Robotics Topic 4 – Robots in daily life

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1 Social robots

Previously, we have seen how robots have been developed from simple mechanical automatons into mobile, intelligent systems. However, there is still an enormous gap between the robots we can build and control today and the robots of science fiction novels and films.

Starting in this topic, you will read several short stories from the *I, Robot* collection by Isaac Asimov. These stories raise interesting questions about possible futures and the relationships we might come to have with advanced robots.

There is nothing unusual or necessarily sinister in the way our relationships with robots are likely to change. The invention of the washing machine, vacuum cleaner and refrigerator have completely transformed people's lives over the past 100 years. Similarly, the motor car and the aeroplane have transformed human life. A hundred years ago it was not possible to have family life centred around the school run, or for the average person to take their holiday in the sun.

We may lament that we have lost a simpler and slower way of life, but we're unlikely to blame the actual machines for the impact they have had. Our cars do not force us to drive on those occasions we could walk or get the bus: we make these decisions, even though we know that they may have damaging effects on our health and the environment. When it comes to using machines of any kind, the practical, moral and ethical choices are ours. Or are they?

In this topic we want you to think beyond the practical constraints of today's technology. Let's assume that anything is possible and examine the consequences. Using this technique, you will investigate the relationships that humans may have with robots. To what extent are we in control of their deployment and use? You will consider this in the context of the relationships humans have with other humans and with other living creatures.

This topic follows the same pattern of work you met in earlier topics.

1.1 Learning outcomes

By the end of Topic 4 you should be able to:

- explain how Asimov's three laws can be seen as guiding principles in robot design

- explain some of the ideas behind fail-safe engineering
- explain the significance of Asimov's zeroth law
- explain and illustrate the kinds of relationships people may have with robots
- discuss the use of robots and automation in everyday life
- discuss the ethics of the use of robots by the military and the police
- discuss robot rights in the context of human rights.

2 *I, Robot*

In Topic 1 you were introduced to Asimov's three laws of robotics. You will also find them at the beginning of Asimov's book *I, Robot*.

> 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 the 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.
>
> (Asimov, 1996 [1950], p. 8)

The formulation of these laws in the 1940s was an intellectual and imaginative tour de force. The laws are simple but span an immense and important range of possibilities. *I, Robot* explores the consequences of the three laws and the ways they interact with each other.

The book contains a series of stories about the problems encountered by the US Robots Corporation during Dr Susan Calvin's 40 years as the company's robopsychologist. They are told as reminiscences by her to a young reporter.

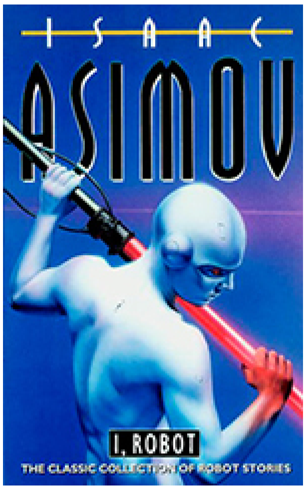

Figure 2.1 Isaac Asimov *I, Robot*

You might find the idea of a robopsychologist strange. However, if robots are to develop as complex intelligent machines capable of learning from their own experiences, then it may be necessary to have a robopsychologist rather than a robot engineer on hand to sort out any problems.

Human cognitive psychologists attempt to explain people's behaviour in rational terms (e.g. the reasons or ways of thinking that make a person decide to act in a particular way). An earlier school of psychologists, known as the behaviourists, tried to explain behaviour solely in terms of training: how previous experience, along with punishments and rewards, could explain current behaviour. It may be that robopsychologists will have to use similar techniques to 'debug' faulty robots and identify the potential causes of behavioural problems!

In the UK, legislation relating to issues surrounding mental health is covered in part by the Mental Health Act 1983. In particular, the Act:

> … makes provision for the compulsory detention and treatment in hospital of those with mental disorder.
>
> (*Mental Health Act 1983*)

In common parlance, this is often referred to as 'sectioning'. Patients with a physical injury can refuse treatment. However, sectioned patients cannot refuse treatment for their mental disorder. Should robots be offered treatment if they are behaving erratically? Should rewiring and/or reprogramming be imposed on them? On what grounds would we want to 'section' an artificially intelligent robot and, if necessary, forcibly treat it?

Each of the Asimov stories you will read investigates a particular theme that is relevant to this block. The first story concerns Robbie, a robot designed to act as a playmate to a young girl. When you read this story, pay attention to the relationships between robots, people and animals.

Activity 2.1 Read

Read the introduction to Asimov's book, then read Chapter 1, 'Robbie'. When you are ready, answer the following SAQ.

SAQ 2.1

a. Who are the main characters in this story? Give a brief summary of the plot.
b. What are the main points being made?
c. To what extent do you think a playmate robot such as Robbie is likely to exist in the future?

Reveal answer

2.1 The laws of robotics

Asimov was a science fiction writer, so he was free to invent robots with very advanced brains – he called them ‘positronic’ which sounded suitably high-tech. But Asimov also had a scientific and engineering bent, and one of the remarkable ideas in *I, Robot* is the notion that robots could be manufactured with brains that have Asimov’s laws immutably built into them, making it impossible for the laws to be disobeyed. This means that, although the robots might have unpredictable behaviour, their behaviour would always be consistent with the laws. Whilst positronic brains and Asimov’s laws of robotics are unlikely to ever be implemented in real robots, the very idea of the three laws, as well as the way in which Asimov saw them interacting with each other, can still provide much food for thought for today’s designers, engineers and programmers.

Interpretation of Asimov’s laws

It is possible to interpret Asimov’s laws of robotics in several ways. Firstly, the laws can be used as the basis of a series of thought experiments, as in *I, Robot.* These thought experiments allow us to explore the tension between what appears at first glance to be three eminently sensible and independent laws. The laws can be seen as embodying a moral code that Asimov’s robot *must* follow. It is also possible to use them as a scheme for evaluating the ‘responsible actions’ of a robot in a particular situation – that is, what it *should* do.

Secondly, the laws can be used to inspire particular logical systems that can be programmed into a robot. You have already seen how robots can have ‘beliefs’ about the world, which are encoded as rules. Researchers who focus on using formal logic techniques have produced many logical reasoning systems that are phrased as ‘logics of belief’. These logical systems can be very complex, and hard for anyone other than a mathematical logician to understand. However, in their own terms, they are capable of expressing statements that correspond to philosophical statements that you or I might make.

A research group at the University of South Carolina has come up with a control system for ‘robust’ space missions that embodies particular, ‘philosophical’ principles within the logical system controlling the robot (Rose *et al*., 2003). For example, the control program must, among other things:

- not harm the mission
- not harm the mission participants
- not harm itself.

It is interesting to note that these rules do not preclude a robot from participating in a mission that will, for example, harm people not regarded as members of the mission, whether deliberately or as a side-effect. Indeed, some missions might include killing people as their primary goal.

A third view of Asimov’s laws sees them as principles that robot designers can use to produce robots that are acceptable to society. In essence, the three laws correspond to three requirements: that a robot be safe, functional and robust. To meet such requirements, designers might decide to ‘design out’ the possibility of the robot performing in a particular way (i.e. prevent it from being in a situation where it could break the three laws). An alternative view would be to regulate the sale of robots to those who do not appear to contravene the three laws in their daily operation. So, while it may not be possible to build robots that implement the three laws, it would be possible to prevent their sale if they did end up breaking the laws. You might also imagine that a self-destructive robot is not likely to be a popular choice in the marketplace!

Finally, Asimov's laws may be thought of as embodying a control strategy. Specifically, the laws describe three rules which the robot must obey, but these rules are prioritised. So, for example, although the Second Law states that a robot should generally follow the command of a human, a robot ordered by one human to kill another would not do so, because this would contravene the First Law.

Systems of control

Many of Asimov's later stories play out situations in which applications of the laws may suggest some sort of conflict. They also consider what would happen if the priorities of particular rules were changed – if they were made equal, for example. Although this might seem like 'just so much science fiction', this sort of control strategy is applied with great effect in real robot control systems.

As a system of control, the way the three laws interact can be compared to subsumption architecture (see Elephants don't play chess (Brooks, 1990)). In subsumption architecture, higher-level behaviours triggered by particular sensor inputs take over from (or subsume) lower-level behaviours in much the same way that the higher-priority First Law can subsume behaviours that may be acceptable under the Second and Third Laws.

Thus, although they are not engineering truths, Asimov's laws of robotics can be a useful starting point for thinking about the social context in which a robot will be used, and the extent to which control over the robot should be delegated from a human controller to computing machinery.

Many of today's complex systems are controlled by computers. In the event of a failure, the computer control system may be able to shut the system down automatically. In other cases, a human is kept 'in the loop'. The question this raises, and to which Asimov's laws allude, is: to what extent should we build in safeguards to protect ourselves from the control or behavioural decisions of a machine, and the actions and consequences of those actions that are likely to result?

2.2 Fail-safe engineering

While we are unable to embed the three laws in a general-purpose robot, we are still faced with the problem of how to go about building safe robots. We might ask the more general question: can any engineered system be fail-safe? To answer this let's consider two major disasters: the collapse of the Tay Bridge in 1879 (as described, for example, in the OpenLearn unit Tay Bridge disaster (The Open University, 2011)) and the Challenger space mission disaster of 1986.

The Tay Bridge was a box construction with box-section legs up to 230 feet apart. It was designed to carry steam trains for a distance of almost two miles over the River Tay in Scotland. The bridge collapsed on 28 December 1879, causing a train to plunge into the waters below, killing all 75 people on board.

Professor Robert Schwartz at Mount Holyoak College writes about The Tay Bridge:

> … the tragedy of the first Tay Bridge and its designer, Thomas Bouch, … was a story of continual changes and errors of design, margins cut down to the limit (for which Bouch was known), appalling negligence and sheer bad workmanship. The inquiry took the view that the defects with the bridge were so numerous that it would sooner or later have to come down.
>
> (Schwartz, no date)

The Tay Bridge was a disaster waiting to happen. The same might be said of the 1986 Challenger disaster, as documented in the Report of the Presidential Commission:

> Chapter IV: The Cause of the Accident [p. 40] … the Commission concluded that the cause of the Challenger accident was the failure of the pressure seal in the aft field joint of the right Solid Rocket Motor. The failure was due to a faulty design unacceptably sensitive to a number of factors. These factors were the effects of temperature, physical dimensions, the character of materials, the effects of reusability, processing, and the reaction of the joint to dynamic loading.
>
> …
>
> Chapter V: The Contributing Cause of The Accident [p. 82] The decision to launch the Challenger was flawed. Those who made that decision were unaware of the recent history of problems concerning the O-rings and the joint and were unaware of the initial written recommendation of the contractor advising against the launch at temperatures below 53 degrees Fahrenheit [the temperature had been below freezing overnight and was below 40 degrees Fahrenheit at launch] and the continuing opposition of the engineers at Thiokol after the management reversed its position. They did not have a clear understanding of Rockwell’s concern that it was not safe to launch because of ice on the pad. If the decisionmakers had known all of the facts, it is highly unlikely that they would have decided to launch 51-L [Challenger] on January 28, 1986.
>
> (Rogers, 1986)

Thus three kinds of *human failure* contributed to the disaster. The first was an engineering design error, the second was a management communication failure, and the third was the manager’s decision to launch.

Software is another area in which engineering failure is common. The reasons for software failures include:

- poor specification (i.e. statement of what the system should do)
- poor implementation (i.e. programming or fabrication)
- poor management of the process
- the impossibility of testing software in all operating conditions.

If it were possible to embed the three laws in robots, then by definition they would be safe. In this case, there would probably be legislation requiring all robots to have the laws built in. But would they be correctly implemented?

2.2.1 Specification and implementation

In software engineering there are two key tasks in developing software:

1. get the specification right
2. implement the specification correctly.

Even if you get the first one right, you can’t guarantee that you will manage the second.

One interesting technique for achieving this is called the ‘formal methods’ approach of software engineering. The idea is that it is possible to mathematically prove that a specification is correct, meaning that you have demonstrated the first key task. However, even if you prove the specification is correct, there is no guarantee that the implementation will also be correct.

Another approach that can be taken towards ensuring that systems are implemented correctly is to implement them more than once through different pieces of software. If the different pieces of software all behave in the same way at all times, then it is fair to assume that they are likely to be recommending the correct action. If the different pieces of software provide different recommendations, then a piece of code called the ‘arbitrator’ chooses which decision to make (such as the majority decision). Approaches such as this are used in many space systems, such as the Shuttle, as well as other safety-critical situations.

Asimov’s positronic brain suggests one way of trying to ensure that a robot behaves as specified. As Asimov described the positronic brain, it is logically impossible for it to do anything that is inconsistent with the three laws. Even so, a wide variety of unexpected behaviours is possible, as explored in Asimov’s stories. From our knowledge of today’s robot control systems, it is unlikely that anything approaching the three laws will ever satisfactorily be used in a real robot. The levels of uncertainty likely to be present when trying to reason sensibly about potentially dangerous and quickly changing human situations are such that implementing rules that could cope with them is simply too problematic.

SAQ 2.2

a. Do you think that engineered systems can be fail-safe?
b. If they existed, do you think that robots with positronic brains would be well behaved?

Reveal answer

3 Relationships with robots

There is nothing new about humans forming strong bonds with inanimate objects. For example, there are the sports car lovers who are prepared to get wet in order to keep their cars dry, and children who treat their teddy bears like living companions. Would the relationships we form with robots be different to this? If so, how? Is it possible to fall in love with a robot?

3.1 Robots in social networks

In Asimov's story of Gloria and Robbie there are five main characters. Figure 3.1 shows a simple example of what is called a 'social network', which shows the main characters in the story and the relationships between them. In fact, the network is more complicated than this – each of the five characters has a relationship with the remaining four, making ten relationships in total. Some of the main relationships are summarised below.

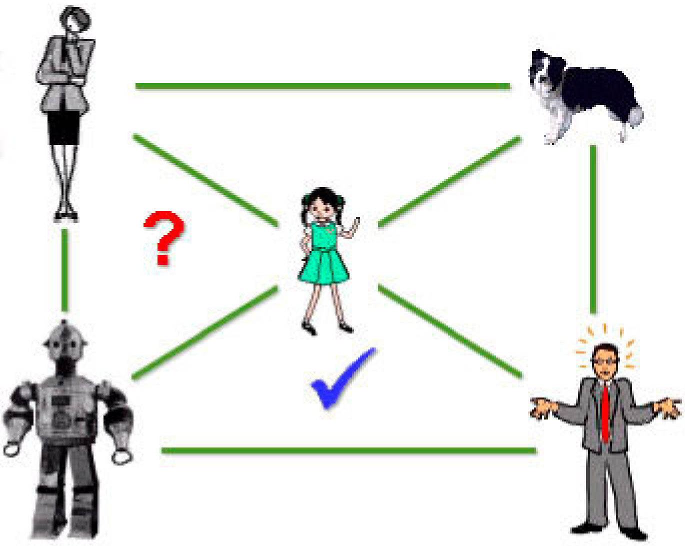

Figure 3.1 A social network of the main characters in 'Robbie'

Show description

Gloria – Robbie: First there is the love that Gloria feels for Robbie, and her dependence on him. She needs him to play with and share news with, such as getting a new dog. For Gloria, Robbie is a living creature whom she bosses around a bit. As far as Robbie is concerned, he is Gloria's slave. But it's a subtle relationship because Robbie's behaviour affects Gloria's. This may be necessary for the robot to satisfy the girl's needs in the relationship. How can she forgive him for being moody if he is not moody in the first place? As a nursemaid, how can Robbie teach Gloria effective patterns of social behaviour if he does not try to direct her behaviour in subtle ways?

Gloria – Mrs Weston: The relationship that Mrs Weston has with her daughter is a combination of maternal love and power. Mrs Weston is a bit bossy and, like many grown-ups, has many pressing concerns and does not listen very carefully to what her daughter says. But Gloria is feisty like her mother. She knows what she wants, and she'll argue for it. Perhaps Gloria's bossiness towards Robbie imitates her mother's bossiness towards everyone, including Mr Weston.

Gloria – Mr Weston: Mr Weston appears to be a loving and caring father. Having made a mistake in letting his wife get rid of Robbie, he devises a plan for them to meet Robbie at US Robots, in the hope that his daughter will be happy again and that his wife won't be too cross with him.

Gloria – the dog: Initially Gloria is disposed to have a loving relationship with the dog. However, when she realises that the dog is supposed to be a substitute for Robbie she comes to hate it.

Mrs Weston – Robbie: If Gloria has a very positive relationship with Robbie, Mrs Weston has the opposite. The relationship is asymmetric. Mrs Weston is the boss and Robbie cowers in her presence, ready to do anything she says without question. At best, Robbie is just a machine; at worst he is threatening and sinister.

Mrs Weston – Mr Weston: Mr Weston is an easy-going man who likes to be comfortable. After ten years of marriage he was 'so unutterably foolish' to love his wife. Getting Robbie was his idea. This link is not shown in the diagram but is important nonetheless.

Mrs Weston – the dog: Mrs Weston bought the dog as a substitute for Robbie. There is no emotional relationship. The dog is a possession, and when it ceases to serve its purpose it is disposed of. I think Mr Weston also feels like this. This may seem rather utilitarian, but it is the attitude that farmers in many parts of the world have towards their animals. This is very much the kind of relationship people actually have with robots: they may form attachments to them, but ultimately they see them as machines to which they have no moral commitment.

Mr Weston – Robbie: Mr Weston is pro-robot, having originally had the idea of getting Robbie for Gloria. He takes a utilitarian approach to his relationship. Trying to resolve Gloria's grief, he schemes for Robbie to be brought back again. Although he has no animosity towards Robbie, the robot is a means to an end. He has no emotional attachment to the robot either way, and for him Robbie is just another gadget, albeit an expensive one that his daughter is very attached to. He sees nothing sinister in Robbie but eventually, under pressure from Mrs Weston, he disposes of Robbie.

As you can see, the story provides a wealth of human–robot interactions. The relationships that people have with the robot are conditioned by the relationships they have with each other.

In Figure 3.1 above, the question mark beside Mrs Weston, Gloria and Robbie denotes the tension that exists between them. Gloria and her mother have a loving mother–daughter relationship. Mrs Weston does not like Robbie; Gloria loves him. This tension between Gloria's love for Robbie, Mrs Weston's concerns for her daughter's welfare and the disapproving neighbours, and Mrs Weston's negative relationship with Robbie is the initial driving force of the story. Mrs Weston gets rid of Robbie because she is concerned that the love Gloria feels towards Robbie may be harming her daughter.

After this, the story is driven by Gloria's unhappiness and Mr Weston's subterfuge in causing Robbie to be 'found' in New York. (Mr Weston plots to get Robbie back because he feels Gloria's relationship with Robbie is not harmful to her, but that her unhappiness is.) These harmonious relationships between Mr Weston, Gloria and Robbie are represented by the tick in the diagram.

There are hints that Robbie feels social slights just like a human. He cowers in the kitchen as the sharp-tongued Mrs Weston tells Gloria he should not be there. And, implicitly, he feels great fondness for his young charge. To Mr and Mrs Weston, any feelings Robbie might have are as irrelevant as those of the dog.

3.2 Robots in the family

Although Robbie the humanoid robot is beyond current technology, there are now a variety of humanoid robots available that can serve as companions at home. One recent example is the Aeolus robot (Aeolus Robotics, 2020), which is designed to do housework: vacuuming and mopping floors, moving furniture, picking up toys off the floor, and it can even fetch you a drink from the fridge!

The manufacturer claims that this is the first multi-functional robot that can actually behave like a human being and goes on to state that 'Right now it's like a child, but we will continue to grow its capability so that it grows from a child to an adult. The more people that use the robot, the stronger it becomes.' (Holley, 2018).

The robot will be connected to a network of other robots in order to share information. It will use AI algorithms to adapt to surroundings and routines, so the robot becomes more intelligent as time passes.

Some of the more detailed features of the Aeolus robot are shown in Figure 3.2.

Figure 3.2 Features of Aeolus robots

Maximise

Show description

Robots like Aeolus give us a glimpse into a possible future with domestic companion robots. Do we need the services that such a robot can provide? Someone who has an elderly relative living on their own might, however, find the presence of such a robot reassuring.

The wide range of domestic robots available are imagined as being very helpful. They could undertake many different tasks such as turning on the cooker, drawing the blinds, switching on the lights, controlling the heating, taking phone messages, and even controlling less intelligent machines. However, perhaps needing an intelligent robot to control other machines will not be necessary. The rise of ubiquitous computing and the Internet of Things (IoT) means that many of our gadgets are becoming more connected and more intelligent – already it is possible to carry out many of these tasks from a smartphone. We will look at the IoT and its interactions with robotics in more detail in Topic 6.

It might also be the case that there won’t be one domestic robot to rule them all, but a range of purpose-built robots to perform different tasks. For example, rather than humans socialising with a robot that doubles up as a vacuum cleaner, maybe human companionship will be provided through telepresence robots. As well as bringing human presence into the home, such robots can project the presence of an elderly person outside the home, such as into the home of a family member, community centre, or even workplace, as well as providing them mobility within those remote spaces.

But let’s imagine very sophisticated robots do become commonplace. Even so, there may be limitations on the things we would want them to do, or even allow them to do. Suppose you need a babysitter. What is the youngest age of a person you would feel comfortable leaving an eight-year-old child with? How about a five-year-old or a new-born baby? Would you be prepared to use a robot babysitter? If so, how old would the child have to be?

3.3 Luddites and anti-robot sentiment

When the reporter in Asimov’s story asked Susan Calvin if Robbie stayed with the girl, she replied:

> ‘Of course, he didn’t. That was 1998. By 2002, we had invented the mobile speaking robot which, of course, made all the non-speaking models out of date, and which seemed the final straw as far as the non-robot elements were concerned. Most of the world governments banned robot use on Earth for any purpose other than scientific research between 2003 and 2007.’
>
> ‘So that Gloria had to give up Robbie eventually?’
>
> ‘I’m afraid so. I imagine, however, that it was easier for her at the age of fifteen than at eight. Still, it was a stupid and unnecessary attitude on the part of humanity.’
>
> (Asimov, 1996 [1950], p. 36)

So Asimov predicted that there would be ‘non-robot elements’ – people against the use of robots – who would succeed in banning the use of robots on Earth. This anti-machine sentiment has a long tradition.

In the early part of the nineteenth century, the Industrial Revolution saw the introduction of machinery into textiles manufacturing. It is said that Ned Ludd led an uprising in Nottinghamshire to destroy two large stocking frames which were producing inexpensive stockings that undercut those produced by skilled knitters. The voice of Ned Ludd was heard in the woollen towns of Lancashire and Yorkshire, where industrial technologies were threatening to replace skilled workers, and the short-lived Luddite movement was born.

The Luddites rose up in defence of their own livelihood and committed several acts of machine breaking, smashing up the machines newly introduced into factories. The time was a period of significant unrest anyway. Many arbitrary acts of violence, partly arising from food shortages and the breakdown of order in a time of war (Napoleonic), came to be associated with the actions of the Luddites. In the end, the British government responded harshly to the threat of sustained civil unrest, and in 1813 seventeen men were executed for machine breaking.

Today, the term ‘Luddite’ is often used to describe someone who opposes the advance of technology. As the origins of Luddism suggest, people have always had an ambivalent relationship with new technologies, especially when their jobs or lifestyles are threatened. However, it appears to be impossible to stop the march of technological progress.

It is interesting to consider whether the widespread introduction of robots into our society will inspire passions as violent as those of the original Luddites. Industrial robots are often seen as being well suited to jobs that are too dirty, dangerous or demeaning (the three D’s) for humans to do. However, what irked the original Luddites was the way industrial technology looked set to replace skilled rather than menial labour.

Today, robots may not be seen as a great threat to the full range of people’s jobs, any more than any type of automation, because robots are still very primitive as ‘all-round’ workers compared with humans. However, many jobs that were traditionally handled by agricultural workers, factory workers, and even knowledge workers have been taken over by machines.

In an article for *Wired* magazine future gazer Kevin Kelly imagines four types of jobs (Kelly, 2012):

- existing jobs that humans can’t do but machines can
- existing jobs that humans do but that machines will (eventually) do better
- new jobs that robots will do that we can’t even imagine yet
- new jobs made possible by advances in technology that humans will do better (at first!).

Kelly seems to ignore jobs that robots will never do – the implication being that there may not be any such jobs. However, he does recognise economics, and the cost of continually setting up machines if they need to do a variety of tasks, as one reason why some tasks may not be automated. Rather more significantly, Kelly also points out that many of the jobs done by robots are impossible for humans to do unaided. In this sense, robots are just tools, although tools that are increasingly able to act autonomously and without human intervention.

3.4 Job replacement

3.4.1 Self-service

Vending machines have been serving us now for many years and have just about become a ubiquitous part of society. They first appeared in the late nineteenth century and use automated processes to serve a variety of goods including sweets, cold and hot drinks, birth control and even hot food, including pizza.

Figure 3.3 Pizza vending machine

Show description

As with vending machines, other automated self-service facilities are now commonplace in society. Self-service checkouts in supermarkets appeared as far back as the 1990s. Nowadays, many consumers are happy to scan, weigh and bag their own shopping. Whereas a few years ago there were just a few self-service checkouts, self-service exists on a much bigger scale and in more types of shops.

A recent article by British Telecom examines the types of jobs that have been taken over by robots and automation. A lot of these we take for granted, for example alarm clocks, lift operators and switchboard operators. However, the article goes on to say that in some supermarkets '…now it only takes one operator/person to monitor a dozen self-checkouts, to correct the mistakes we make as customers.' (Harris, 2018). Other job roles highlighted in the article that have changed or been discontinued as a result of automation include railway station ticket sellers and factory workers.

High street banking

The first automated teller machine (ATM) was introduced into the UK in 1967 and went on to revolutionise high street banking. The functionality available from an ATM has grown steadily over the years and now, as well as withdrawing money, ATMs will let you view account information, deposit money, transfer funds and pay in cash and cheques, among other things.

Even though bank tellers and their automated counterparts have been able to live alongside each other in relative harmony, the recent demise of the high street bank has seen ATMs end up in a rather precarious position. With recent developments in online banking and mobile technologies, this has led to predictions that we are heading towards a cashless society and ATM manufacturers are preparing for a world where cash will be less important (Financial Times, 2018).

3.4.2 Autonomous delivery vehicles

In recent years, companies around the globe have been using a variety of semi-autonomous vehicles to deliver a range of goods and services, including retail goods, medical goods, food and postal deliveries.

A variety of services use wheeled vehicles. For example, the vehicle from Starship Technologies that we discussed in Topic 1 is used to deliver groceries from supermarkets straight to a person's home.

Unsurprisingly, online retailers have also been interested in the use of autonomous delivery vehicles, particularly Amazon. The Amazon Scout uses self-driving technology to navigate its way over pavements and across roads. The parcels are stored inside a secure box and the vehicle has six wheels. The Scout started delivering goods in the South of England in the summer of 2019.

There is also a lot of effort being invested in the development of unmanned aerial vehicles (UAV) for the delivery of goods. In the UK during 2019, Amazon started their fully autonomous 'Prime Air' service. Amazon claim that this takes only 13 minutes from order to delivery.

UAVs could be invaluable for delivering goods in countries that have disparate populations and low levels of road infrastructure. In Rwanda, trials of delivering blood by drone are ongoing.

In a study by Goldman Sachs during 2018, it was reported that by 2020 drones will be a $100 billion market, with the biggest expansions in business and government. Commercial-sector growth will likely be in the areas of oil refinement, agriculture and insurance (see Figure 3.4).

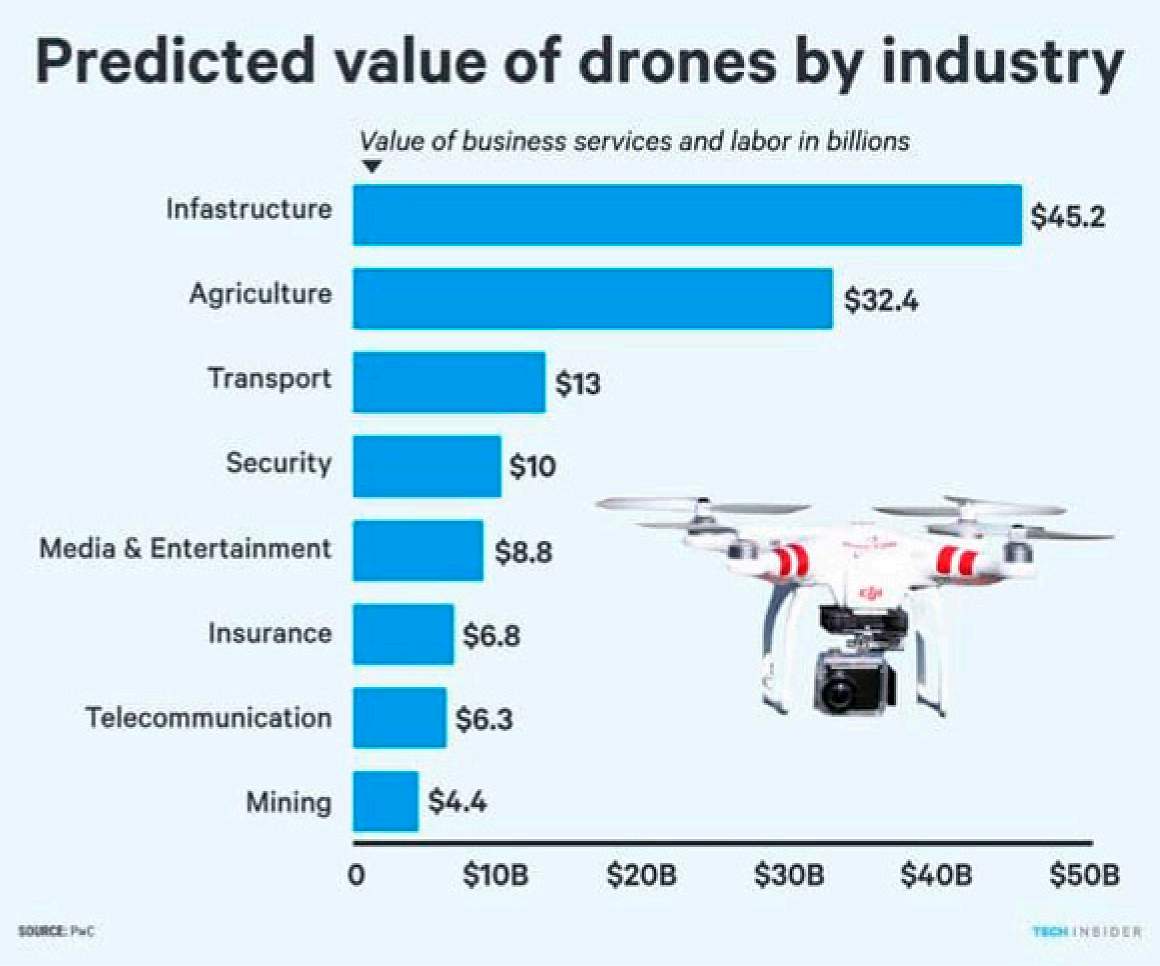

Figure 3.4 Drone industry

Show description

The report also goes on to say that in terms of job replacement, drones are not being viewed as a way of replacing people in the workplace, but instead will create lucrative jobs where drone pilots are able to earn as much as $3500 a day in the USA.

In an article by Verizon on how drones are powering new jobs, more and more industries are now cashing in on the use of drones, for example construction, mining and telecommunications, where they see the use of drones as being critical in disaster-hit areas as well as reaching areas that are difficult to access using traditional transport methods. The article also states that 'revenues from drone sales will top $12 billion in 2021, up from just over $8 billion in 2018' (Powers, 2018).

3.4.3 Autonomous cars

The idea of self-driving, or autonomous, cars can be traced back as far as 1961 at Stanford University. The Stanford Cart was originally built as a remote-control vehicle and was designed to imitate the time delay associated with controlling a robot on the moon. This supplied researchers with critical information on how to control lunar vehicles. The project evolved over the years: by 1970 the Cart had become autonomous and was able to follow a white line whilst moving at a constant walking pace. This, however, proved to be problematic because the vehicle had difficulties manoeuvring sharp corners as well as having problems in certain lighting conditions. By the end of the 1970s the Cart had 3D vision and was able to pause and evaluate its surroundings before deciding on a best path using mechanisms not unlike the sense–think–act model that we encountered in Topic 2.

Activity 3.1 Watch

The following video demonstrates the Stanford Cart in 1979 crossing a room filled with objects. This manoeuvre took five hours! (Note that the video contains flash photography.)

By the 1990s and into the new millennium, DARPA (the US Defense Advanced Research Projects Agency) led the way in the development of autonomous vehicles and unmanned trucks. However, it wasn't until 2004 (and with the aid of heavy investment) that the projects were taken more seriously with the creation of the DARPA Grand Challenge. This invited/challenged anyone that was capable to build an unmanned vehicle to drive across the Mojave Desert in California. Although initially unsuccessful, the idea grew and developed over the following years until cars could easily complete the course whilst avoiding obstacles and obeying traffic laws.

The development of these vehicles for the DARPA challenge led to the development of the first Google self-driving car project in 2009. This project was led by one the inventors of Google Street View (Sebastian Thrun) and used the Toyota Prius as the base for the project. The initial aim was to drive autonomously for 100 miles. The project has evolved over recent years to become the company Waymo (Waymo, 2020). The Waymo vehicles currently drive at autonomy level 4 of the diagram in Figure 3.5.

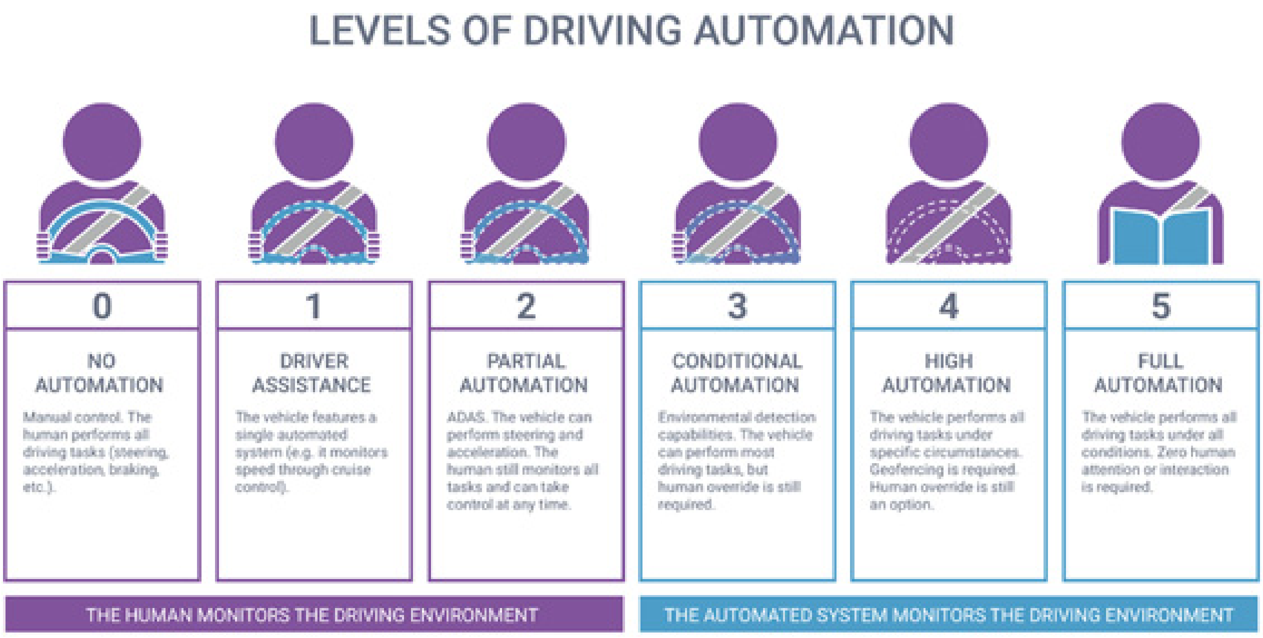

Figure 3.5 Levels of driving automation

Maximise

Show description

There are now many vehicle manufacturing companies stepping into the driverless car arena including Mercedes, BMW, General Motors and Tesla. The Tesla range has proved to be the most popular of these with its autopilot features. The Tesla autopilot provides advanced semi-autonomous driving features such as emergency braking, steering, lane changing, parking and the ability to summon a stationary vehicle. The car has the ability to provide these features through advanced software, myriad cameras and sensors as well as forward- and rear-facing radar.

As with the other automated technologies we have looked at in this section, it is anticipated that the use of driverless cars may significantly change the nature of employment, with some types of jobs being lost (such as delivery drivers) but others being created (such as autonomous fleet maintenance). We will explore autonomous vehicles in more detail in Topic 7.

4 Robot rights

Remember that we are considering a future where anything is possible. Let us now suppose that robots become our equals. Would we be willing to legislate against robot discrimination? Would we decide that robots are not entitled to go on strike? Would we try to ensure equal rights for robots in the workplace?

Equal rights for robots?

In most countries there are laws to give people equal rights and opportunities. How might this work for robots? For example, should lifts be provided for wheeled robots that can't climb stairs? Here are some robot rights issues you might like to consider:

- the right to vote in elections
- the right to freedom and the abolition of robot slavery

- the right to an education
- the right to free speech
- the exercise of religious freedom
- the right to citizenship.

ePortfolio

You can complete and submit the following activity as part of your ePortfolio.

Activity 4.1 Discuss

In an industrial setting, what factors are likely to influence whether a robot or a human is used for a particular task?

Spend ten minutes or so jotting down what factors you think might influence such a decision. Post your thoughts to your Cluster group forum and see what other students think.

Activity 4.2 Read (optional)

If you have time, you may like to read the article 'Viewpoint: will man-made robots rise up and demand their rights?' (Brooks, 2000).

Animal rights versus robot rights

Although animals have some rights in human societies, they certainly do not have full human rights. Animals are generally considered to be property and, for the moment, the same is true of robots. If robots were given rights, would they be as extensive as those enjoyed by people in free societies? Or would they be more limited rights, such as we allow animals?

Children's rights versus robot rights

Children's rights are protected by legislation. Could robots' rights be protected in a similar way?

In 1989, the United Nations Children's Fund (UNICEF) adopted a convention on the rights of the child (UNICEF, 2005). The Convention reiterates some of the rights espoused under the UN's Universal Declaration of Human Rights, as well as introducing additional protection specifically for children relating to their physical and mental health. Parents are held to be responsible for the well-being of their children, and governments are required to assist parents in this duty.

In the UK there is much legislation that relates specifically to children. These regulations protect the rights of children by not only guaranteeing them access to certain provisions, but also preventing them from participating in certain activities. Would the same be true for robots?

Rights to use robots

Even if we can't imagine a future in which robots are given their own rights, we might accept that there will be legislation around the freedom of owners, or 'employers', of robots to use robots in a particular way. This might limit our freedom, for example, by saying that we can't use a robot to do certain things. But legislation may also be required to enable particular forms of usage. For example, several states in the USA are setting up the legal framework necessary to allow autonomous cars on public roads (for example, this Californian Senate Bill passed in 2012 (California Senate, 2012)).

4.1 Robots as slaves

Will you own a personal advanced, intelligent, humanoid robot in the future? If so, would that make it your slave?

In social terms, the notion of the master–slave relationship emphasises that the slave is the property of the master. This is not to say that the slave is necessarily not trusted by the master. In ancient Rome, slaves could often act on behalf of their master, for example by running a household. Slaves in charge of the household were often charged with assigning duties to other slaves lower down the order.

Some slaves were also treated as part of the family, although the master–slave relationship was still evident. Slaves could not own property: as they were the property of their masters, their possessions were also the property of their masters. Slaves would often be freed in old age because they could no longer perform useful service.

Individuals were often enslaved as a result of war. When Rome conquered new territories, everything in the territory, people included, became a possession of the Roman Empire and could be sold on. The prices of slaves depended on their status and how skilled they were.

By contrast, slavery in the United States and Britain was based on racial grounds and the supposed inferiority of the slaves to their masters. Our society now holds such views abhorrent. In the future, will it be equally unacceptable to consider an intelligent humanoid robot inferior to a human?

4.2 Robots as victims

If people were to 'torture' robots or harm them for pleasure, would that make them victims of human cruelty? In the television programme *Robot Wars* the robots were radio-controlled machines, not sentient beings. In fact, they seem little different from the cars taking part in 'banger racing', which speed around rough grass tracks and frequently collide and get damaged – a case of cruelty to cars perhaps!

In the film *Westworld*, holidaymakers went to Westworld precisely because there were humanoid robots there programmed to indulge every passion. Would such advanced robots be indifferent to abuse? Would it be cruel to treat them in this way?

Activity 4.3 Discuss

> In the past, cock fighting, dog fighting, bear baiting and other sports in which animals fight each other to the death were very popular. Today these activities are illegal in the UK, but do unfortunately still occur. My moral commitment to my dog makes the thought of her being subjected to such cruelty repulsive. But what if she really were a robot, even though she looks exactly like a dog? Would it be morally acceptable to watch a ‘dog fight’ between robots? There is no explicit legislation for this as yet, but do you think human blood lust could be satisfied legally or morally by using robotic animals?
>
> Post your thoughts to your Cluster group forum.

5 Robot agents

5.1 Robots as agents of the state

We have already established that it is unlikely that robots will take over the world. But perhaps they could be used less overtly to help states and the forces of government maintain control over their own civilians or prosecute wars against others.

One of the main drivers of robotic technology is the desire by governments to reduce the number of casualties on their side in warfare. The increasing automation of weapons of war, as well as the increasing use of unmanned surveillance vehicles, not only ground based, but also aerial and underwater, may point to a future of robot warriors.

You have already seen in Topic 1 that there are examples of robots such as cruise missiles that don’t obey Asimov’s First Law. This creates a considerable moral dilemma: how can we justify robots that are designed to kill people?

Humans have shown violence to members of their own species since the earliest days, and conflict is a recurrent theme in human history. In human societies the taking of life is occasionally thought of as acceptable – repelling invading armies or, even now in some countries, using capital punishment, for example. Asimov came across this ‘problem’ in some of his stories. In ‘The Evitable Conflict’, he formulated what would later be called the zeroth law which takes precedence over the other three laws:

- No machines may harm humanity; or, through inaction, allow humanity to come to harm.

(Asimov, 2013 [1950], p. 242)

Note the use of the word ‘humanity’ in the zeroth law. In fact, herein lies the problem with the zeroth law. What constitutes humanity? And who judges what is harmful to it? For example, road accidents sometimes result in fatalities – this is true any place where there are cars. Is this not harmful to humanity? Yet we continue to drive cars because we judge driving to give humanity (or our bit of it) great benefits which outweigh the cost in human life. So, what is deemed beneficial to humanity is a matter of judgement, involving a trade-off of good against bad. These judgements depend on individual value systems and these of course vary widely.

Human beings are unable to agree a universal set of values. Despite organisations such as the United Nations, there are still many military conflicts in the world. In the context of a human disagreement, could a robot decide what would 'allow humanity to come to harm'?

5.2 Robots as the agents of war and peace

We have previously mentioned that the US Department of Defense (DARPA) supported much of the early development of autonomous vehicles. One of the major drivers was a million-dollar prize challenge for the winner of a competition for autonomous robot vehicles to race from Los Angeles to Las Vegas (across the Mojave Desert) within ten hours.

Now the US Department of Defense is stepping up efforts to develop future autonomous robotic ground vehicles that would operate in concert with manned systems to form an integrated fighting force. The goal is not simply to replace people with machines, but to team people with robots to create a more capable, agile, and cost-effective force that lowers the risk of US casualties.

Over the years, the DARPA challenge mentioned earlier has evolved into many different categories. These include the Urban, Subterranean and the Launch challenge, all of which continue to bridge the gap between research, fundamental designs and military use.

Progress in other areas of military robotics has also been very rapid, and future conflicts could look very different from those of the past. According to the DARPA announcement, the idea is currently that humans will work together with autonomous robots. Presumably this collaboration will minimise the dangers to humans. Can we 'look forward' to nations having proxy wars through their robot armies? Should robot soldiers fight our wars and police our streets?

Robotic drones already police the skies in some areas of the Middle East. These unmanned aerial vehicles (UAVs) are widely used for both surveillance operations and weapon delivery. They are usually controlled by a human operator, but are increasingly capable of autonomous or semi-autonomous operation. Even in civilian situations – for example the use of police-operated UAVs for surveillance – ethical concerns such as privacy that have been raised around city centre CCTV may be amplified many times over.

Noel Sharkey has written about the ethical concerns that arise with the increasing use of battlefield robots. By December 2008, over 5000 mobile robots had been deployed in Iraq and Afghanistan. These were mostly used for surveillance and bomb disposal, but some are now armed; UAVs are now also used in combat. All currently have a human 'in the loop' to decide when to use lethal force, but there are pressures to give increasing autonomy to such robots. In the words of Professor Sharkey, an expert in AI systems, 'We are going to give decisions on human fatality to machines that are not bright enough to be called stupid' (Sharkey, 2007).

More recently, in the book *Army of None*, Scharre (2018) examines the fundamental change that is taking place in the nature of how wars are being fought. Scharre examines the possibility of a future where autonomous robots powered by AI algorithms are able to make lethal decisions without human intervention, or without a human 'in the loop'.

In Topic 2 we discussed the sense–act model and then what it means to include a cognition subsystem with the sense–think–act model. Scharre goes on to further define robot (weapon) cognition systems; however, as shown in Figure 5.1, he includes how levels of autonomy also play a part as well as what those implications are.

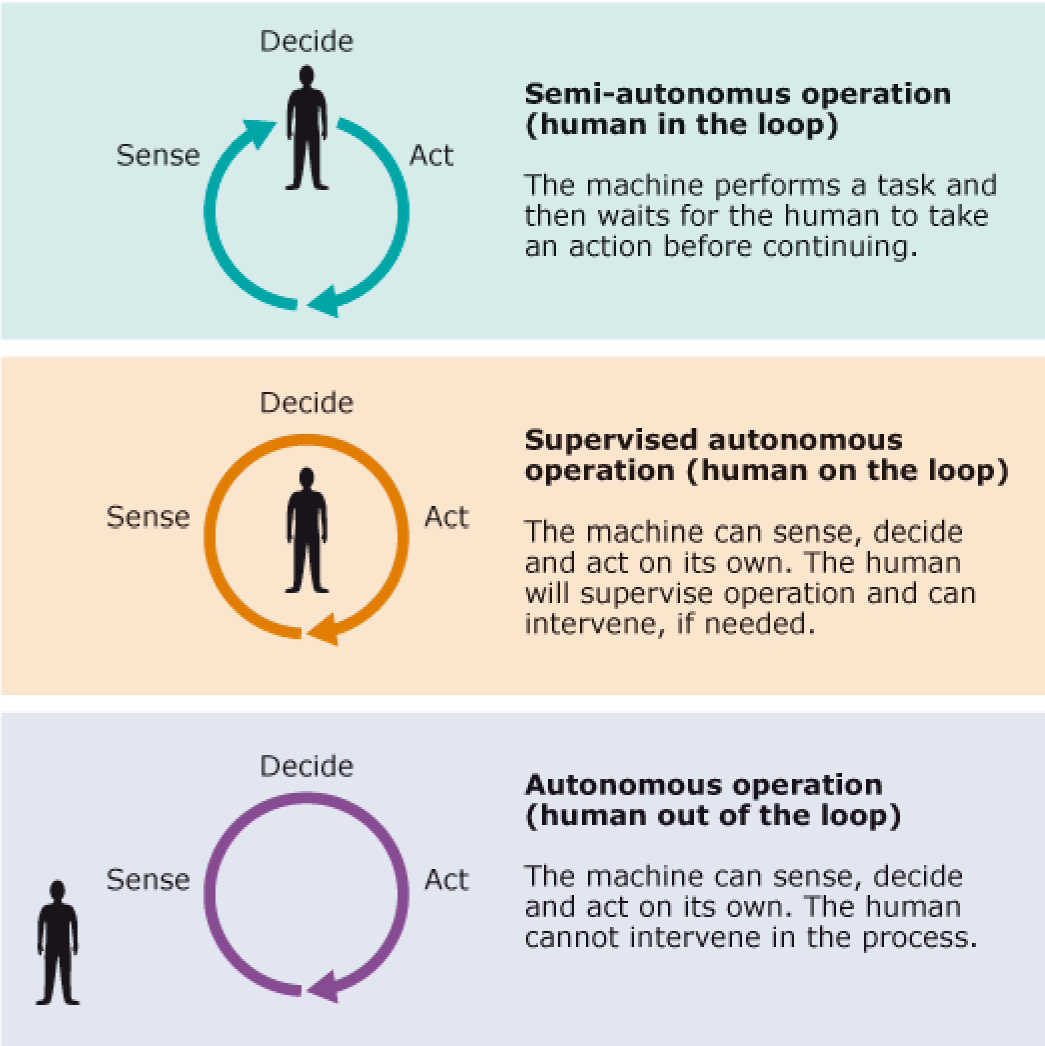

Figure 5.1 Different levels of autonomy in the sense–think–act model

Show description

In an article published in 2019, the International Committee for the Red Cross (ICRC) raised concerns about the autonomous operation of weapons. They go on to say that they have potentially serious consequences for people in armed conflict, raise significant legal questions around humanitarian law, as well as ethical concerns about the responsibilities in life-and-death situations (ICRC, 2019).

We will return to consider the ethical quandaries posed by robots in Topic 7.

6 Practical activities

Activity 6.1 Robot practical activities

Follow the instructions on this week of the study planner and carry out the activities.

7 Summary

In Topic 4 we have begun to analyse in some depth the relationships that people have with robots. During this topic you have looked at:

- how Asimov's laws can be seen as guiding principles in robot design
- the ideas behind fail-safe engineering
- the types of relationships people may have with robots
- how automation impacts on everyday life
- robot rights in the context of human rights
- the significance of Asimov's zeroth law
- the use of robots by the military and the police.

It is clear that there are many moral and ethical issues surrounding the use of robots. The increasing use of robotics by the military is one example that is currently pressing. Looking into the future, as technology improves – especially if humanoid robots become increasingly lifelike – further moral issues concerning human–robot relationships will arise. I hope we have helped you to start thinking about these issues.

Where next

This is the end of Topic 4.

Topic 5 investigates optimisation in problem solving and how this applies to the development of robots.

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Acknowledgements

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Figure 2.1: Taken from: https://www.bustle.com/articles/49003-11-fictional-female-scientists-wholl-stun-you-with-their-brilliance

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Figure 3.4: Taken from: https://www.dronetechplanet.com/will-drones-take-away-jobs/

Figure 3.5: Taken from: https://www.synopsys.com/automotive/autonomous-driving-levels.html

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