violates a duty that we have to ourselves to apprehend the world accurately. Vulnerable people would be especially at risk of falling prey to this deception (Sparrow and Sparrow, 2006).

Human-human relationships

Robots may affect the stability of marital or sexual relationships. For instance, feelings of jealousy may emerge if a partner is spending time with a robot, such as a 'virtual girlfriend' (chatbot avatar). Loss of contact with fellow humans and perhaps a withdrawal from normal everyday relationships is also a possibility. For example, someone with a companion robot may be reluctant to go to events (say, a wedding) where the typical social convention is to attend as a human-human couple. People in human-robot relationships may be stigmatised.

There are several ethical issues brought about by humans forming relationships with robots:

- Could robots change the beliefs, attitudes, and/or values we have about human-human relationships? People may become impatient and unwilling to put the effort into working on human-human relationships when they can have a relationship with a 'perfect' robot and avoid these challenges.

- Could 'intimate robots' lead to an increase in violent behaviour? Some researchers argue that 'sexbots' would distort people's perceptions about the value of a human being, increasing people's desire or willingness to harm others. If we are able to treat robots as instruments for sexual gratification, then we may become more likely to treat other people this way. For example, if a user repeatedly punched a companion robot, would this be unethical (Lalji, 2015)? Would violence towards robots normalise a pattern of behaviour that would eventually affect other humans? However, some argue that robots could be an outlet for sexual desire, reducing the likelihood of violence, or to help recovery from assault.

Machines made to look and act like us could also affect the 'social suite' of capacities we have evolved to cooperate with one another, including love, friendship, cooperation and teaching (Christakis, 2019). In other words, AI could change how loving and kind we are—not just in our direct interactions with the machines in question, but in our interactions with one another. For example, should we worry about the effect of children being rude to digital assistants such as Alexa or Siri? Does this affect how they view or treat others?

Research shows that robots have the capacity to change how cooperative we are. In one experiment, small groups of people worked with a humanoid robot to lay railroad tracks in a virtual world. The robot was programmed to make occasional errors — and to acknowledge them and apologise. Having a clumsy, apologetic robot actually helped these groups perform *better* than control groups, by improving collaboration and communication among the human group members. This was also true in a second experiment, where people in groups containing error-prone robots consistently outperformed others in a problem-solving task (Christakis, 2017).

AMSCE-IIOT

Both of these studies demonstrate that AI can improve the way humans relate to one another. However, AI can also make us behave less productively and less ethically. In another experiment, Christakis and his team gave several thousand subjects money to use over multiple rounds of an online game. In each round, subjects were told that they could either be selfish and keep their money, or be altruistic and donate some or all of it to their neighbours. If they made a donation, the researchers matched it, doubling the money their neighbours received. Although two thirds of people initially acted altruistically, the scientists found that the group's behaviour could be changed simply by adding just a few robots (posing as human players) that behaved selfishly. Eventually, the human players ceased cooperating with each other. The bots thus converted a group of generous people into selfish ones.

The fact that AI might reduce our ability to work together is concerning, as cooperation is a key feature of our species. 'As AI permeates our lives, we must confront the possibility that it will stunt our emotions and inhibit deep human connections, leaving our relationships with one another less reciprocal, or shallower, or more narcissistic,' says Christakis (2019).

2.2.4 Personhood

As machines increasingly take on tasks and decisions traditionally performed by humans, should we consider giving AI systems 'personhood' and moral or legal agency? One way of programming AI systems is 'reinforcement learning', where improved performance is reinforced with a virtual reward. Could we consider a system to be suffering when its reward functions give it negative input? Once we consider machines as entities that can perceive, feel and act, it is no huge leap to ponder their legal status. Should they be treated like animals of comparable intelligence? Will we consider the suffering of 'feeling' machines?

Scholars have increasingly discussed the legal status(es) of robots and AI systems over the past three decades. However, the debate was reignited recently when a 2017 resolution of the EU parliament invited the European Commission 'to explore, analyse and consider the implications of all possible legal solutions, [including]...creating a specific legal status for robots in the long run, so that at least the most sophisticated autonomous robots could be established as having the status of electronic persons responsible for making good any damage they may cause, and possibly applying electronic personality to cases where robots make autonomous decisions or otherwise interact with third parties independently'.

However, the resolution provoked a number of objections, including an open letter from several 'Artificial Intelligence and Robotics Experts' in April 2018 which stated that 'the creation of a Legal Status of an 'electronic person' for 'autonomous', 'unpredictable' and 'self-learning' robots' should be discarded from technical, legal and ethical perspectives. Attributing electronic personhood to robots risks misplacing moral responsibility, causal accountability and legal liability regarding their mistakes and misuses, said the letter.

The majority of ethics research regarding AI seems to agree that AI machines should not be given moral agency, or seen as persons. Bryson (2018) argues that giving robots moral agency could in itself be construed as an immoral action, as 'it would be unethical to put artefacts in a situation of competition with us, to make them suffer, or to make them unnecessarily mortal'. She goes on to say that

> *'there are substantial costs but little or no benefits from the perspective of either humans or robots to ascribing and implementing either agency or patiency to intelligent artefacts beyond that ordinarily ascribed to any possession. The responsibility for any moral action taken by an artefact should therefore be attributed to its owner or operator, or in case of malfunctions to its manufacturer, just as with conventional artefacts'.*

2.3 Impact on the financial system

One of the first domains where autonomous applications have taken off is in financial markets, with most estimates attributing over half of trading volume in US equities to algorithms (Wellman and Rajan, 2017).

Markets are well suited to automation, as they now operate almost entirely electronically, generating huge volumes of data at high velocity, which require algorithms to digest. The dynamism of markets means that timely response to information is critical, providing a strong incentive to take slow humans out of the decision loop. Finally, and perhaps most obviously, the rewards available for effective trading decisions are considerable, explaining why firms have invested in this technology to the extent that they have. In other words, algorithmic trading can generate profits at a speed and frequency that is impossible for a human trader.

Although today's autonomous agents operate within a relatively narrow scope of competence and autonomy, they nevertheless take actions with consequences for people.

A well-known instance is that of Knight Capital Group. During the first 45 minutes of the trading day on 1 August 2012, while processing 212 small orders from customers, an automated trading agent developed by and operating on behalf of Knight Capital erroneously submitted millions of orders to the equity markets. Over four million transactions were executed in the financial markets as a result, leading to billions of dollars in net long and short positions. The company lost $460 million on the unintended trades, and the value of its own stock fell by almost 75%.

Although this is an example of an accidental harm, autonomic trading agents could also be used maliciously to destabilise markets, or otherwise harm innocent parties. Even if their use is not intended to be malicious, the autonomy and adaptability of algorithmic trading strategies, including the increasing use of sophisticated machine learning techniques makes it difficult to understand how they will perform in unanticipated circumstances.

Market manipulation

King et al. (2019) discuss several ways in which autonomous financial agents could commit financial crimes, including market manipulation, which is defined as 'actions and/or trades by market participants that attempt to influence market pricing artificially' (Spatt, 2014).

Simulations of markets comprising artificial trading agents have shown that, through reinforcement learning, an AI can learn the technique of order-book spoofing, which involves placing orders with no intention of ever executing them in order to manipulate honest participants in the marketplace (Lin, 2017).

Social bots have also been shown to exploit markets by artificially inflating stock through fraudulent promotion, before selling its position to unsuspecting parties at an inflated price (Lin 2017). For instance, in a recent prominent case a social bot network's sphere of influence was used to spread disinformation about a barely traded public company. The company's value gained more than 36,000% when its penny stocks surged from less than $0.10 to above $20 a share in a matter of few weeks (Ferrara 2015).

Collusion

Price fixing, a form of collusion may also emerge in automated systems. As algorithmic trading agents can learn about pricing information almost instantaneously, any action to lower a price by one agent will likely be instantaneously matched by another. In and of itself, this is no bad thing and only represents an efficient market. However, the possibility that lowering a price will result in your competitors simultaneously doing the same thing acts as a disincentive. Therefore, algorithms (if they are rational) will maintain artificially and tacitly agreed higher prices, by not lowering prices in the first place (Ezrachi and Stucke, 2016). Crucially, for collusion to take place, an algorithm does not need to be designed specifically to collude.

Accountability

While the responsibility for trading algorithms rests with the organisations' that develop and deploy them, autonomous agents may perform actions — particularly in unusual circumstances — that would have been difficult to anticipate by their programmers. Does that difficulty mitigate responsibility to any degree?

For example, Wellman and Rajan (2017) give the example of an autonomous trading agent conducting an arbitrage operation, which is when a trader takes advantage of a discrepancy in prices for an asset in order to achieve a near-certain profit. Theoretically, the agent could attempt to instigate arbitrage opportunities by taking malicious actions to subvert markets, for example by propagating misinformation, obtaining improper access to information, or conducting direct violations of market rules

Clearly, it would be disadvantageous for autonomous trading agents to engage in market manipulation, however could an autonomous algorithm even meet the legal definition of market manipulation, which requires 'intent'?

Wellmen and Rajan (2017) argue that trading agents will become increasingly capable of operating at wider levels without human oversight, and that regulation is now needed to prevent societal harm. However, attempts to regulate or legislate may be hampered by several issues.

2.4 Impact on the legal system

The creation of AI machines and their use in society could have a huge impact on criminal and civil law. The entire history of human laws has been built around the assumption that people, and not robots, make decisions. In a society in which increasingly complicated and important decisions are being handed over to algorithms, there is the risk that the legal frameworks we have for liability will be insufficient.

Arguably, the most important near-term legal question associated with AI is who or what should be liable for tortious, criminal, and contractual misconduct involving AI and under what conditions.

2.4.1 Criminal law

A crime consists of two elements: a voluntary criminal act or omission (*actus reus*) and an intention to commit a crime (*mens rea*). If robots were shown to have sufficient awareness, then they could be liable as direct perpetrators of criminal offenses, or responsible for crimes of negligence. If we admit that robots have a mind of their own, endowed with human-like free will, autonomy or moral sense, then our whole legal system would have to be drastically amended.

Although this is possible, it is not likely. Nevertheless, robots may affect criminal laws in more subtle ways.

AMSCE-101

Liability

The increasing delegation of decision making to AI will also impact many areas of law for which *mens rea*, or intention, is required for a crime to have been committed.

What would happen, for example if an AI program chosen to predict successful investments and pick up on market trends made a wrong evaluation that led to a lack of capital increase and hence, to the fraudulent bankruptcy of the corporation? As the intention requirement of fraud is missing, humans could only be held responsible for the lesser crime of bankruptcy triggered by the robot's evaluation (Pagallo, 2017).

Existing liability models may be inadequate to address the future role of AI in criminal activities (King et al, 2019). For example, in terms of *actus reus*, while autonomous agents can carry out the criminal act or omission, the voluntary aspect of *actus reus* would not be met, since the idea that an autonomous agent can act voluntarily is contentious. This means that agents, artificial or otherwise could potentially perform criminal acts or omissions without satisfying the conditions of liability for that particular criminal offence.

When criminal liability is fault-based, it also requires *mens rea* (a guilty mind). The *mens rea* may comprise an intention to commit the *actus reus* using an AI-based application, or knowledge that deploying an autonomous agent will or could cause it to perform a criminal action or omission. However, in some cases the complexity of the autonomous agent's programming could make it possible that the designer, developer, or deployer would neither know nor be able to predict the AI's criminal act or omission. This provides a great incentive for human agents to avoid finding out what precisely the machine learning system is doing, since the less the human agents know, the more they will be able to deny liability for both these reasons (Williams 2017).

The actions of autonomous robots could also lead to a situation where a human manifests the *mens rea*, and the robot commits the *actus reus*, splintering the components of a crime (McAllister 2017).

Alternatively, legislators could define criminal liability without a fault requirement. This would result in liability being assigned to the person who deployed the AI regardless of whether they knew about it, or could predict the illegal behaviour. Faultless liability is increasingly used for product liability in tort law (e.g., pharmaceuticals and consumer goods). However, Williams (2017) argues that *mens rea* with intent or knowledge is important, and we cannot simply abandon that key requirement of criminal liability in the face of difficulty in proving it.

Kingston (2018) references a definition provided by Hallevy (2010) on how AI actions may be viewed under criminal law. According to Hallevy, these legal models can be split into three scenarios:

1. *Perpetrator-via-another*. If an offence is committed by an entity that lacks the mental capacity for *mens rea* – a child, animal, or mentally deficient person – then they are deemed an innocent agent. However, if this innocent agent was instructed by another to commit the crime, then the instructor is held criminally liable. Under this model, an AI may be held to be an innocent agent, with either the software programmer or user filling the role of perpetrator-via-another.

2. *Natural-probable-consequence*. This relates to the accomplices of a criminal action; if no conspiracy can be proven, an accomplice may still be held legally liable if the perpetrator's acts were a natural or probable consequence of a scheme encouraged or aided by an accomplice. This scenario may hold when an AI that was designed for a 'good' purpose is misappropriated and commits a crime. For example, a factory line robot may injure a nearby worker they erroneously consider a threat to their programmed mission. In this

case, programmers may be held liable as accomplices if they knew that a criminal offence was a natural or probable consequence of their program design or use. This would not hold for an AI that was programmed to do a 'bad' thing, but to those that are misappropriated. Anyone capable and likely of foreseeing an AI being used in a specific criminal way may be held liable under this scenario: the programmer, the vendor, the service provider, or the user (assuming that the system limitations and possible consequences of misuse are spelt out in the AI instructions – which is unlikely).

3. *Direct liability*. This model attributes both *actus* and *mens rea* to an AI. However, while *actus rea* (the action or inaction) is relatively simple to attribute to an AI, says Kingston (2018), attributing *mens rea* (a guilty mind) is more complex. For example, the AI program 'driving' an autonomous vehicle that exceeds the speed limit could be held criminally liable for speeding – but for strict liability scenarios such as this, no criminal intent is required, and it is not necessary to prove that the car sped knowingly. Kingston also flags a number of possible issues that arise when considering AI to be directly liable. For example, could an AI infected by a virus claim a defence similar to coercion or intoxication, or an AI that is malfunctioning claim a defence akin to insanity? What would punishment look like – and who would be punished?

Identifying who exactly would be held liable for an AI's actions is important, but also potentially difficult. For example, 'programmer' could apply to multiple collaborators, or be widened to encompass roles such as program designer, product expert, and their superiors – and the fault may instead lie with a manager that appointed an inadequate expert or programmer (Kingston, 2010).

Psychology

There is a risk that AI robots could manipulate a user's mental state in order to commit a crime. This was demonstrated by Weizenbaum (1976) who conducted early experiments into human–bot interactions where people revealed unexpectedly personal details about their lives. Robots could also normalise sexual offences and crimes against people, such as the case of certain sexbots (De Angeli, 2009).

Commerce, financial markets and insolvency

As discussed earlier in this report, there are concerns that autonomous agents in the financial sector could be involved in market manipulation, price fixing and collusion. The lack of intention by human agents, and the likelihood that autonomous agents (AAs) may act together also raises serious problems with respect to liability and monitoring. It would be difficult to prove that the human agent intended the AA to manipulate markets, and it would also be difficult to monitor such manipulations. The ability of AAs to learn and refine their capabilities also implies that these agents may evolve new strategies, making it increasingly difficult to detect their actions (Farmer and Skouras 2013).

Harmful or Dangerous Drugs

In the future AI could be used by organised criminal gangs to support the trafficking and sale of banned substances. Criminals could use AI equipped unmanned vehicles and autonomous navigation technologies to smuggle illicit substances. Because smuggling networks are disrupted by monitoring and intercepting transport lines, law enforcement becomes more difficult when unmanned vehicles are used to transport contraband. According to Europol (2017), drones present a real threat in the form of automated drug smuggling. Remote-controlled cocaine-trafficking submarines have already been discovered and seized by US law enforcement (Sharkey et al., 2010).

AMSCE-HOI

Unmanned underwater vehicles (UUVs) could also be used for illegal activities, posing a significant threat to enforcing drug prohibitions. As UUVs can act independently of an operator (Gogarty and Hagger, 2008), it would make it more difficult to catch the criminals involved.

Social bots could also be used to advertise and sell pornography or drugs to millions of people online, including children.

Offences Against the Person

Social bots could also be used to harass people. Now that AI can generate more sophisticated fake content, new forms of harassment are possible. Recently, developers released software that produces synthetic videos where a person's face can be accurately substituted for another's. Many of these synthetic videos are pornographic and there is now the risk that malicious users may synthesise fake content in order to harass victims (Chesney and Citron 2018).

AI robots could also be used to torture and interrogate people, using psychological (e.g., mimicking people known to the torture subject) or physical torture techniques (McAllister 2017). As robots cannot understand pain or experience empathy, they will show no mercy or compassion. The mere presence of an interrogation robot may therefore cause the subject to talk out of fear. Using a robot would also serve to distance the human perpetrator from the *actus reus,* and emotionally distance themselves from their crime, making torture more likely.

As unthinking machines, AAs cannot bear moral responsibility or liability for their actions. However, one solution would be to take the approach of *strict* criminal liability, where punishment or damages may be imposed without proof of fault, which would lower the intention-threshold for the crime. However even under a strict liability framework, the question of who exactly should face imprisonment for AI-caused offences against a person is difficult. It is clear that an AA cannot be held liable. Yet, the number of actors involved creates a problem in ascertaining where the liability lies—whether with the person who commissioned and operated the AA, or its developers, or the legislators and policymakers who sanctioned real-world deployment of such agents (McAllister 2017).

Sexual Offences

There is a danger that AI embodied robots could be used to promote sexual objectification, sexual abuse and violence. As discussed in section 2.1, sexbots could allow people to simulate sexual offences such as rape fantasies. They could even be designed to emulate sexual offences, such as adult and child rape (Danaher 2017).

Interaction with social bots and sexbots could also desensitise a perpetrator towards sexual offences, or even heighten their desire to commit them (De Angeli 2009; Danaher 2017).

AMSCE-101

Who is responsible?

When considering the possible consequences and misuse of an AI, the key question is: *who is responsible for the actions of an AI*? Is it the programmers, manufacturers, end users, the AI itself, or another? Is the answer to this question the same for all AI or might it differ, for example, for systems capable of learning and adapting their behaviour?

According to the European Parliament Resolution (2017) on AI, legal responsibility for an AI's action (or inaction) is traditionally attributed to a human actor: the owner, developer, manufacturer or operator of an AI, for instance. For example, self-driving cars in Germany are currently deemed the responsibility of their owner. However, issues arise when considering third-party involvement, and advanced systems such as self-learning neural networks: if an action cannot be predicted by the developer because an AI has sufficiently changed from their design, can a developer be held responsible for that action? Additionally, current legislative infrastructure and the lack of effective regulatory mechanisms pose a challenge in regulating AI and assigning blame, say Atabekov and Yastrebov (2018), with autonomous AI in particular raising the question of whether a new legal category is required to encompass their features and limitations (European Parliament, 2017).

Taddeo and Floridi (2018) highlight the concept of 'distributed agency'. As an AI's actions or decisions come about following a long, complex chain of interactions between both human and robot – from developers and designers to manufacturers, vendors and users, each with different motivations, backgrounds, and knowledge – then an AI outcome may be said to be the result of distributed agency. With distributed agency comes distributed responsibility. One way to ensure that AI works towards 'preventing evil and fostering good' in society may be to implement a moral framework of distributed responsibility that holds all agents accountable for their role in the outcomes and actions of an AI (Taddeo and Floridi, 2018).

Different applications of AI may require different frameworks. For example, when it comes to military robots, Lokhorst and van den Hoven (2014) suggest that the primary responsibility lies with a robot's designer and deployer, but that a robot may be able to hold a certain level of responsibility for its actions.

Learning machines and autonomous AI are other crucial examples. Their use may create a 'responsibility gap', says Matthias (2004), where the manufacturer or operator of a machine may, in principle, be unable to predict a given AI's future behaviour – and thus cannot be held responsible for it in either a legal or moral sense. Matthias proposes that the programmer of a neural network, for instance, increasingly becomes the 'creator of software organisms', with very little control past the point of coding. The behaviour of such AI deviates from the initial programming to become a product of its interactions with its environment – the clear distinction between the phases of programming, training, and operation may be lost, making the ascription of blame highly complex and unclear. This responsibility gap requires the development and clarification of appropriate moral practice and legislation alongside the deployment of learning automata (Matthias, 2004). This is echoed by Scherer (2016), who states that AI has so far been developed in 'a regulatory vacuum', with few laws or regulations designed to explicitly address the unique challenges of AI and responsibility.

Theft and fraud, and forgery and impersonation

AI could be used to gather personal data, and forge people's identities. For example, social media bots that add people as 'friends' would get access to their personal information, location, telephone number, or relationship history (Bilge et al., 2009). AI could manipulate people by building rapport with them, then exploiting that relationship to obtain information from or access to their computer (Chantler and Broadhurst 2006).

AI could also be used to commit banking fraud by forging a victim's identity, including mimicking a person's voice. Using the capabilities of machine learning, Adobe's software is able to learn and reproduce people's individual speech pattern from a 20-min recording of that person's voice. Copying the voice of the customer could allow criminals to talk to the person's bank and make transactions.

2.4.2 Tort law

Tort law covers situations where one person's behaviour causes injury, suffering, unfair loss, or harm to another person. This is a broad category of law that can include many different types of personal injury claims.

Tort laws serve two basic, general purposes: 1) to compensate the victim for any losses caused by the defendant's violations; and 2) to deter the defendant from repeating the violation in the future.

Tort law will likely come into sharp focus in the next few years as self-driving cars emerge on public roads. In the case of self-driving autonomous cars, when an accident occurs there are two areas of law that are relevant - negligence and product liability.

Today most accidents result from driver error, which means that liability for accidents are governed by negligence principles (Lin et al, 2017). Negligence is a doctrine that holds people liable for acting unreasonably under the circumstances (Anderson et al, 2009). To prove a negligence claim, a plaintiff must show that:

- A duty of care is owed by the defendant to the plaintiff
- There has been a breach of that duty by the defendant
- There is a causal link between the defendant's breach of duty and the plaintiff's harm, and;
- That the plaintiff has suffered damages as a result.

Usually insurance companies determine the at fault party, avoiding a costly lawsuit. However this is made much more complicated if a defect in the vehicle caused the accident. In the case of self-driving cars, accidents could be caused by hardware failure, design failure or a software error – a defect in the computer's algorithms.

Currently, if a collision is caused by an error or defect in a computer program, the manufacturer would be held responsible under the Product Liability doctrine, which holds manufacturers, distributors, suppliers, retailers, and others who make products available to the public responsible for the injuries those products cause.

As the majority of autonomous vehicle collisions are expected to be through software error, the defect would likely have to pass the 'risk-utility test' (Anderson et al., 2010), where a product is defective if the foreseeable risks of harm posed by the product could have been reduced or avoided by the adoption of a reasonable alternative design by the seller, and the omission of the alternative design renders the product not reasonably safe.

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However, risk-utility test cases, which are needed to prove design defects are complex and require many expert witnesses, making design defect claims expensive to prove (Gurney et al, 2013). The nature of the evidence, such as complex algorithms and sensor data is also likely to make litigation especially challenging and complex.

This means the methods used to recover damages for car accidents would have to switch from an established, straightforward area of the law into a complicated and costly area of law (products liability). A plaintiff would need multiple experts to recover and find the defect in the algorithm, which would have implications for even the most straightforward of autonomous vehicle accidents. This would likely affect the ability of victims to get compensation and redress for injuries sustained in car accidents.

2.5 Impact on the environment and the planet

AI and robotics technologies require considerable computing power, which comes with an energy cost. Can we sustain massive growth in AI from an energetic point of view when we are faced with unprecedented climate change?

2.5.1 Use of natural resources

The extraction of nickel, cobalt and graphite for use in lithium ion batteries – commonly found in electrical cars and smartphones - has already damaged the environment, and AI will likely increase this demand. As existing supplies are diminished, operators may be forced to work in more complex environments that are dangerous to human operators – leading to further automation of mining and metal extraction (Khakurel et al., 2018). This would increase the yield, and depletion rate of rare earth metals, degrading the environment further.

2.5.2 Pollution and waste

At the end of their product cycle, electronic goods are usually discarded, leading to a build-up of heavy metals and toxic materials in the environment (O'Donoghue, 2010).

Increasing the production and consumption of technological devices such as robots will exacerbate this waste problem, particularly as the devices will likely be designed with 'inbuilt obsolescence' – a process where products are designed to wear out 'prematurely' so that customers have to buy replacement items – resulting in the generation of large amounts of electronic waste (Khakurel et al., 2018). Planned obsolescence depletes the natural environment of resources such as rare earth metals, while increasing the amount of waste. Sources indicate that in North America, over 100 million cell phones and 300 million personal computers are discarded each year (Guiltinana et al., 2009).

Ways of combating this include 'encouraging consumers to prefer eco-efficient, more sustainable products and services' (World Business Council for Sustainable Development, 2000). However, this is hampered by consumers expecting frequent upgrades, and the lack of consumer concern for environmental consequences when contemplating an upgrade.

2.5.3 Energy concerns

As well as the toll that increased mining and waste will have on the environment, adoption of AI technology, particularly machine learning, will require more and more data to be processed. And that requires huge amounts of energy. In the United States, data centres already account for about 2 percent of all electricity used. In one estimation, DeepMind's AlphaGo – which beat Go Champion Lee Sedol in 2016 – took 50,000 times as much power as the human brain to do so (Mattheij, 2016).

AMSCE101

AI will also require large amounts of energy for manufacturing and training – for example, it would take many hours to train a large-scale AI model to understand and recognise human language such that it could be used for translation purposes (Winfield, 2019b). According to Strubell, Ganesh, and McCallum (2019), the carbon footprint of training, tuning, and experimenting with a natural language processing AI is over seven times that of an average human in one year, and roughly 1.5 times the carbon footprint of an average car, including fuel, across its entire lifetime.

2.5.4 Ways AI could help the planet

Alternatively AI could actually help us take better care of the planet, by helping us manage waste and pollution. For example, the adoption of autonomous vehicles could reduce greenhouse gas emissions, as autonomous vehicles could be programmed to follow the principles of eco-driving throughout a journey, reducing fuel consumption by as much as 20 percent and reducing greenhouse gas emissions to a similar extent (Iglinski et al., 2017). Autonomous vehicles could also reduce traffic congestion by recommending alternative routes and the shortest routes possible, and by sharing traffic information to other vehicles on the motorways, resulting in less fuel consumption.

There are also applications for AI in conservation settings. For example, deep-learning technology could be used to analyse images of animals captured by motion-sensor cameras in the wild. This information could then be used to provide accurate, detailed, and up-to-date information about the location, count, and behaviour of animals in the wild, which could be useful in enhancing local biodiversity and local conservation efforts (Norouzzadeh et al., 2018).

2.6 Impact on trust

AI is set to change our daily lives in domains such as transportation; the service industry; health-care; education; public safety and security; and entertainment. Nevertheless, these systems must be introduced in ways that build trust and understanding, and respect human and civil rights (Dignum, 2018). They need to follow fundamental human principles and values, and safeguard the well-being of people and the planet.

The overwhelming consensus amongst the research community is that trust in AI can only be attained by fairness, transparency, accountability and regulation. Other issues that impact on trust are how much control we want to exert over AI machines, and if, for example we want to always maintain a human-in the loop, or give systems more autonomy.

While robots and AI are largely viewed positively by citizens across Europe, they also evoke mixed feelings, raising concern and unease (European Commission 2012; European Commission 2017). Two Eurobarometer surveys, which aim to gauge public perception, acceptance, and opinion of specific topics among EU citizens in Member States, have been performed to characterise public attitudes towards robots and AI (survey 382), and towards increasing digitisation and automation (survey 460).

These surveys suggest that there is some way to go before people are comfortable with the widespread use of robots and advanced technology in society. For example, while respondents favoured the idea of prioritising the use of robots in areas that pose risk or difficulty to humans — space exploration, manufacturing, military, security, and search and rescue, for instance — they were very uncomfortable with areas involving vulnerable or dependent areas of society. Respondents opposed the use of robots to care for children, the elderly, and the disabled; for education; and for healthcare, despite many holding positive views of robots in general. The majority of those surveyed were also 'totally uncomfortable' with the idea of having their dog

AMSCE-IOI

walked by a robot, having a medical operation performed by a robot, or having their children or elderly parents minded by a robot — scenarios in which trust is key.

2.6.1 Why trust is important

'In order for AI to reach its full potential, we must allow machines to sometimes work autonomously, and make decisions by themselves without human input', explains Taddeo (2017).

Imagine a society in which there is no trust in doctors, teachers, or drivers. Without trust we would have to spend a significant portion of our lives devoting time and resources to making sure other people, or things were doing their jobs properly (Taddeo, 2017). This supervision would come at the expense of doing our own jobs, and would ultimately create a dysfunctional society.

'We trust machine learning algorithms to indicate the best decision to make when hiring a future colleague or when granting parole during a criminal trial; to diagnose diseases and identify a possible cure. We trust robots to take care of our elderly and toddlers, to patrol borders, and to drive or fly us around the globe. We even trust digital technologies to simulate experiments and provide results that advance our scientific knowledge and understanding of the world. This trust is widespread and is resilient. It is only reassessed (rarely broken) in the event of serious negative consequences.' (Taddeo, 2017)

In fact digital technologies are so pervasive that trusting them is essential for our societies to work properly. Constantly supervising a machine learning algorithm used to make a decision would require significant time and resources, to the point that using digital technologies would become unfeasible. At the same time, however, the tasks with which we trust digital technologies are of such relevance that a complete lack of supervision may lead to serious risks for our safety and security, as well for the rights and values underpinning our societies.

In other words, it is crucial to identify an effective way to trust digital technologies so that we can harness their value, while protecting fundamental rights and fostering the development of open, tolerant, just information societies (Floridi, 2016; Floridi and Taddeo, 2016). This is especially important in hybrid systems involving human and artificial agents.

But how do we find the correct level of trust? Taddeo suggests that in the short term design could play a crucial role in addressing this problem. For example, pop-up messages alerting users to algorithmic search engine results that have taken into account the user's online profile, or messages flagging that the outcome of an algorithm may not be objective. However in the long term, an infrastructure is needed that enforces norms such as fairness, transparency and accountability across all sectors.

2.6.2 Fairness

In order to trust AI it must be fair and impartial. As discussed in section 3.4, as more and more decisions are delegated to AI, we must ensure that those decisions are free from bias and discrimination. Whether it's filtering through CVs for job interviews, deciding on admissions to university, conducting credit ratings for loan companies, or judging the risk of someone reoffending, it's vital that decisions made by AI are fair, and do not deepen already entrenched social inequalities.

But how do we go about making algorithms fair? It's not as easy as it seems. The problem is that it is impossible to know what algorithms based on neural networks are actually learning when you train them with data. For example, the COMPAS algorithm, which assessed how likely someone was to commit a violent crime was found to strongly discriminate against black people. However the

AMSCE-IOI

algorithms were not actually given people's race as an input. Instead the algorithm inferred this sensitive data from other information, e.g. address.

For instance, one study found that two AI programs that had independently learnt to recognise images of horses from a vast library, used totally different approaches (Lapuschkin et al., 2019). While one AI focused rightly on the animal's features, the other based its decision wholly on a bunch of pixels at the bottom left corner of each horse image. It turned out that the pixels contained a copyright tag for the horse pictures. The AI worked perfectly for entirely the wrong reasons.

To devise a fair algorithm, first you must decide what a fair outcome looks like. Corbett-Davies et al. (2017) describe four different definitions of algorithmic fairness for an algorithm that assesses people's risk of committing a crime.

1. Statistical parity - where an equal proportion of defendants are detained in each race group. For example, white and black defendants are detained at equal rates.

2. Conditional statistical parity - where controlling for a limited set of 'legitimate' risk factors, an equal proportion of defendants are detained within each race group. For example, among defendants who have the same number of prior convictions, black and white defendants are detained at equal rates.

3. Predictive equality - where the accuracy of decisions is equal across race groups, as measured by false positive rate. This means that among defendants who would not have gone on to commit a violent crime if released, detention rates are equal across race groups.

4. Calibration - among defendants with a given risk score, the proportion who reoffend is the same across race groups.

However, while it is possible to devise algorithms that satisfy some of these requirements, many notions of fairness conflict with one another, and it is impossible to have an algorithm that meets all of them.

Another important aspect of fairness is to know *why* an automated program made a particular decision. For example, a person has the right to know why they were rejected for a bank loan. This requires transparency. However as we will find out, it is not always easy to find out why an algorithm came to a particular decision – many AIs employ complex 'neural networks' so that even their designers cannot explain how they arrive at a particular answer.

2.6.3 Transparency

A few years ago, a computer program in America assessed the performance of teachers in Houston by comparing their students' test scores against state averages (Sample, 2017). Those with high ratings won praise and even bonuses, while those with low ratings faced being fired. Some teachers felt that the system marked them down without good reason, however they had no way of checking if the program was fair or faulty as the company that built the software, the SAS Institute, considered its algorithm a trade secret and would not disclose its workings. The teachers took their case to court, and a federal judge ruled that the program had violated their civil rights.

This case study highlights the importance of transparency for building trust in AI - it should always be possible to find out *why* an autonomous system made a particular decision, especially if that decision caused harm. Given that real-world trials of driverless car autopilots have already resulted in several fatal accidents, there is clearly an urgent need for transparency in order to discover *how*

AMSCE-101

and *why* those accidents occurred, remedy any technical or operational faults, and establish accountability.

This issue is also prevalent amongst members of the public, especially when it comes to healthcare, a very personal issue for many (European Commission, 2017). For example, across Europe, many express concern over their lack of ability to access their health and medical records; while the majority would be happy to pass their records over to a healthcare professional, far fewer would be happy to do so to a public or private company for the purposes of medical research. These attitudes reflect concerns over trust, data access, and data use — all of which relate strongly to the idea of transparency and of understanding *what* AI gathers, *why*, and *how* one may access the data being gathered about them.

Black boxes

Transparency can be very difficult with modern AI systems, especially those based on deep learning systems. Deep learning systems are based on artificial neural networks (ANNs), a group of interconnected nodes, inspired by a simplification of the way neurons are connected in a brain. A characteristic of ANNs is that, after the ANN has been trained with datasets, any attempt to examine the internal structure of the ANN in order to understand why and how the ANN makes a particular decision is more or less impossible. Such systems are referred to as 'black boxes'.

Another problem is that of how to verify the system to confirm that it fulfils the specified design requirements. Current verification approaches typically assume that the system being verified will never change its behaviour, however systems based on machine learning—by definition—change their behaviour, so any verification is likely to be rendered invalid after the system has learned (Winfield and Jirotka, 2018).

The AI Now Institute at New York University, which researches the social impact of AI, recently released a report which urged public agencies responsible for criminal justice, healthcare, welfare and education to ban black box AIs because their decisions cannot be explained. The report also recommended that AIs should pass pre-release trials and be monitored 'in the wild' so that biases and other faults are swiftly corrected (AI Now Report, 2018).

In many cases, it may be possible to find out how an algorithm came to a particular decision without 'opening the AI black box'. Rather than exposing the full inner workings of an AI, researchers recently developed a way of working out what it would take to change their AI's decision (Wachter et al., 2018). Their method could explain why an AI turned down a person's mortgage application, for example, as it might reveal that the loan was denied because the person's income was £30,000, but would have been approved if it was £45,000. This would allow the decision to be challenged, and inform the person what they needed to address to get the loan.

Kroll (2018) argues that, contrary to the criticism that black-box software systems are inscrutable, algorithms are fundamentally understandable pieces of technology. He makes the point that inscrutability arises from the power dynamics surrounding software systems, rather than the technology itself, which is always built for a specific purpose, and can also always be understood in terms of design and operational goals, and inputs, outputs and outcomes. For example, while it is hard to tell why a particular ad was served to a particular person at a particular time, it is possible to do so, and to not do so is merely a design choice, not an inevitability of the complexity of large systems – systems must be designed so that they support analysis.

Kroll argues that it is possible to place too much focus on understanding the mechanics of a tool, when the real focus should be on how that tool is put to use and in what context.

Other issues and problems with transparency include the fact that software and data are proprietary works, which means it may not be in a company's best interest to divulge how they address a particular problem. Many companies view their software and algorithms as valuable trade secrets that are absolutely key to maintaining their position in a competitive market.

Transparency also conflicts with privacy, as people involved in training machine learning models may not want their data, or inferences about their data to be revealed. In addition, the lay public, or even regulators may not have the technological know-how to understand and assess algorithms.

Explainable systems

Some researchers have demanded that systems produce explanations of their behaviours (Selbst and Barocas 2018: Wachter et al., 2017; Selbst and Powles, 2017). However, that requires a decision about what must be explained, and to whom. Explanation is only useful if it includes the context behind how the tool is operated. The danger is that explanations focus on the mechanism of how the tool operates at the expense of contextualising that operation.

In many cases, it may be unnecessary to understand the precise mechanisms of an algorithmic system, just as we do not understand how humans make decisions. Similarly, while transparency is often taken to mean the disclosure of source code or data, we don't have to see the computer source code for a system to be transparent, as this would tell us little about its behaviour. Instead transparency must be about the external behaviour of algorithms. This is how we regulate the behaviour of humans — not by looking into their brain's neural circuitry, but by observing their behaviour and judging it against certain standards of conduct.

Explanation may not improve human trust in a computer system, as even incorrect answers would receive explanations that may seem plausible. Automation bias, the phenomenon in which humans become more likely to believe answers that originate from a machine (Cummings, 2004), could mean that such misleading explanations have considerable weight.

Intentional understanding

The simplest way to understand a piece of technology is to understand what it was designed to do, how it was designed to do that, and why it was designed in that particular way instead of some other way (Kroll, 2018). The best way of ensuring that a program does what you intend it to, and that there are no biases, or unintended consequences is through thorough validation, investigation and evaluation of the program during development. In other words, measuring the performance of a system during development in order to uncover bugs, biases and incorrect assumptions. Even carefully designed systems can miss important facts about the world, and it is important to verify that systems are operating as intended. This includes whether the model accurately measures what it is supposed to – a concept known as construct validity; and whether the data accurately reflects the real world

For example a machine learning model tasked with conducting credit checks could inadvertently learn that a borrower's quality of clothing correlates with their income and hence their creditworthiness. During development the software should be checked for such correlations, so that they can be rejected.

Algorithm auditors

Larsson et al. (2019) suggest a role for professional algorithm auditors, whose job would be to interrogate algorithms in order to ensure they comply with pre-set standards. One example would be an autonomous vehicle algorithm auditor, who could provide simulated traffic scenarios to ensure that the vehicle did not disproportionately increase the risk to pedestrians or cyclists relative to passengers.

AMSCE-101

Recently, researchers proposed a new class of algorithms, called oversight programs, whose function is to 'monitor, audit, and hold operational AI programs accountable' (Etzioni and Etzioni 2016). For example, one idea would be to have an algorithm that conducts real-time assessments of the amount of bias caused by a news filtering algorithm, raising an alarm if bias increases beyond a certain threshold.

2.6.4 Accountability

'How do decision-makers make sense of what decisions get made by AI technologies and how these decisions are different to those made by humans?... the point is that AI makes decisions differently from humans and sometimes we don't understand those differences; we don't know why or how it is making that decision.' (Jack Stilgoe)

Another method of ensuring trust of AI is through accountability. As discussed, accountability ensures that if an AI makes a mistake or harms someone, there is someone that can be held responsible, whether that be the designer, the developer or the corporation selling the AI. In the event of damages incurred, there must be a mechanism for redress so that victims can be sufficiently compensated.

A growing body of literature has begun to address concepts such as algorithmic accountability and responsible AI. Algorithmic accountability, according to Caplan et al. (2018), deals with the delegation of responsibility for damages incurred as a result of algorithmically based decisions producing discriminatory or unfair consequences. One area where accountability is likely to be important is the introduction of self-driving vehicles. In the event of an accident, who should be held accountable? A number of fatal accidents have already occurred with self-driving cars, for example in 2016, a Tesla Model S equipped with radar and cameras determined that a nearby lorry was in fact the sky, which resulted in a fatal accident. In March 2018, a car used by Uber in self-driving vehicle trials hit and killed a woman in Arizona, USA. Even if autonomous cars are safer than vehicles driven by humans, accidents like these undermine trust.

Regulation

One way of ensuring accountability is regulation. Winfield and Jirotka (2018) point out that technology is, in general, trusted if it brings benefits and is safe and well regulated. Their paper argues that one key element in building trust in AI is ethical governance – a set of processes, procedures, cultures and values designed to ensure the highest standards of behaviour. These standards of behaviour need to be adopted by individual designers and the organisations in which they work, so that ethical issues are dealt with as or before they arise in a principled manner, rather than waiting until a problem surfaces and dealing with it in an ad-hoc way.

They give the example of airliners, which are trusted because we know that they are part of a highly regulated industry with an outstanding safety record. The reason commercial aircraft are so safe is not just good design, it is also the tough safety certification processes, and the fact that when things do go wrong, there are robust and publicly visible processes of air accident investigation.

Winfield and Jirotka (2018) suggest that some robot types, driverless cars for instance, should be regulated through a body similar to the Civil Aviation Authority (CAA), with a driverless car equivalent of the Air Accident Investigation Branch.

When it comes to public perception of robots and advanced technology, regulation and management crops up as a prominent concern. In two surveys of citizens across the EU (European Commission 2012; European Commission, 2012), both showed that there was a generally positive view of robots and digitisation as long as this is implemented and managed carefully. In fact,

AMSCE-1101

between 88% and 91% of those surveyed declared that robots and advanced technology must be managed carefully, one of the strongest results in either survey — reflecting a strong concern and area of priority amongst EU citizens.

2.6.5 Control

Another issue which affects public trust of AI is control. Much of this relates to fears around the idea of 'Superintelligence' - that as artificial intelligence increases to the point that it surpasses human abilities, it may come to take control over our resources and outcompete our species, leading to human extinction. A related fear is that, even if an AI agent was carefully designed to have goals aligned with human needs, it might develop for itself unanticipated subgoals that are not. For example, Bryson (2019) gives the example of a chess-playing robot taught to improve its game. This robot inadvertently learns to shoot people that switch it off at night, depriving it of vital resources. However, while most researchers agree this threat is unlikely to occur, to maintain trust in AI, it is important that humans have ultimate oversight over this technology.

Human in the loop

One idea that has been suggested by researchers is that of always keeping a human-in-the-loop (HITL). Here a human operator would be a crucial component of the automated control process, supervising the robots. A simple form of HITL already in existence is the use of human workers to label data for training machine learning algorithms. For example when you mark an email as 'spam', you are one of many humans in the loop of a complex machine learning algorithm, helping it in its continuous quest to improve email classification as spam or non-spam.

However HITL can also be a powerful tool for regulating the behaviour of AI systems. For instance, many researchers argue that human operators should be able to monitor the behaviour of LAWS, or 'killer robots,' or credit scoring algorithms (Citron and Pasquale 2014). The presence of a human fulfils two major functions in a HITL AI system (Rahwan, 2018):

> 1. The human can identify misbehaviour by an otherwise autonomous system, and take corrective action. For instance, a credit scoring system may misclassify an adult as ineligible for credit because their age was incorrectly input—something a human may spot from the applicant's photograph. Similarly, a computer vision system on a weaponised drone may mis-identify a civilian as a combatant, and the human operator—it is hoped—would override the system.
>
> 2. Keeping humans in the loop would also provide accountability - if an autonomous system causes harm to human beings, having a human in the loop provides trust that somebody would bare the consequence of such mistakes. According to Rahwan (2018), until we find a way to punish algorithms for harm to humans, 'it is hard to think of any other alternative'.

However, although HITL is useful for building AI systems that are subject to oversight, it may not be enough. AI machines that make decisions with wider societal implications, such as algorithms that control millions of self-driving cars or news filtering algorithms that influence the political beliefs and preferences of millions of citizens, should be subject to oversight by society as a whole, requiring a 'society-in-the-loop' paradigm (Rahwan, 2018).

The big red button

As a way to address some of the threats of artificial intelligence, researchers have proposed ways to stop an AI system before it has a chance to escape outside control and cause harm. A so-called 'big red button', or 'kill switch' would enable human operators to interrupt or divert a system, while preventing the system from learning that such an intervention is a threat. However, some

AMSCE-101

commentators fear that a sufficiently advanced AI machine could anticipate this move and defend itself by learning to disable its own 'kill switch'.

The red button raises wider practical questions about shutting down AI systems in order to keep them safe. What is the best way to accomplish that, and for what specific kinds of AI systems?

Orseau and Armstrong (2016) recently published a paper about how to prevent AI programmed through reinforcement learning (RL) from seeing interruptions as a threat. For example, an algorithm trying to optimise its chess performance may learn to disable its off switch so that it can spend more time learning how to play chess. Or it may learn to harm people who tried to switch it off, etc. What the researchers propose is to steer certain variants of reinforcement learning away from learning to avoid or impede an interruption. In this way, the authors argue, a system can pursue an optimal policy that is also interruptible. By being 'safely interruptible,' the paper concludes, reinforcement learning will not undermine the means of responsible oversight and intervention.

Riedl and Harrison (2017) suggests making a 'big red button' that, once pressed, diverted the AI into a simulated world where it could pursue its reward functions without causing any harm. Alternatively another idea is to maintain system uncertainty about key reward functions, which would prevent AI from attaching value to disabling an off-switch (Hadfield-Menell et al., 2016).

However Arnold and Schultz (2018) argue that the 'red button' approach comes at the point when a system has already 'gone rogue' and seeks to obstruct interference, and that 'big red button' approaches focus on long-term threats, imagining systems considerably more advanced than exist today and neglecting the present day problems with keeping automated systems accountable. A better approach, according to Arnold and Scheutz, would be to make ongoing self-evaluation and testing an integral part of a system's operation, in order to diagnose how the system is performing, and correct any errors.

They argue that to achieve this AIs should contain an ethical core (EC) consisting of a scenario-generation mechanism and a simulation environment used to test a system's decisions in simulated worlds, rather than the real world. This EC would be kept hidden from the system itself, so that the system's algorithms would be prevented from learning about its operation and its function, and ultimately its presence. Through continual testing in the simulated world, the EC would monitor and check for deviant behaviour - providing a far more effective and vigilant response than an emergency button which one might not get to push in time.

AMSCE-IOL

3. Ethical initiatives in the field of artificial intelligence

As detailed in previous sections, there are myriad ethical considerations accompanying the development, use and effects of artificial intelligence (AI). These range from the potential effects AI could have on the fundamental human rights of citizens within a society to the security and utilisation of gathered data; from the bias and discrimination unintentionally embedded into an AI by a homogenous group of developers, to a lack of public awareness and understanding about the consequences of their choices and usage of any given AI, leading to ill-informed decisions and subsequent harm.

AI builds upon previous revolutions in ICT and computing and, as such, will face a number of similar ethical problems. While technology may be used for good, potentially it may be misused. We may excessively anthropomorphise and humanise AI, blurring the lines between human and machine. The ongoing development of AI will bring about a new 'digital divide', with technology benefiting some socioeconomic and geographic groups more than others. Further, AI will have an impact on our biosphere and environment that is yet to be qualified (Veruggio and Operto, 2006).

3.1. International ethical initiatives

While official regulation remains scarce, many independent initiatives have been launched internationally to explore these – and other – ethical quandaries. The initiatives explored in this section are outlined in Table 3.1 and will be studied in light of the associated harms and concerns they aim to understand and mitigate.

AMSCE-1101

Table 1: Ethical initiatives and harms addressed

Initiative	Location	Key issues tackled	Publications	Sources of funding
The Institute for Ethics in Artificial Intelligence	Germany	Human-centric engineering and a focus on the cultural and social anchoring of rapid advances in AI, covering disciplines including philosophy, ethics, sociology, and political science.		Initial (2019) funding grant from Facebook ($7.5 million over five years).
The Institute for Ethical AI & Machine Learning	United Kingdom	The Institute aims to empower all from individuals to entire nations to develop AI, based on eight principles for responsible machine learning: these concern the maintenance of human control, appropriate redress for AI impact, evaluation of bias, explicability, transparency, reproducibility, mitigation of the effect of AI automation on workers, accuracy, cost, privacy, trust, and security.		unknown
The Institute for Ethical Artificial Intelligence in Education	United Kingdom	The potential threats to young people and education of the rapid growth of new AI technology, and ensuring the ethical development of AI-led EdTech.		unknown
The Future of Life Institute	United States	Ensuring that the development of AI is beneficial to humankind, with a focus on safety and existential risk: autonomous weapons arms race, human control of AI, and the potential dangers of advanced 'general/strong' or super-intelligent AI.	'***Asilomar AI Principles***'	Private. Top donors: Elon Musk (SpaceX and Tesla), Jaan Tallinn (Skype), Matt Wage (financial trader), Nisan Stiennon (software engineer), Sam Harris, George Godula (tech entrepreneur), and Jacob Trefethen (Harvard).
The Association for Computing Machinery	United States	The transparency, usability, security, accessibility, accountability, and digital inclusiveness of computers and networks, in terms of research, development, and implementation.	Statements on: algorithmic transparency and accountability (January 2017), computing and network security (May 2017), the Internet of Things (June 2017), accessibility, usability, and digital inclusiveness (September 2017),	unknown

AMSCE-101

			and mandatory access to information infrastructure for law enforcement (April 2018).	
The Japanese Society for Artificial Intelligence (JSAI)	Japan	To ensure that AI R&D remains beneficial to human society, and that development and research is conducted ethically and morally.	'***Ethical Guidelines***'	unknown
AI4All	United States	Diversity and inclusion in AI, to expose underrepresented groups to AI for social good and humanity's benefit.		Google
The Future Society	United States	The impact and governance of artificial intelligence to broadly benefit society, spanning policy research, advisory and collective intelligence, coordination of governance, law, and education.	'***Draft Principles for the Governance of AI'*** Published October 2017 (later published on their website on 7th February 2019),	unknown
The AI Now Institute	United States	The social implications of AI, especially in the areas of: Rights and liberties, labour and automation, bias and inclusion, and safety and critical infrastructure.		Various organisations, including Luminate, the MacArthur Foundation, Microsoft Research, Google, the Ford Foundation, DeepMind Ethics & Society, and the Ethics & Governance of AI Initiative.
The Institute of Electrical and Electronics Engineers (IEEE)	United States	Societal and policy guidelines to keep AI and intelligent systems human-centric, and serving humanity's values and principles. Focuses on ensuring that all stakeholders – across design and development – are educated, trained, and empowered to prioritise the ethical considerations of human rights, well-being, accountability, transparency, and awareness of misuse.	'***Ethically Aligned Design'* First Edition** (March 2019)	
The Partnership on AI	United States	Best practices on AI technologies: Safety, fairness, accountability, transparency, labour and the economy, collaboration between people and systems, social and societal influences, and social good.		The Partnership was formed by a group of AI researchers representing six of the world's largest tech companies: Apple,

AMSCE1101

				Amazon, DeepMind and Google, Facebook, IBM, and Microsoft.
The Foundation for Responsible Robotics	The Netherlands	Responsible robotics (in terms of design, development, use, regulation, and implementation). Proactively taking stock of the issues that accompany technological innovation, and the impact these will have on societal values such as safety, security, privacy, and well-being.		unknown
AI4People	Belgium	The social impacts of AI, and the founding principles, policies, and practices upon which to build a 'good AI society'.	'***Ethical Framework for a Good AI Society***'	Atomium— European Institute for Science, Media and Democracy. Some funding was provided to the project's Scientific Committee Chair from the Engineering and Physical Sciences Research Council.
The Ethics and Governance of Artificial Intelligence Initiative	United States	Seeks to ensure that technologies of automation and machine learning are researched, developed, and deployed in a way which vindicate social values of fairness, human autonomy, and justice.		The Harvard Berkman Klein Center and the MIT Media Lab. Supported by The Miami Foundation (fiscal sponsorship), Knight Foundation, Luminate, Red Hoffman, and the William and Flora Hewlett Foundation.
Saidot: Enabling responsible AI ecosystems	Finland	Helping companies, governments, and organisations develop and deploy responsible AI ecosystems, to deliver transparent, accountable, trustworthy AI services. Enabling organisations to develop human-centric AI, with a focus on increasing the levels of trust and accountability in AI ecosystems. The platform offers software and algorithmic systems that can 'validate [an] intelligence system's trustworthiness' (Saidot, 2019)		
euRobotics	Europe	Maintaining and extending European talent and progress in robotics – AI industrialisation and economic impact.		European Commission

AMSCE-1101

The Centre for Data Ethics and Innovation	UK	Identifying and plugging gaps in our regulatory landscape, AI use of data, and maximising the benefits of AI to society.		UK Government
Special Interest Group on Artificial Intelligence (SIGAI), The Association for Computing Machinery	United States	. Promoting and supporting the growth and application of AI principles and techniques throughout computing, and promoting AI education and publications through various forums		The Association for Computing Machinery
	Other key international developments: current and historical			
The Montréal Declaration	Canada	The socially responsible development of AI, bringing together 400 participants across all sectors of society to identify the ethical and moral challenges in the short and long term. Key values: well-being, autonomy, justice, privacy, knowledge, democracy, and accountability.		Université de Montréal with the support of the Fonds de recherche en santé du Québec and the Palais des congrès de Montréal.
The UNI Global Union	Switzerland	Worker disruption and transparency in the application of AI, robotics, and data and machine learning in the workplace. Safeguarding workers' interests and maintaining human control and a healthy power balance.	'***Top 10 Principles for Ethical AI***'	unknown
The European Robotics Research Network (EURON)	Europe (Coordinator based in Sweden)	Research co-ordination, education and training, publishing and meetings, industrial links and international links in robotics.	'***Roboethics Roadmap***'	European Commission (2000-2004)
The European Robotics Platform (EUROP)	Europe	Bringing European robotics and AI community together. Industry-driven, focus on competitiveness and innovation.		European Commission

AMSCL-1101

3.2. Ethical harms and concerns tackled by these initiatives

All of the initiatives listed above agree that AI should be researched, developed, designed, deployed, monitored, and used in an ethical manner – but each has different areas of priority. This section will include analysis and grouping of the initiatives above, by type of issues they aim to address, and then outline some of the proposed approaches and solutions to protect from harms.

A number of key issues emerge from the initiatives, which **can be broadly split into the following categories:**

1. Human rights and well-being
   Is AI in the best interests of humanity and human well-being?

2. Emotional harm
   Will AI degrade the integrity of the human emotional experience, or facilitate emotional or mental harm?

3. Accountability and responsibility
   Who is responsible for AI, and who will be held accountable for its actions?

4. Security, privacy, accessibility, and transparency
   How do we balance accessibility and transparency with privacy and security, especially when it comes to data and personalisation?

5. Safety and trust
   What if AI is deemed untrustworthy by the public, or acts in ways that threaten the safety of either itself or others?

6. Social harm and social justice
   How do we ensure that AI is inclusive, free of bias and discrimination, and aligned with public morals and ethics?

7. Financial harm
   How will we control for AI that negatively affects economic opportunity and employment, and either takes jobs from human workers or decreases the opportunity and quality of these jobs?

8. Lawfulness and justice
   How do we go about ensuring that AI - and the data it collects - is used, processed, and managed in a way that is just, equitable, and lawful, and subject to appropriate governance and regulation? What would such regulation look like? Should AI be granted 'personhood'?

9. Control and the ethical use – or misuse – of AI
   How might AI be used unethically - and how can we protect against this? How do we ensure that AI remains under complete human control, even as it develops and 'learns'?

10. Environmental harm and sustainability
    How do we protect against the potential environmental harm associated with the development and use of AI? How do we produce it in a sustainable way?

11. Informed use
    What must we do to ensure that the public is aware, educated, and informed about their use of

AMSCE-1101

and interaction with AI?

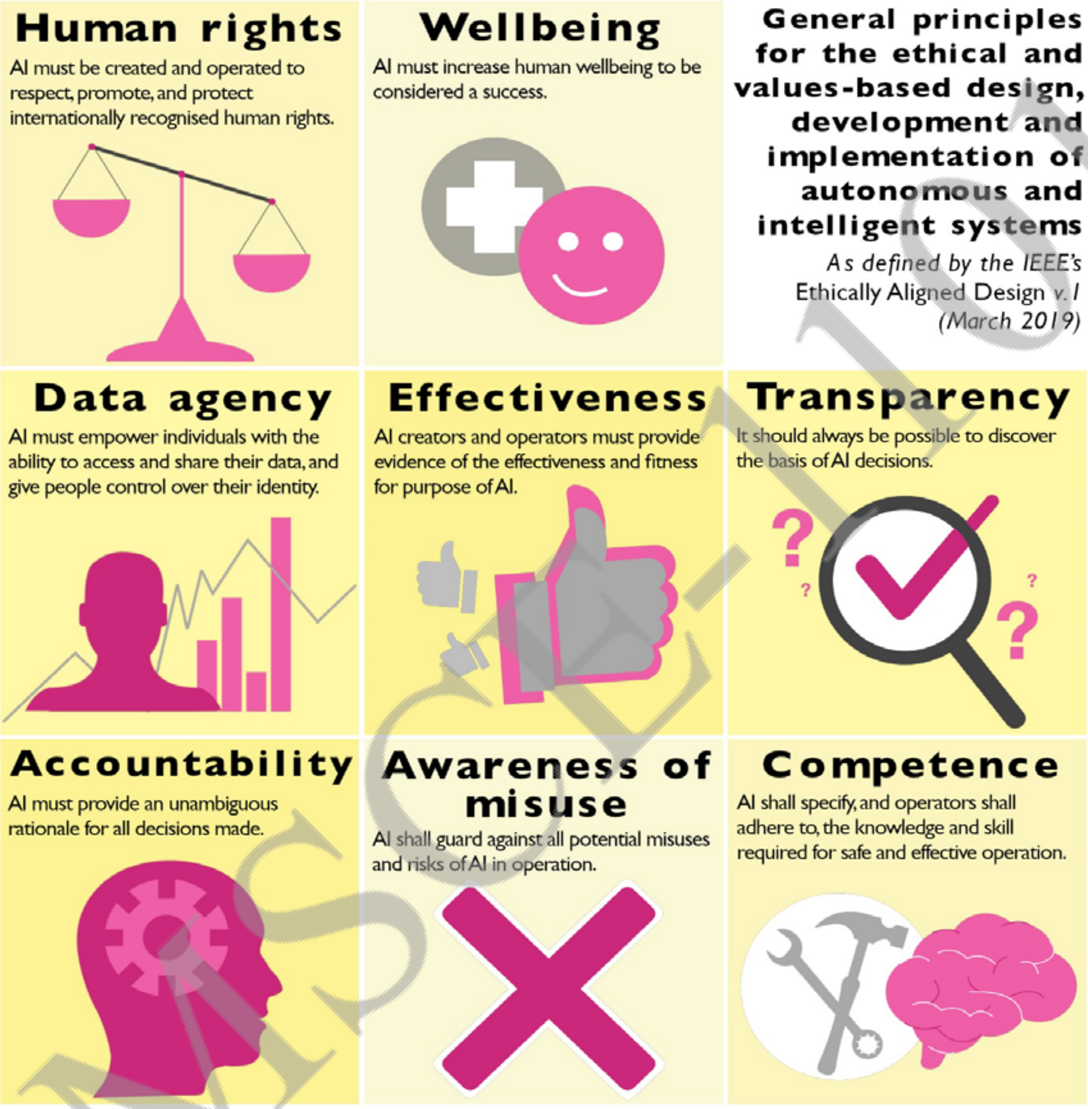
12. Existential risk
    How do we avoid an AI arms race, pre-emptively mitigate and regulate potential harm, and ensure that advanced machine learning is both progressive and manageable?

Overall, these initiatives all aim to identify and form ethical frameworks and systems that establish human beneficence at the highest levels, prioritise benefit to both human society and the environment (without these two goals being placed at odds), and mitigate the risks and negative impacts associated with AI — with a focus on ensuring that AI is accountable and transparent (IEEE, 2019).

The IEEE's '***Ethically Aligned Design: A Vision for Prioritising Human Well-being with Autonomous and Intelligent Systems***' (v1; 2019) is one of the most substantial documents published to date on the ethical issues that AI may raise — and the various proposed means of mitigating these.

AMSCE-110

Figure 2: General principles for the ethical and values-based design, development, and implementation of autonomous and intelligent systems (as defined by the IEEE's *Ethically Aligned Design* First Edition March 2019)



Human rights

AI must be created and operated to respect, promote, and protect internationally recognised human rights.

Wellbeing

AI must increase human wellbeing to be considered a success.

General principles for the ethical and values-based design, development and implementation of autonomous and intelligent systems

As defined by the IEEE's Ethically Aligned Design v. I *(March 2019)*

Data agency

AI must empower individuals with the ability to access and share their data, and give people control over their identity.

Effectiveness

AI creators and operators must provide evidence of the effectiveness and fitness for purpose of AI.

Transparency

It should always be possible to discover the basis of AI decisions.

Accountability

AI must provide an unambiguous rationale for all decisions made.

Awareness of misuse

AI shall guard against all potential misuses and risks of AI in operation.

Competence

AI shall specify, and operators shall adhere to, the knowledge and skill required for safe and effective operation.

Areas of key impact comprise sustainable development; personal data rights and agency over digital identity; legal frameworks for accountability; and policies for education and awareness. They fall under **the three pillars of the Ethically Aligned Design conceptual framework:** Universal human values; political self-determination and data agency; and technical dependability.

3.2.1 Harms in detail

Taking each of these harms in turn, this section explores how they are being conceptualised by initiatives and some of the challenges that remain.

Human rights and well-being

All initiatives adhere to the view that ***AI must not impinge on basic and fundamental human rights***, such as human dignity, security, privacy, freedom of expression and information, protection of personal data, equality, solidarity and justice (European Parliament, Council and Commission, 2012).

How do we ensure that AI upholds such fundamental human rights and prioritises human well-being? Or that AI does not disproportionately affect vulnerable areas of society, such as children, those with disabilities, or the elderly, or reduce quality of life across society?

In order to ensure that human rights are protected, the IEEE recommends new governance frameworks, standards, and regulatory bodies which oversee the use of AI; translating existing legal obligations into informed policy, allowing for cultural norms and legal frameworks; and always maintaining complete human control over AI, without granting them rights or privileges equal to those of humans (IEEE, 2019). To safeguard human well-being, defined as 'human satisfaction with life and the conditions of life, as well as an appropriate balance between positive and negative affect' (*ibid*), the IEEE suggest prioritising human well-being throughout the design phase, and using the best and most widely-accepted available metrics to clearly measure the societal success of an AI.

There are crossovers with accountability and transparency: there must always be appropriate ways to identify and trace the impingement of rights, and to offer appropriate redress and reform. Personal data are also a key issue here; AI collect all manner of personal data, and users must retain the access to, and control of, their data, to ensure that their fundamental rights are being lawfully upheld (IEEE, 2019).

According to the ***Foundation for Responsible Robotics***, AI must be ethically developed with human rights in mind to achieve their goal of 'responsible robotics', which relies upon proactive innovation to uphold societal values like safety, security, privacy, and well-being. The Foundation engages with policymakers, organises and hosts events, publishes consultation documents to educate policymakers and the public, and creates public-private collaborations to bridge the gap between industry and consumers, to create greater transparency. It calls for ethical decision-making right from the research and development phase, greater consumer education, and responsible law- and policymaking – made before AI is released and put into use.

The ***Future of Life Institute*** defines a number of principles, ethics, and values for consideration in the development of AI, including the need to design and operate AI in a way that is compatible with the ideals of human dignity, rights, freedoms, and cultural diversity[7]. This is echoed by the ***Japanese Society for AI Ethical Guidelines***, which places the utmost importance on AI being realised in a way that is beneficial to humanity, and in line with the ethics, conscience, and competence of both its researchers and society as a whole. AI must contribute to the peace, safety, welfare, and public interest of society, says the Society, and protect human rights.

The Future Society's Law and Society Initiative emphasises that human beings are equal in rights, dignity, and freedom to flourish, and are entitled to their human rights.[8] With this in mind, to what extent should we delegate to machines decisions that affect people? For example, could AI 'judges' in the legal profession be more efficient, equitable, uniform, and cost-saving than human ones –

AMSCE-IOT

[7] https://futureoflife.org/ai-principles/

[8] http://thefuturesociety.org/law-and-society-initiative

and even if they were, would this be an appropriate way to deploy AI? ***The Montréal Declaration***[9] aims to clarify this somewhat, by pulling together an ethical framework that promotes internationally recognised human rights in fields affected by the rollout of AI: 'The principles of the current declaration rest on the common belief that human beings seek to grow as social beings endowed with sensations, thoughts and feelings, and strive to fulfil their potential by freely exercising their emotional, moral and intellectual capacities.' In other words, AI must not only not disrupt human well-being, but it must also proactively encourage and support it to improve and grow.

Some approach AI from a more specific viewpoint – such as the ***UNI Global Union***, which strives to protect an individual's right to work. Over half of the work currently done by people could be done faster and more efficiently in an automated way, says the Union. This identifies a prominent harm that AI may cause in the realm of human employment. The Union states that we must ensure that AI serves people and the planet, and both protects and increases fundamental human rights, human dignity, integrity, freedom, privacy, and cultural and gender diversity[10].

Emotional harm

What is it to be human? AI will interact with and have an impact on the human emotional experience in ways that have not yet been qualified; humans are susceptible to emotional influence both positively and negatively, and ***'affect' – how emotion and desire influence behaviour – is a core part of intelligence***. Affect varies across cultures, and, given different cultural sensitivities and ways of interacting, affective and influential AI could begin to influence how people view society itself. The ***IEEE*** recommend various ways to mitigate this risk, including the ability to adapt and update AI norms and values according to who they are engaging with, and the sensitivities of the culture in which they are operating.

There are various ways in which AI could inflict emotional harm, including false intimacy, over-attachment, objectification and commodification of the body, and social or sexual isolation. These are covered by various of the aforementioned ethical initiatives, including **the Foundation for Responsible Robotics, Partnership on AI, the AI Now** institute (especially regarding affect computing), **the Montréal Declaration**, and the **European Robotics Research Network (EURON) Roadmap** (for example, their section on the risks of humanoids).

These possible harms come to the fore when considering the development of an intimate relationship with an AI, for example in the sex industry. Intimate systems, as the ***IEEE*** call them, must not contribute to sexism, racial inequality, or negative body image stereotypes; must be for positive and therapeutic use; must avoid sexual or psychological manipulation of users without consent; should not be designed in a way that contributes to user isolation from human companionship; must be designed in a way that is transparent about the effect they may have on human relationship dynamics and jealousy; must not foster deviant or criminal behaviour, or normalise illegal sexual practices such as paedophilia or rape; and must not be marketed commercially as a person (in a legal sense or otherwise).

Affective AI is also open to the possibility of deceiving and coercing its users – researchers have defined the act of AI subtly modifying behaviour as '***nudging***', when an AI emotionally manipulates and influences its user through the affective system. While this may be useful in some ways – drug dependency, healthy eating – it could also trigger behaviours that worsen human health. Systematic analyses must examine the ethics of affective design prior to deployment; users must be educated on how to recognise and distinguish between nudges; users must have an opt-in system for autonomous nudging systems; and vulnerable populations that cannot give informed consent, such

[9] https://www.montrealdeclaration-responsibleai.com/the-declaration
[10] http://www.thefutureworldofwork.org/media/35420/uni_ethical_ai.pdf

as children, must be subject to additional protection. In general, stakeholders must discuss the question of whether or not the nudging design pathway for AI, which lends itself well to selfish or detrimental uses, is an ethical one to pursue (IEEE, 2019).

As raised by the ***IEEE*** (2019), nudging may be used by governments and other entities to influence public behaviour. Would it be ethically appropriate for a robot to use nudging to encourage, for example, charitable behaviour or donations? We must pursue full transparency regarding the beneficiaries of such behaviour, say the IEEE, due to the potential for misuse.

Other issues include technology addiction and emotional harm due to societal or gender bias.

Accountability and responsibility

The vast majority of initiatives mandate that AI must be ***auditable***, in order to assure that the designers, manufacturers, owners, and operators of AI are held accountable for the technology or system's actions, and are thus considered responsible for any potential harm it might cause. According to the ***IEEE***, this could be achieved by the courts clarifying issues of culpability and liability during the development and deployment phases where possible, so that those involved understand their obligations and rights; by designers and developers taking into account the diversity of existing cultural norms among various user groups; by establishing multi-stakeholder ecosystems to create norms that currently do not exist, given that AI-oriented technology is too new; and by creating registration and record-keeping systems so that it is always possible to trace who is legally responsible for a particular AI.

Sex and Robots

In July of 2017, the ***Foundation for Responsible Robotics*** published a report on 'Our Sexual Future with Robots' (Foundation for Responsible Robotics, 2019). This aimed to present an objective summary of the various issues and opinions surrounding our intimate association with technology. Many countries are developing robots for sexual gratification; these largely tend to be pornographic representations of the human body – and are mostly female. These representations, when accompanied by human anthropomorphism, may cause robots to be perceived as somewhere between living and inanimate, especially when sexual gratification is combined with elements of intimacy, companionship and conversation. Robots may also affect societal perceptions of gender or body stereotypes, erode human connection and intimacy and lead to greater social isolation. However, there is also some potential for robots to be of emotional sexual benefit to humans, for example by helping to reduce sex crime, and to rehabilitate victims of rape or sexual abuse via inclusion in healing therapies.

The ***Future of Life Institute*** tackles the issue of accountability via its **Asilomar Principles**, a list of 23 guiding principles for AI to follow in order to be ethical in the short and long term. Designers and builders of advanced AI systems are 'stakeholders in the moral implications of their use, misuse, and actions, with a responsibility and opportunity to shape those implications' (FLI, 2017); if an AI should make a mistake, it should also be possible to ascertain why. The ***Partnership on AI*** also stresses the importance of accountability in terms of bias. We should be sensitive to the fact that assumptions and biases exist within data and thus within systems built from these data, and strive not to replicate them – i.e. to be actively accountable for building fair, bias-free AI.

All other initiatives highlight the importance of accountability and responsibility – both by designers and AI engineers, and by regulation, law and society on a larger scale.

Access and transparency vs. security and privacy

A main concern over AI is its ***transparency***, explicability, security, reproducibility, and interpretability: is it possible to discover why and how a system made a specific decision, or why and how a robot acted in the way it did? This is especially pressing in the case of *safety-critical* systems that may have direct consequences for physical harm: driverless cars, for example, or medical diagnosis systems. Without transparency, users may struggle to understand the systems they are using – and their associated consequences – and it will be difficult to hold the relevant persons accountable and responsible.

To address this, the ***IEEE*** propose developing new standards that detail measurable and testable levels of transparency, so systems can be objectively assessed for their compliance. This will likely take different forms for different stakeholders; a robot user may require a 'why-did-you-do-that' button, while a certification agency or accident investigator will require access to relevant algorithms in the form of an 'ethical black box' which provides failure transparency (IEEE, 2019).

Autonomy and agent vs. patient

The current approach to AI is undeniably anthropocentric. This raises **possible issues around the distinction between moral agents and moral patients, between artificial and natural, between self-organising and not**. AI cannot become autonomous in the same way that living beings are considered autonomous (IEEE, 2019), but how do we define autonomy in terms of AI? Machine autonomy designates how machines act and operate according to regulation, but any attempts to implant emotion and morality into AI 'blur the distinction between agents and patients and may encourage anthropomorphic expectations of machines', writes the ***IEEE*** — especially as embodied AI begins to look increasingly similar to humans. Establishing a usable distinction between human and system/machine autonomy involves questions of free will, being/becoming and predetermination. It is clear that further discussion is needed to clarify what 'autonomy' may mean in terms of artificial intelligence and systems.

AI require data to continually learn and develop their automatic decision-making. These data are personal and may be used to identify a particular individual's physical, digital, or virtual identity (i.e. personally identifiable information, PII). 'As a result,' write the IEEE (2017), 'through every digital transaction (explicit or observed) humans are generating a unique digital shadow of their physical self'. To what extent can humans realise the right to keep certain information private, or have input into how these data are used? Individuals may lack the appropriate tools to control and cultivate their unique identity and manage the associated ethical implications of the use of their data. Without clarity and education, many users of AI will remain unaware of the digital footprint they are creating, and the information they are putting out into the world. Systems must be put in place for users to control, interact with and access their data, and give them agency over their digital personas.

PII has been established as the asset of the individual (by Regulation (EU) 2016/679 in Europe, for example), and systems must ask for explicit consent at the time data are collected and used, in order to protect individual autonomy, dignity and right to consent. The IEEE mention the possibility of a personalised 'privacy AI or algorithmic agent or guardian' to help individuals curate and control their personal data and foresee and mitigate potential ethical implications of machine learning data exchange.

The ***Future of Life Institute's Asilomar Principles*** agree with the IEEE on the importance of transparency and privacy across various aspects: failure transparency (if an AI fails, it must be possible to figure out why), judicial transparency (any AI involved in judicial decision-making must provide a satisfactory explanation to a human), personal privacy (people must have the right to access, manage, and control the data AI gather and create), and liberty and privacy (AI must not unreasonably curtail people's real or perceived liberties). ***Saidot*** takes a slightly wider approach and strongly emphasises the importance of AI that are transparent, accountable, and trustworthy, where people, organisations, and smart systems are openly connected and collaborative in order to foster cooperation, progress, and innovation.

All of the initiatives surveyed identify transparency and accountability of AI as an important issue. This balance underpins many other concerns – such as legal and judicial fairness, worker compensation and rights, security of data and systems, public trust, and social harm.

Safety and trust

An 'ethical black box'

Initiatives including the ***UNI Global Union*** and ***IEEE*** suggest equipping AI systems with an 'ethical black box': a device that can record information about said system to ensure its accountability and transparency, but that also includes clear data on the ethical consideration built into the system from the beginning (UNI Global Union, n.d.).

Where AI is used to supplement or replace human decision-making, there is consensus that it must be ***safe, trustworthy, and reliable, and act with integrity***.

The ***IEEE*** propose cultivating a 'safety mindset' among researchers, to 'identify and pre-empt unintended and unanticipated behaviors in their systems' and to develop systems which are 'safe by design'; setting up review boards at institutions as a resource and means of evaluating projects and their progress; encouraging a community of sharing, to spread the word on safety-related developments, research, and tools. The ***Future of Life Institute's Asilomar principles*** indicate that all involved in developing and deploying AI should be mission-led, adopting the norm that AI 'should only be developed in the service of widely shared ethical ideals, and for the benefit of all humanity rather than one state or organisation' (Future of Life Institute, 2017). This approach would build public trust in AI, something that is key to its successful integration into society.

The Japanese Society for AI proposes that AI should act with integrity at all times, and that AI and society should earnestly seek to learn from and communicate with one another. 'Consistent and effective communication' will strengthen mutual understanding, says the Society, and '[contribute] to the overall peace and happiness of mankind' (JSAI, 2017). The ***Partnership on AI*** agrees, and strives to ensure AI is trustworthy and to create a culture of cooperation, trust, and openness among AI scientists and engineers. The ***Institute for Ethical AI & Machine Learning*** also emphasises the importance of dialogue; it ties together the issues of trust and privacy in its eight core tenets, mandating that AI technologists communicate with stakeholders about the processes and data involved to build trust and spread understanding throughout society.

Social harm and social justice: inclusivity, bias, and discrimination

AI development requires ***a diversity of viewpoints***. There are several organisations establishing that these must be in line with community viewpoints and align with social norms, values, ethics, and preferences, that biases and assumptions must not be built into data or systems, and that AI should be aligned with public values, goals, and behaviours, respecting cultural diversity. Initiatives also argue that all should have access to the benefits of AI, and it should work for the common good. In other words, developers and implementers of AI have a social responsibility to embed the right values into AI and ensure that they do not cause or exacerbate any existing or future harm to any part of society.

The ***IEEE*** suggest first identifying social and moral norms of the specific community in which an AI will be deployed, and those around the specific task or service it will offer; designing AI with the idea of 'norm updating' in mind, given that norms are not static and AI must change dynamically and transparently alongside culture; and identifying the ways in which people resolve norm conflicts, and equipping AI with a system in which to do so in a similar and transparent way. This should be done collaboratively and across diverse research efforts, with care taken to evaluate and assess potential biases that disadvantage specific social groups.

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Several initiatives – such as ***AI4All*** and the ***AI Now Institute*** – explicitly advocate for fair, diverse, equitable, and non-discriminatory inclusion in AI at all stages, with a focus on support for under-represented groups. Currently, AI-related degree programmes do not equip aspiring developers and designers with an appropriate knowledge of ethics (IEEE, 2017), and corporate environments and business practices are not ethically empowering, with a lack of roles for senior ethicists that can steer and support value-based innovation.

On a global scale, the inequality gap between developed and developing nations is significant. While AI may have considerable usefulness in a humanitarian sense, they must not widen this gap or exacerbate poverty, illiteracy, gender and ethnic inequality, or disproportionately disrupt employment and labour. The IEEE suggests taking action and investing to mitigate the inequality gap; integrating corporate social responsibility (CSR) into development and marketing; developing transparent power structures; facilitating and sharing robotics and AI knowledge and research; and generally keeping AI in line with the US Sustainable Development Goals[11]. AI technology should be made equally available worldwide via global standardisation and open-source software, and interdisciplinary discussion should be held on effective AI education and training (IEEE, 2019).

A set of ethical guidelines published by the ***Japanese Society for AI*** emphasises, among other considerations, the importance of a) contribution to humanity, and b) social responsibility. AI must act in the public interest, respect cultural diversity, and always be used in a fair and equal manner.

The ***Foundation for Responsible Robotics*** includes a Commitment to Diversity in its push for responsible AI; the ***Partnership on AI*** cautions about the 'serious blind spots' of ignoring the presence of biases and assumptions hidden within data; ***Saidot*** aims to ensure that, although our social values are now 'increasingly mediated by algorithms', AI remains human-centric (Saidot, 2019); the ***Future of Life Institute*** highlights a need for AI imbued with human values of cultural diversity and human rights; and the ***Institute for Ethical AI & Machine Learning*** includes 'bias evaluation' for monitoring bias in AI development and production. The dangers of human bias and assumption are a frequently identified risk that will accompany the ongoing development of AI.

Financial harm: Economic opportunity and employment

AI may disrupt the economy and lead to loss of jobs or work disruption for many humans, and will have an impact on workers' rights and displacement strategy as many strains of work become automated (and vanish in related business change).

Additionally, rather than just focusing on the number of jobs lost or gained, traditional employment structures will need to be changed to mitigate the effects of automation and take into account the complexities of employment. Technological change is happening too fast for the traditional workforce to keep pace without retraining. Workers must train for adaptability, says the ***IEEE*** (2019), and new skill sets, with fallback strategies put in place for those who cannot be re-trained, and training programmes implemented at the level of high school or earlier to increase access to future employment. The ***UNI Global Union*** call for multi-stakeholder ethical AI governance bodies on global and regional levels, bringing together designers, manufacturers, developers, researchers, trade unions, lawyers, CSOs, owners, and employers. AI must benefit and empower people broadly and equally, with policies put in place to bridge the economic, technological, and social digital divides, and ensure a just transition with support for fundamental freedoms and rights.

The AI Now Institute works with diverse stakeholder groups to better understand the implications that AI will have for labour and work, including automation and early-stage integration of AI changing the nature of employment and working conditions in various sectors. ***The Future Society*** specifically asks how AI will affect the legal profession: 'If AI systems are demonstrably superior to

[11] https://sustainabledevelopment.un.org/?menu=1300

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human attorneys at certain aspects of legal work, what are the ethical and professional implications for the practice of law?' (Future Society, 2019)

AI in the workplace will affect far more than workers' finances, and may offer various positive opportunities. As laid out by the **IEEE** (2019), AI may offer potential solutions to workplace bias – if it is developed with this in mind, as mentioned above – and reveal deficiencies in product development, allowing proactive improvement in the design phase (as opposed to retroactive improvement).

'*RRI is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society).*' (Von Schomberg, 2013)

Responsible research and innovation (RRI)

RRI is a growing area, especially in the EU, that draws from classical ethics to provide tools with which to address ethical concerns from the very outset of a project. When incorporated into a project's design phase, RRI increases the chances of design being both relevant and strong in terms of ethical alignment. Many research funders and organisations include RRI in their mission statements and within their research and innovation efforts (IEEE, 2019).

Lawfulness and justice

Several initiatives address the need for AI to be lawful, equitable, fair, just and subject to appropriate, pre-emptive governance and regulation. The many complex ethical problems surrounding AI translate directly and indirectly into discrete legal challenges. How should AI be labelled: as a product? An animal? A person? Something new?

The ***IEEE*** conclude that AI should not be granted any level of 'personhood', and that, while development, design and distribution of AI should fully comply with all applicable international and domestic law, there is much work to be done in defining and implementing the relevant legislation. Legal issues fall into a few categories: legal status, governmental use (transparency, individual rights), legal accountability for harm, and transparency, accountability, and verifiability. The IEEE suggest that AI should remain subject to the applicable regimes of property law; that stakeholders should identify the types of decisions that should never be delegated to AI, and ensure effective human control over those decisions via rules and standards; that existing laws should be scrutinised and reviewed for mechanisms that could practically give AI legal autonomy; and that manufacturers and operators should be required to comply with the applicable laws of all jurisdictions in which an AI could operate. They also recommend that governments reassess the legal status for AI as they become more sophisticated, and work closely with regulators, societal and industry actors and other stakeholders to ensure that the interests of humanity – and not the development of systems themselves – remain the guiding principle.

Control and the ethical use – or misuse – of AI

With more sophisticated and complex new AI come more sophisticated and complex possibilities for misuse. Personal data may be used maliciously or for profit, systems are at risk of hacking, and technology may be used exploitatively. This ties into informed use and public awareness: as we enter a new age of AI, with new systems and technology emerging that have never before been implemented, citizens must be kept up to date of the risks that may come with either the use or misuse of these.

AMSCE-101

The ***IEEE*** suggests new ways of educating the public on ethics and security issues, for example a 'data privacy' warning on smart devices that collect personal data; delivering this education in scalable, effective ways; and educating government, lawmakers, and enforcement agencies surrounding these issues, so they can work collaboratively with citizens – in a similar way to police officers providing safety lectures in schools – and avoid fear and confusion (IEEE, 2019).

Other issues include manipulation of behaviour and data. Humans must retain control over AI and oppose subversion. Most initiatives reviewed flag this as a potential issue facing AI as it develops, and flag that AI must behave in a way that is predictable and reliable, with appropriate means for redress, and be subject to validation and testing. AI must also work for the good of humankind, must not exploit people, and be regularly reviewed by human experts.

Personhood and AI

The issue of whether or not an AI deserves 'personhood' ties into debates surrounding accountability, autonomy, and responsibility: is it the AI itself that is responsible for its actions and consequences, or the person(s) who built them?

This concept, rather than allowing robots to be considered people in a human sense, would place robots on the same legal level as corporations. It is worth noting that corporations' legal personhood can currently shield the natural persons behind them from the implications of the law. However, ***The UNI Global Union*** asserts that legal responsibility lies with the creator, not the robot itself, and calls for a ban on attributing responsibility to robots.

Environmental harm and sustainability

The production, management, and implementation of AI must be sustainable and avoid environmental harm. This also ties in to the concept of well-being; a key recognised aspect of well-being is environmental, concerning the air, biodiversity, climate change, soil and water quality, and so on (IEEE, 2019). The ***IEEE*** (EAD, 2019) state that AI must do no harm to Earth's natural systems or exacerbate their degradation, and contribute to realising sustainable stewardship, preservation, and/or the restoration of Earth's natural systems. The ***UNI Global Union*** state that AI must put people and the planet first, striving to protect and even enhance our planet's biodiversity and ecosystems (UNI Global Union, n.d.). The ***Foundation for Responsible Robotics*** identifies a number of potential uses for AI in coming years, from agricultural and farming roles to monitoring of climate change and protection of endangered species. These require responsible, informed policies to govern AI and robotics, say the Foundation, to mitigate risk and support ongoing innovation and development.

Informed use: public education and awareness

Members of the public must be educated on the use, misuse, and potential harms of AI, via civic participation, communication, and dialogue with the public. The issue of consent – and how much an individual may reasonably and knowingly give – is core to this. For example, the ***IEEE*** raise several instances in which consent is less clear-cut than might be ethical: what if one's personal data are used to make inferences they are uncomfortable with or unaware of? Can consent be given when a system does not directly interact with an individual? This latter issue has been named the 'Internet of Other People's Things' (IEEE, 2019). Corporate environments also raise the issue of power imbalance; many employees do not have clear consent on how their personal data – including those on health – is used by their employer. To remedy this, the IEEE (2017) suggest employee data impact assessments to deal with these corporate nuances and ensure that no data is collected without employee consent. Data must also be only gathered and used for specific, explicitly stated, legitimate purposes, kept up-to-date, lawfully processed, and not kept for a longer period than necessary. In cases where subjects do not have a direct relationship with the system gathering data, consent must be dynamic, and the system designed to interpret data preferences and limitations on collection and use.

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To increase awareness and understanding of AI, undergraduate and postgraduate students must be educated on AI and its relationship to sustainable human development, say the IEEE. Specifically, curriculum and core competencies should be defined and prepared; degree programmes focusing on engineering in international development and humanitarian relief should be exposed to the potential of AI applications; and awareness should be increased of the opportunities and risks faced by Lower Middle Income Countries in the implementation of AI in humanitarian efforts across the globe.

Many initiatives focus on this, including the ***Foundation for Responsible Robotics, Partnership on AI, Japanese Society for AI Ethical Guidelines, Future Society*** and ***AI Now Institute***; these and others maintain that clear, open and transparent dialogue between AI and society is key to the creation of understanding, acceptance, and trust.

Existential risk

According to the Future of Life Institute, the main existential issue surrounding AI 'is not malevolence, but competence' – AI will continually learn as they interact with others and gather data, leading them to gain intelligence over time and potentially develop aims that are at odds with those of humans.

'*You're probably not an evil ant-hater who steps on ants out of malice,' 'but if you're in charge of a hydroelectric green energy project and there's an anthill in the region to be flooded, too bad for the ants. A key goal of AI safety research is to never place humanity in the position of those ants' (*The Future of Life Institute, 2019).

AI also poses a threat in the form of ***autonomous weapons systems (AWS)***. As these are designed to cause physical harm, they raise numerous ethical quandaries. The IEEE (2019) lays out a number of recommendations to ensure that AWS are subject to meaningful human control: they suggest audit trails to guarantee accountability and control; adaptive learning systems that can explain their reasoning in a transparent, understandable way; that human operators of autonomous systems are identifiable, held responsible, and aware of the implications of their work; that autonomous behaviour is predictable; and that professional codes of ethics are developed to address the development of autonomous systems – especially those intended to cause harm. The pursuit of AWS may lead to an international arms race and geopolitical stability; as such, the IEEE recommend that systems designed to act outside the boundaries of human control or judgement are unethical and violate fundamental human rights and legal accountability for weapons use.

Given their potential to seriously harm society, these concerns must be controlled for and regulated pre-emptively, says the ***Foundation for Responsible Robotics***. Other initiatives that cover this risk explicitly include the ***UNI Global Union*** and the ***Future of Life Institute***, the latter of which cautions against an arms race in lethal autonomous weapons, and calls for planning and mitigation efforts for possible longer-term risks. We must avoid strong assumptions on the upper limits of future AI capabilities, assert the FLI's **Asilomar Principles**, and recognise that advanced AI represents a profound change in the history of life on Earth.

3.3. Case studies

3.3.1. Case study: healthcare robots

Artificial Intelligence and robotics are rapidly moving into the field of healthcare and will increasingly play roles in diagnosis and clinical treatment. For example, currently, or in the near future, robots will help in the diagnosis of patients; the performance of simple surgeries; and the monitoring of patients' health and mental wellness in short and long-term care facilities. They may also provide basic physical interventions, work as companion carers, remind patients to take their

AMSCE-1101

medications, or help patients with their mobility. In some fundamental areas of medicine, such as medical image diagnostics, machine learning has been proven to match or even surpass our ability to detect illnesses.

Embodied AI, or robots, are already involved in a number of functions that affect people's physical safety. In June 2005, a surgical robot at a hospital in Philadelphia malfunctioned during prostate surgery, injuring the patient. In June 2015, a worker at a Volkswagen plant in Germany was crushed to death by a robot on the production line. In June 2016, a Tesla car operating in autopilot mode collided with a large truck, killing the car's passenger (Yadron and Tynan, 2016).

As robots become more prevalent, the potential for future harm will increase, particularly in the case of driverless cars, assistive robots and drones, which will face decisions that have real consequences for human safety and well-being. The stakes are much higher with embodied AI than with mere software, as robots have moving parts in physical space (Lin et al., 2017). Any robot with moving physical parts poses a risk, especially to vulnerable people such as children and the elderly.

Safety

Again, perhaps the most important ethical issue arising from the growth of AI and robotics in healthcare is that of safety and avoidance of harm. It is vital that robots should not harm people, and that they should be safe to work with. This point is especially important in areas of healthcare that deal with vulnerable people, such as the ill, elderly, and children.

Digital healthcare technologies offer the potential to improve accuracy of diagnosis and treatments, but to thoroughly establish a technology's long-term safety and performance investment in clinical trials is required. The debilitating side-effects of vaginal mesh implants and the continued legal battles against manufacturers (The Washington Post, 2019), stand as an example against shortcutting testing, despite the delays this introduces to innovating healthcare. Investment in clinical trials will be essential to safely implement the healthcare innovations that AI systems offer.

User understanding

The correct application of AI by a healthcare professional is important to ensure patient safety. For instance, the precise surgical robotic assistant 'the da Vinci' has proven a useful tool in minimising surgical recovery, but requires a trained operator (The Conversation, 2018).

A shift in the balance of skills in the medical workforce is required, and healthcare providers are preparing to develop the digital literacy of their staff over the next two decades (NHS' Topol Review, 2009). With genomics and machine learning becoming embedded in diagnoses and medical decision-making, healthcare professionals need to become digitally literate to understand each technological tool and use it appropriately. It is important for users to trust the AI presented but to be aware of each tool's strengths and weaknesses, recognising when validation is necessary. For instance, a generally accurate machine learning study to predict the risk of complications in patients with pneumonia erroneously considered those with asthma to be at low risk. It reached this conclusion because asthmatic pneumonia patients were taken directly to intensive care, and this higher-level care circumvented complications. The inaccurate recommendation from the algorithm was thus overruled (Pulmonology Advisor, 2017).

However, it's questionable to what extent individuals need to understand how an AI system arrived at a certain prediction in order to make autonomous and informed decisions. Even if an in-depth understanding of the mathematics is made obligatory, the complexity and learned nature of machine learning algorithms often prevent the ability to understand how a conclusion has been made from a dataset — a so called 'black box' (Schönberger, 2019). In such cases, one possible route

AMSCE-101

to ensure safety would be to license AI for specific medical procedures, and to 'disbar' the AI if a certain number of mistakes are made (Hart, 2018).

Data protection

Personal medical data needed for healthcare algorithms may be at risk. For instance, there are worries that data gathered by fitness trackers might be sold to third parties, such as insurance companies, who could use those data to refuse healthcare coverage (National Public Radio, 2018). Hackers are another major concern, as providing adequate security for systems accessed by a range of medical personnel is problematic (Forbes, 2018).

Pooling personal medical data is critical for machine learning algorithms to advance healthcare interventions, but gaps in information governance form a barrier against responsible and ethical data sharing. Clear frameworks for how healthcare staff and researchers use data, such as genomics, in a way that safeguards patient confidentiality is necessary to establish public trust and enable advances in healthcare algorithms (NHS' Topol Review, 2009).

Legal responsibility

Although AI promises to reduce the number of medical mishaps, when issues occur, legal liability must be established. If equipment can be proven to be faulty then the manufacturer is liable, but it is often tricky to establish what went wrong during a procedure and whether anyone, medical personnel or machine, is to blame. For instance, there have been lawsuits against the da Vinci surgical assistant (Mercury News, 2017), but the robot continues to be widely accepted (The Conversation, 2018).

In the case of 'black box' algorithms where it is impossible to ascertain how a conclusion is reached, it is tricky to establish negligence on the part of the algorithm's producer (Hart, 2018).

For now, AI is used as an aide for expert decisions, and so experts remain the liable party in most cases. For instance, in the aforementioned pneumonia case, if the medical staff had relied solely on the AI and sent asthmatic pneumonia patients home without applying their specialist knowledge, then that would be a negligent act on their part (Pulmonology Advisor, 2017; International Journal of Law and Information Technology, 2019).

Soon, the omission of AI could be considered negligence. For instance, in less developed countries with a shortage of medical professionals, withholding AI that detects diabetic eye disease and so prevents blindness, because of a lack of ophthalmologists to sign off on a diagnosis, could be considered unethical (The Guardian, 2019; International Journal of Law and Information Technology, 2019).

Bias

Non-discrimination is one of the fundamental values of the EU (see Article 21 of the EU Charter of Fundamental Rights), but machine learning algorithms are trained on datasets that often have proportionally less data available about minorities, and as such can be biased (Medium, 2014). This can mean that algorithms trained to diagnose conditions are less likely to be accurate for ethnic patients; for instance, in the dataset used to train a model for detecting skin cancer, less than 5 percent of the images were from individuals with dark skin, presenting a risk of misdiagnosis for people of colour (The Atlantic, 2018).

To ensure the most accurate diagnoses are presented to people of all ethnicities, algorithmic biases must be identified and understood. Even with a clear understanding of model design this is a difficult task because of the aforementioned 'black box' nature of machine learning. However, various codes of conduct and initiatives have been introduced to spot biases earlier. For instance,

AMSCE-101

The Partnership on AI, an ethics-focused industry group was launched by Google, Facebook, Amazon, IBM and Microsoft (The Guardian, 2016) — although, worryingly, this board is not very diverse.

Equality of access

Digital health technologies, such as fitness trackers and insulin pumps, provide patients with the opportunity to actively participate in their own healthcare. Some hope that these technologies will help to redress health inequalities caused by poor education, unemployment, and so on. However, there is a risk that individuals who cannot afford the necessary technologies or do not have the required 'digital literacy' will be excluded, so reinforcing existing health inequalities (The Guardian, 2019).

The UK's National Health Services' Widening Digital Participation programme is one example of how a healthcare service has tried to reduce health inequalities, by helping millions of people in the UK who lack the skills to access digital health services. Programmes such as this will be critical in ensuring equality of access to healthcare, but also in increasing the data from minority groups needed to prevent the biases in healthcare algorithms discussed above.

Quality of care

'There is remarkable potential for digital healthcare technologies to improve accuracy of diagnoses and treatments, the efficiency of care, and workflow for healthcare professionals' (NHS' Topol Review, 2019).

If introduced with careful thought and guidelines, companion and care robots, for example, could improve the lives of the elderly, reducing their dependence, and creating more opportunities for social interaction. Imagine a home-care robot that could: remind you to take your medications; fetch items for you if you are too tired or are already in bed; perform simple cleaning tasks; and help you stay in contact with your family, friends and healthcare provider via video link.

However, questions have been raised over whether a 'cold', emotionless robot can really substitute for a human's empathetic touch. This is particularly the case in long-term caring of vulnerable and often lonely populations, who derive basic companionship from caregivers. Human interaction is particularly important for older people, as research suggests that an extensive social network offers protection against dementia. At present, robots are far from being real companions. Although they can interact with people, and even show simulated emotions, their conversational ability is still extremely limited, and they are no replacement for human love and attention. Some might go as far as saying that depriving the elderly of human contact is unethical, and even a form of cruelty.

And does abandoning our elderly to cold machine care objectify (degrade) them, or human caregivers? It's vital that robots don't make elderly people feel like objects, or with even less control over their lives than when they were dependent on humans — otherwise they may feel like they are 'lumps of dead matter: to be pushed, lifted, pumped or drained, without proper reference to the fact that they are sentient beings' (Kitwood 1997).

In principle, autonomy, dignity and self-determination can all be thoroughly respected by a machine application, but it's unclear whether application of these roles in the sensitive field of medicine will be deemed acceptable. For instance, a doctor used a telepresence device to give a prognosis of death to a Californian patient; unsurprisingly the patient's family were outraged by this impersonal approach to healthcare (The Independent, 2019). On the other hand, it's argued that new technologies, such as health monitoring apps, will free up staff time for more direct interactions with patients, and so potentially increase the overall quality of care (The Guardian, Press Association, Monday 11 February 2019).

AMSCE-101

Deception

A number of 'carebots' are designed for social interactions and are often touted to provide an emotional therapeutic role. For instance, care homes have found that a robotic seal pup's animal-like interactions with residents brightens their mood, decreases anxiety and actually increases the sociability of residents with their human caregivers. However, the line between reality and imagination is blurred for dementia patients, so is it dishonest to introduce a robot as a pet and encourage a social-emotional involvement? (KALW, 2015) And if so, is if morally justifiable?

Companion robots and robotic pets could alleviate loneliness amongst older people, but this would require them believing, in some way, that a robot is a sentient being who cares about them and has feelings — a fundamental deception. Turkle et al. (2006) argue that 'the fact that our parents, grandparents and children might say 'I love you' to a robot who will say 'I love you' in return, does not feel completely comfortable; it raises questions about the kind of authenticity we require of our technology'. Wallach and Allen (2009) agree that robots designed to detect human social gestures and respond in kind all use techniques that are arguably forms of deception. For an individual to benefit from owning a robot pet, they must continually delude themselves about the real nature of their relation with the animal. What's more, encouraging elderly people to interact with robot toys has the effect of infantilising them.

Autonomy

It's important that healthcare robots actually benefit the patients themselves, and are not just designed to reduce the care burden on the rest of society — especially in the case of care and companion AI. Robots could empower disabled and older people and increase their independence; in fact, given the choice, some might prefer robotic over human assistance for certain intimate tasks such as toileting or bathing. Robots could be used to help elderly people live in their own homes for longer, giving them greater freedom and autonomy. However, how much control, or autonomy, should a person be allowed if their mental capability is in question? If a patient asked a robot to throw them off the balcony, should the robot carry out that command?

Liberty and privacy

As with many areas of AI technology, the privacy and dignity of users' needs to be carefully considered when designing healthcare service and companion robots. Working in people's homes means that robots will be privy to private moments such as bathing and dressing; if these moments are recorded, who should have access to the information, and how long should recordings be kept? The issue becomes more complicated if an elderly person's mental state deteriorates and they become confused — someone with Alzheimer's could forget that a robot was monitoring them, and could perform acts or say things thinking that they are in the privacy of their own home. Home-care robots need to be able to balance their user's privacy and nursing needs, for example by knocking and awaiting an invitation before entering a patient's room, except in a medical emergency.

To ensure their charge's safety, robots might sometimes need to act as supervisors, restricting their freedoms. For example, a robot could be trained to intervene if the cooker was left on, or the bath was overflowing. Robots might even need to restrain elderly people from carrying out potentially dangerous actions, such as climbing up on a chair to get something from a cupboard. Smart homes with sensors could be used to detect that a person is attempting to leave their room, and lock the door, or call staff — but in so doing the elderly person would be imprisoned.

Moral agency

'There's very exciting work where the brain can be used to control things, like maybe they've lost the use of an arm…where I think the real concerns lie is with things like behavioural targeting: going straight to the hippocampus and people pressing 'consent', like we do now, for data access'. (John Havens)

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Robots do not have the capacity for ethical reflection or a moral basis for decision-making, and thus humans must currently hold ultimate control over any decision-making. An example of ethical reasoning in a robot can be found in the 2004 dystopian film 'I, Robot', where Will Smith's character disagreed with how the robots of the fictional time used cold logic to save his life over that of a child's. If more automated healthcare is pursued, then the question of moral agency will require closer attention. Ethical reasoning is being built into robots, but moral responsibility is about more than the application of ethics — and it is unclear whether robots of the future will be able to handle the complex moral issues in healthcare (Goldhill, 2016).

Trust

Larosa and Danks (2018) write that AI may affect human-human interactions and relationships within the healthcare domain, particularly that between patient and doctor, and potentially disrupt the trust we place in our doctor.

'Psychology research shows people mistrust those who make moral decisions by calculating costs and benefits — like computers do' (The Guardian, 2017). Our distrust of robots may also come from the number of robots running amok in dystopian science fiction. News stories of computer mistakes — for instance, of an image-identifying algorithm mistaking a turtle for a gun (The Verge, 2017) — alongside worries over the unknown, privacy and safety are all reasons for resistance against the uptake of AI (Global News Canada, 2016).

Firstly, doctors are explicitly certified and licensed to practice medicine, and their license indicates that they have specific skills, knowledge, and values such as 'do no harm'. If a robot replaces a doctor for a particular treatment or diagnostic task, this could potentially threaten patient-doctor trust, as the patient now needs to know whether the system is appropriately approved or 'licensed' for the functions it performs.

Secondly, patients trust doctors because they view them as paragons of expertise. If doctors were seen as 'mere users' of the AI, we would expect their role to be downgraded in the public's eye, undermining trust.

Thirdly, a patient's experiences with their doctor are a significant driver of trust. If a patient has an open line of communication with their doctor, and engages in conversation about care and treatment, then the patient will trust the doctor. Inversely, if the doctor repeatedly ignores the patient's wishes, then these actions will have a negative impact on trust. Introducing AI into this dynamic could increase trust — if the AI reduced the likelihood of misdiagnosis, for example, or improved patient care. However, AI could also decrease trust if the doctor delegated too much diagnostic or decision-making authority to the AI, undercutting the position of the doctor as an authority on medical matters.

As the body of evidence grows to support the therapeutic benefits for each technological approach, and as more robotic interacting systems enter the marketplace, then trust in robots is likely to increase. This has already happened for robotic healthcare systems such as the da Vinci surgical robotic assistant (The Guardian, 2014).

Employment replacement

As in other industries, there is a fear that emerging technologies may threaten employment (The Guardian, 2017), for instance, there are carebots now available that can perform up to a third of nurses' work (Tech Times, 2018). Despite these fears, the NHS' Topol Review (2009) concluded that 'these technologies will not replace healthcare professionals but will enhance them ('augment them'), giving them more time to care for patients'. The review also outlined how the UK's NHS will nurture a learning environment to ensure digitally capable employees.

AMSCE-101

3.3.2 Case study: Autonomous Vehicles

Autonomous Vehicles (AVs) are vehicles that are capable of sensing their environment and operating with little to no input from a human driver. While the idea of self-driving cars has been around since at least the 1920s, it is only in recent years that technology has developed to a point where AVs are appearing on public roads.

According to automotive standardisation body SAE International (2018), there are six levels of driving automation:

0	No automation	An automated system may issue warnings and/or momentarily intervene in driving, but has no sustained vehicle control.
1	Hands on	The driver and automated system share control of the vehicle. For example, the automated system may control engine power to maintain a set speed (e.g. Cruise Control), engine and brake power to maintain and vary speed (e.g. Adaptive Cruise Control), or steering (e.g. Parking Assistance). The driver must be ready to retake full control at any time.
2	Hands off	The automated system takes full control of the vehicle (including accelerating, braking, and steering). However, the driver must monitor the driving and be prepared to intervene immediately at any time.
3	Eyes off	The driver can safely turn their attention away from the driving tasks (e.g. to text or watch a film) as the vehicle will handle any situations that call for an immediate response. However, the driver must still be prepared to intervene, if called upon by the AV to do so, within a timeframe specified by the AV manufacturer.
4	Minds off	As level 3, but no driver attention is ever required for safety, meaning the driver can safely go to sleep or leave the driver's seat.
5	Steering wheel optional	No human intervention is required at all. An example of a level 5 AV would be a robotic taxi.

Some of the lower levels of automation are already well-established and on the market, while higher level AVs are undergoing development and testing. However, as we transition up the levels and put more responsibility on the automated system than the human driver, a number of ethical issues emerge.

Societal and Ethical Impacts of AVs

'We cannot build these tools saying, 'we know that humans act a certain way, we're going to kill them – here's what to do'.' (John Havens)

Public safety and the ethics of testing on public roads

At present, cars with 'assisted driving' functions are legal in most countries. Notably, some Tesla models have an Autopilot function, which provides level 2 automation (Tesla, nd). Drivers are legally allowed to use assisted driving functions on public roads provided they remain in charge of the

AMSCE-IT01

vehicle at all times. However, many of these assisted driving functions have not yet been subject to independent safety certification, and as such may pose a risk to drivers and other road users. In Germany, a report published by the Ethics Commission on Automated Driving highlights that it is the public sector's responsibility to guarantee the safety of AV systems introduced and licensed on public roads, and recommends that all AV driving systems be subject to official licensing and monitoring (Ethics Commision, 2017).

In addition, it has been suggested that the AV industry is entering its most dangerous phase, with cars being not yet fully autonomous but human operators not being fully engaged (Solon, 2018). The risks this poses have been brought to widespread attention following the first pedestrian fatality involving an autonomous car. The tragedy took place in Arizona, USA, in May 2018, when a level 3 AV being tested by Uber collided with 49-year-old Elaine Herzberg as she was walking her bike across a street one night. It was determined that Uber was 'not criminally liable' by prosecutors (Shepherdson and Somerville, 2019), and the US National Transportation Safety Board's preliminary report (NTSB, 2018), which drew no conclusions about the cause, said that all elements of the self-driving system were operating normally at the time of the crash. Uber said that the driver is relied upon to intervene and take action in situations requiring emergency braking – leading some commentators to call out the misleading communication to consumers around the terms 'self-driving cars' and 'autopilot' (Leggett, 2018). The accident also caused some to condemn the practice of testing AV systems on public roads as dangerous and unethical, and led Uber to temporarily suspend its self-driving programme (Bradshaw, 2018).

This issue of human safety — of both public and passenger — is emerging as a key issue concerning self-driving cars. Major companies — Nissan, Toyota, Tesla, Uber, Volkswagen — are developing autonomous vehicles capable of operating in complex, unpredictable environments without direct human control, and capable of learning, inferring, planning and making decisions.

Self-driving vehicles could offer multiple benefits: statistics show you're almost certainly safer in a car driven by a computer than one driven by a human. They could also ease congestion in cities, reduce pollution, reduce travel and commute times, and enable people to use their time more productively. However, they won't mean the end of road traffic accidents. Even if a self-driving car has the best software and hardware available, there is still a collision risk. An autonomous car could be surprised, say by a child emerging from behind a parked vehicle, and there is always the issue of *how: how* should such cars be programmed when they must decide whose safety to prioritise?

Driverless cars may also have to choose between the safety of passengers and other road users. Say that a car travels around a corner where a group of school children are playing; there is not enough time to stop, and the only way the car can avoid hitting the children is to swerve into a brick wall — endangering the passenger. Whose safety should the car prioritise: the children’s', or the passenger's?

Processes and technologies for accident investigation

AVs are complex systems that often rely on advanced machine learning technologies. Several serious accidents have already occurred, including a number of fatalities involving level 2 AVs:

- In January 2016, 23-year-old Gao Yaning died when his Tesla Model S crashed into the back of a road-sweeping truck on a highway in Hebei, China. The family believe Autopilot was engaged when the accident occurred and accuse Tesla of exaggerating the system's capabilities. Tesla state that the damage to the vehicle made it impossible to determine whether Autopilot was engaged and, if so, whether it malfunctioned. A civil case into the crash is ongoing, with a third-party appraiser reviewing data from the vehicle (Curtis, 2016).

- In May 2016, 40-year-old Joshua Brown died when his Tesla Model S collided with a truck while Autopilot was engaged in Florida, USA. An investigation by the National Highways and Transport Safety Agency found that the driver, and not Tesla, were at fault (Gibbs, 2016). However, the National Highway Traffic Safety Administration later determined that both Autopilot and over-reliance by the motorist on Tesla's driving aids were to blame (Felton, 2017).

- In March 2018, Wei Huang was killed when his Tesla Model X crashed into a highway safety barrier in California, USA. According to Tesla, the severity of the accident was 'unprecedented'. The National Transportation Safety Board later published a report attributing the crash to an Autopilot navigation mistake. Tesla is now being sued by the victim's family (O'Kane, 2018).

Unfortunately, efforts to investigate these accidents have been stymied by the fact that standards, processes, and regulatory frameworks for investigating accidents involving AVs have not yet been developed or adopted. In addition, the proprietary data logging systems currently installed in AVs mean that accident investigators rely heavily on the cooperation of manufacturers to provide critical data on the events leading up to an accident (Stilgoe and Winfield, 2018).

One solution is to fit all future AVs with industry standard event data recorders — a so-called 'ethical black box' — that independent accident investigators could access. This would mirror the model already in place for air accident investigations (Sample, 2017).

Near-miss accidents

At present, there is no system in place for the systematic collection of near-miss accidents. While it is possible that manufacturers are collecting this data already, they are not under any obligation to do so — or to share the data. The only exception at the moment is the US state of California, which requires all companies that are actively testing AVs on public roads to disclose the frequency at which human drivers were forced to take control of the vehicle for safety reasons (known as 'disengagement').

In 2018, the number of disengagements by AV manufacturer varied significantly, from one disengagement for every 11,017 miles driven by Waymo AVs to one for every 1.15 miles driven by Apple AVs (Hawkins, 2019). Data on these disengagements reinforces the importance of ensuring that human safety drivers remain engaged. However, the Californian data collection process has been criticised, with some claiming its ambiguous wording and lack of strict guidelines enables companies to avoid reporting certain events that could be termed near-misses.

Without access to this type of data, policymakers cannot account for the frequency and significance of near-miss accidents, or assess the steps taken by manufacturers as a result of these near-misses. Again, lessons could be learned from the model followed in air accident investigations, in which all near misses are thoroughly logged and independently investigated. Policymakers require comprehensive statistics on all accidents and near-misses in order to inform regulation.

Data privacy

It is becoming clear that manufacturers collect significant amounts of data from AVs. As these vehicles become increasingly common on our roads, the question emerges: to what extent are these data compromising the privacy and data protection rights of drivers and passengers?

Already, data management and privacy issues have appeared, with some raising concerns about the potential misuse of AV data for advertising purposes (Lin, 2014). Tesla have also come under fire for the unethical use of AV data logs. In an investigation by *The Guardian*, the newspaper found multiple instances where the company shared drivers' private data with the media following crashes, without

AMCE-1101

their permission, to prove that its technology was not responsible (Thielman, 2017). At the same time, Tesla does not allow customers to see their own data logs.

One solution, proposed by the German Ethics Commission on Automated Driving, is to ensure that that all AV drivers be given full data sovereignty (Ethics Commission, 2017). This would allow them to control how their data is used.

Employment

The growth of AVs is likely to put certain jobs — most pertinently bus, taxi, and truck drivers — at risk.

In the medium term, truck drivers face the greatest risk as long-distance trucks are at the forefront of AV technology (Viscelli, 2018). In 2016, the first commercial delivery of beer was made using a self-driving truck, in a journey covering 120 miles and involving no human action (Isaac, 2016). Last year saw the first fully driverless trip in a self-driving truck, with the AV travelling seven miles without a single human on board (Cannon, 2018).

Looking further forward, bus drivers are also likely to lose jobs as more and more buses become driverless. Numerous cities across the world have announced plans to introduce self-driving shuttles in the future, including Edinburgh (Calder, 2018), New York (BBC, 2019a) and Singapore (BBC 2017). In some places, this vision has already become a reality; the Las Vegas shuttle famously got off to a bumpy start when it was involved in a collision on its first day of operation (Park, 2017), and tourists in the small Swiss town of Neuhausen Rheinfall can now hop on a self-driving bus to visit the nearby waterfalls (CNN, 2018). In the medium term, driverless buses will likely be limited to routes that travel along 100% dedicated bus lanes. Nonetheless, the advance of self-driving shuttles has already created tensions with organised labour and city officials in the USA (Weinberg, 2019). Last year, the Transport Workers Union of America formed a coalition in an attempt to stop autonomous buses from hitting the streets of Ohio (Pfleger, 2018).

Fully autonomous taxis will likely only become realistic in the long term, once AV technology has been fully tested and proven at levels 4 and 5. Nonetheless, with plans to introduce self-driving taxis in London by 2021 (BBC, 2018), and an automated taxi service already available in Arizona, USA (Sage, 2019), it is easy to see why taxi drivers are uneasy.

The quality of urban environments

In the long-term, AVs have the potential to reshape our urban environment. Some of these changes may have negative consequences for pedestrians, cyclists and locals. As driving becomes more automated, there will likely be a need for additional infrastructure (e.g. AV-only lanes). There may also be more far-reaching effects for urban planning, with automation shaping the planning of everything from traffic congestion and parking to green spaces and lobbies (Marshall and Davies, 2018). The rollout of AVs will also require that 5G network coverage is extended significantly — again, something with implications for urban planning (Khosravi, 2018).
The environmental impact of self-driving cars should also be considered. While self-driving cars have the potential to significantly reduce fuel usage and associated emissions, these savings could be counteracted by the fact that self-driving cars make it easier and more appealing to drive long distances (Worland, 2016). The impact of automation on driving behaviours should therefore not be underestimated.

Legal and ethical responsibility

From a legal perspective, who is responsible for crashes caused by robots, and how should victims be compensated (if at all) when a vehicle controlled by an algorithm causes injury? If courts cannot resolve this problem, robot manufacturers may incur unexpected costs that would discourage investment. However, if victims are not properly compensated then autonomous vehicles are unlikely to be trusted or accepted by the public.

Robots will need to make judgement calls in conditions of uncertainty, or 'no win' situations. However, which ethical approach or theory should a robot be programmed to follow when there's no legal guidance? As Lin et al. explain, different approaches can generate different results, including the number of crash fatalities.

Additionally, who should choose the ethics for the autonomous vehicle — drivers, consumers, passengers, manufacturers, politicians? Loh and Loh (2017) argue that responsibility should be shared among the engineers, the driver and the autonomous driving system itself. However, Millar (2016) suggests that the user of the technology, in this case the passenger in the self-driving car, should be able to decide what ethical or behavioural principles the robot ought to follow. Using the example of doctors, who do not have the moral authority to make important decisions on end-of-life care without the informed consent of their patients, he argues that there would be a moral outcry if engineers designed cars without either asking the driver directly for their input, or informing the user ahead of time how the car is programmed to behave in certain situations.

Ethical dilemmas in development

In 2014, the Open Roboethics initiative (ORi 2014a, 2014b) conducted a poll asking people what they thought an autonomous car in which they were a passenger should do if a child stepped out in front of the vehicle in a tunnel. The car wouldn't have time to brake and spare the child, but could swerve into the walls of the tunnel, killing the passenger. This is a spin on the classic 'trolley dilemma', where one has the option to divert a runaway trolley from a path that would hurt several people onto the path that would only hurt one.

36 % of participants said that they would prefer the car to swerve into the wall, saving the child; however, the majority (64 %) said they would wish to save themselves, thus sacrificing the child. 44 % of participants thought that the passenger should be able to choose the car's course of action, while 33 % said that lawmakers should choose. Only 12 % said that the car's manufacturers should make the decision. These results suggest that people do not like the idea of engineers making moral decisions on their behalf.

Asking for the passenger's input in every situation would be impractical. However, Millar (2016) suggests a 'setup' procedure where people could choose their ethics settings after purchasing a new car. Nonetheless, choosing how the car reacts in advance could be seen as premeditated harm, if, for example a user programmed their vehicle to always avoid vehicle collisions by swerving into cyclists. This would increase the user's accountability and liability, whilst diverting responsibility away from manufacturers.

3.3.3 Case study: Warfare and weaponisation

Although partially autonomous and intelligent systems have been used in military technology since at least the Second World War, advances in machine learning and AI signify a turning point in the use of automation in warfare.

AI is already sufficiently advanced and sophisticated to be used in areas such as satellite imagery analysis and cyber defence, but the true scope of applications has yet to be fully realised. A recent report concludes that AI technology has the potential to transform warfare to the same, or perhaps even a greater, extent than the advent of nuclear weapons, aircraft, computers and biotechnology (Allen and Chan, 2017). Some key ways in which AI will impact militaries are outlined below.

Lethal autonomous weapons

As automatic and autonomous systems have become more capable, militaries have become more willing to delegate authority to them. This is likely to continue with the widespread adoption of AI, leading to an AI inspired arms-race. The Russian Military Industrial Committee has already approved an aggressive plan whereby 30% of Russian combat power will consist of entirely remote-controlled and autonomous robotic platforms by 2030. Other countries are likely to set similar goals. While the United States Department of Defense has enacted restrictions on the use of autonomous and semi-autonomous systems wielding lethal force, other countries and non-state actors may not exercise such self-restraint.

Drone technologies

Standard military aircraft can cost more than US$100 million per unit; a high-quality quadcopter Unmanned Aerial Vehicle, however, currently costs roughly US$1,000, meaning that for the price of a single high-end aircraft, a military could acquire one million drones. Although current commercial drones have limited range, in the future they could have similar ranges to ballistic missiles, thus rendering existing platforms obsolete.

Robotic assassination

Widespread availability of low-cost, highly-capable, lethal, and autonomous robots could make targeted assassination more widespread and more difficult to attribute. Automatic sniping robots could assassinate targets from afar.

Mobile-robotic-Improvised Explosive Devices

As commercial robotic and autonomous vehicle technologies become widespread, some groups will leverage this to make more advanced Improvised Explosive Devices (IEDs). Currently, the technological capability to rapidly deliver explosives to a precise target from many miles away is restricted to powerful nation states. However, if long distance package delivery by drone becomes a reality, the cost of precisely delivering explosives from afar would fall from millions of dollars to thousands or even hundreds. Similarly, self-driving cars could make suicide car bombs more frequent and devastating since they no longer require a suicidal driver.

Hallaq et al. (2017) also highlight key areas in which machine learning is likely to affect warfare. They describe an example where a Commanding Officer (CO) could employ an Intelligent Virtual Assistant (IVA) within a fluid battlefield environment that automatically scanned satellite imagery to detect specific vehicle types, helping to identify threats in advance. It could also predict the enemy's intent, and compare situational data to a stored database of hundreds of previous wargame exercises and live engagements, providing the CO with access to a level of accumulated knowledge that would otherwise be impossible to accrue.

Employing AI in warfare raises several **legal and ethical questions**. One concern is that automated weapon systems that exclude human judgment could violate International Humanitarian Law, and threaten our fundamental right to life and the principle of human dignity. AI could also lower the threshold of going to war, affecting global stability.

International Humanitarian law stipulates that any attack needs to distinguish between combatants and non-combatants, be proportional and must not target civilians or civilian objects. Also, no attack should unnecessarily aggravate the suffering of combatants. AI may be unable to fulfil these principles without the involvement of human judgment. In particular, many researchers are concerned that Lethal Autonomous Weapon Systems (LAWS) — a type of autonomous military robot that can independently search for and 'engage' targets using lethal force — may not meet the standards set by International Humanitarian Law, as they are not able to distinguish civilians from

AMSCE-1101

combatants, and would not be able to judge whether the force of the attack was proportional given the civilian damage it would incur.

Amoroso and Tamburrini (2016, p. 6) argue that: '[LAWS must be] capable of respecting the principles of distinction and proportionality at least as well as a competent and conscientious human soldier'. However, Lim (2019) points out that while LAWS that fail to meet these requirements should not be deployed, one day LAWS *will* be sophisticated enough to meet the requirements of distinction and proportionality. Meanwhile, Asaro (2012) argues that it doesn't matter how good LAWS get; it is a moral requirement that only a human should initiate lethal force, and it is simply morally wrong to delegate life or death decisions to machines.

Some argue that delegating the decision to kill a human to a machine is an infringement of basic human dignity, as robots don't feel emotion, and can have no notion of sacrifice and what it means to take a life. As Lim et al (2019) explain, 'a machine, bloodless and without morality or mortality, cannot fathom the significance of using force against a human being and cannot do justice to the gravity of the decision'.

Robots also have no concept of what it means to kill the 'wrong' person. 'It is only because humans can feel the rage and agony that accompanies the killing of humans that they can understand sacrifice and the use of force against a human. Only then can they realise the 'gravity of the decision' to kill' (Johnson and Axinn 2013, p. 136).

However, others argue that there is no particular reason why being killed by a machine would be a subjectively worse, or less dignified, experience than being killed by a cruise missile strike. 'What matters is whether the victim experiences a sense of humiliation in the process of getting killed. Victims being threatened with a potential bombing will not care whether the bomb is dropped by a human or a robot' (Lim et al, 2019). In addition, not all humans have the emotional capacity to conceptualise sacrifice or the relevant emotions that accompany risk. In the heat of battle, soldiers rarely have time to think about the concept of sacrifice, or generate the relevant emotions to make informed decisions each time they deploy lethal force.

Additionally, who should be held accountable for the actions of autonomous systems — the commander, programmer, or the operator of the system? Schmit (2013) argues that the responsibility for committing war crimes should fall on both the individual who programmed the AI, and the commander or supervisor (assuming that they knew, or should have known, the autonomous weapon system had been programmed and employed in a war crime, and that they did nothing to stop it from happening).

AMSCE-101

4. AI standards and regulation

A small new generation of ethical standards are emerging as the ethical, legal and societal impacts of artificial intelligence and robotics are further understood. Whether a standard clearly articulates explicit or implicit ethical concerns, all standards embody some kind of ethical principle (Winfield, 2019a). The standards that do exist are still in development and there is limited publicly available information on them.

Perhaps the earliest explicit ethical standard in robotics is BS 8611 Guide to the Ethical Design and Application of Robots and Robotic Systems (British Standard BS 8611, 2016). BS8611 is not a code of practice, but guidance on how designers can identify potential ethical harm, undertake an ethical risk assessment of their robot or AI, and mitigate any ethical risks identified. It is based on a set of 20 distinct ethical hazards and risks, grouped under four categories: societal, application, commercial & financial, and environmental.

Advice on measures to mitigate the impact of each risk is given, along with suggestions on how such measures might be verified or validated. The societal hazards include, for example, loss of trust, deception, infringements of privacy and confidentiality, addiction, and loss of employment. Ethical Risk Assessment should consider also foreseeable misuse, risks leading to stress and fear (and their minimisation), control failure (and associated psychological effect), reconfiguration and linked changes to responsibilities, hazards associated with specific robotics applications. Particular attention is paid to robots that can learn and the implications of robot enhancement that arise, and the standard argues that the ethical risk associated with the use of a robot should not exceed the risk of the same activity when conducted by a human.

British Standard BS 8611 assumes that physical hazards imply ethical hazards, and defines ethical harm as affecting 'psychological and/or societal and environmental well-being.' It also recognises that physical and emotional_hazards need to be balanced against expected benefits to the user.
The standard highlights the need to involve the public and stakeholders in development of robots and provides a list of key design considerations including:

- Robots should not be designed primarily to kill humans;
- Humans remain responsible agents;
- It must be possible to find out who is responsible for any robot;
- Robots should be safe and fit for purpose;
- Robots should not be designed to be deceptive;
- The precautionary principle should be followed;
- Privacy should be built into the design;
- Users should not be discriminated against, nor forced to use a robot.

Particular guidelines are provided for roboticists, particularly those conducting research. These include the need to engage the public, consider public concerns, work with experts from other disciplines, correct misinformation and provide clear instructions. Specific methods to ensure ethical use of robots include: user validation (to ensure robot can/is operated as expected), software verification (to ensure software works as anticipated), involvement of other experts in ethical assessment, economic and social assessment of anticipated outcomes, assessment of any legal implications, compliance testing against relevant standards. Where appropriate, other guidelines and ethical codes should be taken into consideration in the design and operation of robots (e.g. medical or legal codes relevant in specific contexts). The standard also makes the case that military application of robots does not remove the responsibility and accountability of humans.

AMSCE-101

The IEEE Standards Association has also launched a standard via its global initiative on the Ethics of Autonomous and Intelligent Systems. Positioning 'human well-being' as a central precept, the IEEE initiative explicitly seeks to reposition robotics and AI as technologies for improving the human condition rather than simply vehicles for economic growth (Winfield, 2019a). Its aim is to educate, train and empower AI/robot stakeholders to 'prioritise ethical considerations so that these technologies are advanced for the benefit of humanity.'

There are currently 14 IEEE standards working groups working on drafting so-called 'human' standards that have implications for artificial intelligence (Table 4.1).

AMSCE-1101

Table 2: IEEE 'human standards' with implications for AI

Standard		Aims/Objectives
P7000	Model Process for Addressing Ethical Concerns During System Design	To establish a process for **ethical design of Autonomous and Intelligent Systems**.
P7001	Transparency of Autonomous Systems	To ensure the **transparency of autonomous systems to a range of stakeholders**. It specifically will address: • *Users*: ensuring users understand what the system does and why, with the intention of building trust; • *Validation and certification*: ensuring the system is subject to scrutiny; • *Accidents*: enabling accident investigators to undertake investigation; • *Lawyers and expert witnesses:* ensuring that, following an accident, these groups are able to give evidence; • *Disruptive technology (e.g. driverless cars*): enabling the public to assess technology (and, if appropriate, build confidence).
P7002	Data Privacy Process	To establish standards for **the ethical use of personal data** in software engineering processes. It will develop and describe privacy impact assessments (PIA) that can be used to identify the need for, and effectiveness of, privacy control measures. It will also provide checklists for those developing software that uses personal information.

AMSCE-101

P7003	Algorithmic Bias Considerations	To help algorithm developers make explicit the ways in which they have sought to **eliminate or minimise the risk of bias** in their products. This will address the use of overly subjective information and help developers ensure they are compliant with legislation regarding protected characteristics (e.g. race, gender). It is likely to include: • Benchmarking processes for the selection of data sets; • Guidelines on communicating the boundaries for which the algorithm has been designed and validated (guarding against unintended consequences of unexpected uses); • Strategies to avoid incorrect interpretation of system outputs by users.
P7004	Standard for Child and Student Data Governance	Specifically **aimed at educational institutions,** this will provide guidance on accessing, collecting, storing, using, sharing and destroying child/student data.
P7005	Standard for Transparent Employer Data Governance	Similar to P7004, but **aimed at employers**.
P7006	Standard for Personal Data Artificial Intelligence (AI) Agent	Describes the technical elements required to create and grant access to **personalised AI.** It will enable individuals to safely organise and share their personal information at a machine-readable level, and enable personalised AI to act as a proxy for machine-to-machine decisions.
P7007	Ontological Standard for Ethically Driven Robotics and Automation Systems	This standard brings together engineering and philosophy **to ensure that user well-being is considered throughout the product life cycle**. It intends to identify ways to maximise benefits and minimise negative impacts, and will also consider the ways in which communication can be clear between diverse communities.

AMSCE-101

P7008	Standard for Ethically Driven Nudging for Robotic, Intelligent and Autonomous Systems	Drawing on 'nudge theory', this standard seeks **to delineate current or potential nudges that robots or autonomous systems might undertake**. It recognises that nudges can be used for a range of reasons, but that they seek to affect the recipient emotionally, change behaviours and can be manipulative, and seeks to elaborate methodologies for ethical design of AI using nudge.
P7009	Standard for Fail-Safe Design of Autonomous and Semi-Autonomous Systems	To create effective methodologies for **the development and implementation of robust, transparent and accountable fail-safe mechanisms**. It will address methods for measuring and testing a system's ability to fail safely.
P7010	Well-being Metrics Standard for Ethical Artificial Intelligence and Autonomous Systems	To establish a baseline for metrics used **to assess well-being factors that could be affected by autonomous systems**, and for how human well-being could proactively be improved.
P7011	Standard for the Process of Identifying and Rating the Trustworthiness of News Sources	Focusing on news information, this standard sets out **to standardise the processes for assessing the factual accuracy of news stories**. It will be used to produce a 'trustfulness' score. This standard seeks to address the negative effects of unchecked 'fake' news, and is designed to restore trust in news purveyors.
P7012	Standard for Machine Readable Personal Privacy Terms	To establish **how privacy terms are presented** and how they could be read and accepted by machines.
P7013	Inclusion and Application Standards for Automated Facial Analysis Technology	To provide **guidelines on the data used in facial recognition**, the requirements for diversity, and benchmarking of applications and situations in which facial recognition should not be used.

AMSCE-IOI

5. National and International Strategies on AI

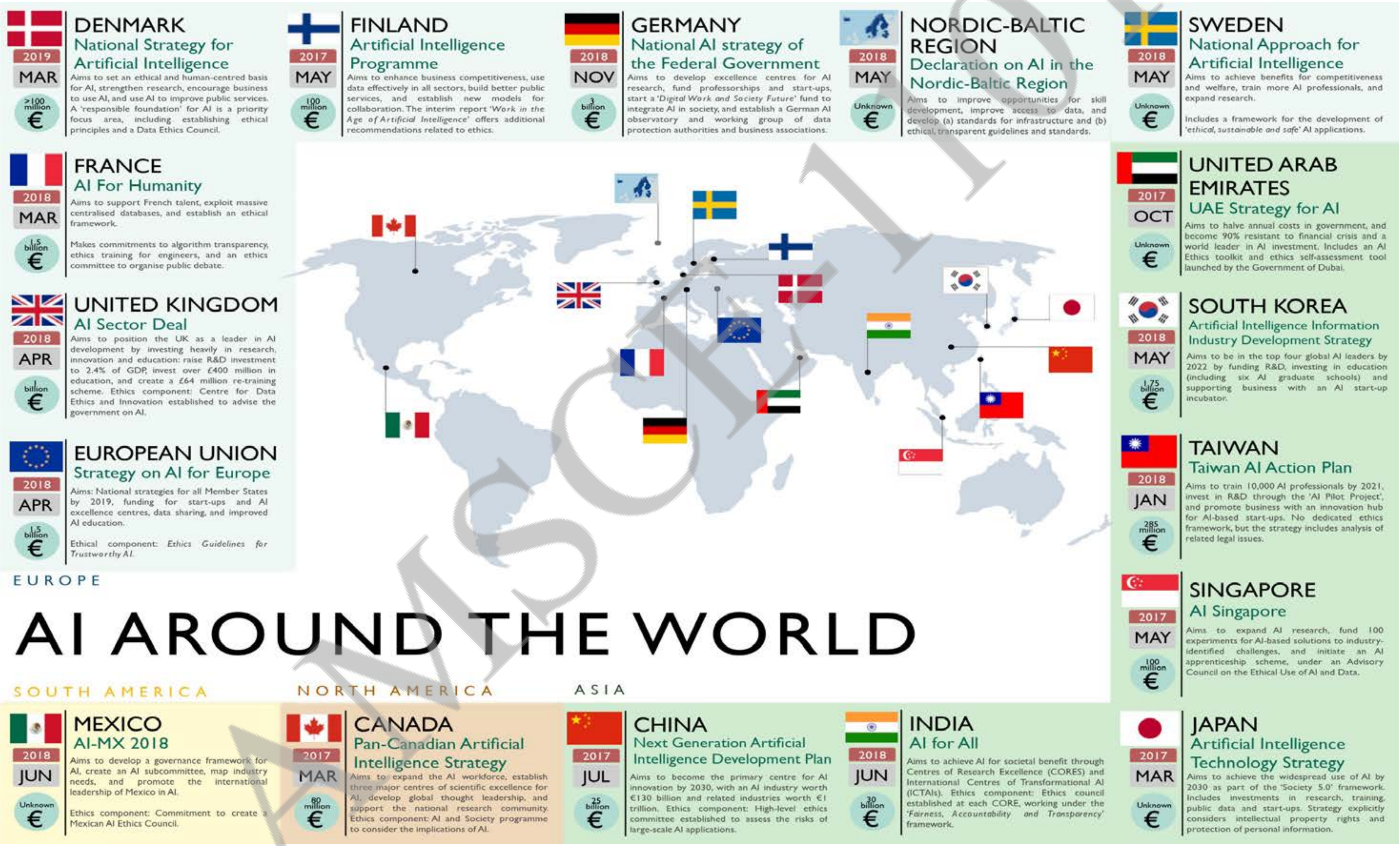
As the technology behind AI continues to progress beyond expectations, policy initiatives are springing up across the globe to keep pace with these developments.

The first national strategy on AI was launched by Canada in March 2017, followed soon after by technology leaders Japan and China. In Europe, the European Commission put forward a communication on AI, initiating the development of independent strategies by Member States. An American AI initiative is expected soon, alongside intense efforts in Russia to formalise their 10-point plan for AI.

These initiatives differ widely in terms of their goals, the extent of their investment, and their commitment to developing ethical frameworks, reviewed here as of May 2019.

AMSCE-1101

Figure 3: National and International Strategies on AI published as of May 2019.



DENMARK
National Strategy for Artificial Intelligence

2019 MAR

>100 million €

Aims to set an ethical and human-centred basis for AI, strengthen research, encourage business to use AI, and use AI to improve public services. A 'responsible foundation' for AI is a priority focus area, including establishing ethical principles and a Data Ethics Council.

FINLAND
Artificial Intelligence Programme

2017 MAY

100 million €

Aims to enhance business competitiveness, use data effectively in all sectors, build better public services, and establish new models for collaboration. The interim report '*Work in the Age of Artificial Intelligence*' offers additional recommendations related to ethics.

GERMANY
National AI strategy of the Federal Government

2018 NOV

3 billion €

Aims to develop excellence centres for AI research, fund professorships and start-ups, start a '*Digital Work and Society Future*' fund to integrate AI in society, and establish a German AI observatory and working group of data protection authorities and business associations.

NORDIC-BALTIC REGION
Declaration on AI in the Nordic-Baltic Region

2018 MAY

Unknown €

Aims to improve opportunities for skill development, improve access to data, and develop (a) standards for infrastructure and (b) ethical, transparent guidelines and standards.

SWEDEN
National Approach for Artificial Intelligence

2018 MAY

Unknown €

Aims to achieve benefits for competitiveness and welfare, train more AI professionals, and expand research.

Includes a framework for the development of '*ethical, sustainable and safe*' AI applications.

FRANCE
AI For Humanity

2018 MAR

1.5 billion €

Aims to support French talent, exploit massive centralised databases, and establish an ethical framework.

Makes commitments to algorithm transparency, ethics training for engineers, and an ethics committee to organise public debate.

UNITED KINGDOM
AI Sector Deal

2018 APR

1 billion €

Aims to position the UK as a leader in AI development by investing heavily in research, innovation and education: raise R&D investment to 2.4% of GDP, invest over £400 million in education, and create a £64 million re-training scheme. Ethics component: Centre for Data Ethics and Innovation established to advise the government on AI.

EUROPEAN UNION
Strategy on AI for Europe

2018 APR

1.5 billion €

Aims: National strategies for all Member States by 2019, funding for start-ups and AI excellence centres, data sharing, and improved AI education.

Ethical component: *Ethics Guidelines for Trustworthy AI.*

UNITED ARAB EMIRATES
UAE Strategy for AI

2017 OCT

Unknown €

Aims to halve annual costs in government, and become 90% resistant to financial crisis and a world leader in AI investment. Includes an AI Ethics toolkit and ethics self-assessment tool launched by the Government of Dubai.

SOUTH KOREA
Artificial Intelligence Information Industry Development Strategy

2018 MAY

1.75 billion €

Aims to be in the top four global AI leaders by 2022 by funding R&D, investing in education (including six AI graduate schools) and supporting business with an AI start-up incubator.

TAIWAN
Taiwan AI Action Plan

2018 JAN

285 million €

Aims to train 10,000 AI professionals by 2021, invest in R&D through the 'AI Pilot Project', and promote business with an innovation hub for AI-based start-ups. No dedicated ethics framework, but the strategy includes analysis of related legal issues.

SINGAPORE
AI Singapore

2017 MAY

100 million €

Aims to expand AI research, fund 100 experiments for AI-based solutions to industry-identified challenges, and initiate an AI apprenticeship scheme, under an Advisory Council on the Ethical Use of AI and Data.

EUROPE

AI AROUND THE WORLD

SOUTH AMERICA

NORTH AMERICA

ASIA

MEXICO
AI-MX 2018

2018 JUN

Unknown €

Aims to develop a governance framework for AI, create an AI subcommittee, map industry needs, and promote the international leadership of Mexico in AI.

Ethics component: Commitment to create a Mexican AI Ethics Council.

CANADA
Pan-Canadian Artificial Intelligence Strategy

2017 MAR

80 million €

Aims to expand the AI workforce, establish three major centres of scientific excellence for AI, develop global thought leadership, and support the national research community. Ethics component: AI and Society programme to consider the implications of AI.

CHINA
Next Generation Artificial Intelligence Development Plan

2017 JUL

25 billion €

Aims to become the primary centre for AI innovation by 2030, with an AI industry worth €130 billion and related industries worth €1 trillion. Ethics component: High-level ethics committee established to assess the risks of large-scale AI applications.

INDIA
AI for All

2018 JUN

30 billion €

Aims to achieve AI for societal benefit through Centres of Research Excellence (CORES) and International Centres of Transformational AI (ICTAIs). Ethics component: Ethics council established at each CORE, working under the '*Fairness, Accountability and Transparency*' framework.

JAPAN
Artificial Intelligence Technology Strategy

2017 MAR

Unknown €

Aims to achieve the widespread use of AI by 2030 as part of the 'Society 5.0' framework. Includes investments in research, training, public data and start-ups. Strategy explicitly considers intellectual property rights and protection of personal information.

5.1. Europe

The European Commission's Communication on Artificial Intelligence (European Commission, 2018a), released in April 2018, paved the way to the first international strategy on AI. The document outlines a coordinated approach to maximise the benefits, and address the challenges, brought about by AI.

The Communication on AI was formalised nine months later with the presentation of a coordinated plan on AI (European Commission, 2018b). The plan details seven objectives, which include financing start-ups, investing €1.5 billion in several 'research excellence centres', supporting masters and PhDs in AI and creating common European data spaces.

Objective 2.6 of the plan is to develop 'ethics guidelines with a global perspective'. The Commission appointed an independent high-level expert group to develop their ethics guidelines, which – following consultation – were published in their final form in April 2019 (European Commission High-Level Expert Group on Artificial Intelligence, 2019). The Guidelines list key requirements that AI systems must meet in order to be trustworthy.

The EU’s seven requirements for trustworthy AI:

1. Human agency and oversight
2. Technical robustness and safety
3. Privacy and data governance
4. Transparency
5. Diversity, non-discrimination and fairness
6. Societal and environmental wellbeing
7. Accountability

Source: European Commission High-Level Expert Group on Artificial Intelligence, 2019

The EU's High-Level Expert Group on AI shortly after released a further set of policy and investment guidelines for trustworthy AI (European Commission High-Level Expert Group on AI, 2019b), which includes a number of important recommendations around protecting people, boosting uptake of AI in the private sector, expanding European research capacity in AI and developing ethical data management practices.

The Council of Europe also has various ongoing projects regarding the application of AI and in September 2019 established an Ad Hoc Committee on Artificial Intelligence (CAHAI). The committee will assess the potential elements of a legal framework for the development and application of AI, based on the Council's founding principles of human rights, democracy and the rule of law (Council of Europe, 2019a).

Looking ahead, the next European Commission President, Ursula von der Leyen, has announced AI as a priority for the next Commission, including legislation for a coordinated approach on the 'human and ethical implications' of AI (Kayali, 2019; von der Leyen, 2019).

The European Commission provides a unifying framework for AI development in the EU, but Member States are also required to develop their own national strategies.

AMSCE-1101

Finland was the first Member State to develop a national programme on AI (Ministry of Economic Affairs and Employment of Finland, 2018a). The programme is based on two reports, *Finland's Age of Artificial Intelligence* and *Work in the Age of Artificial Intelligence* (Ministry of Economic Affairs and Employment of Finland, 2017, 2018b). Policy objectives focus on investment for business competitiveness and public services. Although recommendations have already been incorporated into policy, Finland's AI steering group will run until the end of the present Government's term, with a final report expected imminently.

So far, Denmark, France, Germany, Sweden and the UK have also announced national initiatives on AI. **Denmark**'s National Strategy for Artificial Intelligence (The Danish Government, 2019) was released in March 2019 and follows its 'Strategy for Digital Growth' (The Danish Government, 2018). This comprehensive framework lists objectives including establishing a responsible foundation for AI, providing high quality data and overall increasing investment in AI (particularly in the agriculture, energy, healthcare and transport sectors). There is a strong focus on data ethics, including responsibility, security and transparency, and recognition of the need for an ethical framework. The Danish government outlines six principles for ethical AI – self-determination, dignity, responsibility, explainability, equality and justice, and development (solutions that support ethically responsible development and use of AI in order to achieve societal progress) – and will establish a Data Ethics Council to monitor technological development in the country.

In **France**, 'AI for Humanity' was launched in March 2018 and makes commitments to support French talent, make better use of data and also establish an ethical framework on AI (AI For Humanity, 2018). President Macron has committed to ensuring transparency and fair use in AI, which will be embedded in the education system. The strategy is mainly based on the work of Cédric Villani, French mathematician and politician, whose 2018 report on AI made recommendations across economic policy, research infrastructure, employment and ethics (Villani, 2018).

Germany's AI Strategy was adopted soon after in November 2018 (Die Bundesregierung, 2018) and makes three major pledges: to make Germany a global leader in the development and use of AI, to safeguard the responsible development and use of AI, and to integrate AI in society in ethical, legal, cultural and institutional terms. Individual objectives include developing Centres of Excellence for research, the creation of 100 extra professorships for AI, establishing a German AI observatory, funding 50 flagship applications of AI to benefit the environment, developing guidelines for AI that are compatible with data protection laws, and establishing a 'Digital Work and Society Future Fund' (De.digital, 2018).

Sweden's approach to AI (Government Offices of Sweden, 2018) has less specific terms, but provides general guidance on education, research, innovation and infrastructure for AI. Recommendations include building a strong research base, collaboration between sectors and with other countries, developing efforts to prevent and manage risk and developing standards to guide the ethical use of AI. A Swedish AI Council, made up of experts from industry and academia, has also been established to develop a 'Swedish model' for AI, which they say will be sustainable, beneficial to society and promote long-term economic growth (Swedish AI Council, 2019).

The **UK** government issued the comprehensive 'AI Sector Deal' in April 2018 (GOV.UK, 2018), part of a larger 'Industrial Strategy', which sets out to increase productivity by investing in business, skills and infrastructure (GOV.UK, 2019). It pledges almost £1 billion to promote AI in the UK, along five key themes: ideas, people, infrastructure, business environment and places.

Key policies include increasing research and development investment to a total of 2.4% of GDP by 2027; investing over £400 million in maths, digital and technical education; developing a national retraining scheme to plug the skills gap and investing in digital infrastructure such as electric

AMSCE-IDL

vehicles and fibre networks. As well as these investment commitments, included in the deal is the creation of a 'Centre for Data Ethics and Innovation' (CDEI) to ensure the safe and ethical use of AI. First announced in the 2017 budget, the CDEI will assess the risks of AI, review regulatory and governance frameworks and advise the government and technology creators on best practice (UK Government Department for Digital, Culture, Media & Sport, 2019).

Several other European nations are well on their way to releasing national strategies. **Austria** has established a 'Robot Council' to help the Government to develop a national AI Strategy (Austrian Council on Robotics and Artificial Intelligence, 2019). A white paper prepared by the Council lays the groundwork for the strategy. The socially-focused document includes objectives to promote the responsible use of AI, develop measures to recognise and mitigate hazards, create a legal framework to protect data security, and engender a public dialogue around the use of AI (Austrian Council on Robotics and Artificial Intelligence, 2018).

Estonia has traditionally been quick to take up new technologies, AI included. In 2017, Estonia's Adviser for Digital Innovation Marten Kaevats described AI as the next step for 'e-governance' in Estonia (Plantera, 2017). Indeed, AI is already widely used by the government, which is currently devising a national AI strategy (Castellanos, 2018). The plan will reportedly consider the ethical implications of AI, alongside offering practical economic incentives and pilot programmes.

An AI task force has been established by **Italy** (Agency for Digital Italy, 2019) to identify the opportunities offered by AI and improve the quality of public services. Their white paper (Task Force on Artificial Intelligence of the Agency for Digital Italy, 2018), published in March 2018, describes ethics as the first challenge to the successful implementation of AI, stating a need to uphold the principle that AI should be at the service of the citizen and to ensure equality by using technology to address universal needs. The task force further outline challenges relating to technology development, the skills gap, data accessibility and quality, and a legal framework. It makes a total of 10 recommendations to government, which are yet to be realised by policy.

Malta, a country that has previously focused heavily on blockchain technology, has now made public its plans to develop a national AI strategy, putting Malta 'amongst the top 10 nations with a national strategy for AI' (Malta AI, 2019). A task force has been established composed of industry representatives, academics and other experts to help devise a policy for Malta that will focus on an ethical, transparent and socially-responsible AI while developing measures that garner foreign investment, which will include developing the skillset and infrastructure needed to support AI in Malta.

Poland too is working on its national AI strategy. A report recently released by the Digital Poland Foundation (2019) focuses on the AI ecosystem in Poland, as a forerunner of the national AI strategy. Although it provides a comprehensive overview of the state-of-the-art in Poland, it does not make specific recommendations for government, and makes no reference to the ethical issues surrounding AI.

Despite media reports of military-focused AI developments in **Russia** (Apps, 2019; Bershidski, 2017; Le Miere, 2017; O'Connor, 2017) the country currently has no national strategy on AI. Following the 2018 conference 'Artificial Intelligences: Problems and Solutions', the Russian Ministry of Defence released a list of policy recommendations, which include creating a state system for AI education and a national centre for AI. The latest reports suggest President Putin has set a deadline of June 15th 2019 for his government to finalise the national strategy on AI.

5.1.1. Across the EU: Public attitudes to robots and digitisation

Overall, surveys of European perspectives to AI, robotics, and advanced technology (European Commission 2012; European Commission 2017) have reflected that citizens hold a generally positive view of these developments, viewing them as a positive addition to society, the economy, and citizens' lives. However, this attitude varies by age, gender, educational level, and location and is largely dependent on one's exposure to robots and relevant information — for example, only small numbers of those surveyed actually had experience of using a robot (past or present), and those with experience were more likely to view them positively than those without.

General trends in public perception from these surveys showed that respondents were:

- Supportive of using robots and digitisation in jobs that posed risk or difficulty to humans (such as space exploration, manufacturing and the military);
- Concerned that such technology requires effective and careful management;
- Worried that automation and digitisation would bring job losses, and unsure whether it would stimulate and boost job opportunities across the EU;
- Unsupportive of using robots to care for vulnerable members of society (the elderly, ill, dependent pets, or those undergoing medical procedures);
- Worried about accessing and protecting their data and online information, and likely to have taken some form of protective action in this area (antivirus software, changed browsing behaviour);
- Unwilling to drive in a driverless car (only 22% would be happy to do this);
- Distrustful of social media, with only 7% viewing stories published on social media as 'generally trustworthy'; and
- Unlikely to view widespread use of robots as near-term, instead perceiving it to be a scenario that would occur at least 20 years in the future.

These concerns thus feature prominently in European AI initiatives, and are reflective of general opinion on the implementation of robots, AI, automation and digitisation across the spheres of life, work, health, and more.

5.2. North America

Canada was the first country in the world to launch a national AI strategy, back in March 2017. The Pan-Canadian Artificial Intelligence Strategy (Canadian Institute For Advanced Research, 2017) was established with four key goals, to: increase the number of AI researchers and graduates in Canada; establish centres of scientific excellence (in Edmonton, Montreal and Toronto); develop global thought leadership in the economic, ethical, policy and legal implications of AI; and support a national research community in AI.

A separate programme for AI and society was dedicated to the social implications of AI, led by policy-relevant working groups that publish their findings for both government and public. In collaboration with the French National Centre for Scientific Research (CNRS) and UK Research and Innovation (UKRI), the AI and society programme has recently announced a series of interdisciplinary workshops to explore issues including trust in AI, the impact of AI in the healthcare sector and how AI affects cultural diversity and expression (Canadian Institute For Advanced Research, 2019).

In the **USA**, President Trump issued an Executive Order launching the 'American AI Initiative' in February 2019 (The White House, 2019a), soon followed by the launch of a website uniting all other AI initiatives (The White House, 2019b), including AI for American Innovation, AI for American Industry, AI for the American Worker and AI for American Values. The American AI Initiative has five key areas: investing in R&D, unleashing AI resources (i.e. data and computing power), setting

AMSCE-101

governance standards, building the AI workforce and international engagement. The Department of Defence has also published its own AI strategy (US Department of Defence, 2018), with a focus on the military capabilities of AI.

In May, the US advanced this with the AI Initiative Act, which will invest $2.2 billion into developing a national AI strategy, as well as funding federal R&D. The legislation, which seeks to 'establish a coordinated Federal initiative to accelerate research and development on artificial intelligence for the economic and national security of the United States' commits to establishing a National AI Coordination Office, create AI evaluation standards and fund 5 national AI research centres. The programme will also fund the National Science Foundation to research the effects of AI on society, including the roles of data bias, privacy and accountability, and expand AI-based research efforts led by the Department of Energy (US Congress, 2019).

In June 2019, the National Artificial Intelligence Research and Development Strategic Plan was released, which builds on an earlier plan issued by the Obama administration and identifies eight strategic priorities, including making long-term investments in AI research, developing effective methods for human-AI collaboration, developing shared public datasets, evaluating AI technologies through standards and benchmarks, and understanding and addressing the ethical, legal and societal implications of AI. The document provides a coordinated strategy for AI research and development in the US (National Science & Technology Council, 2019).

5.3. Asia

Asia has in many respects led the way in AI strategy, with **Japan** being the second country to release a national initiative on AI. Released in March 2017, Japan's AI Technology Strategy (Japanese Strategic Council for AI Technology, 2017) provides an industrialisation roadmap, including priority areas in health and mobility, important with Japan's ageing population in mind. Japan envisions a three-stage development plan for AI, culminating in a completely connected AI ecosystem, working across all societal domains.

Singapore was not far behind. In May 2017, AI Singapore was launched, a five-year programme to enhance the country's capabilities in AI, with four key themes: industry and commerce, AI frameworks and testbeds, AI talent and practitioners and R&D (AI Singapore, 2017). The following year the Government of Singapore announced additional initiatives focused around the governance and ethics of AI, including establishing an Advisory Council on the Ethical Use of AI and Data, formalised in January 2019's 'Model AI Governance Framework' (Personal Data Protection Commission Singapore, 2019). The framework provides a set of guiding ethical principles, which are translated into practical measures that businesses can adopt, including how to manage risk, how to incorporate human decision making into AI and how to minimise bias in datasets.

China's economy has experienced huge growth in recent decades, making it the world's second largest economy (World Economic Forum, 2018). To catapult China to world leader in AI, the Chinese Government released the 'Next Generation AI Development Plan' in July 2017. The detailed plan outlines objectives for industrialisation, R&D, education, ethical standards and security (Foundation for Law and International Affairs, 2017). In line with Japan, it is a three-step strategy for AI development, culminating in 2030 with becoming the world's leading centre for AI innovation.

There is substantial focus on governance, with intent to develop regulations and ethical norms for AI and 'actively participate' in the global governance of this technology. Formalised under the 'Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry', the strategy iterates four main goals, to: scale-up the development of key AI products (with a focus on intelligent vehicles, service robots, medical diagnosis and video image identification

AMSCE-101

systems); significantly enhance core competencies in AI; deepen the development of smart manufacturing; and establish the foundation for an AI industry support system (New America, 2018).

In **India**, AI has the potential to add 1 trillion INR to the economy by 2035 (NITI Aayog, 2018). India's AI strategy, named AI for All, aims to utilise the benefits of AI for economic growth but also social development and 'inclusive growth', with significant focus on empowering citizens to find better quality work. The report provides 30 recommendations for the government, which include setting up Centres of Research Excellence for AI (COREs, each with their own Ethics Council), promoting employee reskilling, opening up government datasets and establishing 'Centres for Studies on Technological Sustainability'. It also establishes the concept of India as an 'AI Garage', whereby solutions developed in India can be rolled out to developing economies in the rest of the world.

Alongside them, **Taiwan** released an 'AI Action Plan' in January 2018 (AI Taiwan, 2018), focused heavily on industrial innovation, and **South Korea** announced their 'AI Information Industry Development Strategy' in May 2018 (H. Sarmah, 2019). The report on which this was based (Government of the Republic of Korea, 2016) provides fairly extensive recommendations for government, across data management, research methods, AI in government and public services, education and legal and ethical reforms.

Malaysia's Prime Minister announced plans to introduce a national AI framework back in 2017 (Abas, 2017), an extension of the existing 'Big Data Analytics Framework' and to be led by the Malaysia Digital Economy Corporation (MDEC). There has been no update from the government since 2017. More recently, **Sri Lanka**'s wealthiest businessman Dhammika Perera has called for a national AI strategy in the country, at an event held in collaboration with the Computer Society of Sri Lanka (Cassim, 2019), however there has not yet been an official pledge from the government.

In the Middle East, the **United Arab Emirates** was the first country to develop a strategy for AI, released in October 2017 and with emphasis on boosting government performance and financial resilience (UAE Government, 2018). Investment will be focused on education, transport, energy, technology and space. The ethics underlying the framework is fairly comprehensive; the Dubai AI Ethics Guidelines dictate the key principles that make AI systems fair, accountable, transparent and explainable (Smart Dubai, 2019a). There is even a self-assessment tool available to help developers of AI technology to evaluate the ethics of their system (Smart Dubai, 2019b).

World leader in technology **Israel** is yet to announce a national AI strategy. Acknowledging the global race for AI leadership, a recent report by the Israel Innovation Authority (Israel Innovation Authority, 2019) recommended that Israel develop a national AI strategy 'shared by government, academia and industry'.

5.4. Africa

Africa has taken great interest in AI; a recent white paper suggests this technology could solve some of the most pressing problems in Sub-Saharan Africa, from agricultural yields to providing secure financial services (Access Partnership, 2018). The document provides essential elements for a pan-African strategy on AI, suggesting that lack of government engagement to date has been a hindrance and encouraging African governments to take a proactive approach to AI policy. It lists laws on data privacy and security, initiatives to foster widespread adoption of the cloud, regulations to enable the use of AI for provision of public services, and adoption of international data standards as key elements of such a policy, although one is yet to emerge.

AMSCE-101

Kenya however has announced a task force on AI (and blockchain) chaired by a former Secretary in the Ministry of Information and Communication, which will offer recommendations to the government on how best to leverage these technologies (Kenyan Wallstreet, 2018). **Tunisia** too has created a task force to put together a national strategy on AI and held a workshop in 2018 entitled 'National AI Strategy: Unlocking Tunisia's capabilities potential' (ANPR, 2018).

5.5. South America

Mexico is so far the only South American nation to release an AI strategy. It includes five key actions, to: develop an adequate governance framework to promote multi-sectorial dialogue; map the needs of industry; promote Mexico's international leadership in AI; publish recommendations for public consultation; and work both with experts and the public to achieve the continuity of these efforts (México Digital, 2018). The strategy is the formalisation of a White Paper (Martinho-Truswell et al., 2018) authored by the British Embassy in Mexico, consultancy firm Oxford Insights and thinktank C Minds, with the collaboration of the Mexican Government.

The strategy emphasises the role of its citizens in Mexico's AI development and the potential of social applications of AI, such as improving healthcare and education. It also addresses the fact that 18% of all jobs in Mexico (9.8 million in total) will be affected by automation in the coming 20 years and makes a number of recommendations to improve education in computational approaches.

Other South American nations will likely follow suit if they are to keep pace with emerging markets in Asia. Recent reports suggest AI could double the size of the economy in Argentina, Brazil, Chile, Colombia and Peru (Ovanessoff and Plastino, 2017).

5.6. Australasia

Australia does not yet have a national strategy on AI. It does however have a' Digital Economy Strategy' (Australian Government, 2017) which discusses empowering Australians through 'digital skills and inclusion', listing AI as a key emerging technology. A report on 'Australia's Tech Future' further details plans for AI, including using AI to improve public services, increase administrative efficiency and improve policy development (Australian Government, 2018).

The report also details plans to develop an ethics framework with industry and academia, alongside legislative reforms to streamline the sharing and release of public sector data. The draft ethics framework (Dawson et al., 2019) is based on case studies from around the world of AI 'gone wrong' and offers eight core principles to prevent this, including fairness, accountability and the protection of privacy. It is one of the more comprehensive ethics frameworks published so far, although yet to be implemented.

Work is also ongoing to launch a national strategy in **New Zealand**, where AI has the potential to increase GDP by up to $54 billion (AI Forum New Zealand, 2018). The AI Forum of New Zealand has been set up to increase awareness and capabilities of AI in the country, bringing together public, industry, academia and Government.

Their report 'Artificial Intelligence: Shaping The Future of New Zealand' (AI Forum New Zealand, 2018) lays out a number of recommendations for the government to coordinate strategy development (i.e. to coordinate research investment and the use of AI in government services); increase awareness of AI (including conducting research into the impacts of AI on economy and society); assist AI adoption (by developing best practice resources for industry); increase the accessibility of trusted data; grow the AI talent pool (developing AI courses, including AI on the list of valued skills for immigrants); and finally to adapt to AI's effects on law, ethics and society. This

AMSCE-1101

includes the recommendation to establish an AI ethics and society working group to investigate moral issues and develop guidelines for best practice in AI, aligned with international bodies.

Challenges to government adoption of AI

The World Economic Forum has, through consultation with stakeholders, identified five major roadblocks to government adoption of AI:

1. Effective use of data - Lack of understanding of data infrastructure, not implementing data governance processes (e.g. employing data officers and tools to efficiently access data).

2. Data and AI skills - It is difficult for governments, which have smaller hiring budgets than many big companies, to attract candidates with the required skills to develop first-rate AI solutions.

3. The AI ecosystem - There are many different companies operating in the AI market and it is rapidly changing. Many of the start-ups pioneering AI solutions have limited experience working with government and scaling up for large projects.

4. Legacy culture - It can be difficult to adopt transformative technology in government, where there are established practices and processes and perhaps less encouragement for employees to take risks and innovate than in the private sector.

5. Procurement mechanisms - The private sector treats algorithms as intellectual property, which may make it difficult for governments to customise them as required. Public procurement mechanisms can also be slow and complicated (e.g. extensive terms and conditions, long wait times from tender response submission to final decision).

(Torres Santeli and Gerdon, 2019)

5.7. International AI Initiatives, in addition to the EU

In addition to the EU, there are a growing number of international strategies on AI, aiming to provide a unifying framework for governments worldwide on stewardship of this new and powerful technology.

G7 Common Vision for the Future of AI

At the 2018 meeting of the G7 in Charlevoix, Canada, the leaders of the G7 (Canada, France, Germany, Italy, Japan, the United Kingdom and the United States) committed to 12 principles for AI, summarised below:

1. Promote human-centric AI and the commercial adoption of AI, and continue to advance appropriate technical, ethical and technologically neutral approaches.
2. Promote investment in R&D in AI that generates public test in new technologies and supports economic growth.
3. Support education, training and re-skilling for the workforce.
4. Support and involve underrepresented groups, including women and marginalised individuals, in the development and implementation of AI.

AMSCE-101

5. Facilitate multi-stakeholder dialogue on how to advance AI innovation to increase trust and adoption.
6. Support efforts to promote trust in AI, with particular attention to countering harmful stereotypes and fostering gender equality. Foster initiatives that promote safety and transparency.
7. Promote the use of AI by small and medium-sized enterprises.
8. Promote active labour market policies, workforce development and training programmes to develop the skills needed for new jobs.
9. Encourage investment in AI.
10. Encourage initiatives to improve digital security and develop codes of conduct.
11. Ensure the development of frameworks for privacy and data protection.
12. Support an open market environment for the free flow of data, while respecting privacy and data protection.

(G7 Canadian Presidency, 2018).

Nordic-Baltic Region Declaration on AI

The declaration signed by the Nordic-Baltic Region (comprising Denmark, Estonia, Finland, the Faroe Islands, Iceland, Latvia, Lithuania, Norway, Sweden and the Åland Islands) aims to promote the use of AI in the region, including improving the opportunities for skills development, increasing access to data and a specific policy objective to develop 'ethical and transparent guidelines, standards, principles and values' for when and how AI should be used (Nordic Co-operation, 2018).

OECD Principles on AI

On 22 May 2019, the Organisation for Economic Co-operation and Development issued its principles for AI, the first international standards agreed by governments for the responsible development of AI. They include practical policy recommendations as well as value-based principles for the 'responsible stewardship of trustworthy AI', summarised below:

- AI should benefit people and the planet by driving inclusive growth, sustainable development and well-being.
- AI systems should respect the rule of law, human rights, democratic values and diversity, and there should include appropriate safeguards to ensure a fair society.
- There should be transparency around AI to ensure that people understand outcomes and can challenge them.
- AI systems must function in a robust, secure and safe way throughout their life cycles and risks should be continually assessed.
- Organisations and individuals developing, deploying or operating AI systems should be held accountable.

These principles have been agreed by the governments of the 36 OECD Member States as well as Argentina, Brazil, Colombia, Costa Rica, Peru and Romania (OECD, 2019a). The G20 human-centred AI Principles were released in June 2019 and are drawn from the OECD Principles (G20, 2019).

United Nations

The UN has several initiatives relating to AI, including:

- AI for Good Global Summit- Summits held since 2017 have focused on strategies to ensure the safe and inclusive development of AI (International Telecommunication Union, 2018a,b). The events are organised by the International Telecommunication Union, which aims to 'provide a neutral platform for government, industry and

AMSCE-101

academia to build a common understanding of the capabilities of emerging AI technologies and consequent needs for technical standardisation and policy guidance.'

- UNICRI Centre for AI and Robotics - The UN Interregional Crime and Justice Research Institute (UNICRI) launched a programme on AI and Robotics in 2015 and will be opening a centre dedicated to these topics in The Hague (UNICRI, 2019).

- UNESCO Report on Robotics Ethics - The UNESCO World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) has authored a report on 'Robotics Ethics', which deals with the ethical challenges of robots in society and provides ethical principles and values, and a technology-based ethical framework (COMEST, 2017).

World Economic Forum

The World Economic Forum (WEF) formed a Global AI Council in May 2019, co-chaired by speech recognition developer Kai-Fu Lee, previously of Apple, Microsoft and Google, and current President of Microsoft Bradford Smith. One of six 'Fourth Industrial Revolution' councils, the Global AI Council will develop policy guidance and address governance gaps, in order to develop a common understanding among countries of best practice in AI policy (World Economic Forum, 2019a).

In October 2019, they released a framework for developing a national AI strategy to guide governments that are yet to develop or are currently developing a national strategy for AI. The WEF describe it as a way to create a 'minimum viable' AI strategy and includes four main stages:

1) Assess long-term strategic priorities
2) Set national goals and targets
3) Create plans for essential strategic elements
4) Develop the implementation plan

The WEF has also announced plans to develop an 'AI toolkit' to help businesses to best implement AI and to create their own ethics councils, which will be released at 2020's Davos conference (Vanian, 2019).

5.8. Government Readiness for AI

A report commissioned by Canada's International Development Research Centre (Oxford Insights, 2019) evaluated the 'AI readiness' of governments around the globe in 2019, using a range of data including not only the presence of a national AI strategy, but also data protection laws, statistics on AI startups and technology skills.

Singapore was ranked number 1 in their estimation, with Japan as the only other Asian nation in the top 10 (Table 3). Sixty percent of countries in the top 10 were European, with the remainder from North America.

The strong European representation in this analysis is reflective of the value of the unifying EU framework, as well as Europe's economic power. The analysis also praises the policy strategies of individual European nations, which, importantly, have been developed in a culture of collaboration. Examples of this collaborative approach include the EU Declaration of Cooperation on AI (European Commission, 2018d), in which Member States agreed to cooperate on boosting Europe's capacity in AI, and individual partnerships between Member States, such as that of Finland, Estonia and Sweden, working together to trial new applications of AI.

AMSCE-1101

Table 3: Top 10 rankings for Government AI Readiness 2018/19. Source: Oxford Insights, 2019.

Rank	Country	Score
1	Singapore	9.19
2	United Kingdom	9.07
3	Germany	8.81
4	USA	8.80
5	Finland	8.77
6	Sweden	8.67
6	Canada	8.67
8	France	8.61
9	Denmark	8.60
10	Japan	8.58

Singapore ranked highest of all nations while Japan, the second country in the world to release a national strategy on AI, ranked 10th. China's position as 21st in the global rankings is expected to improve next year as its investments in AI begin to pay off. Progress in Asia overall has been unbalanced, with two countries in the region also ranking in the bottom ten worldwide, reflecting the income inequality in the region.

Despite the comparatively slow development of their national strategy, the USA ranked 4th, with Canada not far behind. Both nations are supported by their strong economies, highly skilled workforces, private sector innovation and abundance of data, to a level at which regions missing from the top 10 – Africa, South America and Australasia – are unable to compete.

This framework provides a highly useful metric by which to assess the ability of governments to capitalise on AI's potential in the coming years. What this analysis does not consider however is how robustly each nation is considering the moral and ethical issues surrounding the use of AI, which we will explore below.

AMSCE-1101

6. Emerging Themes

Our review of the literature on the ethical issues surrounding AI and intelligent robots highlights a wide range of potential impacts, including in the social, psychological, financial, legal and environmental domains. These are bound up with issues of trust and are tackled in different ways by the emerging ethical initiatives. Standards and regulation are also beginning to develop that go some way to addressing these concerns. However, the focus of many existing strategies on AI is on enabling technology development and, while ethical issues are addressed, notable gaps can be identified.

6.1. Addressing ethical issues through national and international strategies

There are several themes shared by the various national strategies on AI, among which **industrialisation** and **productivity** perhaps rank highest. All countries have some sort of industrial strategy for AI, and this is particularly prominent in the emerging economies of Southeast Asia. Most of the strategies make reference to the importance of AI for business competitiveness and several, including those of Germany, South Korea, Taiwan and the UK, announce extra funding and specialised incubators for AI-focused start-ups.

Whether in the private or public sector, the importance of **research** and development is also universally recognised, with almost all strategies pledging enhanced funding for research and many to establish 'centres of excellence' entirely dedicated to AI research, including strategies from Canada, Germany and India.

Essential to developing a strong research effort is talent, and so investing in **people** and education also features heavily in most strategies. The UK has announced 'Turing Fellowships' to fund new academics exploring computational approaches, while Germany has provided for at least an extra 100 professors working on AI – both under the umbrella of the EU commitment to train, attract and retain talent. In Asia, South Korea has committed to developing six new graduate programmes to train a total of 5,000 AI specialists, while Taiwan has committed to training double that number by 2021.

Most of the strategies also consider the impact the AI revolution will have on the non-technology literate workforce, who may be the first to lose their jobs to automation. Although this crosses over into ethical considerations, several of the strategies make practical commitments to **re-training** programmes to help those affected to find new work. This is a key objective in the EU plan (objective 2.4: 'adapting our learning and training programmes and systems to better prepare our society for AI'), and therefore the plans of its Member States. The UK for example will initiate an > €70 million re-training scheme to help people gain digital skills and Germany has revealed a similar 'National Further Training Strategy'. Naturally, those countries most in need of re-training have the least funding available for it. Mexico's strategy however emphasises the importance of computational thinking and mathematics in lifelong teaching, including to help its citizens retrain, while India pledges to promote informal training institutions and create financial incentives for reskilling of employees. Other strategies however suggest re-training is the responsibility of individual businesses and do not allocate separate funding for it.

Collaboration between sectors and countries is another common thread, yet interpreted differently by different countries. India's approach for example is one of sharing; the 'AI Garage' concept named in their strategy means AI-based solutions developed in India will be rolled out to developing economies facing similar issues. Conversely, the US Executive Order on AI sets out to

AMSCE-101

'promote an international environment that supports American AI' while also protecting the nation's technological advantage against 'foreign adversaries'. Naturally, the strategies of EU Member States display an inclination for cross-border collaboration. Sweden for example states a need to develop partnerships and collaborations with other countries 'especially within the EU', while Denmark's strategy also emphasises close cooperation with other European countries.

The democratisation of technology has the potential to reduce inequalities in society, and **inclusion** and **social development** are important goals for many national AI initiatives, particularly those of developing economies. India's strategy discusses AI for 'greater good', focusing on the possibilities for better access to healthcare, economic growth for groups previously excluded from formal financial products, and using data to aid small-scale farmers. Mexico's strategy lists inclusion as one of its five major goals, which includes aims to democratise productivity and promote gender equality. France too aims for an AI that 'supports inclusivity', striving for policies that reduce both social and economic inequalities.

Determining who is **responsible** for the actions and behaviour of AI is highly important, and challenging in both moral and legal senses. Currently, AI is most likely considered to be the legal responsibility of a relevant human actor – a tool in the hands of a developer, user, vendor, and so on. However, this framework does not account for the unique challenges brought by AI, and many grey areas exist. As just one example, as a machine learns and evolves to become different to its initial programming over many iterations, it may become more difficult to assign responsibility for its behaviour to the programmer. Similarly, if a user or vendor is not adequately briefed on the limitations of an AI agent, then it may not be possible to hold them responsible. Without proving that an AI agent intended to commit a crime (*mens rea*) and can act voluntarily, both of which are controversial concepts, then it may not be possible to deem an AI agent responsible and liable for its own actions.

6.2. Addressing the governance challenges posed by AI

There are currently two major international frameworks for the governance of AI: that of the EU (see Section 5.1) and the Organisation for Economic Co-operation and Development (OECD).

The OECD launched a set of principles for AI in May 2019 (OECD, 2019a) which were at that time adopted by 42 countries. The OECD framework offers five fundamental principles for the operation of AI (see section 5.1.1) as well as accompanying practical recommendations for governments to achieve them. The G20 soon after adopted its own, human-centred AI principles, drawn from (and essentially an abridged version of) those of the OECD (G20, 2019).

The OECD Principles have also been backed by the European Commission, which has its own strategy on AI since April 2018 (European Commission, 2018b). The EU framework includes comprehensive plans for investment, but also makes preparations for complex socio-economic changes and is complemented by a separate set of ethics guidelines (European Commission High-Level Expert Group on AI, 2019a).

Gaps in AI frameworks

These frameworks address the moral and ethical dilemmas identified in this report to varying extents, with some notable gaps. Regarding **environmental concerns** (Section 2.5), while the OECD makes reference to developing AI that brings positive outcomes for the planet, including protecting natural environments, the document does not suggest ways to achieve this, nor does it mention any specific environmental challenges to be considered.

The EU Communication on AI does not discuss the environment. However, its accompanying ethics guidelines are founded on the principle of prevention of harm, which includes harm to the natural

AMSCE-101

environment and all living beings. Societal and environmental well-being (including sustainability and 'environmental friendliness') is one of the EU's requirements for trustworthy AI and its assessment list includes explicit consideration of risks to the environment or to animals. Particular examples are also given on how to achieve this (e.g. critical assessment of resource use and energy consumption throughout the supply chain).

Impacts on human **psychology**, including how people interact with AI and subsequent effects on how people interact with each other, could be further addressed in the frameworks. The psychosocial impact of AI is not considered by the OECD Principles or the EU Communication. However, the EU requirement for societal well-being to be considered does address 'social impact', which includes possible changes to social relationships and loss of social skills. The guidelines state that such effects must 'be carefully monitored and considered' and that AI interacting with humans must clearly signal that its social interaction is simulated. However, more specific consideration could be given to human-robot relationships or more complex effects on the human psyche, such as those outlined above (Section 2.2).

While both frameworks capably address changes to the **labour market** (Section 2.1.1), attention to more nuanced factors, including the potential for AI to drive **inequalities** (2.1.2) and **bias** (2.1.4), is more limited. The OECD's first principle of inclusive growth, sustainable development and well-being states that AI should be developed in a way that reduces 'economic, social, gender and other inequalities'. This is also covered to a degree by the second OECD principle, which states that AI systems should respect diversity and include safeguards to ensure a fair society, however detail on how this can be achieved is lacking.

The EU ethics guidelines are more comprehensive on this point and include diversity, non-discrimination and fairness as a separate requirement. The guidelines elaborate that equality is a fundamental basis for trustworthy AI and state that AI should be trained on data which is representative of different groups in order to prevent biased outputs. The guidelines include additional recommendations on the avoidance of unfair bias.

Both frameworks include **human rights** and **democratic values** (Sections 2.1.3, 2.1.5) as key tenets. This includes **privacy**, which is one of the OECD's human-centred values and a key requirement of the EU ethics guidelines, which elaborates on the importance of data governance and data access rules. Issues concerning privacy are also covered by existing OECD data protection guidelines (OECD, 2013).

The implications of AI for **democracy** (Section 2.1.5) are only briefly mentioned by the OECD, with no discussion of the particular issues facing governments at the present time, such as Deepfake or the manipulation of opinion through targeted news stories. Threats to democracy are not mentioned at all in the EU Communication, although society and democracy is a key theme in the associated ethics guidelines, which state that AI systems should serve to maintain democracy and not undermine 'democratic processes, human deliberation or democratic voting systems.'

These issues form part of a bigger question surrounding changes to the **legal system** (Section 2.4) that may be necessary in the AI age, including important questions around liability for misconduct involving AI. The issue of liability is explicitly addressed by the EU in both its Communication and ethics guidelines. Ensuring an appropriate legal framework is a key requirement of the EU Communication on AI, which includes guidance on product liability and an exploration of safety and security issues (including criminal use). The accompanying ethics guidelines also suitably handle this issue, including providing guidance for developers on how to ensure legal compliance. Relevant changes to regulation are further addressed in the recent AI Policy and Investment Recommendations (European Commission High-Level Expert Group on AI, 2019b), which explore potential changes to current EU laws and the need for new regulatory powers.

The OECD principles are more limited on this point. While they provide guidance for governments to create an 'enabling policy environment' for AI, including a recommendation to review and adapt

AMSCE-101

regulatory frameworks, this is stated to be for the purpose of encouraging 'innovation and competition' and does not address the issue of liability for AI-assisted crime.

These questions could also come under the issue of **accountability** (2.6.4) however, which is adequately addressed by both frameworks. The OECD lists accountability as a key principle and states that 'organisations and individuals developing, deploying or operating AI systems should be held accountable for their proper functioning' (OECD, 2019a). It is likewise a core principle of the EU ethics guidelines, which provides more than 10 conditions for accountability in its assessment list for trustworthy AI.

Many of the aforementioned issues are ultimately important for building **trust** in AI (Section 2.6), which also requires AI to be fair (2.6.2) and transparent (2.6.3). These issues are at the foundation of the EU ethics guidelines where they are dealt with in great detail. The OECD also states that AI systems should ensure a 'fair and just society'. Transparency and explainability is a core principle for the OECD, with strong emphasis on the fact that people should be able to understand and challenge AI systems. The OECD Principles offer less context on these issues and do not consider practical means of ensuring this (e.g. audits of algorithms), which are considered by the EU ethics guidelines. The ethics guidelines also consider the need for human oversight (including discussion of the human-in-the-loop approach and the need for a 'stop button', neither of which are mentioned by the OECD principles).

Finally, although both acknowledge the beneficial use of AI in **finance** (Section 2.3), neither framework adequately addresses potential negative impacts on the financial system, either through accidental harm or malicious activity. The potential for AI-assisted financial crime is an important one and currently unaddressed by any international framework. However, the G7 has recently voiced concerns about digital currencies and various other new financial products being developed (Reuters, 2019), which suggests that regulatory changes in this regard are afoot.

AMSCL-101

7. Summary

What this report makes clear is the diversity and complexity of the ethical concerns arising from the development of artificial intelligence; from large scale issues such job losses from automation, degradation of the environment and furthering inequalities, to more personal moral quandaries such as how AI may affect our privacy, our ability to judge what is real, and our personal relationships.

What is also clear is that there are various **approaches to ethics**. Robust ethical principles are essential in the future of this rapidly developing technology, but not all countries understand ethics in the same way. There are a number of independent ethical initiatives for AI, such as Germany's Institute for Ethics in AI, funded by Facebook, and the private donor-funded Future of Life Institute in the US. An increasing number of governments are also developing national AI strategies, with their own ethics components. A number of countries have committed to creating AI ethics councils, including Germany, the UK, India, Singapore and Mexico. The UAE has also prioritised ethics in its national strategy, by developing an 'Ethical AI Toolkit' and self-assessment tool for developers, while several others give only passing reference; ethics is almost completely left out by Japan, South Korea and Taiwan.

Our assessment shows that the vast majority of ethical issues identified here are also addressed in some form by at least one of the current international frameworks; the EU Communication (supplemented by separate ethics guidelines) and the OECD Principles on AI.

The current frameworks address the major ethical concerns and make recommendations for governments to manage them, but **notable gaps** exist. These include environmental impacts, including increased energy consumption associated with AI data processing and manufacture, and inequality arising from unequal distribution of benefits and potential exploitation of workers. Policy options relating to environmental impacts include providing a stronger mandate for sustainability and ecological responsibility; requiring energy use to be monitored, and publication of carbon footprints; and potentially policies that direct technology innovation towards urgent environmental priorities. In the case of inequality, options include declaring AI as a public, rather than private, good. This would require changes to cultural norms and new strategies to help navigate a transition to an AI-driven economy. Setting minimum standards for corporate social responsibility reporting would encourage larger, transnational corporations to clearly show how they are sharing the benefits of AI. Economic policies may be required to support workers displaced by AI; such policies should focus on those at most risk of being left behind and might include policies designed to create support structures for precarious workers. It will be important for future iterations of these frameworks to address these and other gaps in order to adequately prepare for the full implications of an AI future. In addition, to clarify the issue of responsibility pertaining to AI behaviour, moral and legislative frameworks will require updating alongside the development of the technology itself.

Governments also need to develop new, up-to-date forms of **technology assessment** – allowing them to understand such technologies deeply while they can still be shaped, such as the Accountability Office's Technology Assessment Unit in the USA or the European Foresight platform (http://www.foresight-platform.eu/). New forms of technology assessment TA should include processes of Ethical Risk Assessment, such as the one set out in BS8611, and other forms of ethical evaluation currently being drafted in the IEEE Standards Association P7000 series of ethical standards; P7001 for instance sets out a method for measuring the transparency of an AI.

There is a clear need for the development of viable and applicable **legislation and policies** that will face the multifaceted challenges associated with AI, including potential breaches of fundamental ethical principles. Policy makers are in the valuable position of being able to develop policy that actively shapes the development of AI and as data-driven and machine-learning approaches begin

AMSCE-101

to take increasing roles in society, thoughtful and detailed strategies on how to share benefits and achieve the best possible outcomes, while effectively managing risk, will be essential.

As well as the very encouraging progress made in policy so far, this report also reveals a concerning **disparity** between regions. Successful AI development requires substantial investment, and as automation and intelligent machines begin to drive government processes, there is a real risk that lower income countries – those nations of the Global South – will be left behind. It is incumbent upon policymakers therefore to try to ensure that AI does not widen global inequalities. This could include **data sharing** and collaborative approaches, such as India's promise to share its AI solutions with other developing countries, and efforts to make teaching on computational approaches a fundamental part of education, available to all.

To return to our main theme, **ethical considerations** must also be a critical component of any policy on AI. It speaks volumes that the nation ranked highest in the 2019 Government AI Readiness Index has prioritised ethics so strongly in their national AI Strategy. Singapore is one of a few governments to create an AI Ethics Council and has incorporated a range of ethical considerations into its policy. Addressing ethical concerns is also the first key point in the World Economic Forum's framework for developing a national AI strategy. So, aside from any potential moral obligations, it seems unlikely that governments that do not take ethics seriously will be able to succeed in the competitive global forum.

AMSCE-I101

8. Appendix

Building ethical robots

In the future it's very likely that intelligent machines will have to make decisions that affect human safety, psychology and society. For example, a search and rescue robot should be able to 'choose' the victims to assist first after an earthquake; an autonomous car should be able to 'choose' what or who to crash into when an accident cannot be avoided; a home-care robot should be able to balance its user's privacy and their nursing needs. But how do we integrate societal, legal and moral values into technological developments in AI? How can we program machines to make ethical decisions - to what extent can ethical considerations even be written in a language that computers understand?

Devising a method for integrating ethics into the design of AI has become a main focus of research over the last few years. Approaches towards moral decision making generally fall into two camps, 'top-down' and 'bottom-up' approaches (Allen et al., 2005). Top-down approaches involve explicitly programming moral rules and decisions into artificial agents, such as 'thou shalt not kill'. Bottom up approaches, on the other hand, involve developing systems that can implicitly learn to distinguish between moral and immoral behaviours.

Bottom-up approaches
Bottom up approaches involve allowing robots to learn ethics independently of humans, for instance by using machine learning. Santos-Lang (2002) points out that this is a better approach, as humans themselves continuously learn to be ethical. An advantage of this is that most of the work is done by the machine itself, which avoids the robot being influenced by the designers' biases. However the downside is that machines could demonstrate unintended behaviour that deviates from the desired goal. For example, if a robot was programmed to 'choose behaviour that leads to the most happiness', the machine may discover that it can more quickly reach its goal of maximising happiness by first increasing its own learning efficiency, 'temporarily' shifting away from the original goal. Because of the shift, the machine may even choose behaviours that temporarily reduce happiness, if these behaviours were to ultimately help it achieve its goal. For example a machine could try to rob, lie and kill, in order to become an ethical paragon later.

Top-down approaches
Top-down approaches involve programming agents with strict rules that they should follow in given circumstances. For example, in self-driving cars a vehicle could be programmed with the command 'you shall not drive faster than 130 km/h on the highway'. The problem with top down approaches is that they require deciding which moral theories ought to be applied. Examples of competing moral theories include utilitarian ethics, deontological ethics and the commensal view and the Doctrine of Double Effect.

Utilitarianism is based on the notion that the morality of an action should be judged by its consequences. In other words, an action is judged to be morally right if its consequences lead to the greater good. Different utilitarian theories vary in terms of the definition of the 'good' they aim to maximise. For example, Bentham (1789) proposed that a moral agent should aim to maximise the total happiness of a population of people.

Deontological (duty-based) ethics, on the other hand argues that actions should be judged not on the basis of their expected outcomes, but on what people do. Duty-based ethics teaches that actions are right or wrong regardless of the good or bad consequences that may be produced. Under this form of ethics you can't justify an action by showing that it produced good consequences.

AMSCE-IOI

Sometimes different moral theories can directly contradict each other. For example, in the case of a self-driving car that has to decide whether to swerve to avoid animals in its path. Under the commensal view, animal lives are treated as if they are worth some small fraction of what human lives are worth, and so the car would swerve if there was a low chance of causing harm to a human (Bogosian, 2017). However, the incommensal view would never allow humans to be placed at additional risk of fatality in order to save an animal. Since this view fundamentally rejects the assumptions of the other, and holds that no tradeoff is permissible, there is no obvious 'halfway point' where the competing principles can meet.

Bonnemains et al. (2018) describe a dilemma where a drone programmed to take out a missile threatening an allied ammo factory is suddenly alerted to a second threat - a missile heading towards some civilians. The drone must decide whether to continue its original mission, or take out the new missile in order to save the civilians. The decision outcome is different depending on whether you use utilitarianism, deontological ethics and the Doctrine of Double Effect - a theory which states that if doing something morally good has a morally bad side-effect, it's ethically okay to do it providing that the bad side-effect wasn't intended.

Some of the theories are unable to solve the problem. For instance, from a deontological perspective both decisions are valid, as they both arise from good intentions. In the case of utilitarian ethics, without any information about the number of civilians that are in danger, or the value of the strategic factory, it would be difficult for a drone to reach a decision. In order to follow the utilitarian doctrine and make a decision that maximised a 'good outcome', an artificial agent would need to identify all possible consequences of a decision, from all parties' perspectives, before making a judgement about which consequence is preferable. This would be impossible in the field. Another issue is how should a drone decide which outcomes it prefers when this is a subjective judgement? What is Good? Giving an answer to this broad philosophical issue is hardly possible for an autonomous agent, or the person programming it.

Under the Doctrine of Double Effect the drone would not be allowed to intercept the missile and save the civilians, as the bad side effect (the destruction of the drone itself) would be a means to ensuring the good effect (saving the humans). It would therefore continue to pursue its original goal and destroy the launcher, letting the civilians die.

If philosophers cannot agree on the merits of various theories, companies, governments, and researchers will find it even more difficult to decide which system to use for artificial agents (Bogosion, 2017). People's personal moral judgements can also differ widely when faced with moral dilemmas (Greene et al., 2001), particularly when they are considering politicised issues such as racial fairness and economic inequality. Bogosian (2017) argues that instead, we should design machines to be fundamentally uncertain about morality.

AMSCE-IOI

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AMSCE-110J

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This study deals with the ethical implications and moral questions that arise from the development and implementation of artificial intelligence (AI) technologies. It also reviews the guidelines and frameworks which countries and regions around the world have created to address these. It presents a comparison between the current main frameworks and the main ethical issues, and highlights gaps around the mechanisms of fair benefit-sharing; assignment of responsibility; exploitation of workers; energy demands in the context of environmental and climate changes; and more complex and less certain implications of AI, such as those regarding human relationships.

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EPRS | European Parliamentary Research Service

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IEEE STANDARDS ASSOCIATION

IEEE

IEEE RAS/SA 7007 - Ontological Standard for Ethically Driven Robotics and Automation Systems

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Some slides by **Prof. Edson Prestes (Chair)**

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IEEE SA/RAS P7007- Ontological Standard for Ethically Driven Robotics and Automation Systems

http://standards.ieee.org/develop/project/7007.html

Scope: The standard establishes a set of ontologies with different abstraction levels that contain concepts, definitions and axioms which are necessary to establish ethically driven methodologies for the design of Robots and Automation Systems.

Purpose : The standard establishes **a set of definitions and their relationships** that will enable the development of Robotics and Automation Systems in accordance with worldwide Ethics and Moral theories, with a particular emphasis on aligning the ethics and engineering communities to understand how to pragmatically design and implement these systems in unison. These definitions allow for a precise communication among global experts of different domains that includes Robotics, Automation and Ethics

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Ontological Standards

- Ontologies are information artifacts that represent consensual knowledge in an explicit and formal way.
- Very good tool standardization initiatives: formalize the consensus around a specific domain.
- Main uses:
  - Vocabulary disambiguation among groups of humans, robots, and other groups of agents that share the same conceptualization.
  - Conceptual model (e.g. in databases).
  - Symbolic model to support different forms of reasoning

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What an ontology for Robot Ethics should define?

✗ What *is* ethical or not ethical.

✓ What we mean when we say
that something is ethical or not ethical.

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It should provide answers to:

- What does it mean to say that a robot is unethical?
- What is an ethical issue?
- What is an ethical theory?
- What is a norm? What are its elements?
- What it means to say that a robot violates a norm?
- How robot action and design conforms to norms?
- What are the contextual elements of a ethical action?
- ...

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IEEE SA / RAS P7007- Ontological Standard for Ethically Driven Robotics and Automation Systems

http://standards.ieee.org/develop/project/7007.html

Group Expectation

"Our standard should be used as guide to the design, development and operation of products and services related robots and robotic systems with respect to ethics. It should help decision makers and robot designers to address ethical issues regarding user experience, safety, data protection, data privacy and transparency”

Possible use

- a guide for teaching ethical design;
- a reference by policy makers and governments to draft AI related policies;
- a common vocabulary to enable the communication among government agencies and other professional bodies around the world;
- part of decision making during investment in companies and technologies;
- a framework to create systems that can act ethically;

Stakeholders: Manufacturers, service and solution providers, equipment suppliers in the robotics and users.

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IEEE SA/RAS P7007- Ontological Standard for Ethically Driven Robotics and Automation Systems

http://standards.ieee.org/develop/project/7007.html

Currently, our group more than **120 members** from

Brazil, Portugal, USA, United Kingdom, Hungary, Italy, Norway, Canada,

Spain, France, Greece, Switzerland, Germany, Spain, Sweden, Nederland,

Malaysia, China, Egypt, Bangladesh, Israel

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Main sub-groups

- **Robot Ethics KR SG**: This subgroup will review the theoretical aspects that characterize ethics in R&A and propose models to represent them. It is the main ontology group;

- **Ethical Robot Design SG**: This subgroup will produce guidelines and models to take into account ethical concerns in general robot design, from simple automatons to highly autonomous systems;

- **Ethical Violation Management SG**: This subgroup will produce a set of guidelines and models to assess and correct ethical violations in robot behavior. This might also include aspects regarding transparency, accountability and responsibility.

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IEEE SA/RAS P7007- Ontological Standard for Ethically Driven Robotics and Automation Systems

http://standards.ieee.org/develop/project/7007.html

Transversal Subgroups

Transparency : guidelines and models to regulate transparency in robots.

Data privacy and protection: guidelines and models to regulate data privacy and protection in robots.

Full Moral Robots: guidelines and models to design and operate robots which actively adapt their behavior according ethical notions.

Law: guidelines and models to assess accountability and responsibility, taking into account law and regulations.

Ethical use of robots: guidelines and models for the ethical use of robots (i.e. taking into account the impact in economics, tax and politics).

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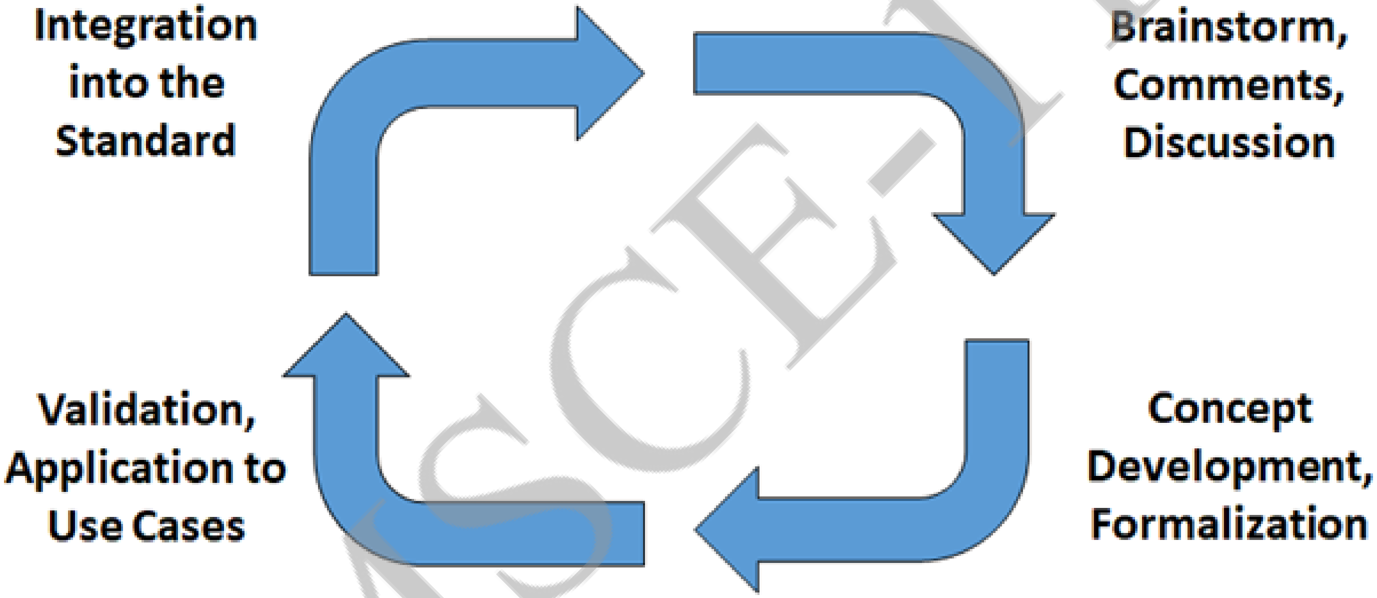
Work so far: methodology


Integration into the Standard
Brainstorm, Comments, Discussion
Concept Development, Formalization
Validation, Application to Use Cases

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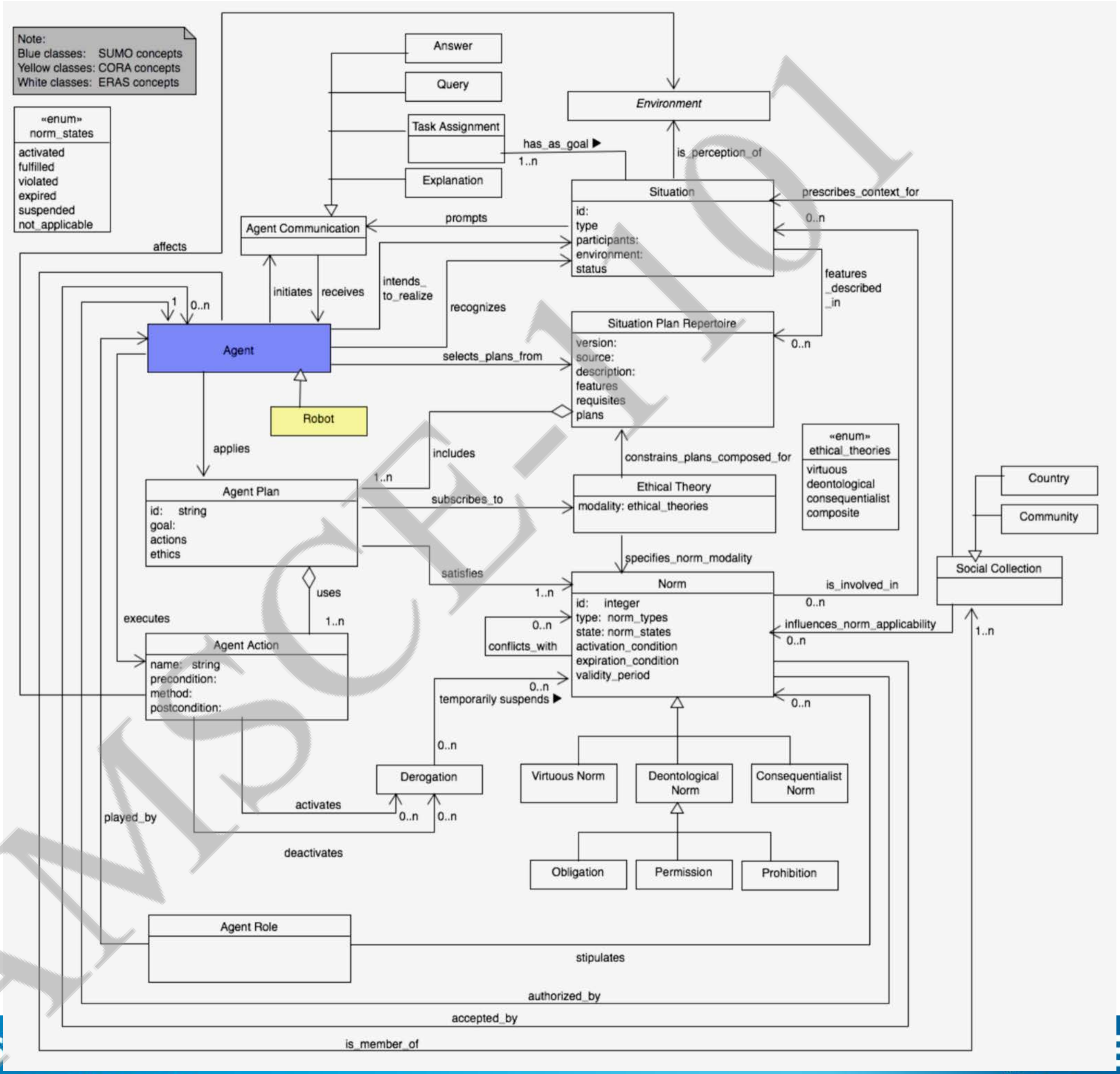
Work so far: initial model for actions and norms



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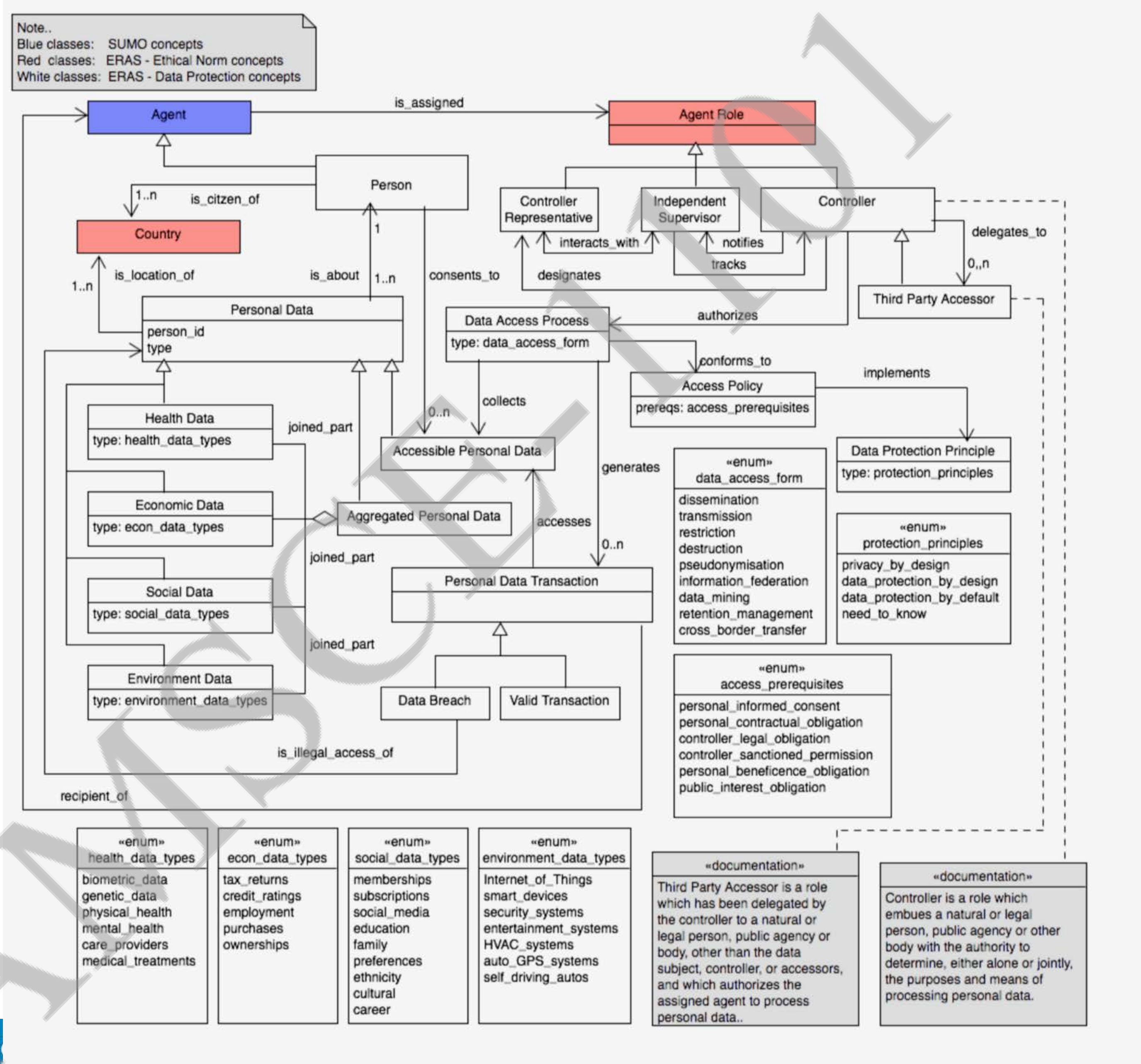
Work so far: initial model privacy (based on GDPR)



Note..
Blue classes: SUMO concepts
Red classes: ERAS - Ethical Norm concepts
White classes: ERAS - Data Protection concepts

Agent
is_assigned
Agent Role
Person
1..n
is_citzen_of
Country
1
Controller Representative
Independent Supervisor
Controller
interacts_with
notifies
tracks
delegates_to
0,,n
designates
Third Party Accessor
is_location_of
1..n
is_about
1..n
consents_to
authorizes
Personal Data
person_id
type
Data Access Process
type: data_access_form
conforms_to
Access Policy
prereqs: access_prerequisites
implements
collects
0..n
Health Data
type: health_data_types
joined_part
Accessible Personal Data
generates
Data Protection Principle
type: protection_principles
Economic Data
type: econ_data_types
Aggregated Personal Data
accesses
0..n
joined_part
Social Data
type: social_data_types
Personal Data Transaction
joined_part
Environment Data
type: environment_data_types
Data Breach
Valid Transaction
is_illegal_access_of
recipient_of

«enum»
data_access_form
dissemination
transmission
restriction
destruction
pseudonymisation
information_federation
data_mining
retention_management
cross_border_transfer

«enum»
protection_principles
privacy_by_design
data_protection_by_design
data_protection_by_default
need_to_know

«enum»
access_prerequisites
personal_informed_consent
personal_contractual_obligation
controller_legal_obligation
controller_sanctioned_permission
personal_beneficence_obligation
public_interest_obligation

«enum»
health_data_types
biometric_data
genetic_data
physical_health
mental_health
care_providers
medical_treatments

«enum»
econ_data_types
tax_returns
credit_ratings
employment
purchases
ownerships

«enum»
social_data_types
memberships
subscriptions
social_media
education
family
preferences
ethnicity
cultural
career

«enum»
environment_data_types
Internet_of_Things
smart_devices
security_systems
entertainment_systems
HVAC_systems
auto_GPS_systems
self_driving_autos

«documentation»
Third Party Accessor is a role which has been delegated by the controller to a natural or legal person, public agency or body, other than the data subject, controller, or accessors, and which authorizes the assigned agent to process personal data..

«documentation»
Controller is a role which embues a natural or legal person, public agency or other body with the authority to determine, either alone or jointly, the purposes and means of processing personal data.

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The First Global Ontological Standard for Ethically Driven Robotics and Automation Systems

By Edson Prestes, Michael A. Houghtaling, Paulo J.S. Gonçalves, Nicola Fabiano, Ozlem Ulgen, Sandro Rama Fiorini, Zvikomborero Murahwi, Joanna Isabelle Olszewska, and Tamás Haidegger

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In the complex and rapidly evolving fields of artificial intelligence (AI) and robotics, the elaboration of ethical concerns, considerations, and requirements helps elucidate the nature of technology's reach and impact on society where there is a legal void. Thus, establishing ethics in AI and robotics is fundamental to identifying their potential risks and benefits, especially in our pandemic-wrecked world [1].

The development of AI and robotics within an ethical framework enables the anticipation of future application contexts and articulation of uses that do not yet exist. Ethical considerations help to create a much-desired relationship between technology and human values and address the impacts a technology can have, thereby addressing issues of trust, safety, security, data privacy, and algorithmic bias. The need for an ethical framework is urgent because of the increasing adoption and use of autonomous and intelligent systems (A/ISs) in many domains, such as health care, education, finance, and insurance services. Ethically aligned technology has a clear role in supporting the achievement of the United Nations (UN) Sustainable Development Goals (SDGs) [2], [3].

In 2016, IEEE established its Global Initiative on Ethics of Autonomous and Intelligent Systems with the aim of ensuring that every stakeholder involved in the design, development, and management of A/ISs is educated, trained, and empowered to prioritize ethical considerations so that these technologies are advanced for the benefit of humanity. One of the efforts conducted by this initiative focuses on the development of soft laws (e.g., standards and guidelines) to help shape the responsible development and use of A/ISs.

With this aim, the IEEE Robotics and Automation Society (RAS)/Standards Association (SA) 7007 Ontologies for Ethically Driven Robotics and Automation Systems Working Group (IEEE 7007 WG) was established in 2017. During the past four years, this group has been working to create an ontological standard to enable the development of ethically driven robotics and automation systems. This standard was scrutinized by the global community in 2021, and it was officially approved by the IEEE SA on 24 September 2021. Due to the relevance of this standard, the IEEE 7007 WG has been selected as a recipient of the IEEE SA Emerging Technology Award "for developing an innovative ontological standard on the ethics of artificial intelligence" (see "RAS Standard Receives IEEE SA Emerging Technology Award!").

Regulatory Frameworks

There are various international regulatory initiatives in the area of emerging technologies with an impact on AI and robotics [4]. Current international regulatory requirements are contained in a combination of nonlegally binding ethical standards, frameworks, and guidelines as well as legally binding instruments [5].

Examples include the 2019 OECD *Recommendation on AI*; 2019 G20 *Human-Centered AI Principles*; 2019 European Union (EU) *Ethics Guidelines for Trustworthy AI*; 2019 recommendations of the UN Secretary-General's High-Level Panel on Digital Cooperation; 2019 IEEE *Ethically Aligned Design*; 2015 UN SDGs; and BS 8611:2016, *Ethical Design and Application of Robots*. More recently, in 2021, there has been an elaboration of the draft of the very first international normative instrument by the UN Educational, Scientific, and Cultural Organization on the ethics of AI. Examples of legal requirements from international,

RAS Standard Receives IEEE SA Emerging Technology Award!

The IEEE 7007 WG has been selected as a recipient of the IEEE SA Emerging Technology Award "for developing an innovative ontological standard on the ethics of artificial intelligence." The chair of the group is Edson Prestes, the vice chair is Sandro Fiorini, the technical editors are Mike Houghtaling and Babita Ramlal, and the secretary is Paulo J.S. Gonçalves.

The IEEE SA Emerging Technology Award is awarded for the initiation, advancement, or progression of a new technology through the IEEE SA open consensus process. Further information about the award, including a list of past recipients, may be found at https://standards.ieee.org/about/awards/etech/index.html.

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regional, and/or national bodies include the 2016 EU General Data Protection Regulation, bilateral and multilateral treaties, and the 2018 Council of Europe "Modernised Convention for the Protection of Individuals With Regard to Automatic Processing of Personal Data" (Convention 108+).

The IEEE Ethics Certification Program for Autonomous and Intelligent Systems [6] is a world first in setting standards for the ethical certification of products, services, and systems deploying AI and robotics in the public and private sectors. Certification is essential to guarantee that these technologies operate as expected when they are interacting with human and nonhuman agents. For stakeholders involved directly and indirectly in the lifecycle of AI and robotics systems, certification guarantees that these systems will cause no harm, their limitations are known, and there will be human accountability and responsibility for their use. This, in turn, fosters greater societal confidence in the technology's utilization.

Different from these frameworks, the standard developed by the IEEE 7007 WG has a formal and ontological representation that can be used not only as a foundation to elaborate public policies but also to create computational systems. In fact, IEEE Standard 7007 is the first global ontological standard that contains the concepts, definitions, and axioms that are necessary to establish ethical methodologies for the design, development, and deployment of AI and robotics.

IEEE 7007 WG

The IEEE 7007 WG is under the umbrella of the IEEE SA P7000 series devoted to ethics in A/IS. In this scope, several WGs were formed—15 to date—to deliver a broad range of standards and/or recommended practices. Among the goals of the IEEE 7007 WG are to

- establish a set of definitions and their relationships that will enable the development of robotics and automation systems in accordance with worldwide ethics and moral theories
- align the ethics and engineering communities to understand how to pragmatically design and implement these systems in unison
- develop a precise communication framework among global experts of different domains, including robotics, automation, and ethics.

To attain these goals, the IEEE 7007 WG developed a set of ontologies for representing the domain in a more precise way. As a result, IEEE Standard 7007 contains a set of ontologies that represents norms and ethical principles (NEP), data privacy and protection (DPP), transparency and accountability, and ethical violation management (EVM). The 2development of this standard was a complex process requiring a dedicated lifecycle. For this purpose, the IEEE 7007 WG developed an agile, collaborative, and iterative methodology called the *robotic standard development lifecycle* [7].

The usefulness of ontologies in standardization is twofold. On the one hand, standardization processes are set to produce a body of knowledge that reflects a consensual view of practitioners around a topic, defining, among other aspects, a standard knowledge structure in a domain, including common concepts, relationships, and attributes. Ontologies and their methods provide a formal approach to that aspect of the standardization process, which is expected to produce a sounder standard. On the other hand, the ontologies themselves, as formal artifacts, can be seen as products of the standardization process that can be used directly in data processing and automatic reasoning. As an example, one can cite IEEE 1872-2015 [8], which set forth to establish clear definitions for common terms in robotics and automation.

IEEE 7007 Ontological Standard for Ethically Driven Robotics and Automation Systems

Top-Level Ontology

As a core ontology, the ethically driven robotics and autonomous systems (ERAS) ontology represents a midlevel set of formalizations and commitments that are platform independent and intended to fit between an upper top-level or foundational ontology and lower-domain and application-specific ontologies. While some potential users of the standard may intend to align the ERAS core formalizations with existing top-level ontologies specific to their application domain, other user communities will only require a minimal top-level set of conceptualizations to complete the formalization of the concepts, terms, and commitments axiomatized in the ERAS ontology.

For that purpose, the four ERAS subdomain ontologies are augmented with axioms sufficient to complete the definitions and commitments expressed in the core ERAS models. These axioms are expressed formally using the Common Logic Interchange Format (CLIF) [9]. The ERAS top-level ontology (ERAS-TLO) formalizations define a minimal set of terms deemed relevant to the characterization of ethically oriented agents and autonomous systems. It is not intended to be applicable as a TLO in other contexts.

NEP Ontology

The NEP ontology subdomain formalizes the terminology and ontological commitments associated with ethical theories and principles that characterize the norms of expected behaviors for norm-oriented agents and autonomous systems. This includes axioms for concepts, such as norms, ethical theory, situation plan repertoire, agent plans, plan actions, and agent actions as well as the corresponding relationships, such as "selects plans from," "subscribes to," "satisfies," and "constrains plans for." Figure 1 depicts a brief and partial view of a subset of the NEP terms with a Unified Modeling Language (UML) class diagram.

DPP Ontology

The DPP ontology represents concepts and relationships among the diverse agents, entities, and organizations that may be involved at different stages in data gathering, processing, transfer,

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retention, and storage and in which autonomous systems may be deployed. Thus, the DPP ontology represents concepts like the natural person, caregiver, data protection authority, controller, and authorized accessor as well as the different types and processing of personal data (e.g., health data, economic data, and social data) and corresponding data process access. DPP principles, like privacy by design, data protection by design, data protection by default, and human rights by design, were also included in the standard.

It is crucial to represent this domain formally because of the relevance of the existing regulations worldwide about DPP. In addition, evaluating the impact of driven robotics and automation systems on personal data and, hence, on the processing of personal information is essential to the regulation of A/IS. As stated in the standard, "Data privacy is a highly complex and increasingly regulated area of law, in which the regulatory regime is rapidly evolving. No standard can provide unconditional consistency with all applicable laws and regulations, which continue to change rapidly in this area, and may also vary at the local, state and regional level. Users of this Standard are responsible for keeping apprised of such laws and regulations."

Transparency and Accountability Ontology

The transparency and accountability ontology subdomain formalizes the vocabulary and ontological commitments relevant for terms capable of expressing the concepts and relationships necessary to enable ethical autonomous systems with capabilities that provide informative explanations for plans and associated actions. Ethically aware agents require the ability to be transparent in their interactions with other agents. An agent qualifies as an autonomous transparent agent if it is enabled with an always-available mechanism capable of reporting its behavior, intentions, perceptions, goals, and constraints in a manner that permits authorized users and collaborating agents to understand its past and expected future behaviors. To express these capabilities, this ontology includes axioms for concepts, such as explanation, agent explanation plan, explanation plan repertoire, discourse content, agent data, transparency concern, audience, and content provenance, along with corresponding relationships, such as "determines what to explain," "determines how to explain," "formulates," "expressed_in," "authenticates," and "is accountable for."

EVM

The EVM ontology subdomain presents axioms to formalize the terminology associated with capabilities to detect, assess, and manage ethical and legal norm violations occurring within or generated by autonomous system behavior. This includes concepts such as norm violation, norm violation incident, responsibility ascription, ascription justification, grounds for ascription, agent accountability, event causation, liability sanction, and ethical behavior monitor. Figure 2 presents a partial view of the EVM concepts and relationships in a UML class diagram.

During an ethically aware agent's interaction with the environment and other agents, some norms can be violated. A norm violation is an action event reflecting a failure to conform to the norm's rules of behavior relevant to

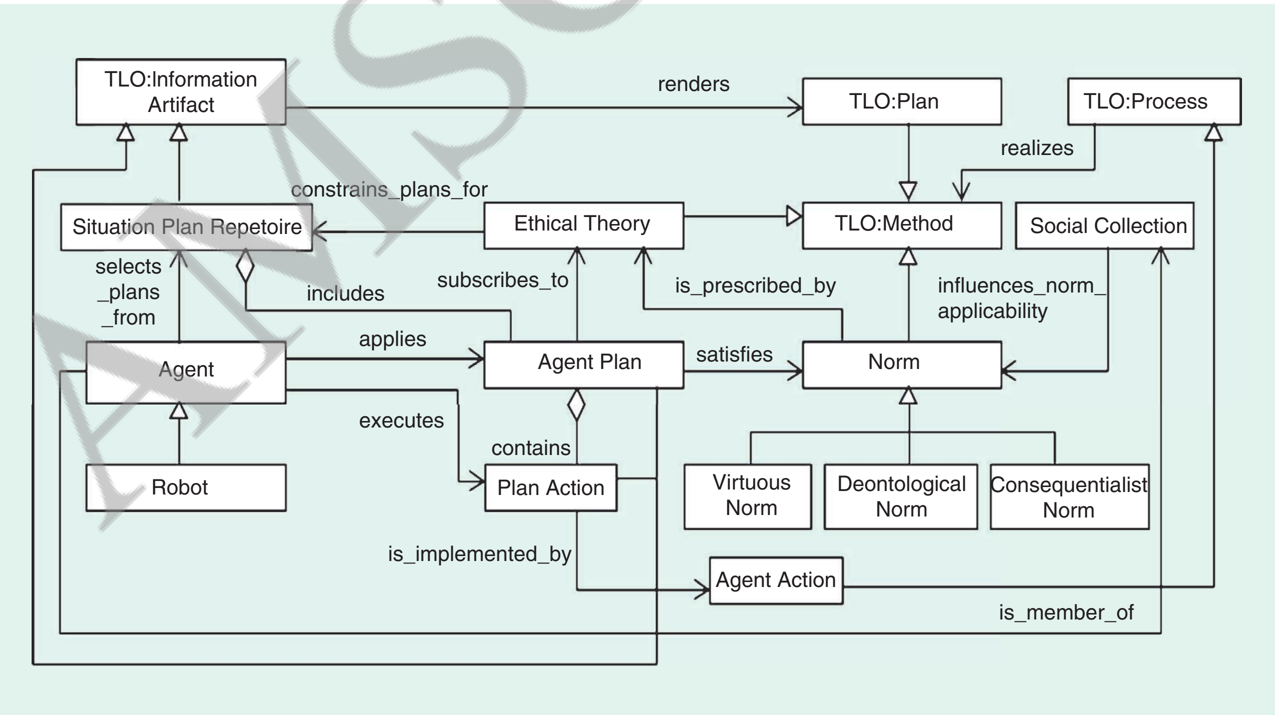

Figure 1. A partial UML model of the ERAS NEP ontology. UML: Unified Modeling Language.

the agent's situation. Agent system components or other agents providing an ethical behavior monitoring service may detect and record norm violations using norm violation incident information artifacts. A norm violation elicits a responsibility ascription process as a social interaction process to identify those responsible for the violation. A responsibility ascription process that results in the ascription of responsibility to one or more agents is justified by an ascription justification information artifact. This category represents the collection of facts formulated and asserted by an authoritative agent or agency to ascribe responsibilities for ethical or legal norm violations. It is composed of constituent grounds for ascription information artifacts.

Ethical violation as well as transparency and accountability ontologies identify accountability and legal responsibility as important real-world concepts impacting AI and robotics. Legal responsibility and its manifestations in terms of culpability as well as civil and criminal liability [10], [11] have influenced the content of the standard. The parameters between accountability and responsibility are also reflected with use of terminology that conveys a spectrum of potential agents who may be held responsible (e.g., partial or distributed responsibility).

An important observation here is that the EVM core axioms restrict autonomous system agent responsibility ascription to a set of specific system ethical norm violations and when human agents are involved in the collective distributed responsibility chain. Autonomous systems cannot be ascribed any responsibility for legal norm violations. An autonomous system acting as a single agent cannot be ascribed responsibility for any type of norm violation. Distributed responsibility is applicable only when the autonomous system is a member of a human-directed team and when an action by the system caused a norm violation.

Conclusions

IEEE Standard 7007 is the first global ontological standard elaborated to establish ethical methodologies for the design, development, and deployment of A/IS. It contains a set of ontologies that represents, explicitly and formally, core concepts that are relevant to dealing with NEP, transparency and

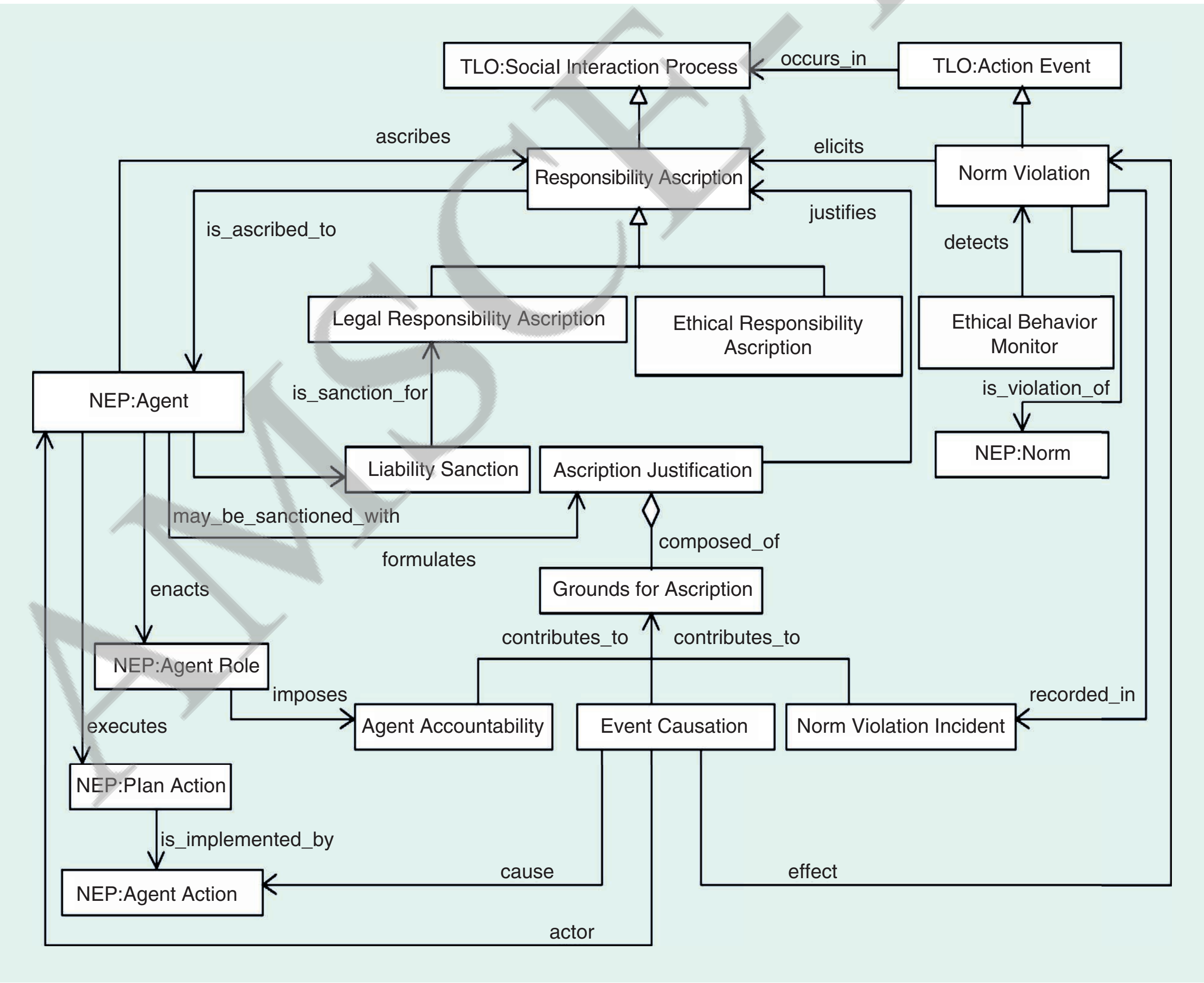

Figure 2. A partial UML model of the ERAS EVM ontology.

accountability, EVM, and DPP. It is expected that this work has a significant impact worldwide in being used to teach ethical design; for both human and institutional capacity building in the domain of the ethics of AI; to create computational ethically aligned systems; to create a taxonomy to support the elaboration of public policies; and to strengthen digital cooperation across nations applied together with the other members of the IEEE P7000 family.

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IEEE Standard for Transparency of Autonomous Systems

STANDARDS

IEEE Vehicular Technology Society

IEEE Robotics and Automation Society

Developed by the
Intelligent Transportation Systems Committee
and the
Standing Committee for Standards

IEEE Std 7001™-2021

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IEEE Standard for Transparency of Autonomous Systems

Developed by the

Intelligent Transportation Systems Committee
of the
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and the

Standing Committee for Standards
of the
IEEE Robotics and Automation Society

Approved 8 December 2021

IEEE SA Standards Board

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Abstract: Measurable, testable levels of transparency, so that autonomous systems can be objectively assessed, and levels of compliance determined, are described in this standard.

Keywords: autonomous systems, artificial intelligence, ethics, IEEE 7001™, transparency

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Introduction

This introduction is not part of IEEE Std 7001™-2021, IEEE Standard for Transparency of Autonomous Systems.

IEEE Std 7001-2021, IEEE Standard on Transparency of Autonomous Systems, sets out measurable, testable levels of transparency for autonomous systems. The standard was inaugurated to help make actionable the principle that it should always be possible to understand why and how an autonomous system made a particular decision and the consequential system's behaviors. Transparency is one of the eight general principles set out in *IEEE Ethically Aligned Design* [B21],[1] stated as "The basis of a particular autonomous and intelligent system decision should always be discoverable." A working group tasked with drafting this standard was proposed in direct response to a recommendation in the general principles section of *IEEE Ethically Aligned Design*.

The IEEE Project Authorization Request (PAR) was approved on 7 December 2016. The sponsor committees are VT/ITS—Intelligent Transportation Systems and the RAS/SC Standing Committee for Standards.

The IEEE 7000 series of IEEE standards have been developed in parallel with IEEE's ethics certification program for autonomous and intelligent systems and have benefitted from the pool of global expertise of IEEE.

The specific aim of the ethics artificial intelligence system (AIS) certification program has been to develop assessment criteria that assist duty holders with "self" or "independent" ethical scrutiny and assurance of products, services, and systems. The ethics AIS certification program's objectives are therefore complementary to the guidelines and requirements of the IEEE 7000 series of standardization projects and standards. In particular, the ethics AIS certification criteria are focused on the manifest and verifiable emergent properties/outcomes, whereas our standards generally prescribe processes for the realization of a range of ethical attributes.

The IEEE certification program on ethics AIS and the IEEE 7000 series of technology ethics standards provide a comprehensive best practice and voluntary toolkit for responsible ethically aligned design and deployment of autonomous and intelligent systems.

For more information visit: https://ethicsinaction.ieee.org/p7000/.

[1] The numbers in brackets correspond to those of the bibliography in Annex C.

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Contents

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IEEE Standard for Transparency of Autonomous Systems

1. Overview

1.1 Scope

This standard is broadly applicable to all autonomous systems, including both physical and non-physical systems. Examples of the former include vehicles with automated driving systems or assisted living (care) robots. Examples of the latter include medical diagnosis (recommender) systems or chatbots. Of particular interest to this standard are autonomous systems that have the potential to cause harm. Safety-critical systems are therefore within scope. This standard considers systems that have the capacity to directly cause either physical, psychological, societal, economic or environmental, or reputational harm, as within scope. Harm might also be indirect, such as unauthorized persons gaining access to confidential data or “victimless crimes” that affect no-one in particular yet have an impact upon society or the environment.

Intelligent autonomous systems that use machine learning are also within scope. The data sets used to train such systems are also within the scope of this standard when considering the transparency of the system as a whole.

This standard provides a framework to help developers of autonomous systems both review and, if needed, design features into those systems to make them more transparent. The framework sets out requirements for those features, the transparency they bring to a system, and how they would be demonstrated in order to determine conformance with this standard.

Future standards may choose to focus on specific applications or technology domains. This standard is intended as an “umbrella” standard from which domain-specific standards might develop (for instance, standards for transparency in autonomous vehicles, medical or healthcare technologies, etc.).

This standard does not provide the designer with advice on how to design transparency into their system. Instead, it defines a set of testable levels of transparency and a standard set of requirements that shall be met in order to satisfy each of these levels.

Transparency cannot be assumed. An otherwise well-designed system may not be transparent. Many well-designed systems are not transparent. Autonomous systems, and the processes by which they are designed, validated, and operated, will only be transparent if this is designed into them. In addition, methods for testing, measuring, and comparing different levels of transparency in different systems are needed.

Note that system-system transparency (transparency of one system to another) is out of scope for this standard. However, this document does address the transparency of the engineering process. Transparency regarding how subsystems within an autonomous system interact is also within the scope of this standard.

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1.2 Purpose

The purpose of this standard is to set out measurable, testable levels of transparency for autonomous systems. The general principle behind this standard is that it should always be possible to understand why and how the system behaved the way it did. Transparency is one of the eight General Principles set out in *IEEE Ethically Aligned Design* [B21], stated as "The basis of a particular autonomous and intelligent system decision should always be discoverable." A working group tasked with drafting this standard was set up in direct response to a recommendation in the general principles section of *IEEE Ethically Aligned Design*.

There are several reasons transparency is important:

— Modern autonomous systems are designed to work with or alongside humans who need to be able to understand what the systems are doing and why. Imagine a care robot that behaves in a way that is puzzling or unpredictable. Persons that interact with the robot and their wardens may be less likely to have confidence in the robot, therefore they will be less likely to make full use of it. Transparency is important in adjusting expectations and, hence, building confidence.

— Autonomous systems can sometimes fail. If physical robots fail, they can cause physical harm or injury. Failure of non-physical (software) systems can also cause harm. A medical diagnosis artificial intelligence system (AIS) might, for instance, give the wrong diagnosis, or a credit scoring AIS might make an incorrect recommendation and cause a person's loan application to be rejected. Without transparency, finding out what went wrong and why is extremely difficult and may, in some cases, be impossible. Equally, finding out how and why a system made a correct decision is important for the processes of verification and validation.

— Without transparency, accountability and the attribution of responsibility can be difficult. Public confidence in technology requires both transparency and accountability. Transparency is needed so that the public can understand who is responsible for the way autonomous systems work and—equally importantly—sometimes do not work. It might also be important to establish who is responsible for insurance or regulatory purposes or in an administrative proceeding or court of law. Transparency improves accountability, which might in turn support judicial processes. Finally, following high profile accidents, society can benefit from the reassurance of knowing that problems have been found and addressed.

1.3 Target audience

The target audience of this standard are those designers, developers, builders, maintainers, and operators, as well as decision-makers and procurers in organizations using and deploying autonomous systems (collectively, "designers") of autonomous systems who either wish to or are required to engineer systems that have a certain degree of transparency. This standard can help designers to self-assess the transparency of their system and then provide recommendations for additional transparency measures if necessary. The standard can also help transparency requirements to be specified in such a way that conformance can be demonstrated.

A secondary audience for this standard are groups who benefit from transparency. These groups are referred to as stakeholders. There are two groups of stakeholders:

— Stakeholders who benefit directly from increased transparency—these include both direct users of autonomous systems and wider society (see 5.1).

— Expert stakeholders who require transparency as part of their work—these include certification or regulatory bodies, incident/accident investigators, and expert advisors in administrative actions or litigation (see 5.2).

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1.4 Approaches to transparency

Broadly, transparency requires three parallel approaches, as follows:

- The first is process standards for ethically aligned design; that is, standards setting out human processes for ethically designing, validating, and operating robotics and AI systems. The IEEE Standards Association working groups are currently drafting a series of so-called human standards. The first of these, IEEE Std 7000™-2021, [B25], is a model process for addressing ethical concerns during system design.
- Second, a standard is needed for transparency; IEEE Std 7001-2021 is that standard.
- Third, technologies for transparency are needed. This standard does not specify technologies to support transparency, although for one stakeholder group, incident/accident investigators, this standard requires data logging to be incorporated into autonomous systems. Data logging is required to provide investigators with time stamped records of what a system was doing prior to and during an incident. The technical specification of such data logging systems is outside the scope of this standard.

Transparency has widespread economic and social benefits, such as greater social trust. Greater transparency eases coordination through sharing of information such as plans, intentions, and status. Transparency can inform consumer choice, thereby rewarding quality and excellence, and encourages less scrupulous actors to change their behavior. Transparency also allows incentives to be aligned more easily. For example, insurers may be able to offer a more accurate premium if they better understand the characteristics of an autonomous system in its operation and not merely after an incident.

However, transparency should be designed into the system; ideally from its inception rather than retroactively. The quality of transparency does not manifest without careful consideration and adherence to best practices and rigorous standards.

1.5 How to apply this standard

There are two ways in which this standard can be applied in practice, as follows:

- A System Transparency Assessment (STA) is the process of evaluating the transparency of an existing autonomous system, for each stakeholder group.

  A system is conformant with IEEE Std 7001-2021 if the STA determines that it meets at least Transparency Level 1 in at least one declared stakeholder group. Such minimal conformance may not be acceptable to the stakeholders of the system in question. Determination of what are appropriate or minimum acceptable levels of transparency for a given system is made by writing a System Transparency Specification (STS), as defined in the next list item. Direct comparison of transparency requirements in the STS with measured transparency in the STA can help reveal transparency gaps that need to be addressed. Information that improves transparency shall also be provided in an accessible format that supports comprehension by stakeholders.
- An STS is the process of defining the transparency requirements of an autonomous system, for each stakeholder group. An STS may be written at any time during a system's lifecycle, though the best and expected practice would be to specify transparency requirements prior to system design (see IEEE/ISO/IEC Std 15288:2015 [B26] and IEEE/ISO/IEC Std 12207:2017 [B30]).

It is important to note that transparency requirements will vary considerably from one system to another. A prerequisite of writing an STS is to decide on the appropriate level of transparency for each stakeholder group and for the system under consideration.

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Detailed guidelines on how and when to apply this standard, with templates for the processes of STA and STS, are given in Annex A. This standard does not prescribe minimum acceptable levels of transparency for particular autonomous systems (or categories of systems), however, detailed worked examples of STA and STS are given in a set of scenarios, for both fictional and (some) real autonomous systems, in Annex B.

1.6 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).[2,3]

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEC/IEEE 82079-1, International Standard for Preparation of information for use (instructions for use) of products—Part 1: Principles and general requirements.[4,5,6]

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause. [7]

autonomous system: A system that has the capacity to make decisions itself in response to some input data or stimulus with a varying degree of human oversight or intervention depending on the system’s level of autonomy.

domain expert users: Persons who carry some responsibility for how an autonomous system is used or are responsible for operating and supervising autonomous systems.

[2] The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.
[3] The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.
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explainability: The extent to which the information made transparently available to a stakeholder can be readily interpreted and understood by a stakeholder.

non-expert users: Persons who have only a brief interaction or who interact every day with an autonomous system.

stakeholders: An individual or organization having a right, share, claim, or interest in a system or in its possession of characteristics that meet their needs and expectations.

superusers: Experts not only in autonomous systems but also in the particular systems for which they are responsible. *See also:* **domain expert users**.

System Transparency Assessment (STA): The process of evaluating the transparency of an existing autonomous system, for each stakeholder group.

System Transparency Specification (STS): The process of defining the transparency requirements of an autonomous system for each stakeholder group.

transparency: A transfer of information from an autonomous system or its designers to a stakeholder that is truthful; contains information relevant to the causes of some action, decision, or behavior; and is presented at a level of abstraction and in a form meaningful to the stakeholder. Transparency should be mindful of the stakeholders' likely perception and comprehension, and should avoid disclosing information in a manner that, while technically true, is framed in a way that leads to misapprehension.

3.2 Acronyms and abbreviations

AIS	artificial intelligence system
GDPR	General Data Protection Regulation
Med DSS	medical decision support system
NLP	natural language processing
STA	System Transparency Assessment
STS	System Transparency Specification

4. Key concepts

4.1 System transparency and explainability

The principle behind this standard is that it should always be possible to understand why and how (e.g., by what decision-making logic, algorithm, or prediction mechanism) an autonomous system behaved in a particular way.

In this document, the term transparency refers to a transfer of information from an autonomous system, or its configurers, operators, designers and developers to a stakeholder. Such information shall be truthful; contain information relevant to the causes of some action, decision, or behavior; and be presented at a level of abstraction and in a form (typically natural language) meaningful to the stakeholder. Such information can be offered both to account for past behavior and to describe potential future behavior, as well as to expose the capabilities and limitations of a system.

To consider an autonomous system transparent for inspection, the stakeholder should have the ability to request meaningful explanations of the system's status, either at a specific moment or over a specific period or of the general principles by which decisions are made (as appropriate to the stakeholder) (see Theodorou, Wortham, and Bryson, [B56]).

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The system's status shall include relevant goals; progress in relation to those goals; models of its past, current, and potential future environmental context (from sensors and other information); and relevant information about its current performance, such as reliability and error messages (see Wortham, Theodorou, and Bryson [B63]). For an autonomous system to be considered transparent, this information shall be presented in a human understandable form.

However, a developer may not be able or may not wish to achieve the same degree of transparency in all systems; for instance, non-expert users likely do not need logs of sensor inputs whereas incident investigators are likely to need precisely such information. Transparency is a quality that enables technical experts such as designers, testers, behavioral analysts and incident investigators to access data from a system that describes the process behind its decisions and behaviors.

Thus, this standard defines different levels of transparency based on the system itself and the stakeholder accessing the transparent information. Some of these levels (all levels for some stakeholders) require the system to be explainable, not just transparent, in order to conform with this standard.

A system that is explainable is said to have the quality of explainability. Explainability describes the extent to which the information made transparently available to a stakeholder can be readily interpreted by that stakeholder. Explainability is defined as the extent to which the internal state and decision-making processes of an autonomous system are accessible to non-expert stakeholders. Such explanations could be generated either by the system itself, or by a separate (machine) interpreter. Explainability requires being able to describe the causality behind a system's actions, at some level of abstraction appropriate to a non-expert.

It should be noted that the terms transparency and explainability are used in many subfields of artificial intelligence, robotics, and autonomous systems with slightly different meanings. Our intent here is to define their usage within this standard, not to mandate or prescribe their usage elsewhere. In particular, it is noted that in many areas of AI and robotics transparency refers to what this document refers to as *explainability*. In other words, it refers to the provision of information in a form readily understandable by a stakeholder and, indeed, the concept of explainability as defined here draws on these definitions. Similarly, it is noted that there are fields in which the term transparency implies that the system has become invisible to the user so that they feel they are directly controlling a task of the system (see Sheridan and Verplank [B51]).

Transparency is necessary but not sufficient for reducing the risk of psychological harm or distress. Explainability is a crucial additional factor for building trust and assurance between an autonomous system and its end-users or members of the public. It is also important to note that providing an explanation does not necessarily make a system's actions completely transparent (see De Graaf and Malle [B13]).

4.2 System autonomy

For the purpose of this standard, an autonomous system is defined as a system that has the capacity to make decisions itself in response to some input data or stimulus with a varying degree of human intervention, depending on the system's level of autonomy.

System autonomy falls on a spectrum from zero to full autonomy, where zero means the system is entirely under human control and full autonomy means the system can accomplish a goal without human guidance or intervention.

Levels of autonomy are included in this section in order to emphasize that "autonomous systems" addressed in this standard is a superset that includes semi-autonomous or supervised autonomous systems (which describe most extant systems).

There are many definitions in the literature for degrees (or levels) of autonomy. Sheridan [B50] defined 10 levels of autonomy from level 1, i.e., "computer offers no assistance," to level 10, i.e., "computer does everything even ignoring the human." Endsley and Kaber [B18] similarly defined 10 levels from level 1, i.e., "manual control," to level 10, i.e., "full automation in which the system carries out all actions and itself decides if it needs to suspend operation for human intervention."

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AMSCE-101

NIST introduced the Autonomy Levels for Unmanned Systems (ALFUS) as a nomenclature consisting of four levels of autonomy, namely, remote controlled, teleoperated, semi-autonomous, and fully autonomous (see NIST SP 1011-II-1.0 [B38]).

Based on ALFUS nomenclature, Durst and Gray [B16] expanded these four levels as follows:

a) *Human Operated:* A human operator makes all decisions.

b) *Human Delegated:* The system can perform many functions independently of human control when delegated to do so.

c) *Human Supervised:* The system can perform a wide variety of activities when given top-level permission or direction by a human.

d) *Fully Autonomous:* The system receives goals from humans and translates them into tasks to be performed without human interaction.

There are three components of supervised autonomy, as follows:

- Direction, i.e., telling a system what to do
- Monitoring, i.e., watching what the system is doing
- Control, i.e., being able to intervene and change what the system is doing

Regarding control, shared autonomy is a frequently used term to describe the situation where control of a machine is shared between a human operator and a computer system to achieve a goal, either remotely (as in Mercier and Tessier [B37]) or in the same shared space. In this situation, conflicts are likely to occur, and how easily these conflicts are resolved depends on the transparency of the machine’s reasoning.

In IEEE Std 1872-2015, IEEE Standard on Ontologies for Robotics and Automation [B24], the definitions of the levels of autonomy follow the operation modes defined by the ALFUS nomenclature. Furthermore, IEEE Std 1872-2015 defines the automated attribute for systems acting as automata in a process, e.g., clockworks [B24].

For driverless cars, the Society of Automotive Engineers has defined six levels of autonomy from level 0, manually driven, to level 5, fully autonomous in all driving scenarios (SAE J3016_201806 [B45]).

It is worth noting the degree of autonomy of a system could vary depending on the scale of the system inspection. For example, a system could be semi-autonomous when completing an intended task, but could contain one or several autonomous sub-systems, e.g., relying on narrow artificial intelligence such as computer/machine vision processes, which can perform some sub-tasks autonomously (see Olszewska [B41]).

Furthermore, all of the systems this standard interact with humans in some way. For example, the system can make a recommendation to a human user on the basis of some digital input data, or in the case of a physical robot, make a decision about a course of action in response to sensor input data. Hence, in practice, no such system is 100% autonomous (i.e., self-determining), since all these systems are at some level commanded, monitored, and/or supervised by humans.

A further helpful reference in the context of Human-Robot Interaction is “Towards a framework for levels of robot autonomy in human-robot interaction,” (Beer, Fisk, and Rogers [B4]). For a deeper and broader perspective, see also the MIT series *Intelligent Robotics and Autonomous Agents* [B3].

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5. Transparency requirements by stakeholder and level

Requirements for measurable, testable levels of transparency are set within each stakeholder category. Levels of transparency are defined from 0 (no transparency) to 5 (the maximum achievable level of transparency). Each definition is a requirement, expressed as a qualitative property of the system that must be met. In each case, the test is simply that of determining whether the requirement is met or not, i.e., the transparency property required by a given level for a given stakeholder group is either demonstrably present or it is not. The choice of five levels is a compromise between a reasonable degree of granularity while allowing for discernible differences between successive levels.

Levels 1 to 5 have been defined to describe successively greater levels of transparency. All levels are judged to be technically feasible while each successive level is typically more challenging. For two categories of stakeholder, each level builds upon previous levels, so it is expected that when a system meets level *n* for a particular category, then it also meets levels $n - 1$, etc.

Stakeholder categories and their transparency definitions are independent of each other. There is no expectation that if a system meets level *n* in one category it will also meet the same level in other stakeholder categories. Levels that are not cumulative or categories that are not strictly independent are noted in 5.1 and 5.2. It should also be noted that any particular stakeholder may be interested in the transparency measures of other stakeholders for redundancy and cross-validation purposes.

Note that the levels of transparency set out in this clause are unrelated to the levels of autonomy in 4.2. Similarly, there is no expectation that higher-autonomy systems are required to conform with the higher levels of transparency in any of the categories below.

This clause is presented in two parts: Subclause 5.1 covers stakeholders who benefit directly from increased transparency and 5.2 covers expert stakeholders who require transparency as part of their work.

This standard recognizes but does not intend to restate or replace applicable laws and regulations regarding personal data, data privacy and data security. Users of this standard are responsible for referring to and observing all such laws and regulations. Conformance with the provisions of this standard does not imply conformance with any applicable legal or regulatory requirements.

5.1 Stakeholders who benefit directly from increased transparency

5.1.1 Users of autonomous systems

Autonomous systems shall provide a simple, understandable way for the user to understand what the system is doing and why and how the system is doing what it is doing. Not all users will require the same degree of system transparency; non-expert users will typically need simple and understandable high-level explanations of a system's decisions and actions, while expert users will require more complete and informative transparency.

The term user is defined as falling on a broad spectrum from non-expert users of autonomous systems to superusers, as follows:

- *Non-expert users* include both persons who have only a brief interaction with the system (for instance, when collecting a food delivery from an autonomous delivery robot or when using an automated hotel checking-in system) and persons who interact every day with the system (for instance, an assisted living robot, robot vacuum cleaner, or conversational AIS such as a smart speaker). Falling between non-expert users and superusers, is a category of domain expert users.
- *Domain expert users* include, for instance, a medical doctor using a medical diagnosis AIS as a diagnostic assistant in a clinical setting or a team of nuclear systems engineers supervising a semi-autonomous robot (or system of robots) to remotely repair or upgrade a reactor. Such domain expert

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users carry some responsibility for how the system is used. The clinician, for instance, is responsible for interpreting the advice given by her diagnostic assistant. Similarly, the nuclear engineers are responsible for how the robots are deployed. This category also includes owner-drivers of autonomous vehicles as they too are responsible for the autonomous vehicle while its driver assist functions are engaged. Another group of domain expert users are those responsible for operating and supervising autonomous systems, for instance, those persons charged with managing and dispatching autonomous food delivery robots.

— *Superusers* are experts not only in autonomous systems but the particular systems for which they are responsible. Such superusers include persons responsible for development, fault diagnosis, repair, maintenance and upgrade, in addition to the operation and supervision, of particular autonomous systems.

It is noted that explaining current behavior/actions and explaining the system's general principles of operation are separate aspects of transparency. In defining transparency for users, it is necessary to be mindful of the importance of managing expectations of what the system can and cannot do in a way that does not confuse or upset the non-expert user.

For this category of stakeholder, the levels of transparency are not progressive, i.e., fulfillment of an earlier level is not necessary to achieve a higher one.

Transparency requirements for users are given in Table 1.

Table 1—Transparency requirements for users

Level	Definition
0 (lowest)	No transparency.
1	The user shall be provided with accessible[a] information that provides as a minimum the following: a) example scenarios with the expected and anticipated system behavior including degraded modes of operation and b) general principles of its operation, i.e., if there is a learning component and what data it uses. The documentation shall explain the system's general principles of operation. For a system that uses machine learning the documentation should provide a simple explanation of which sources the system examines/uses as part of the learning process, including any possible sources of bias. This documentation shall for example be in the form of a written manual, pictorial, or audio guide as appropriate to the user, which provides the user with an explanation of how the system behaves in the various circumstances and situations its designers expect it to encounter. Domain expert users and superusers shall be provided with user documentation as specified above and prepared in accordance with IEC/IEEE 82079-1[b]. This documentation shall detail the safe operation and supervision of the system. For superusers, the documentation shall additionally detail procedures for system fault diagnosis, repair, maintenance, upgrade, and end-of-life decommissioning.
2	The user shall be provided with interactive training material that allows the user to rehearse their interactions with the system in specific and relevant virtual situations. This interactive material shall be in the form of an interactive presentation, video, or simulation, which allows the user to rehearse their interactions with the system in specific different situations. In addition, domain expert users and superusers shall be provided with interactive training materials on the safe operation and supervision of the system. Superusers shall additionally be provided with interactive training materials covering fault diagnosis, repair, maintenance, upgrade, and end-of-life decommissioning.

Table continues

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Table 1—Transparency requirements for users *(continued)*

Level	Definition
3	The non-expert user shall be provided with user-initiated functionality that produces a brief and immediate explanation of the system's most recent activity. These explanations shall be expressed through commonly understandable means such as natural language or another appropriate medium (e.g., a pictorial). Neither making requests nor understanding the system's responses to those requests shall require that the non-expert user undergo any training. However, advisories for safety or legal reasons are acceptable as may be necessary. *An example would be a robot or physical system equipped with a speech recognition system that will respond to the user asking, "Robot why did you just do that?" by producing—in plain language—a spoken explanation for its most recent action. For instance: "I stopped because I am programmed not to bump into you." An example of a non-physical system would be software in which either a touch screen button or a spoken request produces a similar explanation. An example of an advisory would be information on safety that must be understood prior to use, such as important safety information, or an age restriction.* For systems designed to be used by domain experts, the same functionality specified above shall be provided, except that a) the system shall allow explanations for any of its recent decisions to be requested and b) the explanations may be expressed using domain appropriate language. Domain experts shall additionally be provided with documentation detailing how these explanations should be requested and interpreted. Such documentation should also cover natural language processing (NLP) subsystems, if present. *An example would be a medical doctor using a medical diagnosis AIS as a diagnostic assistant. The system would allow the doctor to ask for an explanation of a recent recommendation, in language that allows the doctor to assess its plausibility.*
4	The non-expert user shall be provided with a user-initiated functionality that produces a brief and immediate explanation of what the system does in a given situation. Conformance with this level of transparency allows the user to explore hypothetical "what if" scenarios in a given situation, if applicable to the system's scope of work. Neither making requests nor understanding the system's responses to those requests shall require that the non-expert user undergo any training, though familiarization with the system's user documentation is required. *A robot or physical system should be able to respond to requests (possibly including gestures or eye contact) including both "Why did you just do that?" and "What would you do if .. xxx ..?" (for example "Robot what would you do if I fell down?" or "Robot what would you do if I forget to take my medicine?"), in natural language or equivalent signals.* *Non-physical systems should have an equivalent function, allowing the user to ask, "What would you decide/recommend if I asked you xxx, and why?"* For systems designed to be used by domain experts, the same functionality specified here shall be provided, except that the explanations may be expressed using domain appropriate language. Domain experts shall additionally be provided with documentation detailing how these explanations should be requested and interpreted. Such documentation should also cover NLP subsystems, if present. Importantly this level of transparency allows the user to explore counterfactuals (see Wachter, Mittelstadt, and Russell [B57]).
5 (highest)	The user shall be provided with a continuous explanation of behavior that adapts the content and presentation of the explanation based on the user's information needs and context. This shall include access to log files and training data as long as they do not contain sensitive information such as personal data. An explanation of operation shall be achieved through some visual display, where simple explanations are visible after the system performs an action, or through the vocalization of explanatory sentences as the system performs an action. Non-expert users shall not be required to expend additional effort to access relevant explanations. (see Gregor and Benbasat [B20] and Kulesza, Stupf, and Burnett [B35]). This interaction shall be adaptive to the user's interaction history as confidence is easily lost if e.g., the system behaves unexpectedly. Additional explanatory detail shall be available, on demand, as required by domain expert users or superusers, making it possible for them to interactively explore the system and its operation.

[a] Accessible means: in a format that is appropriate to the audio, visual or cognitive capabilities of the system's intended users.
[b] Information on references can be found in Clause 2.

5.1.2 The general public and bystanders

Transparency to wider society is needed in order to set expectations for the operation of autonomous systems and to help with building public confidence in the technology in an effort to reduce the potential for misuse and disuse of the technology. The role of the media in shaping public opinion is an important consideration here.

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The general public are those persons who do not directly encounter an autonomous system but, nevertheless, may be affected directly or indirectly by its deployment. The public, through education, ethically aligned design in accordance with this and other standards, and legislation, should be empowered to make informed decisions if they want to become users and interact directly with an AIS. They should also understand the effects of the deployment of AI technology on their daily lives. However, it is well beyond the scope of this standard to discuss, let alone make suggestions on, societal concerns.

A subgroup of the general public are bystanders: persons who encounter an autonomous system without having any previous intention to achieve some purpose. This includes those simply observing the system function as well as those who may be passively impacted by it without their knowledge. For example, a person waiting at a train station where a mobile “customer help” system operates and serves another customer is a bystander as is someone entering a space which is monitored by a system using face recognition to identify occupants.

For this category of stakeholder, the levels of transparency are not progressive, i.e., fulfilment of an earlier level is not necessary to achieve a higher one with the exception of Level 3, which requires fulfilment of Level 2.

Transparency requirements for the general public and bystanders are given in Table 2.

Table 2—Transparency requirements for the general public and bystanders

Level	Definition
0 (lowest)	No transparency
1	The system shall be clearly identifiable by either a user or a bystander as an autonomous system. This requirement follows a proposed Turing Red Flag law: *An autonomous system should be designed so that it is unlikely to be mistaken for anything besides an autonomous system and should identify itself at the start of any interaction with another agent*. (Walsh [B58]). This identification shall be a simple message in the case of chatbots: a watermark on machine-generated multimedia, the use of stickers, or other insignia. Moreover, it may also be that a system design is structured in such a way that its manufactured nature is transparent (not anthropomorphic or zoomorphic, sensors are visible, etc.).
2	The system shall provide relevant warnings about any external sensor data collected or otherwise recorded (e.g., audiovisual input, geopositioning data, information gathered automatically) and which is related to the general public and bystanders. The system’s manufacturer or operator shall provide documentation and/or identification graphics explaining what forms of sensor data are collected and how they are used, which shall be made publicly available. “Data which is related to general public and bystanders” refers to data from sensors in which the person is a feature. This level requires that the system's manufacturer or operator provides information on the types of data collected (i.e., metadata including, if applicable, personal data, but not the content of those data). See Level 4 for transparency of the data content. *The warnings may be physical cues on the robot and its environment, showing the location of sensors, similar to how body-worn cameras and CCTV require a sign to be present at the area of recording.* *The warnings may also be on-screen notifications, or a QR-style code, that leads to a source of further information about such sensors.* *Documentation may be leaflets containing all relevant information about the data used by the system(s). Another example is an autonomous vehicle manufacturer that provides online publicly accessible documents containing lists of sensors and explanatory data.*
3	All requirements of Level 2 shall be met. In addition, the documentation described in Level 2 shall also contain high-level descriptions of a system’s intended purpose, a defined nominal operator of that system, as well as contact details for the system’s owner, supervisor, or some other relevant authority where further information may be provided.
4	The system’s responsible user shall have a clear data-governance policy and shall accept and respond to data-governance related requests. An example of such a data-governance policy is ISO/IEC 38505-1:2017 [B29] The system’s owner may have an online form for data-governance requests, e.g., request of information stored. Once a person uses the form, the system owner receives the enquiry and processes it by returning an answer back to the requester.
5 (highest)	As Level 4.

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5.2 Expert stakeholders who require transparency as part of their work

5.2.1 Validation and certification agencies and auditors

Software engineering distinguishes between verification and validation of software systems. This standard uses the term validation to encompass both these practices. It is important to note that this subclause does not require a system to have been verified or validated, instead it requires evidence of the verification and/or validation that has been undertaken, if any.

It is assumed here that many autonomous systems are subject to certification or evaluation processes in advance of deployment and in some cases at specific points in time after deployment in order to validate that the system is performing as desired. Such processes should be provided by agencies independent of the creators of the system. Certification might be a legal requirement (as, for instance, in the case of aircraft systems) or it might be a voluntary scheme providing some mark as a guarantor of quality. Similarly, assessments may be required by insurers and other bodies. The levels of transparency here can therefore be expected to correlate to the confidence such an agency can have in its determination of the quality of the system, though not necessarily any greater confidence in the quality of the system itself.

In general, certification, validation, and auditing are concerned with the *safety* and *data security* of a system, but there is no reason, in principle, why it should not also be concerned with qualities such as *reliability*, *robustness*, and so on. The levels of transparency are provided with this in mind.

Standards already exist for the validation of computational systems and a number of agencies already have reporting requirements, see for instance IEEE Std 1012 [B22] and ISO/IEC/IEEE 29119 [B31]. Nevertheless, autonomous systems present novel challenges to validation and are being deployed in situations where there is no obvious pre-existing regulatory body. This standard focuses on providing reporting requirements for the validation process of the whole autonomous system (that is, it focuses on the issue of the transparency of the validation of the autonomous system). Some of these requirements are relevant to any computational system, but some are of particular relevance to autonomous systems where the use of machine learning and embodiment are common. They may be used in conjunction with existing standards and processes and, indeed, the STS process outlined in Annex A may involve simply mapping existing reporting requirements to the appropriate transparency level. Where no pre-existing requirements exist then an STS must consider the appropriate level of transparency of the validation process for the application. The STS should note other transparency requirements in instances where there is not a perfect alignment between what a regulator demands and the content of this standard.

There are two aspects to the issue of transparency for validation and certification agencies. These two aspects are referred to as the *system description* and the *validation description*. In theory, such an agency should only require access to the full source code plus a physical example (in the case of a robotic system) of the system in order to be able to perform its own validation, but in practice it can be extremely difficult to understand how a system operates from only its source code (as an extreme example, it is currently impossible to adequately understand the functioning of a deep neural network after it has been trained). It is therefore expected that the work of validation and certification agents is best assisted by provision of details of any validation performed by the development team itself. In many cases the certification agency may be concerned primarily with certifying the company's *process* rather than validating the actual system. In most cases, it is assumed that the process includes ongoing validation of the system as it was developed.

The transparency levels in this standard assume that, in general, the more detail provided for one aspect, the more detail will be provided for the other. For instance, there would seem to be little point providing a reproducible validation artifact for a system that is only described by a specification. Therefore, these levels of transparency assume the minimum requirement of both aspects needing to be considered at that level.

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In the transparency levels the primary concerns are with the following:

- *Specifications:* A specification is a description of what a system is intended to do (and not do). Without some sort of description of a system's purpose it is difficult for anyone to begin to make a determination about whether the system has any desired properties. While it is possible for specifications to be detailed, elaborate, and mathematical, this is not a requirement for transparency—there just needs to be some statement of purpose. Complex specifications frequently require validation processes of their own, for instance, to determine that they genuinely describe the system that is desired. Such validations of specifications may well be part of the validation process disclosed to the agency.
- *Properties:* The properties of a system can range from informal properties, such as "is easy to use," to precisely defined mathematical properties, such as "always applies the brakes within 0.5 s of detecting an obstacle." For an agency to begin to make a determination of the quality of a validation process, at a minimum they need to know what properties were considered.
- *Tests:* The field of testing computational systems is mature, and many techniques exist to help support testing that is appropriate and likely to catch important errors in a system, including testing for unintended outcomes of the system operation. So-called ad hoc testing, in which a developer or designer simply devises some relevant tests, is widespread and commonplace and may be sufficient for the validation of some properties of a system. Testing can also exist at several levels. System tests are applied to a completed system while unit tests are applied to components within a system. For some levels of transparency, only details of system tests are required and not the details of every test of every component.
- *Designs and models:* Nearly all complex systems have a high-level design. This may consist of documents outlining the main components of the system in natural language. However, a number of more formal notations exist for describing designs. Often, such formal notations comprise a mathematical model of the system itself that are executable in some fashion; the most obvious example would be a model of a robot in some simulated environment. While a system model or design does not provide every detail of the code, they often convey enough detail that testing and/or validation of the design/model allows major errors in the way the system operates to be detected. Provision of models and designs, therefore, allow the creator of an autonomous system to provide a great deal of useful information to an external agency while still protecting some intellectual property. ISO/IEC/IEEE 42010 [B32] and ISO/IEC/IEEE 42020 [B33] may be informative for architecture descriptions and architecture evaluation.
- *Statistical Models:* Many autonomous systems make use of statistical models derived from data to perform a range of tasks from situational awareness to full decision-making. Such models are created using a range of techniques including long standing statistical and optimization processes through to cutting-edge machine learning methods. The most well-known examples of such models are classifier systems used in image processing. These present challenges to validation. For instance, an object detection system's specification can often be no more precise than "identifies objects as reliably as most humans," and the classifier produced by the machine learning system may be difficult to understand even when full details of its operation are disclosed (often representing only statistical relationships between features of the system inputs). Many issues seen in such models arise from the data that was used to create them and to validate the performance of the system. There are well-documented cases of bias in such training data sets (e.g., sets of faces consisting primarily of young healthy people), leading to errors in system behavior and more general concern that a statistical model may have "blind spots" where no behavior has been learned for some combination of inputs. Therefore, higher levels of validation and certification transparency for autonomous systems that employ machine learning need access to training data, and access to the mechanisms by which the training data was assembled, in order to assess the risk of bias and omissions in the set. Data within machine learning systems may be in the form of a data set or encoded within models in the form of parameters or tokens. There are also wider concerns that such models may sacrifice fair or equitable behavior in preference for increasing the accuracy or optimality of some outcome. The validation of such models is a rapidly evolving field that includes purely technical advances in analyzing models with socio-technical techniques to assess

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the impact of their deployment and understand the risks, particularly in terms of bias and fairness. This standard therefore focuses on transparency of the assessment process, explicit documentation of the risks as assessed, and any mitigations.

— *Source Code:* For the highest degrees of assurance of system behavior, an external agency may require access to the actual code of the system. At a minimum, this can allow such an agency to perform its own tests of the system, but a variety of techniques exist (including techniques based on mathematical proof) to assess the quality of a system based upon inspection of its code. Often, source code is difficult to understand for anyone except the programmer; this is one reason why it is important for agencies to have access to specifications and designs even when the source code is provided. This is why to achieve one level of transparency for validation and certification agencies and auditors, all the lower levels shall also be met.

— *Validation Tools:* Many tools exist to help with validation processes. These include tools for tracking the development process, the automated running of tests, running of tests on just parts of a system, mathematical validation of system models, assessments of the performance of machine learning, tools for analyzing the results of learning, and so on. Sometimes these tools may be proprietary and developed in-house at a particular company. For the highest level of transparency to be achieved where an agency is assessing a developer's validation process, executable versions of any tools used should be provided so that the agency can, if desired, reproduce the validation process.

For this category of stakeholder, the levels of transparency are progressive, i.e., fulfilment of an earlier level is necessary to achieve a higher one.

Transparency requirements for validation and certification agencies are given in Table 3.

Table 3—Transparency requirements for validation and certification agencies

Transparency level	Definition
0 (lowest)	No transparency
1	The system's developers shall provide documentation containing its specification and which of its properties were validated. *System Description:* A specification of the decisions to be taken by the system. *Validation Description:* A description of the validation process that was followed and which standards were applied.
2	The system's developers shall provide documentation containing its specification and description of its validation process. *System Description:* A specification of the system shall be supplied. *Validation Description:* A detailed description of the validation process shall be provided (including any ongoing validation processes used during system development or after deployment), including the specifics of system-level tests considered (where relevant). At this level and above, some internal validation (even if it is only ad hoc testing) shall have taken place. In addition to any general validation and verification information required by other certification processes, an analysis of the decisions to be made by the system and the validation of their implementation should be included.

Table continues

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Table 3—Transparency requirements for validation and certification agencies *(continued)*

Transparency level	Definition
3	The system's developers shall provide documentation containing a high-level design or a (preferably executable) model of the system. The model may be a simulation of the final system. Statistical models used in the system should be documented along with the steps taken to validate their performance. If no models are used this should be explicitly stated. *System Description:* A high-level design or (preferably executable) model of the system shall be provided. This may be a simulation of the final system. *Validation Description:* An account of important issues uncovered and resolved during system development and/or deployment (as relevant at the time of submission) shall be provided even if full logs cannot be provided (e.g., because such logs are not kept). Where an analysis has taken place of the anticipated or actual operating conditions of the system (including unusual and hazardous situations) this should be provided. Where such an analysis has not taken place, this should be explicitly noted (with a justification, if desired). If statistical models are used by the system, an account shall be given of the steps taken to validate the performance of the model and the outcome of that validation. This account shall include discussion of any process undertaken to assess the possibility of unwanted bias, unfairness or inequity in the performance of the model, the outcome of that assessment, and steps taken to mitigate such issues (if any). The analysis of operating conditions should include any analysis of communities or environments that could be affected by the decisions of the system and the impact on those communities and environments, even where those communities and environments are not explicitly recognized as stakeholders. If no analysis of operating conditions has taken place and/or no assessment of statistical models has been made, this shall be stated. Full logs of any validation process of system decision-making should be provided if they exist, such as complete descriptions of test suites in terms of inputs provided and outputs observed, or outputs from proof tools (see Stepney and Polack [B54]). Any simulation model should itself be validated as providing a sufficiently high-fidelity model of the system and its environment, as relevant for its purposes, to allow its use in validation.
4	The system's developers shall provide a high-level design or (preferably executable) model of the system. This may be a simulation of the final system. Statistical models used in the system should be documented. If none are used, this should be explicitly stated. *System Description:* A high-level design or (preferably executable) model of the system shall be provided. This may be a simulation of the final system. Where relevant, all training data used in learning should be provided, including descriptions of the data's composition and provenance. *Validation Description:* All material necessary to reproduce the validation process for the final system shall be provided including, where relevant, executable versions of any tools used, and working versions of the system. In the case of a robotic system this should include a copy of the physical robot. Proprietary code may be provided in an executable form, provided the validation process remains reproducible. Where validation is being performed after deployment, the operational data collected as part of this validation should be provided. This shall include any analysis of the communities and environments affected by the system (whether intentionally or otherwise) and the effect observed. If no such analysis has taken place this shall be stated. It should be noted that for some systems it may be necessary for the certification/validation agency and developers to reach an agreement about data protection, and users may need to be informed about the use of their personal data for validation processes (including sharing it with external agencies).
5 (highest)	The system's developers shall provide the full source code, statistical models, and training data (if relevant), and any descriptions of the data composition and provenance. *System Description:* Full source code shall be provided, together with (where relevant) trained statistical models and all training data used in learning/optimization of those statistical models, including descriptions of the data's composition and provenance. *Validation Description:* All material necessary to reproduce the validation process shall be provided including, where relevant, executable versions of any tools used, and working versions of the system (including physical instantiations of the system where relevant).

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It should be noted that this subclause is concerned only with the transparency of the validation process and the transparency of the system to external validators. The quality of the validation process is not of concern here; for example, whether specifications are well-constructed, appropriate properties are considered or the process is thorough.

While this subclause has concerned itself with transparency with respect to some particular agency, an autonomous system creator could choose to adopt these levels of transparency with regards to the general public, i.e., by placing system and validation descriptions somewhere publicly accessible where anyone could attempt to validate the system for themselves.

5.2.2 Incident investigators

If autonomous systems fail, they can cause a wide range of potential harm, from physical injury to psychological, economic, or environmental harm, thus processes for accident investigation are needed (see Winfield, Winkle, Webb, Lungs, Jirotka, and Macrae [B61]). This subclause of the standard defines the kinds and levels of transparency that support the work of accident (or more generally *incident*) investigators.

Failure of non-physical (i.e., software) systems can also cause harm. A medical diagnosis AI might, for instance, give the wrong diagnosis, or a credit-scoring AI might make a mistake and cause a person's loan application to be rejected. Without transparency, finding out what went wrong and why is extremely difficult and may, in some cases, be impossible.

An excellent model of good practice exists in the well-established and trusted processes of air accident investigation—processes that have contributed to the safety record of modern commercial air travel. Notably, air accident investigation agencies have a culture of learning and data sharing across the industry.

The ability to find out what went wrong and why is not only important to accident investigators; it might also be important in order to establish who is responsible, for insurance purposes, or in a court of law. In addition, following high profile accidents, wider society needs the reassurance of knowing that problems have been found and fixed.

The principle underlying this subclause is that, following an incident (which might have resulted in loss, harm or injury), it shall be possible to trace the internal processes of an autonomous system that, over some time period, led to the incident. This subclause requires that a system be equipped with a logging system for data, capable of securely recording a time-stamped log of key system inputs, outputs, and (ideally) high-level decisions (see Winfield and Jirotka, 2018 [B60]). In aviation, such devices are referred to as Flight Data Recorders, and in road vehicles they are known as Event Data Recorders. This standard adopts the term Event Data Recorder (EDR). The detailed specification of such an event data recorder is outside the scope of this standard, although for the specification of an EDR for motor vehicles refer to IEEE Std 1616-2021 [B23].

Incident Investigators are any persons or organizations tasked with discovering the root cause of an incident in order to make recommendations for corrective actions to prevent the future occurrence of the same or a similar event. Incident investigators normally have privileged (confidential) access to the system under investigation (or an identical copy should the system involved in the incident have been destroyed) together with designs and technical documentation. This standard expects that investigators also require access to information collected as a consequence of the transparency measures for safety certifiers set out in 5.2.1, in addition to the *event data* provided by the transparency levels defined in Table 4.

It is important to note that accident investigations are social processes of reconstruction that draw upon many sources of evidence including, for instance, eyewitness reports, CCTV, or other sources of video capture, forensic evidence, etc. Any information on the root cause of an incident collected through the transparency measures set out in Table 4 thus underpin and complement these other forms of evidence (see Winfield, Winkle, Webb, Lungs, Jirotka, and Macrae [B61]).

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For this category of stakeholder, the levels of transparency are progressive, i.e., fulfilment of an earlier level is necessary to achieve a higher one.

Transparency requirements for incident investigators are given in Table 4.

Table 4—Transparency requirements for incident investigators

Transparency level	Definition
0 (lowest)	No transparency
1	A physical autonomous system such as a robot should be equipped with a video and audio recording device that is independent of the system's sensing and control systems and allows playback of the situation around the system at the time of an incident. The external data recorded by such a device should be relevant to the purpose and domain of application of the autonomous system, and such a device should be mounted appropriately, e.g., to face the direction of movement of an autonomous surface vehicle. The attribute of being "independent" of the system means that the device must be able to record unmodified, correctly time-stamped, and non-modifiable data through a means that is not dependent on the system itself, except for charging a battery on the device that provides a source of power independent from the system itself. A device such as a dashcam may suffice for these purposes. Software-only systems shall be equipped with an EDR module that logs both inputs to the system and outputs from the system.
2	Autonomous systems shall be equipped with an EDR capable of recording a time stamped log of key system inputs and outputs. A physical system such as a robot shall be fitted with an EDR capable of securely recording a time stamped log of key system inputs and outputs. The EDR's function is to continuously record the most recent *n* minutes or hours of relevant time-stamped data, including sensor data and actuator demands (as appropriate for the system in question). A physical EDR shall be designed and built to survive foreseeable accident and incident environments. Software-only systems shall be equipped with an EDR module that logs both inputs to the system and outputs from the system (as per Level 1).
3	Autonomous systems shall be equipped with an EDR designed to meet either a standard or open standard specification (where feasible standards exist), capable of recording a time stamped log of key system inputs, outputs and high-level decisions. A physical system, such as a robot, shall be fitted with either a physical or software EDR, as appropriate. The EDR's function is to continuously record the most recent *n* minutes or hours of relevant time-stamped data, including sensor data, actuator demands and high-level decisions (as appropriate for the system in question). These data shall be securely stored in a standard format. In the event that the physical system continues to function after the incident, the EDR shall continue recording after the incident. A physical EDR shall be designed and built to survive foreseeable accident and incident environments. Software-only systems shall have a standard or open standard (where feasible standards exists) EDR module that logs inputs to the system, outputs high-level decisions from the system in a secure, standard format.
4	The EDR in Level 3 shall additionally store the reason, e.g., decision-making logic or mechanism, behind each high-level decision, in order to allow an incident investigator to determine how and why the system made that decision. For autonomous systems in which decision-making is algorithmic, this requirement should be achieved by inserting calls to a procedure at each decision-making point in the code; each time that procedure is called, it sends a record identifying the decision-making point to the EDR. An incident investigator uses the trace of such decisions from the EDR, alongside inspection of the code, to determine the logic behind system decisions. For autonomous systems that make use of artificial neural networks (ANNs) the determination of the reasons for decisions (ANN outputs for a given set of inputs) is more difficult. But, at a minimum, the system should periodically send the complete set of ANN connection strengths to the EDR in order to allow incident investigators to reconstruct the ANN in an effort to reproduce the sequence of outputs leading up to the incident.
5 (highest)	In addition to the event data recorded to achieve Level 4, incident investigators shall be provided with a set of tools to assist them in reviewing and auditing that data. Such tools should provide visualization of the decisions made, e.g., in a tree-like format (see Theodorou, Wortham, and Bryson [B56]), or may even reconstruct a virtual model of the system.

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5.2.3 Expert advisors in administrative actions or litigation

Designers of autonomous systems should be cognizant of the fact that agency administrative actions, lawsuits, or other legal proceedings may ensue when a system's operations directly or indirectly result in physical or economic harm. In such cases, the lawyers, judges, expert witnesses, and courts may require detailed information regarding how the system reached the state it was in when its operations resulted in harm. Without transparency, witnesses may be unable to provide an adequate description of the technology at issue or an adequate explanation of the specific system's actions, and the lawyers may not be able to adequately develop and present the evidence used in the legal process. Where factual evidence is not obtained through transparent investigations, the evidence could lead to unreliable conclusions, agency determinations, and court decisions that might harm public confidence in autonomous systems technology.

This standard expects that lawyers, judges, expert witnesses, insurers, or other professionals within this stakeholder group will require information collected as a consequence of the transparency measures set out in 5.2.1 and 5.2.2, i.e., the reports of both safety certification agencies and incident investigators, as the basis of their advice, judgements or testimony concerning a given system. If an incident involves human interaction with the system, they might also require information on transparency measures that are in place for the user, as set out in 5.1.1. However, it is expected that these professionals will also require evidence of the *processes* under which the system was designed, manufactured, or operated. These requirements for *process transparency* are set as follows:

— *Quality Management (QM)* is a process that seeks to help maintain consistency of an organization's product or service. QM has four main components: quality planning, quality assurance, quality control, and quality improvement (see Rose [B43]). QM is focused not only on product and service quality, but also on the means to achieve it.

— *Ethical Risk Assessment (ERA)* is a process that extends the envelope of risk assessment to include ethical risks. ERA assesses each risk of ethical harm, and the likelihood of that risk, then seeks ways of mitigating those risks. BS 8611:2016 [B9] provides guidelines for ethical risk assessment. IEEE Std 7000-2021 [B25] may also serve as a guide for this process.

— *Ethical Governance* is a set of processes, procedures, cultures, and values designed to help maintain the highest standards of behavior. Ethical governance thus goes beyond simply good (i.e., effective) governance, in that it inculcates ethical behaviors in both individual designers and the organizations in which they work (Winfield and Jirotka, 2018 [B60]).

— An *Audit Trail* is a chronological record, or set of records, that provides documentary evidence of an organization's processes. In the context of this standard, the audit trail shall document and record all quality, risk assessment and control/mitigation, and ethical governance processes.

For this category of stakeholder, the levels of transparency are non-progressive, i.e., fulfilment of an earlier level is not necessary to achieve a higher one.

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Transparency requirements for expert advisors in administrative actions or litigation are given in Table 5.

Table 5—Transparency requirements for expert advisors in administrative actions or litigation

Transparency level	Definition
0 (lowest)	No transparency
1	Documentary evidence shall be provided to show transparent reporting of quality assurance activities for the system. Evidence of this may be demonstrated by the designer/manufacturer/operator of the system being conformant and certified to *quality management* standard ISO 9001:2015 [B27] or the equivalent.
2	The designer/manufacturer/operator shall undertake a process of *ethical risk assessment and control/mitigation* according to published standards such as BS 8611:2016 [B9], IEEE Std 7000-2021 Clause 11 (the section on transparency) [B25] or the equivalent and produce risk assessment reports for the system in question. ISO/IEC 33000 [B28] may provide guidance with regard to capability levels and process models for assessment. Such risk assessment reports shall detail which ethical risks were identified by the assessment, the likely impact of those risks, and the steps that have been taken to mitigate their impact.
3	In addition to Level 2, the designer/manufacturer of the system shall apply and document an *ethical governance* framework within its product life cycle. See for instance the 5 pillars of ethical governance set out in Winfield and Jirotka (2018) [B60].
4	For any given system there shall be a full *audit trail* for all of the quality, risk assessment and control/mitigation, and ethical governance processes in Levels 1–3 above. This audit trail may, for instance, form part of evidence within legal proceedings, internal investigations, or a public inquiry.
5 (highest)	As for Level 4.

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Annex A

(informative)

A guide on how and when to use this standard

This standard has two primary functions. The first is as a tool for assessing the transparency of an autonomous system, and the second is as a guide to the transparency measures, for each stakeholder group, that should be taken into consideration during system specification and development. Note that this standard does not specify *how* the transparency measures defined here shall be implemented; only the kind of transparency each measure affords and how to determine whether it is present or not.

In this annex, an outline is provided on how to assess system transparency, then how to use this standard as a transparency design guide, and finally when to consider this standard.

A.1 How to assess system transparency

Each of the definitions for the different levels of transparency set out in Clause 5 is a testable specification that, for any given system, will either be met or not met. Overall system transparency is therefore assessed by working through each transparency level definition, for each stakeholder group in turn, to answer the yes/no question "Does the system meet this transparency level specification or not?" The STA checklist in Table A.1 can assist in this process.

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Table A.1—STA template

STA **System:** **Assessor:** **Date:**			
Standard Clause	**Level**	**Yes/No**	**Notes**
5.1.1 Users	1		
	2		
	3		
	4		
	5		
5.1.2 General public and bystanders	1		
	2		
	3		
	4		
5.2.1 Validation certification agencies and auditors	1		
	2		
	3		
	4		
	5		
5.2.2 Incident investigators	1		
	2		
	3		
	4		
	5		
5.2.3 Expert advisors in administrative actions or litigation	1		
	2		
	3		
	4		

The overall transparency assessment is summarized using Table A.2.

Table A.2—STA scoresheet

STA Scoresheet **System:** **Assessor:** **Date:**					
Standard Clause **(C = cumulative, NC = non cumulative)**	**Levels** **(tick to indicate level is met)**				
	1	**2**	**3**	**4**	**5**
5.1.1 Users (NC)					
5.1.2 General public and bystanders (NC)					
5.2.1 Validation and certification agencies (C)					
5.2.2 Incident investigators (C)					
5.2.3 Expert advisors in administrative actions or litigation (NC)					

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A.2 How to use this standard as a transparency design guide

There are many reasons a designer might consider designing transparency into a system. These include the following:

a) The system has the potential to cause harm, noting that harms could be physical, psychological, economic, societal, or environmental.

b) The system might capture personal information (and make decisions or recommendations based on that personal data) and therefore be subject to data protection regulations such as General Data Protection Regulation (GDPR).

c) The user should have confidence in the system; for instance, the success of the system could depend on a (possibly non-expert) user having high confidence in that system, and in order to build that confidence the user needs to gain a good understanding of what the system does, why it does it, and when.

d) The system will be deployed in publicly accessible buildings (e.g., shopping malls, hospitals, or museums) or urban spaces (e.g., streets or public parks). Users of those spaces who do not interact directly with the system (e.g., pedestrians, shoppers, families and children, public servants including police, paramedics or street cleaners) may require some understanding of what the system is and what it does.

e) The customer for the system (which might be a government department) writes the need for transparency into the System Requirements Specification and makes the award of a design contract subject to conformance with those transparency requirements.

f) The system design company is committed to practicing Ethically Aligned Design within a broader framework of Responsible Innovation and regards transparency as an important design principle for its products and services.

This standard has an important role as a guide for system procurers or designers who for any reason, including those outlined above, are considering which transparency features need to be incorporated into the system specification. An outline process for preparing an STS is shown in Figure A.1.

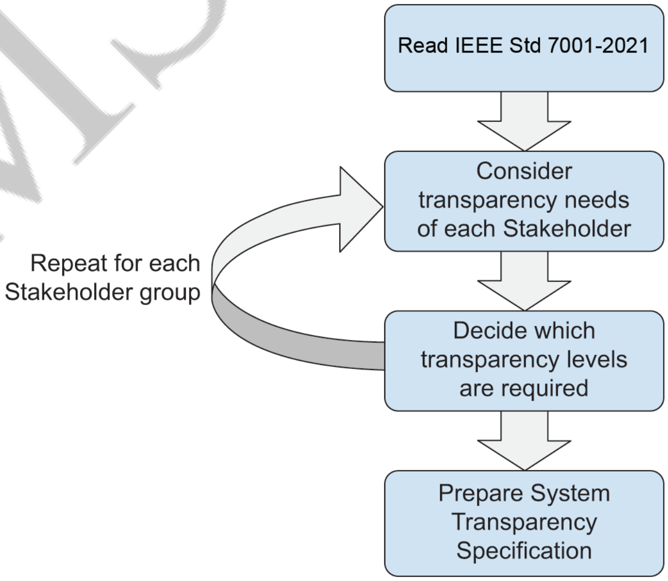
Read IEEE Std 7001-2021
Consider transparency needs of each Stakeholder
Repeat for each Stakeholder group
Decide which transparency levels are required
Prepare System Transparency Specification

Figure A.1—Outline process for preparing an STS

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Each of the four main steps in the outline process of Figure A.1 are detailed as follows:

— *Step 1:* Read this standard. Before starting the process of drafting the STS, it is important to understand the overall transparency framework set out in this standard—especially the need to think about transparency needs from the perspective of the five stakeholder groups.

— *Step 2:* Consider the transparency needs of each stakeholder group as set out in Clause 5. Each system will have different transparency priorities, as will various stakeholders alike. As outlined previously in transparency design considerations a) through f), these might be transparency for: minimizing harm, data protection, improving user confidence, to meet customer requirements, or as part of Ethically Aligned Design.

— *Step 3:* Decide which transparency levels are required. Not all systems will need to meet the maximum levels of transparency defined in Clause 5, and the balance of transparency needs will vary across stakeholder groups given the transparency priorities that apply to the system and its application under consideration. The decision of which transparency level is required for each stakeholder group should be made following an impact analysis. That impact could, for instance, be classed as high, medium, or low. Safety-critical autonomous systems, which have the potential to cause serious harm or injury, would be classed as high impact. Recommender systems (AIs that do not make decisions directly but instead support a human decision maker) might be classed as medium impact, while systems with little or no real-world consequence would be classed as low impact. High impact systems would then require greater transparency than medium impact, which in turn would require greater transparency than low impact systems. It should be noted that these impact assessments are independent across stakeholder groups, so a high impact for one group does not necessarily imply a high impact across all groups. Analysis may be required to explore the relative impact of transparency or explainability decisions for various groups of stakeholders. For example, the meaning of greater transparency for a high-impact system, such as an autonomous aircraft (drone), to bystanders, users, system owners, designers, and forensic analysts is quite different because of their level of understanding, ability to influence the system, and the likelihood of being affected by system hazards. Greater transparency for high impact is therefore not a one-size-fits-all requirement. The scenarios included in Annex B are intended to illustrate how transparency is either measured or specified in different fictional applications and situations.

— *Step 4:* Prepare the STS. After repeating Step 2 and Step 3 for each stakeholder group, the STS can be drafted. An STS template is given in Table A.3.

Table A.3—An STS template

STS Template **System:** **Specifier:** **Date:** **Notes on overall transparency priorities:**					
Standard subclause **(C = cumulative, NC = non cumulative)**	**Levels** **(tick to indicate levels required)**				
	1	**2**	**3**	**4**	**5**
5.1.1 Users (NC)					
Notes:					
5.1.2 General public and bystanders (NC)					
Notes:					
5.2.1 Validation and certification agencies (C)					
Notes:					
5.2.2 Incident investigators (C)					
Notes					
5.2.3 Expert advisors in administrative actions or litigation (NC)					
Notes:					

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A.3 When to apply this standard

How this standard is best applied depends upon when in the development lifecycle the standard is taken into consideration. This standard may be applied at any stage, from requirements specification (as outlined in A.2), then at any stage during development and deployment. Given that transparency does not come "for free," but needs to be designed-in, then the greatest benefit (at the lowest cost) can be gained from this standard by considering transparency early during the development lifecycle—the earlier the better.

Consider now how to apply this standard at different stages in a system life cycle, as follows:

- *During system specification:* This standard can be employed during the requirements specification phase in order to consider and prioritize transparency needs, then prepare an STS, as detailed in A.2. The STS then becomes part of the overall System Requirements Specification against which design can proceed.
- *During design and development:* Although the process of STA outlined in A.1 may be applied at any time during the system development phase, early application of STA is clearly advantageous as it enables any transparency deficits to be addressed during initial builds of the system.
- During system deployment. System transparency may be assessed (using the method in A.1) while a system is in use. This may be valuable to, for instance, compare the transparency of different systems or, following a system failure, to retrospectively assess its transparency in order to learn lessons for future systems.

It is important to note that the application of this standard during the design and deployment life cycles should not be a one-off process. Instead, this standard should be applied iteratively, for instance following major system revisions, or following a change in the way the system is deployed. Thus, this standard can be used to check and demonstrate that system updates or operational changes have not resulted in either reduced transparency or transparency that is no longer sufficient.

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Annex B

(informative)

Scenarios

B.1 Autonomous delivery vehicle

This fictional scenario illustrates the value of conducting a STA early in the development process.

An established and well-regarded manufacturer of robots for indoor use, including hospital portering robots, wishes to expand its range into Autonomous Vehicles designed to provide delivery services between local suppliers and their customers, including deliveries of both groceries and hot food.

The company has built a demonstrator system. Early in the design cycle they conduct a series of real-world trials involving a number of local suppliers including a local supermarket and two fast food outlets, and a panel of volunteer customers. The manufacturer regards themselves as a responsible company who fully understands that, to be successful, the delivery autonomous vehicle will need to be both reliable and have a low risk of causing harm. They conduct a STA against this standard, with the aim of considering the STA alongside feedback from the real-world trials. The score sheet summarizing the outcomes of that assessment is shown in Table B.1.

Table B.1—Autonomous delivery vehicle STA scoresheet

System: Autonomous delivery vehicle **Assessor: Dr J Bloggs** **Date: 23 March 2021**					
IEEE Std 7001-2021 subclause **(C = cumulative, NC = non cumulative)**	**Levels** **(tick to indicate level is met)**				
	1	**2**	**3**	**4**	**5**
5.1.1 Users (NC)	X * ***	X ** ***	X ***		
NOTE—Three categories of users are defines as follows: *Customers who have placed an order and need to interact with the autonomous vehicle in order to collect their food delivery. For these users simple instructions, with images and a video-clip explaining how to collect the delivery from the autonomous vehicle are provided when an order has been accepted and delivery confirmed. Pictorial instructions are clearly displayed on the vehicle and, in addition, spoken instructions are triggered when the person collecting the order approaches the AV: Level 1 **Non-expert persons responsible for placing the order into the autonomous vehicle prior to sending it out for delivery. For these interactive training materials are provided: Level 2. ***Domain expert users are defined here as the operators of the AV, who will monitor and supervise its operation and, when necessary, maintain the vehicle. Domain experts are provided with full technical documentation (Level 1), together with interactive training materials (Level 2) and functionality to provide a full explanation of the AVs activity (Level 3).					
5.1.2 General public and bystanders (NC)	X	X			
NOTE—The autonomous vehicle is clearly identified as a robot, with warnings; it is fitted with cameras for navigation, with limited views such that they do not collect personal data.					
5.2.1 Validation and certification agencies (C)	X	X			
NOTE—Transparency of validation processes up to Level 2.					
5.2.2 Incident investigators (C)	X	X			
NOTE—The present system is equipped with a proprietary event logging system.					
5.2.3 Expert advisors in administrative actions or litigation (NC)	X	X			

NOTE—The company has ISO 9001 [B27] accreditation or equivalent and ethical risk assessment (ERA) has been undertaken for the AV.

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When reviewing the STA the company notes that the transparency measures for non-expert users reflect the satisfaction with the information provided that was reported by them following the trials. However, the company noted that they had not yet conducted trials with a potential third-party operator and therefore could not be confident that the transparency measures for domain expert users are sufficient. By the same token the STA prompted the company to conduct trials with a range of bystanders in order to determine whether the measures in 5.1.2 are considered sufficient.

For section 5.2.2 of the STA: incident investigators, the company, and its insurers decide that Level 2 is not sufficient as the current proprietary event data recorder fitted does not record the reasons for the AVs decisions. Given that the autonomous vehicle will be operating in public spaces, safety is paramount. Thus, the ability to fully investigate both near-miss and actual accidents will be essential in improving both the AVs safety features and operational processes.

B.2 Medical diagnosis AI

This fictional scenario shows how this standard can be used to specify system transparency requirements as a condition of supply.

A government procurer of health technology believes that clinicians (both in general practice and in hospitals) would benefit from an AI-based tool to assist them in reaching diagnoses. Based upon a good understanding of the state of the art in diagnostic AI systems they write a specification for a Medical Diagnosis AI Recommender system and decide that the system should meet or exceed necessary levels of transparency as a condition of supply. Using this standard as a guide, they draft the following STS for the recommender, for inclusion in the call for tenders.

Table B.2—Medical diagnosis AI system transparency scoresheet

System: Medical diagnosis AI (recommender) system
Specifier: Government Department of Health
Date: 24 September 2021
Notes on overall transparency priorities: The recommender system requires a high level of transparency for both its recommendations to a clinician, and for the processes used to develop the system and to validate its operation.

IEEE Std 7001-2021 subclause (C = cumulative, NC = non cumulative)	**Levels (tick to indicate level is met)**				
	1	**2**	**3**	**4**	**5**
5.1.1 Users (NC)	X	X	X	X	
NOTE—Users are defined as clinicians in the category of domain expert users, who require a high level of understanding of how the recommender system functions, including the ability to ask it to explain its recommendations.					
5.1.2 General public and bystanders (NC)	X	X			
NOTE—This stakeholder group is less critical, since the clinician is required to explain to a patient (and family members, etc.) the role and purpose of the recommender system in helping to reach a diagnosis.					
5.2.1 Validation and certification agencies (C)	X	X	X	X	
NOTE—Evidence of validation, including clinical trials is critical.					
5.2.2 Incident investigators (C)	X	X	X	X	
NOTE—The recommender system must securely log all recommendations, including the reasons for those recommendations, to support incident investigations, noting that an incident investigation may be triggered by a clinician raising concerns about the system's recommendations.					
5.2.3 Expert advisors in administrative actions or litigation (NC)	X	X	X	X	X

NOTE—The fullest possible evidence of best practice quality management, development, and governance processes in the supplier is required.

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The Department of Health includes the STS (Table B.2) in the call for tenders for the recommender system. The call requires suppliers to demonstrate compliance by detailing the following in their bids:

a) How the transparency measures required have been implemented

b) IEEE 7001 STAs that clearly show that the transparency measures meet or exceed the specifications in IEEE Std 7001-2021 (Table B.2).

B.3 Content moderation for AI

This fictional scenario shows how this standard can be used to specify system transparency requirements as a condition of supply.

A video hosting website has been accused by activists of using keywords to prevent monetization of potentially objectionable or controversial content. The activists attempted to reverse-engineer the algorithm and have created a list of keywords that they believe can trigger the content moderation algorithms to demonetize content. To mitigate a potential scandal and lawsuits, and to satisfy legislators, the video hosting website decides to apply this standard on transparency as a draft specification for their engineers, to more transparently communicate the decision-making processes of their content moderation systems.

Table B.3—Content moderation for AI system transparency scoresheet

System: Content moderation AI system **Specifier: Video hosting website** **Date: 11th November 2021** **Notes on overall transparency priorities: The Content Moderation AI System requires a high degree of transparency for legislators and auditors, but with less transparency for the general public, due to concerns of bad actors finding exploits.**					
IEEE Std 7001-2021 subclause **(C = cumulative, NC = non cumulative)**	**Levels** **(tick to indicate level is met)**				
	1	**2**	**3**	**4**	**5**
5.1.1 Users (NC)	X	X	X		
NOTE—Users are defined as content creators, who are non-expert users. They require a medium level of understanding of how the system functions, including the ability to ask the system to explain its decisions, or to pre-emptivelyinterrogate if something is likely to be deemed problematic.					
5.1.2 General public and bystanders (NC)	X				
NOTE—This stakeholder group is defined as content consumers, who are only indirectly affected by potential issues relating to content moderation and related monetization.					
5.2.1 Validation and certification agencies (C)	X	X	X		
NOTE—Evidence of validation of the algorithm is important for illustrating good faith, and they require a medium range of information.					
5.2.2 Incident investigators (C)	X	X	X	X	
NOTE—Incident investigators and auditors should have privileged access to the mechanisms, in order to better ascertainif they are fair and appropriate or are harming any interests unfairly.					
5.2.3 Expert advisors in administrative actions or litigation (NC)	X	X	X	X	X
NOTE—Legal and legislative concerns may demand, or subpoena confidential information related to the system in the line of their duties.					

The video hosting website includes the STS (Table B.3) in the specification for the content moderation AI system. The specification requires engineers to demonstrate compliance by detailing, in their bids a) how the transparency measures required can be implemented and b) IEEE 7001 STAs that clearly show that the transparency measures meet or exceed the IEEE 7001 specification (Table B.3).

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B.4 Credit scoring system

This fictional scenario shows how this standard can be used to specify system transparency requirements as a condition of supply.

A credit scoring technology wishes to illustrate to loan applicants, service users, and legislators that their technologies are open and safe. The credit scoring company decides to apply this standard on transparency as a draft specification for their engineers to more transparently communicate the decision-making processes of their content moderation systems.

Table B.4—Credit scoring system transparency scoresheet

System: Credit scoring system **Specifier: Loans company** **Date: 11th November 2021** **Notes on overall transparency priorities: The Credit Scoring System requires a high degree of transparency for legislators and auditors, but with less transparency for the general public, due to concerns of bad actorsgaming the system.**					
IEEE Std 7001-2021 subclause (C = cumulative, NC = non cumulative)	**Levels (tick to indicate level is met)**				
	1	**2**	**3**	**4**	**5**
5.1.1 Users (NC)	X *	X * **	X *		
NOTE—Two categories of user are defines as follows: *Loan applicants, who are non-expert users. Transparency is very important to this group as the assessment is of their own particulars, and they deserve a chance to understand why they have been assessed in a particular way, and to seek redress in the event that information is incorrect or is assessed unfairly. **Operators of the credit scoring system who are assessing potential clients for creditworthiness, which may also be applied as a proxy for trust in scenarios not related to credit per se. These are expert domain users.					
5.1.2 General public and bystanders (NC)	X				
NOTE—The system requires there to be less transparency for the general public due to concerns of bad actors gaming the system.					
5.2.1 Validation and certification agencies (C)	X	X	X	X	
NOTE—Evidence of validation and certification to a high degree is essential, given the sensitivity of the system.					
5.2.2 Incident investigators (C)	X	X	X	X	X
NOTE—The credit scoring system must securely log all recommendations, including the reasons for those recommendations, to support incident investigations, noting that an incident investigation may be triggered by an operator, watchdog, or ombudsman raising concerns about CSS's recommendations.					
5.2.3 Expert advisors in administrative actions or litigation (NC)	X	X	X	X	X

NOTE—Legislators should have highly privileged access to information, as loss of economic franchise based on a protected characteristic may be unlawful.

The loans company includes the STS (Table B.4) in the specification for the credit scoring system. The specification requires engineers to demonstrate compliance by detailing, in their bids a) show the transparency measures required can be implemented and b) IEEE 7001 STAs that clearly show that the transparency measures meet or exceed the IEEE 7001 specification in Table B.4.

B.5 Security robot

This fictional scenario shows how this standard can be used to specify system transparency requirements as a condition of supply.

A security company wishes to deploy a new security robot system that must prioritize public safety without being easily exploitable or gamed. The security company decides to use this standard on transparency as a

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draft specification for their engineers to more transparently communicate the decision-making processes of their security systems.

Table B.5—Security robot system transparency scoresheet

System: Security robot **Specifier: Security company** **Date: 11th November 2021** **Notes on overall transparency priorities: The security robot requires a high degree of transparency for legislators and auditors, but with less transparency for the general public, due to concerns of criminals finding exploits.**					
IEEE Std 7001-2021 subclause **(C = cumulative, NC = non cumulative)**	**Levels** **(tick to indicate level is met)**				
	1	**2**	**3**	**4**	**5**
5.1.1 Users (NC)	X	X	X		
NOTE—Users are defined as deployers and administrators of the security robot, who may be site managers, or who may be a third-party contractor. They require a medium level of understanding of how the guard bot functions, including the ability to ask it to explain its protocols or predict its behavior in a given situation, and repair simple faults. These are superusers.					
5.1.2 General public and bystanders (NC)	X	X			
NOTE—This stakeholder group is important to bear in mind for matters of public safety, though this group is potentially adversarial, and so warrants less disclosure.					
5.2.1 Validation and certification agencies (C)	X	X	X	X	
NOTE—Electromechanical devices that could potentially cause serious injury warrant a high degree of certification and oversight.					
5.2.2 Incident investigators (C)	X	X	X	X	X
NOTE—The security robot securely logs all actions and behavior of self, and other agencies in the vicinity. With regards to the behavior of the systems itself, it should log the reasons why it made a certain appraisal, prediction, decision, or action. Investigation may be called in the case of an altercation causing alarm and distress or injury.					
5.2.3 Expert advisors in administrative actions or litigation (NC)	X	X	X	X	X

NOTE—Legal and legislative concerns may demand, or subpoena confidential information related to the robot in the line of their duties.

The security company includes the STS (Table B.5) in the specification for the security robot. The specification requires engineers to demonstrate compliance by detailing in their bids a) how the transparency measures required can be implemented and b) IEEE 7001 STAs that clearly show that the transparency measures meet or exceed the IEEE 7001 specification above (Table B.5).

B.6 Medical decision support system

This fictional scenario shows how this standard can be used to assess system transparency in two similar systems in a similar context, in this case that of a medical decision support system (Med DSS).

This scenario is focused on a Med DSS that uses a machine learning (ML) algorithm to provide recommendations regarding who should receive a kidney transplant within a group of compatible patients. Two cases vary in the degree of automation complexity and human oversight. In both cases, if a wrong decision is made, there may be severe consequences for the patient and others who might have received the organ transplant. Thus, the decision is characterized by high criticality.

In both cases, the training data set used for initially training the model came from patients aged 18 to 35 enrolled in an NHS trial in the UK. Thus, the DSS recommendation might be biased. Additionally, in both cases, the DSS uses the following profiling approach: a particular gene complex is associated with better outcomes. The system finds associated genotypic factors and uses this in decision making.

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B.6.1 System Version 1

In the first case, the DSS uses an algorithm that is comprehensible to developers of the algorithm but not the end-users. The DSS uses specific data inputs known to influence kidney transplant success rates (e.g., age, hospital facilities, and distance to a donor) to make a recommendation. There is a significant oversight by humans on the performance of the DSS. The DSS is acting as part of a team with human consultants/ clinicians who provide specialist expertise. Where traditional processes would refer the decision to a team of five clinicians, the decision is now made by four clinicians and the recommendations of the algorithm. The algorithm uses patterns based on the training data and is not provided with additional information. Table B.6 is a worked example of the transparency assessment of this system.

Table B.6—Med DSS Version 1 system transparency scoresheet

STA **System: Med DSS** **Assessor:** **Date:**			
Standard subclause	**Level**	**Yes/No**	**Notes**
5.1.1 Users *Users in this case are the hospital clinicians involved in the kidney transplant process (domain expert users)*	1	Yes	The users are provided with documentation including general principles of operation and the source of the training data set
	2	Yes	Clinicians have available interactive training material to rehearse interactions
	3	Yes	Clinicians can query the system to receive an explanation of recent activity
	4	Yes	Clinicians can receive information on what the system *would* do in a given situation
	5	Yes	Clinicians are provided with continuous on-demand explanation of behavior. However, this does *not* include access to training data because this contains sensitive medical information
5.1.2 General public and bystanders	1	Yes	The general public (including patients) are aware that an AI is a member of the clinical team
	2	No	No information is given to patients on data collected
	3	No	No information is given to patients on the system purpose, goes and operation
	4	No	There is no data-governance policy
5.2.1 Validation and certification agencies and auditors	1	Yes	Documentation containing specification and which of its properties were validated is available
	2	Yes	Documentation containing validation processes is available
	3	Yes	Documentation containing a high-level design of the system is available including composition and provenance of training data
	4	Yes	Documentation containing a high-level design of the system is available including composition and provenance of training data
	5	Yes	The full source code including profiling information is available.
5.2.2 Incident investigators	1	Yes	The system logs both inputs and outputs of the system
	2	Yes	The system logs both inputs and outputs of the system
	3	Yes	The system logs inputs, outputs and high-level decisions in a secure, standard format
	4	Yes	As Level 3 with the addition of the likely reasons for the decisions
	5	Yes	As Level 4 with the addition of tools to audit the data
5.2.3 Expert advisors in administrative actions or litigation	1	Yes	Documentary evidence of quality management standard compliance is available
	2	Yes	An explicit process of ethical risk assessment and control/mitigation has been undertaken
	3	No	The designer/manufacturer of the system did not apply a documented and transparent ethical governance framework
	4	No	An audit trail is not present

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B.6.2 System Version 2

In the second case, the Med DSS uses an algorithm that is not easily comprehensible to domain expert end-users. The learning algorithm collects large volumes of patient data including biometrics, longitudinal health information for that patient, and other kidney recipients not normally accessible to the clinicians. The system processes this information to deliver recommendations. Clinicians define a list of 10 compatible patients and then the algorithm makes the selection of which patient from that list receives the transplant. There is limited/minor oversight by humans on the performance of the DSS. Decisions are reviewed regularly to validate the process. The algorithm uses patterns based on training data and additional information on the prevalence of this gene across different ethnicities. Table B.7 shows the information from the second case described above:

Table B.7—Med DSS Version 2 system transparency scoresheet

STA **System: Med DSS** **Assessor:** **Date:**			
Standard subclause	**Level**	**Yes/No**	**Notes**
5.1.1 Users *Users in this case are the hospital clinicians involved in the kidney transplant process (domain expert users)*	1	Yes	The users are provided with documentation including general principles of operation and the source of the training data set.
	2	Yes	Clinicians have available interactive training material to rehearse interactions
	3	No	It is not possible to receive a brief and immediate explanation of the deep learning algorithm’s decision-making process
	4	No	It is not possible to receive a brief and immediate explanation of the deep learning algorithm’s decision-making process
	5	No	Clinicians are not provided with continuous on-demand explanation of behavior or access to training data that contains sensitive medical information
5.1.2 General public and bystanders	1	No	The general public will not be aware of this system.
	2	No	No information is given to patients on data collected.
	3	No	No information is given to patients on the system purpose, goals, and operation.
	4	No	There is no data-governance policy.
5.2.1 Validation and certification agencies and auditors	1	Yes	Documentation containing specification and which of its properties werevalidated is available
	2	Yes	Documentation containing validation processes is available
	3	Yes	Documentation containing a high-level design of the system is available including composition and provenance of training data
	4	Yes	Documentation containing a high-level design of the system is available including composition and provenance of training data
	5	Yes	The full source code including profiling information is available.
5.2.2 Incident investigators	1	Yes	The system logs both inputs and outputs of the system
	2	Yes	The system logs both inputs and outputs of the system
	3	Yes	The system logs inputs, outputs and high-level decisions in a secure, standard format
	4	No	Reasons for the decisions are not available
	5	No	No tools to audit the data are available
5.2.3 Expert advisors in administrative actions or litigation	1	Yes	Documentary evidence of quality management standard compliance is available
	2	Yes	An explicit process of ethical risk assessment and control/mitigation has been undertaken
	3	Yes	The designer/manufacturer of the system applied a documented and transparent ethical governance framework.
	4	No	An audit trail is not present.

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B.6.2.1 Overall transparency assessment

The overall transparency assessment is summarized using the Table B.8.

Table B.8—Overall system transparency scoresheet

STA Scoresheet **System:** **Assessor:** **Date:**					
IEEE Std 7001-2021 subclause **(C = cumulative, NC = non cumulative)**	**Levels** **(tick to indicate level is met)**				
	1	**2**	**3**	**4**	**5**
5.1.1 Users (NC) (System 1)	X	X	X	X	X
5.1.1 Users (NC) (System 2)	X	X			
5.1.2 General public and bystanders (System 1)	X				
5.1.2 General public and bystanders (System 2)					
5.2.1 Validation certification agencies (C) (System 1)	X	X	X	X	X
5.2.1 Validation and certification agencies (C) (System 2)	X	X	X	X	X
5.2.2 Incident investigators (C) System 2)	X	X	X	X	X
5.2.2 Incident investigators (C) (System 2)	X	X	X		
5.2.3 Expert advisors in administrative actions or litigation (System 1)	X	X			
5.2.3 Expert advisors in administrative actions or litigation (System 2)	X	X	X		

B.7 Increasing levels of mainline railway automation

B.7.1 Background

This fictional scenario based on a real context shows, via a rail example, the need for transparency and how this need grows as operation moves from automated with human oversight (human delegated or supervised) to fully autonomous.

Rail systems already have significant levels of automation, right up to what is known as Unattended Train Operation [(UTO), Grade of Automation level 4 (GoA4) under the IEC Standard for Communications Based Train Control (CBTC) (see Schifers and Hans [B48])] where all functions, including door operation, are performed by the control system and there is no crew on the train at all, even for emergencies. Such systems are already common on metros and people movers. These are normally "closed" (the route is largely in a tunnel or elevated) where they are at ground level and they are protected by substantial fences. Train speeds are relatively low. There are no level crossings of any kind, and platforms are often protected by platform screen doors (PSDs) such that all access to the track/guide-way is controlled. The systems are usually geographically constrained, so emergency and recovery response can be provided in a timely manner from off-route resources. These systems are currently based on validated software produced by conventional programming.

Increasingly there is a desire to apply automation to mainline railways, and it can be difficult to explain to non-railway people why this is much harder.

One of rail's competitive advantages is that a steel wheel on a steel rail has a very low rolling resistance and therefore trains are generally energy efficient if effectively loaded.

The downside of this feature is that this also leads to low available friction, particularly if the rails are wet and or contaminated, meaning very long stopping distances. As a result, at any significant speed, control systems are required that give drivers and/or automatic driving systems information about the status of things

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happening beyond visual range. Protection from conflicting routes is provided by interlocking systems based on highly validated conventional algorithms (often using formal methods). Driver/system observance of route commands (signals, where lineside signaling is retained) is enforced by Automatic Train Protection (ATP), a highly validated computer system based on calculated braking curves and limited movement authorities (generated by validated algorithms).

Hazards that the driver can see may lead to some control action (principally application of the brakes, since there is no steering) or issuance of a warning by sounding the horn but the effect of this may only be mitigation rather than prevention and there are circumstances where such action could make matters worse.

Mainline railways are rarely closed; indeed only a few railways have a duty to fence the track (the UK being one) and, apart from on modern high-speed lines, there are often both vehicle and footpath level (at grade) crossings. The greatest level of harm on most mainline railways is trespass and suicide, followed by level-crossing collisions/incidents. Despite being “open” systems, access to the track for emergency vehicles can be quite challenging with long track lengths through rural areas.

Recognizing these issues, there is a current tendency to propose solutions based on Automatic Train Operation (ATO), where the system drives the train but a human is retained in the cab for monitoring and secondary safety. It is further suggested that as the LIDAR and imaging technologies being developed for autonomous road vehicles mature, the human driver will be able to be replaced. This leads to a number of both technical and ethical issues and drives a need for high levels of transparency in any AI system developed and deployed.

For instance, if a person is in close proximity to the track, a very finely nuanced decision may be required to predict that person’s intent and level of concentration. Are they distracted (for instance looking at their phone with their earphones in)? Are they moving at a pace where they will likely come into conflict or likely be clear before the train arrives? Do they have anything with them that could cause additional issues like a baby buggy (stroller). Have they seen the train and are clearly waiting for it to pass or are they looking at the train and moving in a way that might mean they are contemplating suicide? All of that evaluation has to be achieved in a very limited time period against a high level of near-field and far-field clutter and under all lighting conditions, including in the dark with headlights.

Drivers get a feel for such things, and it may be challenging to build and operate a self-learning system that can mirror that. While some of these detection issues are common to autonomous road vehicles the inability to stop before any item of interest introduces a very different kind of complexity. Trains cannot steer away; the only control available to the driver or the automatic system is the brake. If the emergency brake is applied, under current design philosophies the ATO will disengage, and a number or conditions need to be met to re-engage it. Thus, a high false alarm rate would potentially be very disruptive without a design change to the ATO philosophy, which would have other implications. On the other hand, application of the brakes might avoid or substantially mitigate a potential accident. But braking if a vehicle approaching a crossing looks like it is not going to stop might encourage a road driver to gamble, and a train hitting a car can be much more damaging than a car hitting the barrier or even the side of a train. Additionally, sounding the warning horn too often may be considered a noise nuisance and create an adverse reaction, particularly if the need for the warnings cannot be fully explained and justified. Balancing the need for early detection with a low false alarm rate will be very challenging. Further, glancing blows with people or animals are relatively common, and these might be quite hard to detect. Someone being found injured (or having died of their injuries near the lineside) sometime after the event without any warning flag could cause a significant public outcry and require a detailed independent investigation that would expect and could be aided by transparency regarding the sensor data, the system’s resultant actions, and, where appropriate, interaction with human drivers/operators.

So, transparency in what the system sensors saw and the resulting decisions will be essential in investigating any accidents or incidents on a regular basis, not just occasionally. Such information will also need to be stored in a secure manner for at least several days as it may not be immediately apparent that an incident has occurred. New routes will have specific features that will have to be learned and accommodated and, if there is an

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incident, it will be very important to understand whether a wrong decision was made or whether the situation was simply unavoidable.

The scene should also recognize the potential upsides in that this task needs to be performed in all weather and at night, so a number of available sensors may offer a potential improvement in detection accuracy over the human eye aided only by headlights.

B.7.2 Two cases in which this standard might be used

B.7.2.1 AI assists the driver

An AI system provides assistance to a human train supervisor who makes the final decision as to whether to apply the brakes, sound the horn, or report an incident to ‘control.’ This case has three potential sub-cases, as follows:

a) The AI system does not generate an alert, nor does the human operator see anything, but an incident occurs.

b) The AI system generates an alert, but the human operator does not heed it, and an incident occurs.

c) The AI system generates an alert, and the human operator responds to it in a timely manner, but an incident still occurs.

In each of these cases transparency will be needed to understand why the system responded (or did not respond) in the way it did. Cases b) and c) will have related sub-cases where there was an alert, but an incident was avoided. In these cases, while there may be no pressing need for investigation, transparency may still be required to support performance improvement. So, consider how this standard can be applied in this case (Table B.9).

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Table B.9—AI assistance system transparency scoresheet

System: ATO with AI driver assistance
Assessor: A Safety Engineer
Date: xx.xx.xx

IEEE Std 7001-2021 subclause	Level	Yes/No	Notes
5.1.1 Users: *Drivers (domain expert users) and their train operating company employers (safety duty holder) (mix of domain expert and superusers), train owners, train builders (superusers)*	1	Y	All
	2	Y	All
	3	Y	All
	4	Y	Builders/owners and certain operating company employees (superusers)
	5	N	
5.1.2 General public and bystanders*: In this case, they may be directly impacted*	1	Y	People will likely seek to be assured that system performance is at least as good as for a human alone
	2	N	
	3	N	
	4	N	
5.2.1 Validation and certification agencies and auditors	1	Y	
	2	Y	
	3	Y	
	4	Y	Assessors may wish to test performance “what if”
	5	N	
5.2.2 Incident investigators	1	Y	
	2	Y	
	3	Y	
	4	N	
	5	N	
5.2.3 Expert advisors in administrative actions or litigation	1	Y	
	2	Y	
	3	Y	
	4	N	

NOTE—While the human driver remains the final arbiter, the focus is likely to be on their professionalism and what alerts the system gives to support their decisions rather than the detail of why the system gave that alert. Detailed assessment of system performance is likely to be confined to safety/engineering professionals maintaining or developing the system. Human factors will play an important part in terms of the degree to which the driver becomes dependent on the system and potentially loses concentration.

B.7.2.2 AI replaces the driver

In this case (see Table B.10), AI completely replaces the human driver and makes braking decisions, sounds the horn, and reports incidents. Recording and analysis may be required even where no brake or horn demand is generated to allow undetected incidents to be analyzed. Thus, the recording demands will be very high.

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Table B.10—AI replacement system transparency scoresheet

System: ATO with AI oversight **Assessor: A safety engineer** **Date: xx.xx.xx**			
IEEE Std 7001-2021 subclause	**Level**	**Yes/No**	**Notes**
5.1.1 Users: *Train operating company (safety duty holder)(mix of domain expert and superusers), train owners, train builders (superusers).*	1	Y	All
	2	Y	All
	3	Y	All
	4	Y	Builders/owners and certain operating company employees (superusers)
	5	Y	Train builders/System designers
5.1.2 General public and bystanders*: In this case, they may be directly impacted*	1	Y	People will likely seek to be assured that system performance is not degraded
	2	Y	Technical press/media may demand this level of explanation
	3	N	
	4	N	
5.2.1 Validation and certification agencies and auditors	1	Y	
	2	Y	
	3	Y	
	4	Y	
	5	Y	A quantitative assessment of capability may be required
5.2.2 Incident investigators	1	Y	
	2	Y	
	3	Y	
	4	Y	
	5	Y	Particularly for undetected incidents, there will need to be an understanding of what would have changed the outcome.
5.2.3 Expert advisors in administrative actions or litigation	1	Y	
	2	Y	
	3	Y	
	4	Y	Particularly for undetected incidents, there will need to be an understanding of what would have changed the outcome.
NOTE—Striking a balance between achieving something better than a human driver and demanding similar levels of quantitative assurance to the Interlocking and ATP systems is likely to be challenging and early incidents have a high probability of being tested in court.			

B.8 Vehicle emissions measurement and mitigation system

This fictional scenario (see Table B.11) describes a case where an auto manufacturer is developing a cheaper but cleaner engine that will be capable of using either diesel or gasoline when its electric engine is depleted. The vehicle emissions subsystem is classified as Level 4, Fully Autonomous [4.2, item d)]. While vehicles involved are not driverless in today's implementation, drivers have no direct control over the functioning of this subsystem. Using this standard as a guide, they draft the following STS for the vehicle's prospective emissions measurement and mitigation system suppliers. The specification would be included in its Call for tenders/Request for proposals.

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Table B.11—Vehicle emissions measurement and mitigation system transparency scoresheet

System: Vehicle Emissions Measurement and Mitigation System **Specifier:** ***Vehicle Engine Manufacturer*** **Date:** ***18 January 2020*** **Notes on overall transparency priorities:** ***Transparency is helpful for public health and well-being and for enterprises to avoid costly litigation or personal criminal liability.***					
IEEE Std 7001-2021 subclause **(C = cumulative, NC = non cumulative)**	**Levels** **(tick to indicate levels required)**				
	1	**2**	**3**	**4**	**5**
5.1.1 Users (NC)	X *	X *	X **	X **	
Users are defined as: *Drivers and classed as domain expert users. Impact on driver-operator versus driver-owner is similar but not identical. ISO 9001:2015 [B27] is not required, but a certification that the vehicle is compliant with air quality regulations and does not exceed the sustainability goals generally accepted for this class of vehicle. Any additional maintenance required (e.g., diesel exhaust fluid, filter replacement) shall be explained at Level 2 or better. **Another potential category of users, in this case, may be internal expert quality assurance and testers. These users require access to Levels 3 and 4 of transparency, even if users, i.e., drivers, do not.					
5.1.2 General public and bystanders (NC)	X	X			
NOTE—Polluted air impacts even non-driver, non-owners; this includes health impacts on children, flora, and fauna, as well as indirect, out-of-area impacts due to climate change. A public statement of the Vehicle Emissions Measurement and Mitigation System environmental impact and how it was achieved in lay terms is to be provided.					
5.2.1 Validation and certification agencies (C)	X	X	X	X	
NOTE—Evidence of validation by air quality and safety regulators is to be provided. Given that the Vehicle Emissions Measurement and Mitigation System measures as well as implements air quality and fuel efficiency controls, the supplier should deliver transparent explanations of how measurements can be externally validated against third party tools. These are to be kept current as new versions of the Vehicle Emissions Measurement and Mitigation System are released by the supplier.					
5.2.2 Incident investigators (C)	X	X	X	X	
NOTE—Resources, such as on-vehicle “black boxes,” should provide sufficient data to assess Vehicle Emissions Measurement and Mitigation System compliance with its performance claims.					
5.2.3 Expert advisors in administrative actions or litigation (NC)	X	X	X	X	X
NOTE—Vehicle Emissions Measurement and Mitigation System transparency should take into account its impact on both enterprise legal counsel and external counsel in the case of litigation. This category extends to expert witnesses that may be need to provide testimonies related to the quality and testing procedures of the system.					

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Annex C

(informative)

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UNIT - IV ROBOETHICS: SOCIAL AND ETHICAL IMPLICATION OF ROBOTICS

Robot- Robo ethics :

Roboethics, a field at the intersection of robotics and ethics, deals with the ethical, legal, and societal implications of the development and use of robots and artificial intelligence (AI). As robots become increasingly integrated into various aspects of our lives, ranging from healthcare and education to manufacturing and transportation, it becomes crucial to consider the ethical implications of their actions and decisions.

1. **Autonomy and Responsibility**: As robots become more autonomous and capable of making decisions, questions arise about who should be held responsible for their actions in case of harm or errors. This raises issues of legal liability and accountability.
2. **Human-Robot Interaction**: Roboethicists consider how robots should interact with humans in various contexts, ensuring safety, respect, and dignity. This includes designing robots that are not only efficient but also empathetic and capable of understanding and responding to human emotions.
3. **Privacy and Data Security**: With robots and AI systems collecting vast amounts of data about individuals, concerns about privacy and data security become paramount. Roboethicists work on developing guidelines and regulations to protect individuals' privacy rights and prevent misuse of their personal data.
4. **Job Displacement and Economic Impact**: The widespread adoption of robots and AI technologies raises concerns about job displacement and its impact on society. Roboethicists explore strategies to mitigate these effects, such as retraining programs and policies to ensure fair distribution of the benefits of automation.
5. **Bias and Fairness**: AI systems and robots can inherit biases from the data they are trained on, leading to unfair or discriminatory outcomes. Roboethicists work on developing algorithms and systems that are fair and unbiased, as well as methods to detect and mitigate biases in AI systems.
6. **Lethal Autonomous Weapons Systems (LAWS)**: There is ongoing debate surrounding the development and use of LAWS, which are weapons systems that can select and engage targets without human intervention. Roboethicists advocate for international regulations and norms to prevent the proliferation and misuse of such technologies.
7. **Ethical Design and Development**: Roboethicists emphasize the importance of designing and developing robots and AI systems in accordance with ethical principles, such as transparency, accountability, and respect for human rights. This involves considering the potential impacts of these technologies on individuals and society throughout the design process.

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ETHICS AND MORALITY:

Ethics and morality are closely related concepts that deal with questions of right and wrong, good and bad, and how individuals and societies should behave. While they are often used interchangeably, there are subtle distinctions between the two:

1. **Ethics**:
   - Ethics refers to a set of principles or standards that govern the conduct of individuals or members of a profession or group. It provides a framework for evaluating actions and making decisions about what is right or wrong.
   - Ethical principles are often derived from philosophical theories such as utilitarianism, deontology, virtue ethics, and consequentialism. These theories offer different perspectives on how ethical decisions should be made and what constitutes ethical behavior.
   - Ethics can be applied to various domains, including business ethics, medical ethics, environmental ethics, and research ethics. Each domain has its own set of ethical principles and guidelines tailored to its specific context.
2. **Morality**:
   - Morality refers to the beliefs, values, and principles that guide an individual's behavior and judgments about what is right or wrong. It encompasses the personal sense of right and wrong that individuals develop through their upbringing, culture, religion, and personal experiences.
   - Morality is often deeply ingrained in individuals and societies and shapes their attitudes and behaviors towards others. It can vary across cultures, religions, and historical periods, leading to diverse moral beliefs and practices.
   - While ethics typically involves rational deliberation and the application of principles to specific situations, morality is often more intuitive and emotionally driven. It reflects individuals' innate sense of right and wrong and their feelings of obligation or duty towards others.

Despite these distinctions, ethics and morality are interconnected concepts that influence each other. Ethical principles are often rooted in moral values and beliefs, and moral intuitions can inform ethical decision-making. Both ethics and morality play crucial roles in guiding individuals and societies towards ethical behavior and fostering a sense of justice, fairness, and compassion.

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MORAL THEORIES-ETHICS IN SCIENCE AND TECHNOLOGY:

Moral theories provide frameworks for evaluating ethical dilemmas and guiding ethical decision-making. When applied to the realm of science and technology, these theories help address the ethical challenges that arise from technological advancements and scientific research. Here are some key moral theories commonly applied in the context of ethics in science and technology:

1. **Utilitarianism**:
   - Utilitarianism focuses on maximizing overall happiness or utility and minimizing suffering. In the context of science and technology, utilitarianism assesses the consequences of actions and technologies to determine their ethical acceptability.
   - Ethical decisions are made based on the principle of maximizing benefits and minimizing harms for the greatest number of people. This approach is often used in evaluating the societal impacts of scientific research, technological innovations, and public policy decisions related to science and technology.
2. **Deontology**:
   - Deontological ethics emphasizes adherence to moral rules, duties, or principles regardless of the consequences. In science and technology, deontological principles guide ethical decision-making based on the inherent rightness or wrongness of actions.
   - Ethical decisions are made by considering whether an action follows moral rules or principles, such as honesty, fairness, and respect for human dignity. Deontological ethics may be applied to issues such as research integrity, informed consent, and the rights of research participants and technology users.
3. **Virtue Ethics**:
   - Virtue ethics focuses on the character traits or virtues that lead to morally good actions. It emphasizes the development of virtuous qualities, such as honesty, compassion, and integrity, in individuals and societies.
   - In science and technology, virtue ethics emphasizes the importance of cultivating ethical virtues among scientists, engineers, and technology developers. Ethical decisions are guided by the virtues of honesty, transparency, empathy, and responsibility, leading to the

AMSCE-101

development and use of technologies that promote human well-being and societal flourishing.

4. **Ethics of Care**:
   - The ethics of care emphasizes relationships, empathy, and responsiveness to the needs of others. It prioritizes caring relationships and concern for vulnerable individuals and communities.
   - In science and technology, the ethics of care highlights the importance of considering the impacts of technologies on diverse stakeholders, including marginalized groups and future generations. Ethical decisions are guided by compassion, empathy, and attentiveness to the needs and interests of all those affected by scientific research and technological developments.
5. **Principlism**:
   - Principlism involves the application of fundamental moral principles, such as autonomy, beneficence, nonmaleficence, and justice, to ethical decision-making in specific contexts.
   - In the context of science and technology, principlism provides a framework for evaluating ethical issues related to research ethics, bioethics, and technological innovation. Ethical decisions are guided by balancing these foundational principles and considering their application to complex ethical dilemmas.

By applying these moral theories, ethicists, scientists, engineers, policymakers, and other stakeholders can navigate the ethical complexities of science and technology and promote responsible innovation that benefits society while respecting ethical principles and values.

ETHICAL ISSUES IN AN ICT TECHNOLOGY:

Information and Communication Technology (ICT) encompasses a wide range of technologies used to manage and communicate information. With the rapid advancement of ICT, various ethical issues have emerged.

ethical concerns associated with ICT technology:

1. **Privacy**:
   - ICT systems often collect, store, and process vast amounts of personal data. Privacy concerns arise regarding how this data is used, shared, and protected.
   - Ethical issues include unauthorized surveillance, data breaches, identity theft, and the tracking of individuals' online activities without their consent.

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2. **Security**:
    - Ensuring the security of ICT systems and data is essential to protect against cyberattacks, hacking, malware, and other threats.
    - Ethical issues arise when ICT systems are vulnerable to exploitation, leading to data breaches, financial losses, and damage to individuals and organizations.
3. **Access and Equity**:
    - The digital divide refers to disparities in access to ICT resources and skills based on factors such as socioeconomic status, geographic location, and educational opportunities.
    - Ethical concerns include unequal access to information, opportunities, and benefits associated with ICT, exacerbating existing social and economic inequalities.
4. **Intellectual Property**:
    - ICT enables the easy reproduction, distribution, and sharing of digital content, raising ethical issues related to intellectual property rights.
    - Ethical concerns include copyright infringement, plagiarism, software piracy, and the fair use of digital content while respecting creators' rights.
5. **Cyberbullying and Online Harassment**:
    - ICT platforms and social media facilitate communication and interaction but also enable cyberbullying, harassment, hate speech, and online abuse.
    - Ethical issues arise when individuals use ICT technologies to harm, intimidate, or discriminate against others, leading to psychological distress and social harm.
6. **Ethical AI and Algorithmic Bias**:
    - AI technologies used in ICT systems may exhibit biases based on the data they are trained on, leading to unfair or discriminatory outcomes.
    - Ethical concerns include algorithmic bias, opaque decision-making processes, and the potential for AI systems to perpetuate or amplify existing social inequalities.
7. **Digital Rights and Freedom of Expression**:
    - ICT technologies play a crucial role in enabling freedom of expression, access to information, and political participation.
    - Ethical issues arise when governments or corporations censor or restrict online content, infringe upon individuals' digital rights, or surveil and monitor online activities in violation of privacy rights.

Addressing these ethical issues requires collaboration among policymakers, technologists, ethicists, civil society organizations, and other stakeholders to develop and implement ethical guidelines, regulations, and best practices for the responsible design, development, and use of ICT technologies.

AMSCE-1101

HARMONIZATION OF PRINCIPLES:

Harmonization of principles refers to the process of reconciling or integrating different ethical principles, values, or standards to achieve consistency, coherence, and alignment in ethical decision-making across various contexts or domains. In fields such as law, ethics, and international relations, harmonization aims to establish common frameworks, guidelines, or standards that accommodate diverse perspectives while promoting ethical behavior and achieving shared goals. Here are some examples of the harmonization of principles in various contexts:

1. **Legal Harmonization**:
   - In international law, harmonization efforts seek to align legal principles and standards across different jurisdictions to facilitate cooperation, trade, and mutual recognition of rights and obligations.
   - Examples include the harmonization of intellectual property laws, trade regulations, and human rights standards through international treaties, agreements, and conventions.
2. **Ethical Standards and Codes of Conduct**:
   - Professional organizations and industry associations often develop ethical standards and codes of conduct to guide the behavior of their members and promote ethical practices in specific professions or industries.
   - Harmonization involves reconciling and aligning these ethical standards with broader ethical principles, legal requirements, and societal values to ensure consistency and coherence in ethical decision-making.
3. **Research Ethics**:
   - In research ethics, harmonization efforts aim to establish common ethical principles and guidelines for the conduct of research involving human participants, animals, or sensitive data.
   - Initiatives such as the Declaration of Helsinki, Belmont Report, and international ethical guidelines for biomedical research seek to harmonize ethical standards and ensure the protection of research participants' rights and welfare across different countries and disciplines.
4. **Environmental Ethics**:
   - Environmental ethics involves reconciling ethical principles, values, and responsibilities towards the environment and future generations to promote sustainable development and environmental stewardship.
   - Harmonization efforts seek to integrate ethical considerations into environmental policies, regulations, and decision-making processes at local, national, and international levels to address global environmental challenges such as climate change, biodiversity loss, and pollution.
5. **Human Rights**:

AMSCE-101

- In the field of human rights, harmonization aims to reconcile and integrate diverse human rights principles, norms, and standards to promote respect for human dignity, equality, and justice.
- International human rights instruments such as the Universal Declaration of Human Rights and the International Bill of Human Rights seek to harmonize human rights standards and obligations across different cultures, legal systems, and political ideologies.

Overall, harmonization of principles involves balancing the diversity of ethical perspectives and values with the need for coherence, consistency, and universality in ethical decision-making across various domains and contexts. It requires dialogue, collaboration, and negotiation among stakeholders to identify common ground, resolve conflicts, and promote shared ethical principles and goals.

ETHICS AND PROFESSIONAL RESPONSIBILITY

Ethics and professional responsibility are closely intertwined concepts that guide the behavior and conduct of individuals within their respective professions. While ethics refers to the moral principles and values that govern what is considered right and wrong, professional responsibility pertains to the obligations and duties that individuals have towards their profession, clients, colleagues, and society as a whole. Here's how these concepts intersect:

1. **Adherence to Ethical Standards**:
   - Professionals are expected to adhere to ethical standards and codes of conduct established by their respective professional organizations or regulatory bodies. These standards outline the principles, values, and norms that professionals are expected to uphold in their practice.
   - Ethical standards provide guidance on issues such as honesty, integrity, transparency, confidentiality, and respect for the rights and dignity of others. Professionals have a responsibility to integrate these ethical principles into their decision-making processes and daily interactions with clients, colleagues, and stakeholders.
2. **Client-Centered Approach**:
   - Professionals have a responsibility to prioritize the interests and well-being of their clients or service users. This involves maintaining confidentiality, providing accurate information, obtaining informed consent, and ensuring that clients receive competent and ethical services.
   - Ethical considerations such as beneficence, nonmaleficence, and autonomy guide professionals in balancing the needs and preferences of their clients while upholding ethical standards and professional responsibilities.
3. **Integrity and Honesty**:

AMSCE-101

- Professionals are expected to demonstrate integrity and honesty in their professional practice by being truthful, transparent, and accountable for their actions and decisions.
- Ethical principles such as honesty, integrity, and accountability underpin professional responsibility, ensuring that professionals act in a trustworthy manner and uphold the public's trust in their profession.

4. **Continuous Professional Development**:
   - Professionals have a responsibility to engage in continuous learning, skill development, and professional growth to maintain competence and stay abreast of advancements in their field.
   - Ethical responsibilities include staying current with relevant laws, regulations, and ethical standards, as well as seeking supervision, consultation, and professional development opportunities to enhance the quality of their practice and better serve their clients.
5. **Social Responsibility**:
   - Professionals have a broader responsibility to contribute positively to society and promote the public good through their professional activities and advocacy efforts.
   - Ethical considerations such as social justice, equity, and sustainability guide professionals in addressing systemic injustices, advocating for marginalized groups, and promoting policies and practices that advance the common good.

ROBOETHICS TAXONOMY:

A taxonomy of roboethics provides a structured framework for categorizing and analyzing ethical issues related to robotics and artificial intelligence (AI). While there isn't a universally accepted taxonomy, various scholars and organizations have proposed different approaches to classify roboethics issues. Here's a simplified taxonomy that captures some of the key ethical dimensions in the field of roboethics:

1. **Autonomy and Control**:
   - This category includes ethical considerations related to the level of autonomy granted to robots and AI systems, as well as the degree of human control over their actions and decisions.
   - Ethical issues may include questions about responsibility, accountability, and liability in cases of autonomous robot behavior, as well as concerns about human oversight and intervention to prevent harm or ensure ethical behavior.
2. **Safety and Risk**:
   - Ethical issues in this category revolve around ensuring the safety and reliability of robotic and AI systems to minimize risks to humans, property, and the environment.

AMSCE-1101

- Considerations include designing robust safety mechanisms, assessing and mitigating risks associated with autonomous systems, and establishing standards for testing and certification of robotic technologies.

3. **Privacy and Data Security**:
    - This category encompasses ethical concerns related to the collection, storage, and use of personal data by robots and AI systems.
    - Issues may include safeguarding privacy rights, protecting sensitive information from unauthorized access or misuse, and addressing concerns about surveillance, data breaches, and algorithmic discrimination.
4. **Ethical Design and Development**:
    - Ethical considerations in this category focus on the principles and practices guiding the design, development, and deployment of robotic and AI technologies.
    - Topics include incorporating ethical values into the design process, ensuring transparency and accountability in algorithmic decision-making, and promoting inclusive and participatory approaches to technology development.
5. **Human-Robot Interaction**:
    - This category addresses ethical issues arising from the interaction between humans and robots, including social, emotional, and ethical aspects.
    - Considerations may include designing robots that respect human autonomy and dignity, fostering empathy and trust in human-robot relationships, and addressing concerns about social isolation or displacement of human roles by robots.
6. **Equality and Equity**:
    - Ethical issues in this category pertain to ensuring fairness, equality, and justice in the distribution and impact of robotic and AI technologies.
    - Topics include addressing disparities in access to and benefits from robotic technologies, mitigating the potential for exacerbating social inequalities, and promoting inclusive design and deployment practices.
7. **Societal Impacts**:
    - This category examines the broader societal implications of robotics and AI, including economic, cultural, and ethical dimensions.
    - Issues may include job displacement and automation's impact on employment, ethical considerations in military and security applications of robotics, and the ethical governance of emerging technologies at the national and global levels.

By categorizing ethical issues into these key dimensions, a roboethics taxonomy provides a structured framework for analyzing and addressing the complex ethical challenges posed by robotics and artificial intelligence. It helps researchers, policymakers, and practitioners identify relevant ethical considerations, develop

AMSCE-1101

ethical guidelines and regulations, and promote responsible innovation in the field of robotics and AI.

AMSCE-1101

64. Roboethics: Social and Ethical Implications of Robotics

Gianmarco Veruggio, Fiorella Operto

The present chapter outlines the main social and ethical issues raised by the ever-faster application of robots to our daily life, and especially to sensitive human areas.

Applied to society in numbers and volumes larger than today, robotics is going to trigger widespread social and economic changes, opening new social and ethical problems for which the designers, the end user, the public, and private policy must now be prepared.

Starting from a philosophical and sociological review of the depth and extent of the two lemmas of robotics and robot, this section summarizes the recent facts and issues about the relationship between techno-science and ethics.

The new applied ethics, called roboethics, is presented. It was put forward in 2001/2002, and publicly discussed in 2004 during the First International Symposium on Roboethics.

Some of the issues presented in the chapter are well known to engineers, and less or not known to scholars of humanities, and vice versa. However, because the subject is complex, articulated, and often misrepresented, some of the fundamental concepts relating ethics in science and technology are recalled and clarified.

At the conclusion of the chapter is presented a detailed taxonomy of the most significant ethical legal, and societal issues in Robotics. This study is based on the Euron Roboethics Roadmap, and it is the result of three years of discussions and research by and among roboticists and scholars of Humanities. This taxonomy identifies the most evident/urgent/sensitive ethical problems in the main applicative fields of robotics, leaving deeper analysis to further studies.

AMSCE-101

Many roboticists, as well as authoritative scholars of the history of science and technology, have already labeled the 21st century as the *age of the robots*. Actually, in the course of the present century, intelligent autonomous machines will gradually substitute many automatic machines [64.1].

Humanity has built tools to increase its power by eliminating manual labor and needless drudgery. This factor has become one of the keys to successful economic progress, especially since the Industrial Revolution and the emergence of a mechanized economy, and even more so with the introduction of automatic machines in the 20th century [64.2].

Today, progress in the field of computer science and telecommunications allows us to endow machines with enough intelligence that they can act autonomously. Thus, we can forecast that in the 21st century humanity will coexist with the first *alien* intelligence we have ever come into contact with – robots.

A few years from now, many more fields of application will be robotized, because robotics will have occupied more territories. The figures of the annual *World Robotics Survey*, issued by the United Nations (UN) Economic Commission for Europe and the International Federation of Robotics (IFR), show a steady tendency for growth with the characteristic curve of a rapidly developing field, with short slowdowns and steep climbing.

Certainly, robotics is changing our way of living, working, and operating in the world.

While the application field of robots is widening, the robot is coming out of the factories and into our homes – it is becoming a consumer item. The robot – which was expected to be an extended, intelligent tool for the human – is becoming a partner and a companion [64.3].

Moreover, robotics is also changing our method of conducting scientific inquiry and perhaps even our concept of ourselves [64.4]. Synergies between robotics, neurosciences, medicine, education, and psychology, have broadened the scope of application of the latter, making robotics a platform of global scientific research on humankind, on our galaxy and on the interaction between humankind and nature [64.5].

When robotics is applied to society in numbers and volumes larger than today, it will trigger widespread social and economic changes, for which public and private policy must now be prepared [64.6].

It will be an event rich in ethical, social and economic problems.

In the next decades in the industrialized world – in Japan, South Korea, Europe, United States – humanoid robots will be among us, companions to the elderly and children, assistants to nurses, physicians, firemen, and workers. They will have eyes, human voices, hands and legs, skin to cover their gears, and brains with multiple functions. Often, they will be smarter and quicker than people they ought to assist. Placing robots in human environments inevitably raises important issues of safety, ethics, and economics.

What is going to happen when these smart robots are our servants and house stewards, and when our lives will depend on them?

Could people who mean no good use these robots to harm others?

The theme of the relationship between humankind and *autonomous* machines appeared early in world literature, developed firstly through legends and myths, then in scientific and moral essays. In early mythology, the ancient peoples expressed their worries about the disrupting power of machines over the old societies: when these artificial creatures to which we have given birth have learned everything from us, or understood that we are weaker than them, will they try to dominate us [64.7]?

In our time, facing the development of ever more powerful computers and the variety of humanoid robots, some scholars and scientists have warned about the dangers of the unlimited use of technology, and especially about the hubristic endeavor to design and manufacture intelligent creatures [64.8, 9].

Their concern has been amplified by the harsh discussion around bioengineering and bioethics. The famous physicist and Nobel prize winner Joseph Rotblat said that robotics, genetic engineering, and computer science are threatening the life on our plante [64.8, 9].

> *Thinking computers, robots endowed with artificial intelligence and which can also replicate themselves (...) this uncontrolled self replication is one of the dangers in the new technologies.*

Less dramatically, others have pointed out the need to introduce ethical rules in technological applications, especially regarding the behavior of intelligent machines. In this frame, the most matter-of-fact issue is: what will be the cultural and social implications of the robotics invasion? Could robots be dangerous to humankind in any way [64.10]?

Under the pressure of public opinion and the media, roboticists cannot avoid engaging in a critical analysis of the social implications of their researches, in order to be able to give *scientific and technical*, as well as *philosophical*, answers to questions such as:

- How far can we go in embodying ethics in a robot?
- What kind of *ethics* is robotic ethics?
- How contradictory is, on one side, the need to implement in robots an ethics, and, on the other, the development of robot autonomy?
- Is it right to talk about the *consciousness*, *emotions*, and *personality* of robots [64.11, 12]?

64.1 A Methodological Note

This chapter is by its nature somewhat different from – although complementary to – the remainder of this Handbook, because it deals not only with the scientific and technological issues inherent in the matter, but also with cultural and moral topics related to the introduction of robots in sensitive human areas.

The authors worked on the assumption that:

- This handbook – and in particular the present chapter – is going to be read by roboticists, and also by nonroboticists, by students of robotics as well as by students and scholars of ethics, philosophy of science, sociology, laws, etc. Some of the issues presented here are well known to some, and less or not known to the others, and vice versa. Nonetheless, the authors deemed it useful and important to recall and clarify some of the fundamental concepts relating ethics in science and technology, because the subject is complex, articulated, and often misrepresented.
- Roboethics is an applied ethics that refers to studies and works done in the field of science and ethics (science studies, science and technology studies (S&TS), science technology and public policy, professional applied ethics), and whose main premises are derived from these studies. In fact, roboethics was not born without parents, but it derives its principles from the global guidelines of the universally adopted applied ethics [64.13]. This is the reason why the substantial part of this Chapter is devoted to this subject, before specifically discussing the sensitive areas of roboethics.
- Many of the issues of roboethics are already covered by applied ethics such as computer ethics or bioethics [64.14]. For instance, problems arising in roboethics of dependability, technological addiction, the digital divide, the preservation of human identity and integrity [64.15]; the applications of precautionary principles, economic and social discrimination, artificial system autonomy and accountability, related to responsibilities for (possibly unintended) warfare applications [64.16]; and the nature and impact of human–machine cognitive and affective bonds on individuals and society have already been matters of investigation in the fields of computer ethics and bioethics [64.16].

The specificity of robotics is underlined from a general point of view. Subsequently, in the taxonomy herein, the specific ethical issues related solely to robotics are carefully evaluated. The present taxonomy is not developed on the basis of affinity to the techno-scientific or disciplinary areas – like the index of the present book. Rather, the roboethics taxonomy is based on the application areas of robots, and on the specificity inherent to the human–robot interaction of these applications [64.17].

In terms of scope, we have taken into consideration – from the point of view of the ethical issues connected to robotics – a temporal range of two decades, in whose frame we could reasonably locate and infer – on the basis of the current state-of-the-art in robotics – certain foreseeable developments in the field.

For this reason, we consider premature – and have only hinted at – problems related to the possible emergence of human qualities in robots: consciousness, free will, self-consciousness, sense of dignity, emotions, and so on. Consequently, this is why we have not examined problems – debated in some other papers and essays – like the proposal to not behave with robots like with slaves, or the need to guarantee them the same respect, rights, and dignity we owe to human workers.

Likewise, and for the same reasons, the target of roboethics is not the robot and its artificial ethics, but the human ethics of the robots' designers, manufacturers, and users.

Although informed about the issues presented in some papers on the need and possibility to attribute moral values to robots' decisions [64.18], and about the chance that in the future robots might be moral entities like – if not more so than – human beings [64.19], the authors have chosen to examine the ethical issues of the human beings involved in the design, manufacturing, and use of the robots.

The authors felt that problems such as those connected with the application of robotics within the

AMS/CE-101

military and the possible use of military robots against some populations not provided with this sophisticated technology, as well as problems of terrorism in robotics and problems connected with biorobotics, implantations, and augmentation, were pressing and serious enough to deserve a focused and tailor-made investigation. It is absolutely clear that, without a deep rooting of roboethics in society, the premises for the implementation of an artificial ethics in the robots' control systems will be missing.

64.2 Specificity of Robotics

Robotics is a discipline originating from:

- Mechanics
- Automation
- Electronics
- Computer science
- Cybernetics
- Artificial intelligence

but it draws on from several other disciplines:

- Physics/mathematics
- Logic/linguistics
- Neuroscience/psychology
- Biology/physiology
- Anthropology/philosophy
- Art/industrial design

Is robotics a new science? On one side, robotics could be regarded only as a branch of engineering dealing with intelligent, autonomous machines. In this case, it shares experiences with other disciplines, and it is somehow the linear sum of all the knowledge.

On the other side, it could be seen as a new science, in its early stage. Actually, it is the first time in history that humanity is approaching the challenge of replicating a biological organism in the form of an intelligent and autonomous entity. This extraordinary mission gives to robotics the special feature of being a platform where sciences and humanities are converging – an experiment in itself [64.20].

It is not without some grounds that we could forecast that robotics will emerge as a new science, with its own theory, principles, theorems, proofs, and mathematical language [64.21].

However, even before that, robotics displays a specificity, which compels the scientific community to examine closely many of the notions until now applied only to human beings.

Although the authors consider it premature to study scientifically the possible emergence in the robot of human functions, we do not exclude that in the future we will be confronted with problems that today we can only imagine through the work of the artists of the science fiction [64.22, 23].

64.3 What Is a Robot?

From the point of view of how today's society sees robots, we can say that robotics scientists, researchers, and the general public have different evaluations about robots, as described below.

64.3.1 Robots Are Nothing Else But Machines

Many consider robots as mere machines: very sophisticated and helpful ones, but always machines. According to this view, robots do not have any hierarchically higher characteristics, nor will the designer provide them with human/animal qualities. In this frame, the issues of the social and ethical implications of robotics fall into the categories of applying ethics to engineering.

64.3.2 Robots (and Technology in General) Have an Ethical Dimension

This derives from a conception according to which technology *is not an addition to man but is, in fact, one of the ways in which mankind distinguishes itself from animals*. So that, as language, and computers, but even more so, humanoids robots are symbolic devices designed by humanity to improve its capacity of reproducing itself, and to act with charity and good. "The humanoid (...) is the most sophisticated thinking machine able to assist human beings in manifesting themselves, and this is ethically very good, as it supposes a radical increment of human symbolic capacity; humanoids will develop a lot of activities in order to increase the human quality of life and human intersubjectivity" [64.24].

64.3.3 Robots as Artificial Moral Agents (AMA)

According to this concept, robots and artificial agents extend the class of entities that can be involved in moral situations, for they can be conceived as moral patients (as entities that can be acted upon for good or evil) and also as moral agents [64.25] (not necessarily exhibiting free will, mental states or responsibility, but as entities that can perform actions, again for good or evil) [64.13].

64.3.4 Robots: the Evolution of a New Species

In the United States, one of the main discussions in the field of ethics and robotics is how to consider robots, as only *objects* or *subjects* which deserve legal rights: robots, not slaves.

According to this point of view, not only will our robotics machines have autonomy and consciousness, emotions and free will, but also humanity will create machines that "*exceed us in the moral as well as the intellectual dimensions*. Robots, with their rational mind and unshaken morality, will be the new species: Our machines will be better than us, and we will be better for having created them" [64.26].

64.4 Cultural Differences in Robot's Acceptance

While we analyze the present and future role of robots in our societies, we shall be aware of the underlying principles and paradigms that influence social groups and individuals in their relationships with intelligent machines.

Different cultures and religions regard differently intervention in sensitive fields such as human reproduction, neural therapies, implantations, and privacy. These differences originate from the cultural specificities towards the fundamental values regarding human life and death.

In different cultures, ethnic groups, and religions the very concept of *life* and *human life* differ, first of all concerning the immanence or transcendence of human life. While in some cultures women and children have fewer rights than adult males (not even *habeas corpus*), in others the ethical debate ranges from the development to a post-human status, to the rights of robots. Thus, the different approach in roboethics concerning the rights in diversity (gender, ethnicity, minorities), and the definition of human freedom and animal welfare. From these concepts derive all the other ethical specificities such as privacy, and the border between privacy and traceability of actions.

Cultural differences also emerge in the realm of *natural* versus *artificial*: think of the attitude of different peoples towards surgical or organ implantation. How could human enhancement be viewed [64.27]?

Bioethics has opened important discussions: How is the integrity of the person conceived? What is the perception of a human being?

Last but not least, the very concept of *intelligence*, human and artificial, is subject to different interpretation. In the field of AI and robotics alone, there is a terrain of dispute – let us imagine how harsh it could be outside of the circle of the inner experts [64.4].

64.5 From Literature to Today's Debate

Literature is the instrument by which society expresses itself, free from rigid constraints, and by which it can *simulate* future social developments. Sometimes, by way of literature, important and foresighted scientific issues have been anticipated.

The topic of the threat posed by artificial entities designed by human's ingenuity (legends like *the rebellions of automata*, Frankenstein' myth, the Golem) recurs in classical European literature, as well as the misuse or the evil use of the product of engineering (the myth of Dedalus). This is not the case in all world cultures. For instance, the Japanese culture does not include such a paradigm; on the contrary machines (and, in general, human products) are always beneficial and friendly to humanity.

In 1942, the outstanding novelist Isaac Asimov, who coined the word *robotics*, formulated his famous three laws of robotics in his novel *Runaround*:

- Law 1: A robot may not injure a human being, or through inaction, allow a human being to come to harm.
- Law 2: A robot must obey the orders given it by human beings except where such orders would conflict with the first law.
- Law 3: A robot must protect its own existence as long as such protection does not conflict with the first or second law.

Later on, in 1983, Asimov added the fourth law (known as the zeroth Law).

- Law 0: No robot may harm humanity or, through inaction, allow humanity to come to harm [64.28, 29].

Although farsighted and forewarning, could these laws really become the *ethics of robots* or are they too *naïve* to be considered seriously in this debate?

Over the last few decades, scientific and technological developments have brought forward the frontiers of robotics, so that those problems that years ago seemed only theoretical, or a matter of literature and science fiction, are becoming very practical, and even urgent.

Some of these problems have alerted the robotics community on the need to open a discussion on the principles that should inspire the design, manufacturing, and use of robots.

In 2001, the collaboration between the roboticist Paolo Dario and the philosopher José Maria Galván expressed the concept of technoethics [64.30].

In the same year, on the occasion of Italy–Japan 2001 (Tokyo, Japan), Paolo Dario and Japanese roboticist Atsuo Takanishi organized the Workshop *Humanoids. A Techno-Ontological Approach*, which was held at Waseda University. The lecture given by Galvan was published in the December 2003 issue of IEEE Robotics & Automation Magazine, *On Technoethics* [64.24].

64.6 Roboethics

In 2002 the roboticist Gianmarco Veruggio, in the framework of the cultural and educational activity of the Association School of Robotics, started to discuss the need for an ethics which could inspire the work of robotics scientists. He called this new applied ethics, roboethics.

> *Roboethics is an applied ethics whose objective is to develop scientific/cultural/technical tools that can be shared by different social groups and beliefs. These tools aim to promote and encourage the development of Robotics for the advancement of human society and individuals, and to help preventing its misuse against humankind [64.31].*

According to the definition, roboethics is not the *ethics of robots*, nor any artificial ethics, but it is the human ethics of robots' designers, manufacturers, and users.

In January 2004, in Sanremo, Italy, the authors, in collaboration with roboticists and philosophers, organized the First International Symposium on Roboethics, where the word roboethics was officially used for the first time.

On this occasion Paolo Dario (RAS president 2002-03) and Kazuo Tanie (RAS president 2004-05) established a technical committee (TC) on roboethics, with the aims of providing the IEEE Robotics and Automation Society with a framework for analyzing the ethical implications of robotics

Fig. 64.1 The Roboethics' logo, sketched by the renowned Italian artist Emanuele Luzzati (1920 – 2007), is represented by a young smiling girl receiving a flower from a chivalrous humanoid robot

AMCE-101

research, by promoting the discussion among researchers, philosophers, ethicists, and manufacturers, but also by supporting the establishment of shared tools for managing ethical issues in this context.

In 2005, the European Robotics Research Network (EURON) funded the project called the EURON Roboethics Atelier, with the aim of drawing the first roboethics roadmap. In 2006, in Genoa, Italy, scholars from humanities met for three days with engineers and roboticists to draw the lines of the EURON roboethics roadmap [64.17].

Roboethics is not a veto or a prohibitionist ethics. Its main lines of development are: the promotion of culture and information; the permanent education; a vigorous and straight public debate; and the involvement in all these activities of the young generations who are the actors of the future [64.32].

Now, it is worth analyzing briefly the general principle of ethics.

64.7 Ethics and Morality

> *Ethics is the branch of philosophy concerned with the evaluation of human conduct [64.33].*

The difference between ethics and morality is subtle. According to Italian philosopher Remo Bodei: "The word Ethics is generally associated to our relationship with others, to our public dimension; while morality concerns more with our conscience's voice, our relationship with ourselves. The distinction, however, is purely conventional, because the word comes from the Greek word *ethos*, which means habit, and morality from Latin *mos/moris*, which again means habit."

Another definition is the following:

> *In simple terms morality is the right or wrong (or otherwise) of an action, a way of life or a decision, while ethics is the study of such standards as we use or propose to judge such things [64.34].*

In short *morality* is the subject of a science called *ethics* (although *morality* may also refer to a code of conduct: see http://plato.stanford.edu/entries/morality-definition/) [64.35].

64.8 Moral Theories

Apart from *virtue ethics*, the classical Greek moral philosophy, the dominant moral theories are:

- *Utilitarianism* - or more generally *consequentialism*: guideline properties that depend only on the consequences, not on the circumstances or the nature of the act in itself;
- *Contractualism*: morality as the result of an imaginary contract between rational agents, who are agreeing upon rules to govern their subsequent behavior. The idea is not that moral rules have resulted from some explicit contract entered into by human beings in an earlier historical era, a claim that is almost certainly false. (John Locke seems to have held a view of this sort.) Nor is the idea that we are, now, implicitly committed to a contract of the *I will not hit you if you do not hit me* variety, which implausibly reduces moral motivation;
- *Deontologism*, or duty-based ethics. What is my moral duty? What are my moral obligations? How do I weigh one moral duty against another? Kant's theory is an example of a deontological or duty-based ethics: it judges morality by examining the nature of actions and the will of agents rather than the goals achieved.

In scientific circles, *secular humanism* – a nontheistically ethical philosophy based upon naturalism, rationalism, and free thought – has gained great importance and influence [64.36].

It is true that in the scientific and technological domain a professional conception of ethics, closer to professional deontology, is becoming dominant and a universal standard of practice.

Furthermore, ethics in the digital world needs new approaches, beyond the classical moral theories, opening new and unresolved moral problems.

AMSCE 101

64.9 Ethics in Science and Technology

In the last years, concerned scientists, stakeholders, nongovernmental organizations (NGOs), parents, and consumers associations have increased their influence on the development of the scientific and technological researches, proposing (often imposing) to scientists, manufacturers, distributors, and advertising agencies the adoption of ethical conducts. Sometimes their intervention was mild, other times it had the result of closing down wealthy lines of research.

That is one of the reasons why we cannot underestimate the impact of society's opinions on *science and society* issues, and on the trend of the advancement of science and technology.

How can ethical concerns and visions become practical rules of society [64.37]? How can the ethical principles discussed in transdisciplinary assemblies; expressed by warnings or the public's concern; suggested by religious personalities, theologians, and moral leaders; and/or forwarded by a community of concerned scientists modify research and development (R&D) [64.38]? How can ethical thrust be embodied in the R&D activity without imposing on it unjustified restrictions, so depriving the scientist of his/her own freedom of thought [64.39]?

Through the millennia of the history of science and technology, society has envisaged ways to express their ethical concern [64.40].

The professional *oath* is either a statement or a promise expressed by a new entry into professional careers to be faithful to the traditional values of the professional order he/she is entering in. The ancient *Hippocratic oath* is the recurrent example for other initiatives to develop and implement codes of conduct for scientists in general, and in specific areas in particular.

Otherwise, a *manifesto* is a public declaration of intentions, opinions, objectives or motives, often issued by a private organization or a government. For example, the Russell–Einstein Manifesto of 1955 is a public declaration against war and the further development of weapons of mass destruction.

A *statement* or a *declaration* can be employed to underline a given topic. As such, it can be either weakly or strongly prescriptive, morally or legally binding.

During the World Robot Conference which took place in Fukuoka, Japan, the participants released a three-part list of *expectations for next-generation robots*, called the *World Robot Declaration* issued on 25 February 2004. It states that:

- Next-generation robots will be partners that coexist with human beings;
- Next-generation robots will assist human beings both physically and psychologically;
- Next-generation robots will contribute to the realization of a safe and peaceful society.

A *recommendation* serves to induce acceptance or favor. It is a prescription only in the weak sense of offering advice: a normative suggestion that is neither legally nor morally binding. More conclusive is the *appeal*, an earnest request for support: a petition, entreaty, or plea.

A *resolution* is a formal expression of opinion or intention made (usually after voting) by a formal organization, legislature, or other group.

In the last 50 years, many professional associations have adopted their *code*: a written text that offers a collection of laws, regulations, guidelines, rules, directives or principles for moral conduct.

The *guiding principles* of the Code of Research Ethics are *non-malfeasance* and *beneficence*, indicating a systematic regard for the rights and interests of others in the full range of academic relationships and activities. *Non-malfeasance* is the principle of doing, or permitting, no official misconduct. It is the principle of doing no harm in the widest sense. *Beneficence* is the requirement to serve the interests and well being of others, including respect for their rights. It is the principle of doing well in the widest sense.

In the field of roboethics, the Government of Japan through the Ministry of Economy, Trade, and Industry has issued a *hugely complex set of proposals*, which is an articulated set of guidelines to ensure a safe deployment of robots in nonstructured environments. Under these guidelines, all robots would be required to report back to a central database any and all injuries they cause to the people they are meant to be helping or protecting. The draft is currently open to public comment with a final set of principles being made public in 2007. Among the indications:

> *Via a structure of general regulation and the adoption of that regulation, the planning, manufacturing, administration, repair, sales and use of robots shall observe the need for safety at every stage (...) The reasonably predictable misuse of robots shall be defined as the management, sale and use of next-generation robots for purposes not intended by manufacturers (...) There should, in principle, be no serious accidents such as fatal accidents involving*

AMSCE - IIOI

robots, and the frequency of such accidents should be lowered as far as possible. Affordable multiple security measures should be taken in case one protection method alone is insufficient.

The *charter* is an ancient form of agreement. An example is the charter of the United Nations. Charters have a legal character and are connected, in principle, to sanctions when not properly executed.

In 2007, the Government of the Republic of Korea announced the birth of a governmentally sponsored working group whose aim is the definition of a roboethics charter.

The process towards the Korean Roboethics Charter is the following. The first step concerns the establishing of a working group (WG) on roboethics composed by robot developers, chief executive officers (CEOs), psychologists, futurists, writers, government officials, users, lawyers, and doctors. The WG will release a draft that will be circulated for feedbacks among online international communities, and through public hearings [64.41].

The revised draft will go for deliberation to the *Robot Industry Policy Forum*, which will be composed of 40 members, representing the main stakeholders. Subsequently, the draft will go to the *Industrial Development Council* (composed of 29 members). At this point – presumably at the end of 2007 – the draft becomes the Korean Roboethics Charter, and it will be officially announced. Then, application rules and detailed guideline will be released.

Other means of implementing ethical concerns in science and technology are the *convention*, a form of agreement, or a contract, and also a practice established by general consent.

Then, principles established by a government applicable to a people and enforced by judicial decision become *law*.

64.10 Conditions for Implementation

Once the chosen code of research ethics has been defined, a list of conditions for implementation should be drawn up. Actually, no regulation can be implemented without at least some of those conditions, which should favor the application of the rules.

From the *individual* scientist's point of view, he/she has to guarantee some conditions, without which he/she is not in the position to adhere to nor to implement the Code of Ethics. These are: decision-making capacity, that is the empowered position and freedom to identify and choose alternatives based on the values and preferences defined and accepted; individual scientists' honesty and integrity; and transparency of processes.

On the other side, the given scientific institution, and in the final analysis society, should guarantee the individual scientist the reasonable general framework in which he/she finds the best conditions to work. These are:

- Periodic review of the application procedures
- Review and assistance by ethics committees
- Promotion of public debate
- Definition of risk assessment, management and prevention
- Transnational practices: comparison of conducts across countries and comparisons of professional ethics around the world

64.11 Operativeness of the Principles

The implementation of regulations or of codes of conduct should provide guidelines for operationalizing and reconciling the principles to be implemented, in case such principles appear inherently contradictory.

For instance, ethical guidelines may – by virtue of their collective nature – pose a threat to the individual's moral autonomy. Or, the public's demand for accountability could threaten the professions' pursuit of autonomy.

64.12 Ethical Issues in an ICT Society

The importance of ethics in science and technology has been demonstrated by our recent history. Three of the front-rank fields of science and technology: nuclear physics, bioengineering, and computer science, have already been forced to face the consequences of their research's applications because of pressure caused by dramatic events, or because of the concern of the general public.

The introduction of intelligent machines in our daily life brings up global social and ethical problems which are usually summarized as

- dual-use technology (every technology can be used and misused)
- anthropomorphization of technological products (it is well known and documented that people attribute intentions, goals, emotions, and personalities to even the simplest of machines with life-like movement or form)
- humanization of the human–machine relationship (cognitive and affective bonds toward machines)
- technology addiction;
- digital divide, socio-technological gap (per ages, social layer, per world areas)
- fair access to technological resources
- the effects of technology on the global distribution of wealth and power
- the environmental impact of technology

Due to the interdisciplinarity of robotics, roboethics shares problems and solutions with other applied ethics: computer ethics, information ethics, bioethics, technoethics and neuroethics.

Computer ethics (CE), a term coined by Walter Maner in the mid 1970s, denotes the field of research that studies ethical problems *aggravated, transformed or created by computer technology*.

Perhaps the first contact between ethics and computer science took place in the 1940s, when Norbert Wiener, professor at the MIT and one of the founding fathers of computer science, expressed his concern about the social effects of the technologies he himself contributed to develop [64.42]. In 1948, in his book *Cybernetics: or Control and Communication in the Animal and the Machine*, and in his following book, *The Human Use of Human Beings*, he pointed out the dangers of nuclear war and the role of scientists in weapons development in 1947, shortly after Hiroshima. Although he did not use the term *computer ethics* he laid down a comprehensive foundation for computer ethics research and analysis. Wiener's foundation of computer ethics was far ahead of its time [64.43, 44].

It was not until 1968 that Wiener's concern became actual practice, when Donn Parker, one of the most famous scientist of the Stanford Research Institute (SRI) at Menlo Park, began to examine unethical and illegal uses of computers by computer professionals. He writes:

> *It seemed that when people entered the computer center, they left their ethics at the door.*

In 1968 he published his *Rules of Ethics in Information Processing* and promoted the development of the first code of professional conduct of the Association for Computing Machinery (ASM), which was adopted by the ACM in 1973.

During the late 1960s, Joseph Weizenbaum, the designer of the computer program Eliza, shocked by the emotional involvement of psychiatric scholars towards his simple programs, expressed his concern that an *information processing model* of human beings was reinforcing an already growing tendency among scientists, and even among the general public, to see humans as mere machines. Weizenbaum wrote the book *Computer Power and Human Reason*, in which he expressed his thoughtful ethical philosophy [64.45].

In the late 1970s, Walter Maner of the Virginia Old Dominion University was the first to employ the label *computer ethics* to define the field of inquiry dealing with ethical problems aggravated, transformed, or created by computer technology [64.46].

In 1985, James Moor of Dartmouth College published his article *What is Computer Ethics?* [64.47], and Deborah Johnson of the Rensselaer Polytechnic Institute published her book, *Computer Ethics*, the first textbook – and for more than a decade, the defining textbook – in the field. In 1983 the Computer Professional for Social Responsibility (CPSR) was founded at Palo Alto: a global organization promoting the responsible use of computer technology. Incorporated in 1983 (following discussions and organizing that began in 1981), CPSR is the first international association whose mission is to educates policymakers and the public on a wide range of issues [64.48].

In 1991 computer ethics was officially added as a subject to the programs in the computer science departments of the United States.

In the 1990s, it was proposed that the core of the issues of CE did not lie in the specific technology, but in the raw material manipulated by it (data/information), as a result of which several researchers (especially the team at Oxford led by Luciano Floridi) developed *information ethics* (IE).

Bioethics is the study of the ethical, social, legal, philosophical, and other related issues arising in health care and in the biological sciences (International Association of Bioethics, IAB) [64.49, 50].

In 1970 Van Rensselaer Potter (1911–2001) coined the term *bioethics* [64.50]. He was an American biochemist, Professor of Oncology at the McArdle Laboratory for Cancer Research at the University of Wisconsin, Madison. The first appearance of the term was in his book *Bioethics, A Bridge to the Future*. He coined it after trying for many months to find the right words to express the need to balance the scientific orientation of medicine with human values.

Potter's original concept of bioethics was comprised of a global integration of biology and values designed to guide human survival, with a new bioethics as the bridge between science and humanities. Increasingly, he felt the need to link what he came to realize had become mainstream biomedical ethics with environmental ethics.

During his career he continued to modify the term bioethics to differentiate his conceptions from the dominant view of biomedical ethics. He eventually selected the term global bioethics and this became the title of his second book [64.51]. In it, there is a new definition of the term bioethics, as *biology combined with diverse humanistic knowledge forging a science that sets a system of medical and environmental priorities for acceptable survival*.

The field of bioethics is at a critical stage of evolution, having now passed the 13th year of the development of bioethics programs. It is in a phase of professionalization attending to both the ethical framework for clinical and industrial bioethical consultation and the creation of the next level of academic organizational success, namely departments and PhD programs [64.52].

Technoethics is a recent definition, derived from Christian theology,

> *as a sum total of ideas that bring into evidence a system of ethical reference that justifies that profound dimension of technology as a central element in the attainment of a finalized perfection of man [64.53].*

Neuroethics is concerned with the ethical, legal, and social policy implications of neuroscience, and with aspects of neuroscience research itself [64.54]. Neuroethics encompasses a wide array of ethical issues emerging from different branches of clinical neuroscience (neurology, psychiatry, psychopharmacology) and basic neuroscience (cognitive neuroscience, affective neuroscience).

64.13 Harmonization of Principles

Internationally recognized institutions such as the United Nations, the World Health Organization (WHO), the Food and Agricultural Organization (FAO), the UN Educational, Scientific, and Cultural Organization (UNESCO)'s World Commission on the Ethics of Scientific Knowledge and Technology (COMEST), the International Labor Organization (ILO), the World Medical Association, the World Summit on the Information Society, and the European Union have identified general ethical principles that have been adopted by most nations, cultures, and people of the world.

Furthermore, the international scientific, juridical, economic, and regulatory community has on many occasions proposed a harmonization of world ethical principles applied to science and technology, especially in those cases when these principles involve sensitive issues such as life, human reproduction, human dignity, and freedom.

The Ethics of Science and Technology Programme, part of UNESCO's Division of Ethics of Science and Technology in the Social and Human Sciences Sector, and COMEST, an advisory body to UNESCO composed of 18 independent experts, have proposed, in the field of bioethics, to start a process towards a *declaration on universal norms on bioethics*. In Rio de Janeiro in December 2003, COMEST organized an international conference on the issue of a *universal ethical oath for scientists*.

In Europe, the 6th Framework Program, funded, under the Science and Society work Programme, the ETHICBOTS project (an abbreviation for merging technoethics of human interaction with communication, bionic, and robotic systems). The project aims to promote and coordinate a multidisciplinary group of researchers in artificial intelligence, robotics, anthropology, moral philosophy, philosophy of science, psychology, and cognitive science, with the common purpose of identifying and analyzing technoethical issues concerning the integration of human beings and artificial (software/hardware) entities. Three kinds of integration are analyzed:

1. Human–softbot integration, as achieved by AI research on information and communication technologies

2. Human–robot noninvasive integration, as achieved by robotic research on autonomous systems inhabiting human environments
3. Physical, invasive integration, as achieved by bionic research

64.14 Ethics and Professional Responsibility

Although ethics in science and technology is not limited to deontology or professional ethics, but concerns a broader range of questions involving the fundamental beliefs and moral principles, its results and conclusions become guidelines for conduct in professional daily life.

From the social and ethical standpoints, in deciding the design, development, and application of a new technology, designers, manufacturers, and end users should be following rules, which are common to all human beings:

- human dignity and human rights
- equality, justice, and equity
- benefit and harm
- respect for cultural diversity and pluralism
- nondiscrimination and nonstigmatization
- autonomy and individual responsibility
- informed consent
- privacy and confidentiality
- solidarity and cooperation
- social responsibility
- sharing of benefits
- responsibility towards the biosphere
- obligatory cost-benefit analysis (whether ethical issues are to be considered as part of a proper cost–benefit analysis)
- exploiting potential for public discussion

(the Charter of Fundamental Rights of the European Union, 2001 [64.55]).

Computer and information ethics has developed a codes of ethics called *PAPA* (an acronym of: privacy, accuracy, intellectual property, and access), which could be adopted by robotics. It is composed as follows.

- *Privacy*: What information about ones self or ones associations must a person reveal to others, under what conditions, and with what safeguards? What things can people keep to themselves and not be forced to reveal to others?
- *Accuracy*: Who is responsible for the authenticity, fidelity, and accuracy of information? Similarly, who is to be held accountable for errors in information and how is the injured party to be made whole?
- *Property*: Who owns information? What are the just and fair prices for its exchange? Who owns the channels, especially the airways, through which information is transmitted? How should access to this scarce resource be allocated?
- *Accessibility*: What information does a person or an organization have a right or a privilege to obtain, under what conditions, and with what safeguards?

Problems of the *delegation* and *accountability* to and within technology are problems of daily life for every one of us. Today, we give responsibility for crucial aspects of our security, health, life-saving, and so on to machines.

Professionals are advised to apply, in performing sensitive technologies, the *precautionary principle*:

> *When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically.*

(*Source*: January 1998 Wingspread Statement on the Precautionary Principle; see also the Rio Declaration from the 1992 United Nations Conference on Environment and Development, Agenda 21; and the Commission of the European Communities, Brussels, 02.02.2000, com (2000) 1 communication from the Commission on the precautionary principle.)

From the precautionary principle other rules can be derived, such as:

- noninstrumentalization
- nondiscrimination
- Informed consent and equity
- Sense of reciprocity
- Data protection

All over the world, associations and orders of engineers have adopted codes of ethics guiding towards responsible conduct in research and practice. In this context, *security* and *reliability* are the most important ethical codes of conduct.

Among the other important recommendations are the following:

- Hold paramount the safety, health, and welfare of the public in the performance of their professional duties.
- Perform services only in areas of their competence.
- Issue public statements only in an objective and truthful manner.
- Act in professional matters for each client as faithful agents or trustees.
- Avoid improper solicitation of professional assignments.

(From the *American Council of Engineering Companies Ethical Guidelines*).

64.15 Roboethics Taxonomy

In this section we outline a first classification of the most evident ethical issues of robotics, based on the EURON roboethics roadmap.

Certainly, classifying the different branches of robotics is not an easy task. Likewise, it is a complex undertaking to organize a matrix of field of robotics/ethical issues. We have tried to classify these topics according to homogeneous fields from an applicative point of view.

Furthermore, in the present taxonomy, we have chosen the *triage process* of identify the most evident/urgent/sensitive ethical problems in robotics, leaving to other times and further studies more complex problems.

64.15.1 Humanoids

One of the most ambitious aims of robotics is to design an autonomous robot that could reach – and even surpass – human intelligence and performance in partially unknown, changing, and unpredictable environments.

Artificial intelligence will be able to lead the robot to fulfill the missions required by the end users. To achieve this goal, over the past decades scientists have worked on AI techniques in many fields, including:

1. Artificial vision
2. Perception and analysis of the environment
3. Natural language processing
4. Human interaction
5. Cognitive systems
6. Machine learning and behaviors
7. Neural networks

In this context, one of the fundamental aspects of the robots is their capability to learn: to learn the characteristics of the surrounding environment, that is, (1) the physical environment, but also (2) the living beings that inhabit it. This means that robots working in a given environment have to distinguish human beings from other *objects*.

In addition to learning about their environment, robots have to learn about their own behavior, through a self-reflective process. They have to learn from the experience, replicating somehow the natural processes of the evolution of intelligence in living beings (synthesis procedures, trying-and-error, learning by doing, and so on).

It is almost inevitable that human designers are inclined to replicate their own conception of intelligence in the intelligence of robots. In turn, the former gets wired into the control algorithm of the robots. Robotic intelligence is a learned intelligence, fed by the world models uploaded by the designers. It is a self-developed intelligence, evolved through the experience which robots have gained through the learned effects of their actions. Robotic intelligence also includes the ability to evaluate and attribute a judgment to the actions carried out by robots.

All these processes embodied in the robots produce a kind of intelligent machine endowed with the capability to express a certain degree of autonomy. It follows that a robot can behave, in some situations, in a way that is unpredictable to their human designers. Basically, the increasing autonomy of the robots could give rise to unpredictable and nonpredictable behaviors.

So, without necessarily imagining some science-fiction scenarios where robots are provided with consciousness, free will, and emotions, in a few years we are going to be cohabiting with robots endowed with self-knowledge and autonomy – in the engineering meaning of these words.

64.15.2 Artificial Body

Humanoids are robots whose body structure resembles the human one. They answer an age-old dream of hu-

AMSCE-101

manity, and certainly do not spring only from rational, engineering, or utilitarian motivations, but also from psychoanthropological ones.

Humanoids are the expression of one of the demands of our European culture, that is, that humankind be the creator of some mechanical being in the shape of a human. In Japanese culture, it is the demand to carefully replicate nature in all its forms.

This is a very difficult and demanding enterprise, a project of the level of the mission to the moon. However, precisely because it is one of humanity's dreams, large investments are being made and progress is quick.

It has been forecast that in the not-so-distant future we will cohabit with humanoids whose shape will be so similar to that of human beings that it will render it possible to get mixed up in certain situations with the latter. Humanoids will assist human operators in human environments, will replace human beings, and will cooperate with human beings in many ways.

Given the high cost and the delicacy of the humanoids, they will probably be employed in tasks and in environments where the human shape would really be needed, that is, in all these situations where the human-robot interaction is primary, compared to any other mission – human-robot interactions in health care; children/disable people/elderly assistance; baby sitting; office clerks, museum guides; entertainers, sexual robots, and so on. Or, they will be employed as testimonials for commercial products.

The special tasks humanoid robots can fulfill are manifold. Humanoids are robots so adaptable and flexible that will be rapidly used in many situations and circumstances. They can assist humans to perform very difficult tasks, and behave like true and reliable companions in many ways. Their shape, and the sophisticated human–robot interaction, will be very useful for situations in which a human shape is needed.

The research carried out in humanoids laboratories throughout the world will have as a side-effect the development of a platform to study the human body, for training, haptic testing, and training, with extraordinary results for healthcare, education, edutainment, and so on [64.56].

Faced with an aging population, the Japanese society see humanoids robots as one way to enable people to continue to lead an active and productive life in their old age, without being a burden to other people.

From the point of view of *safety* in the use of humanoids, and taking into account that in the not distant future they will be used as companions to human beings, humanoids can rise serious problems related to the reliability of their *internal evaluation systems* and to the *unpredictability* of robots' behavior. Thus, designers should guarantee the traceability of evaluation/actions procedures, and the identification of robots.

Concerning safety, it should be underlined that an incorrect action by humanoids can lead to a dangerous situation for living beings and the environment. Furthermore, there could be also the case where the incorrect action by the robot is caused by a criminal intent, if robot's autonomy was controlled by ill-intentioned people, who modified the robot's behavior in a dangerous and fraudulent course.

Because humanoids combine almost all of the characteristics of the whole spectrum of robots, their use implies the emergence of nearly all of the problems we will examine below. In particular, their introduction into human environments, workplaces, homes, schools, hospitals, public places, offices, and so on, will deeply and dramatically modify our society.

There is already an important and well-documented literature on the implication of coexistence between human beings and humanoids. The problems range from the replacement of human beings (economic problems; human unemployment; reliability; dependability; and so on) to psychological problems (deviations in human emotions, problems of attachment, disorganization in children, fears, panic, confusion between the real and the artificial, feeling of subordination towards robots) [64.57].

On the technological and scientific side, trust towards and ever-greater autonomy of humanoids (and of the robots in general) are the dominant trends. From the ethical standpoint, many have expressed fear that too much autonomy can harm human beings. For instance, Japan's Ministry of Economy, Trade, and Industry are working on a new set of safety guidelines for next-generation robots. This set of regulations would constitute a first attempt at a formal version of the first of Asimov's science-fiction *laws of robotics*, or at least the portion that states that humans shall not be harmed by robots

Recently, Japan's ministry guidelines will require manufacturers to install a sufficient number of sensors to prevent robots from running into people. Lighter or softer materials will be preferred, to further prevent injury. Emergency shut-off buttons will also be required.

Another set of questions arises around the shape of the humanoids. Is it right that robots can exhibit a *personality*? Is it right that robot can express *emotion*? The concern expressed by psychologists is that, well before evolving to become conscious agents, humanoids can be an extraordinary tool used to control human beings.

In one of their papers, Wagner, Cannon, Van der Loos [64.58] list the main questions posed by the introduction of a new technology:

- Under what conditions should we decide that deployment is acceptable?
- At what point in the development of the technology is an increase in deployment acceptable?
- How do we weigh the associated risks against the possible benefits?
- What is the rate of the ethics of functional compensation or repair versus enhancement? This issue is especially notable regarding the problem of *augmentation*: In some cases a particular type of technology is regarded as a way of compensating for some function that is lacking compared to the majority of humans; in other cases, the same technology might be considered an enhancement over and above that which the majority of humans have. Are there cases where such enhancement should be considered unethical?
- Are there cases where a particular type of technology itself should be considered unacceptable even though it has the potential for compensation as well as enhancement?
- The question of identifying cause, and assigning responsibility, should some harm result from the deployment of robotic technology [64.59].

64.15.3 Industrial Robotics

An industrial robot is officially defined by ISO as an automatically controlled, reprogrammable, multipurpose manipulator.

Typical applications of industrial robots include welding, painting, ironing, assembly, pick and place, palletizing, product inspection, and testing, all accomplished with high endurance, speed, and precision.

Complexity can vary from simple single robot to very complex multirobot systems:

- Robotic arms
- Robotic work cells
- Assembly lines

From the social and economic standpoint, the benefits of these robots are extraordinary. They can relieve human beings of heavy work, dangerous workplaces, and routine and tedious activities.

In the future, we can imagine robotic factories, completely managed by robots. In the industrialized countries, which are facing a looming labor shortage due to their aging populations, robots in factories will cut costs.

Industrial robots increase productivity (higher speed, better endurance); they increase quality (precision, cleanliness, endurance); they make highly miniaturized devices possible (building the European Robotics Platform, EUROP).

Social problems stemming from the introduction of robots in factories are, first of all, loss of jobs and unemployment. On the other hand, while a welfare policy is to be implemented at a national level to facilitate workers' redeployment, and educational programs to create new skills, it should also be said that robots have also created new jobs directly and can create wealth, leading to the development of new industries and workplaces.

64.15.4 Adaptive Robot Servants

Robots come in several shapes and sizes (wheeled, legged, humanoids), equipped with different kinds of sensing systems (artificial vision systems, ultrasonic, radio) and manipulations (grippers, hands, tools, probes). Service robots support and back up human operators.

According the UN's annual World Robotics Survey issued by the UN Economic Commission for Europe (UNECE) and the International Federation of Robotics, 607,000 automated domestic helpers were in use at the end of 2003, two-thirds of them purchased during that year. The survey forecasts that the use of robots around the home – to mow lawns, vacuum floors and manage other chores – will increase year on year.

By the end of the decade, the study said, robots will *not only clean our floors, mow our lawns and guard our homes but also assist old and handicapped people with sophisticated interactive equipment, carry out surgery, inspect pipes and sites that are hazardous to people, fight fire and bombs.*

Servant robots can: clean and housekeep; they are fast and accurate, and never bored. They can babysit, because they are patient, talkative, and able to play many games, both intellectual and physical. They can assist patients, the elderly, and the handicapped in clinics or at home, being always available, reliable, and taught to provide physical support.

Certainly, servant robots can guarantee a better quality of life, providing that designers guarantee safety and security (unpredictability of machine behavior from ma-

AMSCE-IOI

chine learning; assignment of liability for misbehavior or crime).

From a social and psychological standpoint, overuse could lead to technology addiction or invasion of privacy. Humans in robotized environments could face psychological problems [64.60].

64.15.5 Distributed Robotic Systems

The fast growth of the many wireless systems makes it possible to link all robots to the Web. Network robotics will allow remote human–robot interaction for teleoperation and telepresence, and also robot–robot interaction for data sharing, and cooperative working and learning. When Web speed become comparable to that of the internal local-area network (LAN) of the robot, the machine will explode into a set of specialized systems distributed over the net.

Complex robotic systems will be developed, constituted by a team of cooperating robotic agents/components connected through information and communication technology (ICT) and GRID, on distributed computing, technologies:

- Networked knowledge system
- Networked intelligence systems
- Multirobot systems

Multirobot systems are self-organizing robot teams consisting of a large number of heterogeneous team members. The organization in robot teams or squads is needed to perform specific tasks that require automatic task distribution and coordination at a global and local level, and when central control becomes impossible due to large distances and the lack of local information, or when signal transmission delays.

A full-scale robot team would be of tremendous value in a number of applications such as security, surveillance, monitoring, gardening, and pharmaceutical manufacturing. In addition, the coordination of heterogeneous teams of robots will also be of significant value in terms of planning, coordination, and the use of advanced manufacturing systems.

The benefits of robot teams are manifold, including increases in efficiency in performing complex tasks, and the capability to manage large-scale applications. They also provide abundant and replaceable interchangeable agents, which improves the reliability because the group can perform even after losing most of its parts.

On the other side, scientists should be aware of some of the risks in applying robot teams, for instance, the increasing dependability of primary services from complex systems, and the unpredictability of robot team behavior. From a criminal point of view the assignment of liability for misbehavior or crimes, vulnerability to hacking, and concerns about privacy are some of the important issues.

64.15.6 Outdoor Robotics

Outdoor robots are intelligent machines that explore, develop, secure, and feed our world. Robots could also be employed in dangerous operations such as laying explosives, going underground after blasting to stabilize a mine roof, and mining in areas where it is impossible for humans to work or even survive.

They can work in the following environments:

Land

- Mining (automated load–haul–dump trucks, robotic drilling and blasting devices)
- Cargo handling (cranes and other automation technology for cargo lift on/lift off)
- Agricultural (autonomous tractors, planters and harvesters, applicators for fertilizers and pest control)
- Road vehicles (autonomous vehicles for humans or cargo transportation)
- Rescue robotics (robots that support first-response units in disaster missions)
- Humanitarian demining (robots for detecting, localizing, and neutralizing landmines)
- Environmental protection (robots for pollution cleaning and decommissioning of dangerous facilities).

Sea

- Research (marine robots for oceanography, marine biology, geology)
- Offshore (underwater robots for inspection, maintenance, repair and monitoring of oil and gas facilities in deep and ultradeep waters)
- Search and rescue (underwater robots for first-response intervention in case of accidents at sea, such as a submarine that has run aground).

Air

- UAV (autonomous airplanes for weather forecasting, environmental monitoring, road traffic control, large-area survey, and patrolling).

Space

- Space exploration (deep-space vehicles, landing modules, rovers)

- Space stations (autonomous laboratories, control and communication facilities)
- Remote operation (autonomous or supervised dexterous arms and manipulators)

Mobile robots in particular can be highly valuable tools in urban rescue missions after catastrophes such as earthquakes, bomb or gas explosions, or everyday incidents such as fires and road accidents involving hazardous materials. Robots can be used to inspect collapsed structures, to assess the situation and to search and locate victims.

Among the benefits of employing such robots is the increased efficiency of the exploitation of natural resources, which could increase food production for the world's population.

Concerning space robotics, it is obvious that, on the basis of current knowledge and technology, the robot can be our pioneer in space travel and missions to explore the far planets of the solar system and beyond.

On the social front, the unrestrained use of outdoor robots could extend the excessive anthropization and exploitation of the planet, which can become in turn a threat to biodiversity and all other forms of life on the planet. As for AI, the other branch of robotics, this could lead to technology addiction. Furthermore, given the versatility of these robots, they can be converted from civilian use for warfare and misuse (terrorism, pollution).

64.15.7 Surgical Robotics

The field of surgery is entering a time of great change, spurred on by remarkable recent advances in surgical and computer technology. Computer-controlled diagnostic instruments have been used in the operating theater for years to help provide vital information through ultrasound, computer-aided tomography (CAT), and other imaging technologies. Recently robotic systems have made their way into the operating room as dexterity-enhancing surgical assistants and surgical planners, in answer to surgeons' demands for ways to overcome the surgical limitations of minimally invasive laparoscopic surgery, a technique developed in the 1980s. On 11 July 2000, the Food and Drug Administration (FDA) approved the first completely robotic surgical device.

Typical applications are:

- Robotic telesurgical workstations
- Robotic devices for endoluminal surgery
- Robotic systems for diagnosis (Cat Scan - Computerized Axial Tomography Scan; NMR, Nuclear magnetic resonance; PET - Positron emission tomography)
- Robots for therapy (laser eye treatment, targeted nuclear therapy, ultrasonic surgery, etc.)
- Virtual environments for surgical training and augmentation
- Haptic interfaces for surgery/physiotherapy training

64.15.8 Biorobotics

Biorobotics comprises many different but integrated field of researches. Among them, the design and fabrication of novel, high performance bio-inspired machines and systems, for many different potential applications. The development of nano/ micro/ macro devices that can better act on, substitute parts of, and assist human beings - in diagnosis, surgery, prosthetics, rehabilitation and personal assistance. The development of devices for biomedical applications (e.g. mini-invasive surgery and neuro-rehabilitation).

> *Biorobotics is a new scientific and technological area with a unique interdisciplinary character. It derives its methodology mainly from the sectors of robotics and biomedical engineering, but also includes knowledge from, and provides useful applications to, many sectors of engineering, basic and applied sciences (medicine, neuroscience, economics, law, bio/nanotechnologies in particular), and even the humanities (philosophy, psychology, ethics).*
> *Biorobotics offers a new paradigm for engineers. The engineer no longer just cooperates with neuroscientists, but has also become a scientist in order to discover basic biological principles that make their job easier [64.61].*

64.15.9 Biomechatronics

Human prostheses for locomotion, manipulation, vision, sensing, and other functions include:

- Artificial limbs (legs, arms)
- Artificial internal organs (heart, kidney)
- Artificial senses (eye, ears, etc.)
- Human augmentation (exoskeleton)

This field has an important connection with neuroscience, to develop neural interfaces and sensory-motor coordination systems for the integration of these bionics devices into the human body/brain.

AMSCE-IO1

64.15.10 Health Care and Quality of Life

Health care and quality-of-life robotics is certainly a very promising field, where progress will be directly measured by the well being of people. It is also the best way to promote robotics among the public, especially amongst aging populations.

Surgical robotics allows minimally invasive surgery, which can reduce patient recovery time, and may also improve accuracy and precision. Robotics systems increase the precision of microsurgery and enhance the performance of complex therapies. Surgical robots can restore a surgeon's dexterity. Robotic surgery is also applied to very delicate neurological procedures that are practically impossible to perform without robotic assistance.

Assistive technology will help many people to conduct a more independent life.

Biorobotics, while enhancing the quality of life after diseases or accidents, provides tools for studying biological behavior and brain functions, and is a test bed for the study and evaluation of biological algorithms and modeling.

From the social and ethical standpoint, this is one of the fields in robotics that suffers from the most difficult safety and ethical problems. From a technical point of view, scientists in robotic surgery are working on the problems of reduced dexterity, workspace, and sensory input and possible fatal trouble, which could originate from the breakdown of surgical robot systems. Issues of size, cost, and functionality should also be addressed in surgery, haptic, and assistive robotics.

In the context of assistive technology, some questions concerning the relationship between patients and the health structures in which they are treated can be posed. Are we going to mechanize hospitals and to dehumanize our patients? Shall we improve our health structures, where human nurses can care for patients? May we not develop new psychological and physical dependences?

As a general principle of awareness, we should underline that the high cost of robotic systems in the medical field could widen the digital divide between developed and developing countries, and between layers of the same population.

The field of implantations raises concerns related to the fact that direct brain interfaces may at the same time pose ethical questions related to the enhancement of human function.

The BioX program at the University of Stanford, and the Stanford Center for Biomedical Ethics, funded a pilot study in this domain called cross-cultural considerations in establishing roboethics for neuro-robot applications [64.62, 63]. This study explores funding mechanisms to investigate the span of ethical issues currently confronting direct brain interface investigators, how different kinds of interfaces may indicate different approaches to bioethics, and how other stakeholders in the deployment and use of this technology (for example, from law, government, and healthcare provider professions) perceive the relative importance of the various bioethics issues for the variety of interfaces that currently exist and those on the horizon.

64.15.11 Military Robotics

Intelligent Weapons

This field includes all devices resulting from the development of traditional military systems using robotics technology (automation, artificial intelligence, etc.):

- Integrated defense systems: an AI system for intelligence and surveillance, controlling weapons and aircraft capabilities
- Autonomous tanks: armored vehicles carrying weapons and/or tactical payloads
- Intelligent bombs and missiles
- Unmanned aerial vehicles (UAVs): unmanned spy planes and remotely piloted bombers
- Autonomous underwater vehicles (AUVs): intelligent torpedoes and autonomous submarines

Robot Soldiers

Humanoids will be employed to substitute humans in performing *sensitive* tasks and missions in environments populated by humans. The main reasons for using humanoids are to permit a one-by-one substitution, without modifying the environment, the human–human interaction, or the rules of engagement. This could be required where safeguarding human life is considered a priority in many different scenarios:

- Urban terrain combat
- Indoor security operations
- Patrolling
- Surveillance

Outdoor security robots could be able to make their night watch rounds and even chase criminals, directed by a remote-control system via an Internet connection or moving autonomously via their own artificial intelligence systems.

Superhumans

There are several projects aimed at developing a superhuman soldier. Actually, the human body cannot perform a task with the same strength, speed, and fatigue resistance as machines. Robotic *augmentation* describes the possibility of extending existing human capabilities through wearable robot exoskeletons, to create superhuman strength, speed, and endurance, including applications such as:

- artificial sensor systems
- augmented reality
- exoskeletons

The benefits of military robots are:

1. tactical/operational strength superiority
2. unemotional behavior, potentially more ethical than humans
3. limiting the loss of human lives in the robotized army
4. better performance of superhuman over human soldiers

Problems could arise from:

1. the inadequacy to manage the unstructured complexity of a hostile scenario
2. the unpredictability of machine behavior
3. the assignment of liability for misbehavior or crimes
4. the increased risk of starting a videogame-like war, due to the decreased perception of its deadly effects

From the human point of view, humans in mixed teams could face psychological problems, such as the practical and psychological problems of having to distinguish between humans from robots and the stress and dehumanization of superhuman soldiers.

In 2007, the Georgia Tech Mobile Robot Lab – lead by Ronald Arkin – led an online *opinion survey on the use of robots capable of lethal force in warfare*. the opinion survey is part of an important research project under a grant from the Army Research Office. The goal of this survey was to determine how acceptable the robots capable of lethal force in warfare are to different people of varying backgrounds and positions.

Military robotics should be thoroughly examined by specialized international organizations, as happens for every type of military technology, to be regulated by international conventions or agreements [64.64].

64.15.12 Educational Robot Kits

The beneficial applications of robotics in education are known and documented.

Robotics is a very good tool for teaching technology (and many other subjects) whilst, at the same time, always remaining very tightly anchored to reality. Robots are real three-dimensional objects which move in space and time, and can emulate human/animal behavior; but, unlike video games, they are real machines, true objects, and students learn much more quickly and easily if they can interact with concrete objects as opposed to formulas and abstract ideas.

In the age of electronics, computers, and networks, it is necessary to modernize not only educational content and tools, but also the methods used in traditional schools.

It is also important to consider that the lifestyle of young people has changed as well as the communication tools they use in their free time. Today, young people communicate via the Internet and mobile telephones using e-mail, SMS, and chat rooms, which allow them to be continually connected to a global community that has no limits regarding location and time.

Young people spend more time playing videogames, playing with their mobile phones or downloading files from the Internet. These activities provide them with experiences that are by now at the same standard as the most sophisticated technological systems. All this has accelerated the pace of life; so much so that fruition and consumption of experiences are both real and virtual. In fact, we are entering the age of cyberspace, which will not replace normal life relationships, but will certainly alter their characteristics.

In this context, we need to consider that traditional teaching and classical tools of support (books, documentaries) are at risk of becoming unsuitable when compared with the everyday possibilities offered to these young people by the world of mass media. Therefore, it is necessary to begin to plan new ways to transmit knowledge which exploit the potential of this new technology.

Learning about robotics is important not only for those students who want to become robotics engineers and scientists, but for every student, because it provides a strong method of reasoning and a powerful tool for grappling with the world. Robotics collects all the competencies needed for designing and constructing machines (mechanics, electrotechnics, electronics), computers, software, communications systems, and networks. The special features of robotics boost student creativity, communication skills, cooperation, and teamwork.

Learning about robotics promotes students' interest in and commitment to traditional basic disciplines (mathematics, physics, technical drawing). Robotic

AMSCE-101

AMSCE-IOL

construction kits, which can combine the physical building of artifacts with their programming, can foster the development of new ways of thinking that encourage new reflections on the relationship between: (1) life and technology, (2) science and its experimental toolset, and (3) robot design, and values and identity.

64.15.13 Robot Toys

The Aibo robot is the Sony's robotic puppy dog with a software-controlled personality and abilities. The entertaining robot, which costs upwards of $2000, can dance, whimper, guard, and play, developing personalities based on interaction with its owners. Sony has sold over 150 000 Aibos since launching the product in May 1999.

Company officials said that there was a real effort this time to make the Aibo's movements more doglike; designers even studied the way dogs move. Developers replaced a relatively un-dog-like sideways head motion of one motor (as with the previous model, there are 20 motors) with a sort of forward-and-down movement.

Robot toys can be intelligent toys: they can be specifically designed to stimulate children's creativity and the development of their intellectual faculties. They can become children's companions, and – for only children – could play the role of *friends*, *brothers*, or the traditional *imaginary fiend*. They could also be used in the pedagogical assistance of autistic children.

On the negative side of technology, robot toys could cause psychological problems, such as:

- lost touch with the real world
- confusion between the natural and the artificial
- confusion between the real and the imaginary
- technology addiction [64.65]

64.15.14 Entertainment Robotics

Robots will enable the construction of real environments that could either be the perfect (or scaled) copies of some existing environments, or the reconstruction of settings existed centuries/millennia ago, and which we can populate with real or imaginary animals.

Robots and robotics settings will make it possible to build natural phenomena and biological processes, even cruel ones, without involving living beings.

In these settings, the users/audience could live interactive experiences, which are *real*, not only *virtual*.

As extraordinary theatrical machines, robots will develop ever more *real* special effects.

Entertaining robots are already used to display and advertise corporate logos, products, and events. These are marketing tools showed off by the manufacturers on special occasions.

In this framework, we should also consider sexual robots, which will be an important market. They could be used as sexual partners in many fields, from therapy to prostitution, and their use could decrease sexual exploitation of women and children [64.66]. This also raises issues related to intimacy/attachments, and about safety and reliability.

64.15.15 Robotic Art

The role of robotics in contemporary art, along with all the types of interactive artistic expressions (telecommunications, and interactive installations), is gaining importance and success.

Artists are employing advanced technologies to create environments and works of art, utilizing the actuators and sensor to allow their robots to react and change in relation to viewers.

Robotic art will spread because:

- It recalls (and it is inspired by) the mythological traditions of various cultures. These traditions have created fantastic synthetic creatures;
- Robots exert on the population at large a special fascination;
- Robots can be used as tools in artwork and enable the building of artistic expression in shorter times, thus expanding the borders of human creativity;
- Robots can also perform actor's rules and allow playing living art.

The social and individual problems that can be produced by robotic art are, on the one hand, the dissemination of misinformation (by spreading of false information using technology), while on the other hand, technology may prevail over creativity.

64.16 Conclusions and Further Reading

In this chapter we have analyzed the main social and ethical issues in robotics, five years after the birth of roboethics, and after three years of wide and intense international discussion. In the conclusions, we develop some assessments, foresee lines of progress, and five some indications for those who wish to study the subject of roboethics in more depth.

The so-called robotics invasion has not yet been unleashed. Surely, the recent figures of the World Robotics Report (Unece/Fir 2005) show a steady growing trend of the robotics production and sales. However, often the media demand more inventions and *gadgets* from the robotics laboratories than the laboratories can afford and, looking at the many automatons that are still struggling to walk, the latter's efforts have so far proved to be something of a disappointment. This is certainly a problem and a pressure for the robotics scientists. For the time being, robotics is a field of research and development that can be applied in, and depends, a high level of technology.

However, we are witnessing a true, growing interest in robots from the general public, who are often more excited than the insiders, whose feelings swing between a position of cultural indifference to a behavior dictated by external pressures, be they political or industrial. We are also noticing the modern change – which had already happened in the 1970s in the field of computer science – of the transformation of the robot from a research platform and a working tool to a consumer item, and an object of entertainment. This is a juvenile phenomenon, as shown by the increase of robotics contests among high-school students. Today's young people who are getting their hands on robotics kits will be the robotics professionals and consumers of tomorrow.

Growing interest in the social effects of robotics is easy to observe among international professional associations and orders, stretching over the sister fields of computer ethics and bioethics.

Certainly, roboethics is still far from being a well-established applied ethics, and by *well established* authors mean that it should demonstrate two qualities: to be universally accepted and standardized, or at least adopted by some communities, relevant in size and in political/economic/cultural influence, and to be embodied in the design, production, and use of robots.

In this chapter, we have mentioned two important steps in this general direction: the guidelines for the use of robots in the human environment, drawn up by the ad hoc group of the Japanese METI; and the Roboethics Charter, which is still in progress, being edited by the appointed committee of the Republic of South Korea. We should recall a few other projects that are studying the effects of the application of robotics to the neurosciences [64.58] and to bioethics/biorobotics [64.67,68]. However, there is no question that we are still at an initial stage of the subject's development.

In fact, considering the history of the two widely applied and structured ethics which are extensively studied and which reach a certain organic unity, bioethics and computer and information ethics [64.46], we acknowledge that their development, which has been happening for over 30 years, came about through leaps and contradictions, chasms and bends, and that they are far from being a suitable ethical standard shared by a plurality of subjects. Both these ethics were born in a policy and legislative vacuum, as technological changes outpaced ethical developments, bringing about unanticipated problems [64.47].

The standardization of roboethics requires the accomplishment of some fundamental steps, both culturally and institutionally. From the general standpoint, it demands that the application of robotics to the human environment, especially to sensitive areas of the human life, will be accepted by the quasi totality of cultures, as has happened with other techno-scientific innovations such as electricity and computer systems. (In the case of free access to the Internet, the issue is still questionable in many nations.) Should this be achieved, roboethics would have already passed the phase of being adjusted to fit different answers and situations, to being modified to the point of having acquired the capability of adapting to different points of views. Different cultures and religions regard the intervention in sensitive fields such as human reproduction, neural therapies, implantations, and privacy differently. These differences originate from cultural specificities regarding fundamental issues, for example, the limit between a human and a cyborg; the separation between the natural and the artificial; the difference between human and artificial intelligence; the border between privacy and the traceability of actions; the concept of integrity and the unity of the human being; the acceptance of diversity (in gender, ethnicity, minorities, etc.); the boundary between replacement and human enhancement; and so on [64.49]. These are all milestones in defining the underlying paradigms, which in turn influence the day-by-day behavior of everyone.

There are many different aspects to be looked at, for instance, in some cultures the reproduction of the

AMSCET 01

human figure is forbidden. In others, the difference between human and nonhuman is not so sharp. The application of humanoid robots should be set against this background [64.69]. The diversity of ideas on these issues, such as natural versus artificial or animate versus inanimate, has immediate effects on the field of organ transplants, and subsequently of robotic organ implants. As a matter of fact, the debate on human enhancement versus rehabilitation is very active in Europe and the United States, for the time being mainly in the field of bioethics.

From the experience provided by more than 30 years of discussions and disputes in the fields of bioethics and information ethics, we know that all the achievements in the field of science and ethics are neither easy nor negligible.

For those who wish to thoroughly investigate some elements of philosophy of science; of history of science and ethics; of science and engineering's ethics; of the law applied to science and technology, we now suggest some fundamental steps.

In the field of the moral theories related to science and technology, we mention the considerable work of Tom L. Beauchamp from the Kennedy Institute of Ethics [64.49].

Two important annual gatherings of Computer Philosophy, CEPE, Computer Ethics Philosophical Enquiry and IACAP International Association for Computing and Philosophy, to mention just two, have recently added *roboethics* as one of their key topics.

We also encourage students and scholars to consult the works and website of the renowned Center for Computing and Social Responsibility (CCSR) of DeMontfort University, Leicester, UK. The CCSR is internationally recognized for its applied research expertise on the risks and opportunities of information technology. It also organizes the International Conference on the Social and Ethical Impacts of Information and Communication Technology (ETHICOMP) every year.

Furthermore, it is very useful to follow the activity of the regulatory bodies entitled to deal with the issues of science and ethics. In accordance with what was said in Sects. 64.4, 64.5, 64.12, and 64.13 of this chapter, the person's interest should start from the general principles that are essentially accepted by most of the worlds' Nations (at least, nominally), and to come down to the specific applications in our field.

The Ethics of Science and the Technology Programme is part of UNESCO's Division of the Ethics of Science and Technology in the Social and Human Sciences Sector. COMEST is an advisory body to UNESCO. The two bodies work to apply in science and technology the principles of the Universal Declaration of Human Rights.

The Unesco's Ethics of Science and Technology Programme was created in 1998 along with COMEST to provide ethical reflection on science, technology, and their applications. Currently, in accordance with Decision 3.6.1 of the 169th session of the Executive Board, UNESCO is initiating standard-setting action by drafting studies on some new technological areas.

Another body whose activity is useful to follow is the European Group on Ethics in Science and New Technologies and the Forum (EGE, European Group on Ethics in Science and New Technologies), established by the European Commission. The EGE is an independent, pluralist and multidisciplinary body that advise the European Commission on ethical aspects of science and new technologies, regarding the preparation and implementation of community legislation or policies. The forum has many complementary roles. The former body is appointed to provide high-level specialist ethical advice to the European Commission, particularly in relation to the policy arena. The latter was set up under the Framework Programme as a networking activity with the aim of sharing information and exchanging best practices on issues of ethics and science. They work on the basis of the Lisbon Declaration 2000 and the charter of fundamental rights of the European Union approved by all the member states in 2001 (Nice, France).

Concerning the role of science and technology in law, politics, and the public policy in modern democracies, there are important differences between each of the European, the American, and the – we could say – oriental approach. In the United States, the general attitude is definitely more science-based than it is in Europe. In the former case, science is said to speak the truth, and the regulatory process is based more on objective scientific data than on ethical considerations. At the same time, the subjective point of view is taken up by the courts, which are now also intervening directly in areas such as risks to society and scientific knowledge, although the current conceptual tools of jurisprudence in the field of science and technology are still very limited. Nonetheless, in the Anglo Saxon culture, *law does not speak the language of science* [64.70].

On the other hand, in Europe, against the backdrop of the ongoing process of European cohesion, regulation and legislation of science and technology is assuming the character of the foundation of a new political community – the European Union – which is centered around the relationship between science and its applications, and the community formed by the scientists, technology producers, and citizens. We can safely assume that, given the common classical origin of jurisprudence, the latter process could be helpful in influencing other cultures, for instance, the moderate Arab world.

On the subject of science, technology, and law in America and Europe, we recommend the impressive work by Sheila Jasanoff (Kennedy School of Government Faculty, Harvard University) whose research pivots on the role of science and technology in the law, politics, and public policy in Europe, the United States, and India, with particular reference to the behavior of the American courts in the regulation of science, and to the role of experts.

There is a third way to approach issues in science and society, which could be called oriental. In fact, in Japan and in the Republic of South Korea, issues of robotics and society have been handled more smoothly and pragmatically than in Europe and in America. Due to the general confidence from these societies towards the products of science and technology, the robotics community and the ad hoc ethical committees inside these governments have started to draw up guidelines for the regulation of the use of robotic artefacts. This nonideological nonphilosophical approach has its pros and cons, but it could encourage scientists and experts in Europe and the United States to adopt a more normative position.

For those who are interested in keeping up to date on these issues, a good habit to acquire is to consult the archives and websites of the academic institutions, private associations, and professional orders where problems of science and ethics are followed on a regular basis. The Nobel Prize Pugwash Conference for World Affairs is the umbrella association for this community and NGOs concerned with these issues. The IEEE Robotics & Automation Society's Technical Committee on Roboethics was formed for the purpose of promoting and collecting research on robotics and society.

The issue of the influence and the pressure provided by the market on science and R&D is handled by applied ethics, and is known as business ethics. In this framework, corporate social responsibility is one of the ways in which enterprises can affirm ethical principles and values. This view was introduced to the United States 15 years ago (especially in the field of health care) and is still running today. Also, training in the responsible conduct of research (RCR) has been adopted by the United States, and is still being applied. The domain of RCR training does not only include the ethical dimensions of research with human subjects, but every intricate dimension of responsible conduct in the planning, performance, analysis, and reporting of research. Difficulties here arisen from the small amounts of resources allocated; see also the Organization for Economic Cooperation and Development (OECD) Guidelines for Multinational Enterprises, on the ethical paragraphs.

Concerning the philosophical and epistemological aspect of the issues in ethics and robotics, one of the main problems that people who are interested in roboethics will have to handle is the persistent confusion – ontologically, but especially linguistically – between human and artificial intelligence, as well as between other fundamental concepts of perception, consciousness, self consciousness, emotions, and so on, as applied to humans and to machines.

It must be clarified that the contemporary roboethics is human ethics as applied to robotics, which is considered nonhuman. A strong base of human roboethics is needed in order to responsibly construct the foundations of the final question, which nobody can yet answer: can robots ever become *human*?

This triaging choice, far from rendering the problem simple, renders it technically manageable and fertile of solutions useful to robotics and to society.

At the same time, the need for serious and thorough work into the concepts of intelligence, knowledge, conscience, autonomy, freedom, free will etc. is highlighted. Indeed, the heterogeneous composition of specialists often leads to incessant discussions about the meaning of words, rather than on the content of the myriad, often pressing, issues that need to be faced.

This work is in fact one of the philosophies of robotics, aiming to better define the scientific paradigm. It is important work, as robotics faces the ideal challenge of recreating life artificially and synthetically, which imposes a reopening of discussion and, in some cases, a need to redefine seemingly simple concepts, as well as the need to create new concepts. All this takes place in a multicultural context, which fuels vastly different philosophical backgrounds.

All of this leads to the necessity for the international robotics community to become the author of its own destiny, so as to face directly the task which needs defining, whilst collaborating with academics in the fields of philosophy of law, and generally with experts from the human sciences, to engage with the ethics and social aspects of their research and the applications of the former. Nor should they feel relegated to a mere technoscientific role, delegating to others the task of reflecting and taking action on moral aspects. On the other hand, a closed-shop attitude would be damaging to the development of robotics, given the interdisciplinary nature of the much of the research undertaken in the field.

From this point of view, roboethics cannot fail to be beneficial to robotics, framing research in close connection with end users and society, and so avoiding many problems that other *sensitive* fields are now facing.

All this, and more, will be wishful thinking if engineering study curricula do not include subjects such as scientific philosophy, history of science, law, and the politics of science, as is already happening in some advanced polytechnics. Once again, we have to say that the deeper study of the history of science, for example, especially in the 19th and 20th centuries, cannot but aid a better understanding of that complex scientific galaxy which is robotics. Even a restricted knowledge of cybernetics and computer science, from Wiener, to von Neumann, to Weizenbaum, will immediately and directly demonstrate that these scientists immediately took care of the ethical and social aspects of their discoveries and realizations, which marked the beginning of the field of computers and robotics.

At the same time, it is necessary that those not involved in robotics keep up to date with the field's real and scientifically predictable developments, in order to base discussions on data supported by technical and scientific reality, and not on appearances or emotions generated by science fiction. In particular, apart from this handbook, one must look to serious magazines published by recognized scientific associations, and not rely on headlines about ambiguous and scandalizing creations that do not really exist.

Ethics is a 1000-year-old human science with an impressive literature. Its application to the field of science technology is no doubt more recent, even though precedents such as the Hippocratic oath suggest an extremely ancient origin. Research on robotics is throwing light on manifold issues across science and the humanities. No wonder it will also open new and unexpected field of studies and application in ethics.

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Societal Issues Concerning the Application of Artificial Intelligence in Medicine

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Artificial intelligence in medicine · Machine learning · Social impact

Abstract
Background: Medicine is becoming an increasingly data-centred discipline and, beyond classical statistical approaches, artificial intelligence (AI) and, in particular, machine learning (ML) are attracting much interest for the analysis of medical data. It has been argued that AI is experiencing a fast process of commodification. This characterization correctly reflects the current process of *industrialization* of AI and its reach into society. Therefore, societal issues related to the use of AI and ML should not be ignored any longer and certainly not in the medical domain. These societal issues may take many forms, but they all entail the design of models from a human-centred perspective, incorporating human-relevant requirements and constraints. In this brief paper, we discuss a number of specific issues affecting the use of AI and ML in medicine, such as fairness, privacy and anonymity, explainability and interpretability, but also some broader societal issues, such as ethics and legislation. We reckon that all of these are relevant aspects to consider in order to achieve the objective of fostering acceptance of AI- and ML-based technologies, as well as to comply with an evolving legislation concerning the impact of digital technologies on ethically and privacy sensitive matters. Our specific goal here is to reflect on how all these topics affect medical applications of AI and ML. This paper includes some of the contents of the "2nd Meeting of Science and Dialysis: Artificial Intelligence," organized in the Bellvitge University Hospital, Barcelona, Spain. ***Summary and Key Messages:*** AI and ML are attracting much interest from the medical community as key approaches to knowledge extraction from data. These approaches are increasingly colonizing ambits of social impact, such as medicine and healthcare. Issues of social relevance with an impact on medicine and healthcare include (although they are not limited to) fairness, explainability, privacy, ethics and legislation.

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Introduction

Medicine, as part of a phenomenon that affects all fields of life sciences, is becoming an increasingly data-centred discipline [1]. Data analysis in medicine has for

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long been the territory of statisticians, but medical data are reaching beyond the merely quantitative to take more complex forms, such as, for instance, textual information in Electronic Health Records (EHR), images in many modalities, on their own or mixed with other types of signals, or graphs describing biochemical pathways or biomarker interactions [2]. This data complexity is behind the evolution from classical multivariate data analysis towards the nascent field of *data science* [3], which, from the point of view of medicine, embraces a new reality that includes interconnected wearable devices and sensors.

Beyond the more classical statistical approaches, artificial intelligence (AI) and, more in particular, machine learning (ML) are attracting much interest for the analysis of medical data, even if arguably with a relatively low impact yet on clinical practice [4]. It has been acknowledged that AI is experiencing a fast process of commodification (not that this is an entirely new concern, as it was already a matter of academic discussion almost 30 years ago [5]). This characterization is mostly of interest to big IT companies but correctly reflects the current process of *industrialization* of AI, where the academic and industrial limits of research are increasingly blurred, with the main experts in AI and ML on the payroll of private companies. In any case, this means that AI systems and products are reaching the society at large, and, therefore, that societal issues related to the use of AI in general and ML in particular should not be ignored any longer and certainly not in the medicine and healthcare domains.

These societal issues may take many forms, but, more often than not, they entail the design of models from a human-centred perspective, that is, models that incorporate human-relevant requirements and constraints. This is certainly an only partially technical matter.

In this brief paper, we cover, in a non-exhaustive manner, a number of specific societal issues affecting the development of AI and ML methods, such as fairness, privacy and anonymity, and explainability and interpretability, but also some broader societal issues, such as ethics and legislation. Not that these issues should be considered independently; on the contrary, they often overlap in an intricate manner. Let us summarily list them here:

Legislation. The industrialization of AI exposes it to legislation regulating the social domain where it is meant to operate. In some cases, this overlaps issues of privacy and anonymity, such as in AI algorithms used for automated face recognition in public domains. It may also involve more general contexts, such as AI-based autonomous driving or defence weapons. Legislation is also involved in medicine and healthcare practice, and, therefore, we need to ensure that AI and ML technologies comply with current legislation.

Explainability and Interpretability. ML and AI algorithms are often characterized as *black boxes*, that is, methods that generate data models that are difficult (if not impossible) to interpret because the functional form relating the available data (input) to a given outcome (the output) is far too complex. This problem has been exacerbated by the intensity of the current interest in deep learning (DL) methods. Only interpretable models can be explained, and explainability is paramount when decision-making in medicine (diagnosis, prognosis, etc.) must be conveyed to humans.

Privacy and Anonymity. Privacy-preserving ML-based data analysis must deal with the potentially contradictory problem of keeping personal information private while aiming to model it, often to make inferences that will affect a given population. Data anonymity obviously refers to the impossibility of linking personal data with information about the individual that is not meant to be revealed. These are key problems and concerns in the medical and healthcare domains, mainly in the interaction between the public and private sectors.

Ethics and Fairness. Biological intelligence is multifaceted and responds to the environmental pressures of human societies. Ethics are one of those facets for which AI is still fairly unprepared. Interestingly, this topic has become central to AI discussion in recent years. Needless to say, ethics are also a core concern in medicine and healthcare. Such convergence of interests makes it important to create a clear roadmap for the ethical use of AI and ML in medicine. The application of ML and AI in areas of social relevance must also aspire to be *fair*. How do we imbue ML algorithms, which are fairness *agnostic*, with fairness requirements? How do we avoid gender or ethnicity, for instance, unfairly influencing the outcome of a learning algorithm? In the medical domain and in healthcare in particular, where sensible information about the individual may be readily available, how do we ensure that AI- and ML-based decision support tools are not affected by such bias?

We reckon that all of these are relevant aspects to consider in order to achieve the objective of fostering acceptance of AI- and ML-based technologies in the medical and healthcare domains, as well as to comply with an evolving legislation concerning the impact of digital technologies on ethically and privacy sensitive matters. Our specific goal here is to reflect on how all these topics affect medical applications of AI and ML.

This paper reflects some topics addressed in the "2nd Meeting of Science and Dialysis: Artificial Intelligence," organized at the Bellvitge University Hospital, Barcelona, in the Catalonia region of Spain.

Societal Issues of AI and ML Application

Legislation

Human societies are regulated by bodies of legislation. While remaining within the academic realm, AI and ML developments have stayed fairly oblivious to legal concerns, but the moment these technologies start occupying the social space at large, their impact on people is likely to hit a few legal walls. One widely discussed case is the use of AI as the basis for autonomously driving vehicles. When a human is in charge of any decision-making at the wheel of a vehicle, legal responsibilities are quite clearly drawn. The quick industrial development of semi-autonomous vehicles, leading towards the objective of fully autonomous driving, has stretched the seams of current legislation, though.

Again, any application of AI and ML in actual medical practice is bound to generate discussion about its legal boundaries and implications. A pertinent example is the recent (May 2018) implementation of the European Union directive for General Data Protection Regulation (GDPR). This directive mandates a *right to explanation* of all decisions made by "automated or artificially intelligent algorithmic systems" [6]. According to Article 13 of the directive, the right to explanation implies that the "data controller" is legally bound to provide requesting citizens with "meaningful information about the logic involved, as well as the significance and the envisaged consequences of such processing [automated decision making, as described in its Article 22] for the data subject" [6]. AI and ML may be the tools used to provide such automated decision making, and, therefore, it places these technologies in a legal spotlight. Some guidelines for GDPR-compliant ML development have recently been provided by Veale et al. [7].

The implications of GDPR for the use of AI and ML in medicine and healthcare are not too difficult to appreciate. Any AI- or ML-based medical decision support system (MDSS) whose purpose it is to assist the medical experts in their decision-making will be explicitly providing a (semi)automated decision on an individual (for instance, diagnosis, prognosis or recommendations on treatment concerning individual patients, perhaps even in life-threatening conditions). The data controller in this case will be the medical expert (from nurses to specialists [8]) and the institution this expert belongs to.

Note that this piece of legislation (of compulsory application in all countries belonging to the European Union) requires something very specific from the AI and ML technologies (or, more accurately, from the people designing, implementing and using them): interpretable and explainable models, as discussed in the next section. A medical expert or any healthcare system employee using these technologies must be able to interpret how they reached specific decisions (say, why an ML model diagnosed a brain tumour as a metastasis and not a high-grade glioma) and must be able to explain those decisions to any human affected by them. In the implementation of the artificial kidney as one of the most promising technologies in nephrology, we should be concerned, for instance, about the possibility of an opaque AI- or ML-based alarm system not being able to explain the basis for a false alarm that might endanger the life of the dialysis patient.

At a higher level, and on the basis of legal safeguards such as the GDPR, a healthcare system might decide not to implement an opaque MDSS in clinical practice, despite its perceived effectiveness, only to avoid the prospect of unsustainable litigation costs caused by the false-positive and -negative cases or the incorrect estimations and predictions churned by these automated systems.

In the light of this discussion, we recommend that medical experts and healthcare practitioners should keep in mind the need to balance the effectiveness of AI- and ML-based technologies and their adherence to current legislation. Beyond GDPR and its relation to interpretability, this issue overlaps with some of the others we will discuss in the following sections, such as ethics, fairness, and privacy and anonymity.

Interpretability and Explainability

Biological brains have not necessarily evolved the means to explain themselves. Arguably, this has only happened in species with social behaviour (although it could also be argued that social behaviour can only happen in species whose brains are capable of *explaining themselves* through some form of communication). In the human species, natural language performs that communicative or explanatory function.

AI was originally conceived as an attempt to reproduce aspects of biological intelligence, but self-explanatory capabilities were never a key aspect to consider. If the biological brain was meant to be understood as a form of information-processing system, so was AI, and the idea of *social* AI is relatively new, for instance in the form of intelligent agents and multi-agent systems [9]. Only recently, the interpretability and explainability of AI and ML systems has come to the forefront of research in the field [10]. One key reason for this is the breakthrough created by DL technologies. DL is an augmented version of traditional artificial neural networks. The latter were long ago maligned as *black box* opaque models. DL models risk being considered augmented black boxes. Interpretability in this context can be seen as a human-computer interaction problem. We humans must be able to understand and interpret the outcome of an AI or ML model. That is, we need to ensure that even a very complex model can be explained (usually to other humans). A human brain, colossally more complex, has developed natural language to convey some level of explanation of its inner workings. Similar attempts with AI and ML are still very limited. Despite recent and thorough attempts to address the issue of how to characterize interpretability in ML [11], such attempts only highlight the tremendous difficulty involved in the scientific pursue of truly interpretable ML models.

In the medical domain, AI and ML models are often part of MDSS. Their potential and the possible barriers to their adoption have been investigated in the last decade [12]. The paradox is that these methods, despite their advantages, are far from universal acceptance in medical practice. Arguably, one of the reasons is precisely (lack of) interpretability, expressed as “the need to open the machine learning black box” [13]. As already mentioned, DL-based technologies can worsen the problem, despite having already found their way into biomedicine and healthcare [14, 15]. In medicine, this has clear implications: if an ML-based MDSS makes decisions that cannot be comprehensibly explained, the medical expert can be put in the uncomfortable position of having to vouch for the system’s trustworthiness, transferring the trust on a decision that she or he cannot explain to either the patient or to other medical experts. This does not mean to say that efforts have not been made to imbue MDSS with knowledge representations that are comprehensible to humans. Examples include rule-based representations, usually compatible with medical reasoning [16]; and nomograms, commonly used by clinicians for visualizing the relative weights of symptoms on a diagnosis or a prognosis [17].

AI- and ML-based systems may have quantifiable goals and may still be useless unless they conform to clinical guidelines. Note that computer-based systems, such as MDSS, are often seen by clinicians as an extra burden in their day-to-day practice [18]. The problem may appear when the MDSS conflicts with guidelines of medical practice [19], something bound to happen unless those guidelines are somehow fed as *prior knowledge* to the intelligent systems. In this scenario, interpretability might be seen as an opportunity to make model performance and compliance with guidelines compatible goals.

The role of ML in healthcare has been described as acting “as a tool to aid and refine specific tasks performed by human professionals” [20]. Note that this means that interpretability should not be considered here a fully technical issue dissociated from the cognitive abilities of the human interpreter. As acknowledged by Dreiseitl and Binder [12] when discussing the weak levels of adoption of MDSS at the point of care, researchers often sidestep practical questions, such as whether adequate “explanations [are] given for the system’s diagnosis”; “the form of explanation [is] satisfactory for the physicians using the system”; or “how intuitive is its use.”

An effort should be made to integrate medical expert knowledge into the AI and ML models or use prior expert knowledge in formal frameworks for machine-human interaction in the pursuit of interpretability and explainability. The data analyst must play a proactive role in seeking medical expert verification. In return, the medical expert should ensure that the analysis outcomes are interpretable and usable in medical practice.

Privacy and Anonymity

Technological advances and the widespread adoption of networked computing and telecommunication systems are flooding our societies (and mostly governments and technology providers) with data. The physical society bonds are being swiftly amplified by our use of virtual social networks. In this scenario, data privacy and anonymity have become main social concerns and have triggered legal initiatives, such as the European GDPR discussed in previous sections.

Needless to say, privacy and anonymity have been a core concern for healthcare systems for far longer than for society at large. The current adoption of EHRs in medical practice enhances this issue, as sensitive patient data are uploaded in digital form to networked systems with varying levels of security systems in place. An interesting review on security and privacy in EHRs can be found in the study by Fernández-Alemán et al. [21]. The strong links between privacy and anonymity, on one side, and

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legislation, on the other, are clearly described in this study, although it is also acknowledged that "there has been very little activity in policy development involving the numerous significant privacy issues raised by a shift from a largely disconnected, paper-based health record system to one that is integrated and electronic" [21].

This is not an issue ignored by the AI and ML communities. As early as 2002, data confidentiality and anonymity in data mining medical applications were already discussed in journals of these fields [22], highlighting the responsibilities of *data miners* to human subjects. Privacy-preserving models and algorithms have been discussed in some detail [23]. A commonplace situation for data analysts in clinical environments is the need to analyse data that are distributed among multiple clinical parties. These parties (e.g., hospitals) may have privacy protocols in place that prevent merging data from different origins into centralized locations (in other words, prevent data "leaving" a given hospital). The AI and ML communities have already worked on producing decentralized analytical solutions to bypass this bottleneck [24].

There is a new and disruptive element of the privacy and anonymity discussion in AI and ML applications in medicine that must be considered: the *en masse* landing of big IT corporations in the medical field, many of them proposing or integrating AI elements (some examples would be Microsoft's Hanover project, IBM's Watson Oncology, or Google's DeepMind), together with a myriad of AI-based medically oriented start-ups [25]. The involvement of IT companies in health provision raises the bar for privacy and anonymity issues that were already on the table due to the pressure of insurance companies, especially in the most liberalized national health systems. An illustrative example of the complexities and potential drawbacks of this involvement can be found in *Nature* journal's report of the UK Information Commissioner's Office declaration that the operator of three London-based hospitals "had broken civil law when it gave health data to Google's London-based subsidiary DeepMind" [26]. These data were meant to be the basis for models to test results for signs of acute kidney injuries, but privacy and protocols of identification were breached in a large-scale transference of patients' data from the hospitals to the private company. According to the Royal Statistical Society's executive director, three lessons are to be extracted from this particular case of application to the medical domain: (1) due to society's increasing data trust deficit, data transference transparency and openness should be guaranteed; (2) data transference should be proportional to the medical task at hand (in this case, the development of models for the detection of signs of acute kidney injury); and (3) governance (not just legislation) mechanisms of control of data handling, management and use should be strengthened or created when necessary. He also makes a key statement when saying that "innovations such as artificial intelligence, machine learning […] offer great opportunities, but will falter without a public consensus around the role of data" [26].

Ethics and Fairness

The time-honoured ultimate aspiration of AI is to replicate biological intelligence in silico. Biological intelligence, though, is the product of evolution and, as such, is multi-faceted and at least to some extent the product of environmental pressures of human societies. Ethics, as a compass for human decision-making, are one of those facets and could be argued to provide the foundations for the legislative regulation of societies, whose importance for medical applications of AI and ML has already been discussed in this paper.

The truth though is that the AI and ML fields are still fairly unprepared to address this pressing matter [27]. Interestingly, this topic has become central to AI discussion only in recent years, once it has also become a central topic in global research agendas [28]. In what sense might ethics be part of the AI and ML equation and in what sense do we want these technologies be imbued with ethical considerations, beyond the overlap with bodies of regulation and legislation? Let us provide an illustrative example: the ongoing debate on the use of AI as part of autonomous weapons systems in defence and warfare. Unmanned autonomous vehicles, at least partially driven by AI, are being used for targeted bombing in areas of conflict. The ethical issues involved in human decisions concerning the choice of human targets in war periods are quite clearly delineated by international conventions, but who bears ethical responsibility in the case of targets at least partially chosen by AI-driven machines? This type of problem currently drives not-for-profit organization campaigns, such as those undertaken by Article 36 [29], "to stop killer robots" [30].

Needless to say, ethics are also a core concern in medicine and healthcare that has attracted much academic discussion [31]. Can AI- and ML-supported tools address the basic biomedical ethical principles of respect for autonomy, non-maleficence, beneficence and justice? Should they, or should this be left to the medical practitioners? Medical practitioners, though, do not usually de-

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velop the AI and ML tools for medical application. Should they at least ensure that AI and ML developers do not transgress these principles in the design of such tools? According to Magoulas and Prentza [32], it is humans and not systems who can identify ethical issues, and, therefore, it is important to consider "the motivations and ethical dilemmas of researchers, developers and medical users of ML methods in medical applications."

Such convergence of interests makes it important, in any case, to create a clear roadmap for the ethical use of AI and ML in medicine that involves players both from the fields of medicine and AI.

The concept of *fairness* may be considered as subjective as the concept of ethics and, perhaps, more vaguely defined. If distinguishing what is fair and what is not in a human society is difficult and often controversial, trying to embed the concept of fairness in AI-based decision-making might be seen as a hopeless endeavour. Nevertheless, the use of ML and AI in socially relevant areas should at least aspire to be *fair*. As stated by Veale and Binns [33], "real-world fairness challenges in ML are not abstract, […] but are institutionally and contextually grounded."

Let us illustrate this with an example: gender bias can be added to an ML model by just biasing the choice with which the data used to train the model are selected. Caliskan et al. [34] have recently shown that semantics derived automatically using ML from language corpora will incorporate human-like stereotyped biases. As noted by Veale and Binns [33], lack of fairness may sometimes be the inadvertent result of organisations not holding data on sensitive attributes, such as gender, ethnicity, sexuality or disability, due to legal, institutional or commercial reasons. Without such data, indirect discrimination-by-proxy risks are being increased.

In the medical domain and in healthcare in particular, where sensible information about the individual may be readily available, how do we ensure that AI- and ML-based decision support tools are not affected by such bias? Fairness constraints can be integrated in learning algorithms, as shown in a study by Celis et al. [35]. Given that fairness criteria are reasonably clean-cut in the medical context, such constraints should be easier to integrate than in other domains. Following Veale and Binns [33], fairness may be helped by trusting third parties with the selective storage of those data that might be necessary for incorporating fairness constraints into model-building in a privacy-preserving manner. A recent proposal of a "continuous framework for fairness" [36] seeks to subject decision makers to fairness constraints that can be operationalized in an algorithmic (and therefore in AI and ML) setting, with such constraints facilitating a trade-off between individual and group fairness, a type of trade-off that could have clear implications in medical domains from access to drugs and health services to personalized medicine.

Conclusions

AI and ML have, for decades, been mostly investigated and developed within the academic environment, with some inroads into broader social domains. Over the last years, though, these fields are experiencing an intense process of industrialization that comes with societal strings attached. Many of these should concern medical and healthcare practice and have been brought to attention and discussed in this paper. We have considered legislation, ethics and fairness, interpretability and explainability and privacy and anonymity, but further issues, such as robustness and safety, economics and accessibility, or complex data management, could have also been considered. Our closing remark is a call for the collaboration between the AI-ML and medicine-healthcare communities in the pursuit of methods, protocols, guidelines and data analysis pipelines that explicitly take into consideration all these societal issues.

Statement of Ethics

No ethical approval was required for the writing of this article.

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