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Robotics Topic 3 – Human–robot interaction

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1 Human–robot interaction

In Topic 3 you will learn about human–robot interaction, and the relationships between people and robots. We will look at robots that can express emotions, and how robots and humans communicate with each other.

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

1.1 Learning outcomes

By the end of Topic 3 you should have an understanding of:

- different forms of human–robot interaction
- displays of robot emotions
- some forms of interaction that robots are currently using in the context of healthcare.

2 Interacting with robots

There are robots in factories and in research labs, but as robots become increasingly common in our everyday lives, we have to think much more about what they look like and how humans should interact with them. Will they be intelligent versions of everyday machines – a robot vacuum cleaner or robot lawnmower? Or will we see fully humanoid robots, the robot servants of science fiction?

One incursion of robots into the home has been in the form of toys. The Sony Aibo robot dogs became a briefly fashionable adult gadget; more recent toys such as the Robosapien family are aimed more clearly at children. Many of these meet our expectations of pets: they have some personality and need to be trained and rewarded rather than programmed.

Figure 2.1 Sony’s Aibo robot dog, which looks cute and can be trained

Show description

How should humans and robots interact? This is the subject of the emerging field of human–robot interaction, which aims to help us to design robots that interact effectively with humans. Should robots look like machines? Or, since we interact so naturally with other people, would it be better for a robot to look human, sound human and move like a human?

When we interact with people, we use language but also rely on many non-verbal cues given by our facial expressions and body language. We understand and follow social conventions, such as taking turns when conversing. We predict the behaviour and reactions of other people. People are said to have a ‘theory of mind’, which means that we understand that other people are thinking beings like ourselves and have their own point of view. We can then empathise with others – and this allows us to predict their behaviour by ‘putting ourselves in their shoes’. Taken a step further, it allows us to influence the behaviour of others by predicting how *our* behaviour will appear to *them*.

We probably use our theory of mind even when not strictly appropriate – we use it to make sense of the behaviour of animals and machines. This tendency to imbue animals and machines with human qualities is called *anthropomorphism* and we will look at it again later, in Section 3.5. Should a robot designer take this into account? Should robots be given the basics of social interaction so that people can interact ‘naturally’ with them?

One important component of social interaction is emotional awareness. This means being aware of both one’s own emotions and the emotions of others. This would imply that a robot needs to be emotionally aware: it must recognise our emotions and have its own emotions that it can display so that we can recognise the robot’s emotional state.

Human–robot interaction raises several other questions. For example:

- Could interacting with robots alter the way we interact with other people?
- Is it healthy and safe for children to play with lifelike robots, possibly at the expense of playing with other children?
- How should we interact with a group of robots that are collaborating together?

We will not answer these questions; instead, we aim to give you enough of an understanding to form your own informed judgement.

3 Conversations with computers

Increasingly, robots interact with the public as robot museum guides, robot waiters and even robot bartenders.

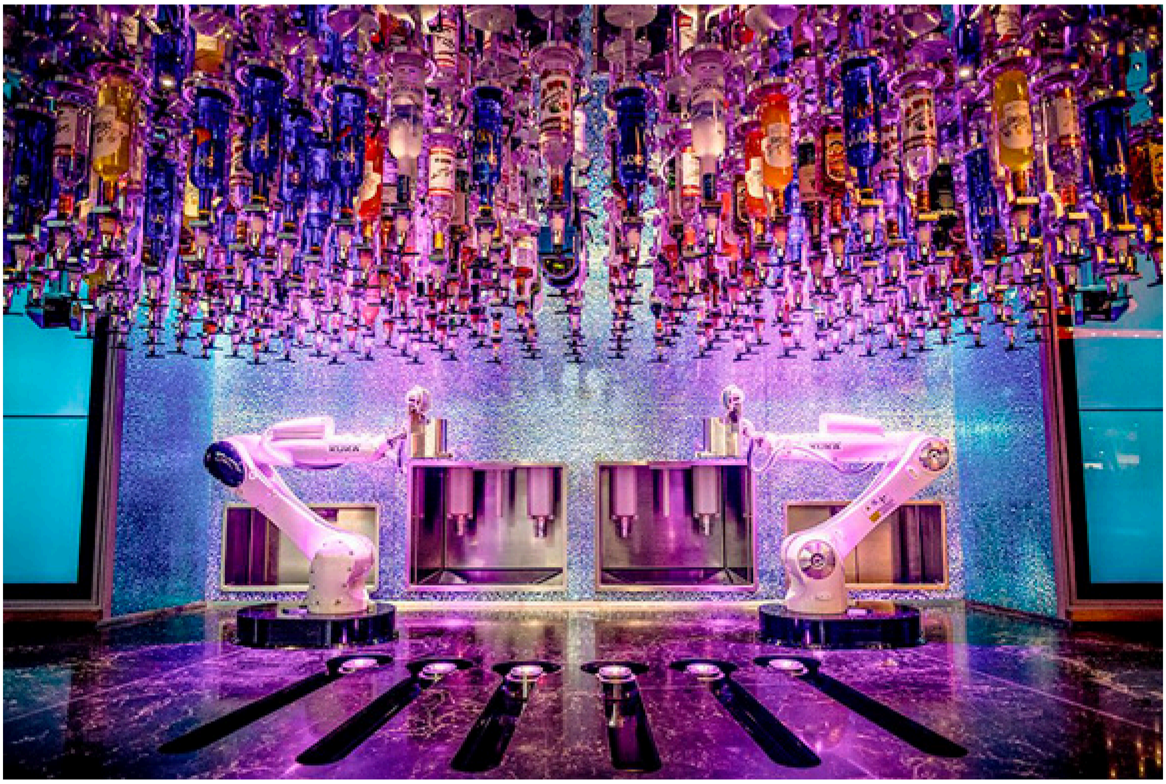

Figure 3.1 Tipsy Robot bar, Las Vegas

Show description

Given that robots are moving into these public spaces, we need to think about how we interact with them. The starting point has generally been to think about how we communicate with people – through speech. Speech recognition has improved to the point where it is commonly used in commercial systems; speech synthesisers are similarly improving.

Do you think people would find it natural to have conversations with robots? Can you imagine telling a sympathetic robot bartender all your troubles? How do you think discretion might be built in? For example, a robot bartender might make conversation along the lines of 'Pete was in here last night telling me all about his new car.' But what if it breezily said something more personal and embarrassing? How do you think it could know the difference? Would you tell a robot intimate details of your life, as you might a friend?

3.1 Eliza

Before speech recognition became so powerful, text communication was the main way of developing advances in human–robot interaction. One of the main advances in this field was Eliza – the most advanced chatbot of her time.

Eliza is a computer program that communicates in natural language as if it were a psychologist. The program was written by the computer scientist Joseph Weizenbaum in 1966. Eliza was something of a sensation when it appeared because finally there was a program that seemed to be able to hold sensible conversations.

Weizenbaum created Eliza to interact in the style of Carl Rogers (1902–1987), a psychologist who developed 'client-centred therapy', which is based on empathy rather than diagnosis and treatment. Client-centred therapists act as understanding listeners – that is, they don't give advice or interpret past events unless asked.

The following dialogue is an edited version of a conversation I had with Eliza.

Me
Hello.

Eliza
How do you do? Please state your problem.

Me
My boss is mean.

Eliza
Your boss is mean?

Me
Yes, really mean.

Eliza
You seem to be quite positive.

Me
I'm certain – she's really horrible.

Eliza
Is it because you are certain she's really horrible that you came to me?

Me
Yes, I need help.

Eliza
You are sure?

Me
Yes. She bullies me.

Eliza
I see.

Me
It makes me sad.

Eliza
Earlier you said your boss is mean.

Me
Yes. That’s what makes me sad. I should stand up to her.

Eliza
I understand.

Me
Do you think I should stand up to her?

Eliza
We were discussing you – not me.

Me
Yes, but I want your opinion.

Eliza
You seem to quite positive.

Me
Yes. Please tell me if I should shout back at my boss.

Eliza
You are sure?

Me
Yes, I can take it.

Eliza
I see.

Me
You’re not helping.

Eliza
What makes you think I am not helping?

Me
I want an opinion about my boss.

Eliza
Why do you say your boss?

Me
Because my boss is making me sad.

Eliza
I am sorry to hear that you are sad.

Me
[pause]

Yes. She sneered at me yesterday.

Eliza
You are sure?

Me
Yes. You can tell.

Eliza
I see.

Me
I wish I could sneer back.

Eliza
Can you elaborate on that?

Me
Just to get even.

Eliza
But your boss.

Me
Yes. She would hate it. Serve her right.

Eliza
I understand.

Me
I feel better now.

Eliza
Do you say you feel better for some special reason?

Me
Yes. Just thinking of sneering at my boss makes me want to laugh.

Eliza
You seem to be quite positive.

Me
Yes, it’s really funny.

Eliza
You are sure?

Me
Yes, fancy getting sad because of a stupid old boss.

Eliza
I see.

Me
I’m not going to let her make me sad any more.

Eliza
Do you think that coming here will help you not to be sad?

Me
Yes. It has helped a lot.

Eliza
I understand.

Activity 3.1 Research

Now it’s your turn to talk to Eliza. There are quite a few versions of Eliza on the Internet. Try the following website and input some text. Don’t worry if your conversation never gets off the ground, but it’s fun and instructive if you can get a dialogue going.

Eliza

Make a note of your conversation. If any part of it is particularly interesting or amusing, post it to your Cluster group forum.

Is Eliza intelligent?

Weizenbaum's creation generated a lot of interest at the Massachusetts Institute of Technology (MIT) where he worked. However, Weizenbaum did not enjoy his success because at the time Eliza's significance was generally misunderstood. The point was that Weizenbaum had shown that a machine could appear to hold an intelligent conversation, when in fact it had no intelligence: there were just simple rules matching and regurgitating the text fed into it. But people like to have conversations with Eliza, which sometimes behaves as if it were a real therapist. Weizenbaum wrote:

> I had thought it essential, as a prerequisite to the very possibility that one person might help another learn to cope with his [sic] emotional problems, that the helper himself participate in the other's experience of those problems and, in large part by way of his own empathic recognition of them, himself come to understand them.
>
> …
>
> I was startled to see how quickly and how very deeply people conversing with DOCTOR [an early name for Eliza] became emotionally involved with the computer and how unequivocally they anthropomorphized it. Once my secretary, who had watched me work on the program for many months and therefore surely knew it to be merely a computer program, started conversing with it. After only a few interchanges with it, she asked me to leave the room. Another time, I suggested I might rig the system so that I could examine all the conversations anyone had with it, say, overnight. I was promptly bombarded with accusations that what I proposed amounted to spying on people's most intimate thoughts; clear evidence that people were conversing with the computer as if it were a person who could be appropriately and usefully addressed in intimate terms.
>
> (Weizenbaum, 1976)

SAQ 3.1

Do you think Eliza would pass the Turing test?

Reveal answer

Conversational agents like Eliza are best suited to situations where the conversation can go in only one of a limited number of directions. Can you think of any conversational situations which would be closed or limited in scope?

One context that exploits a limited conversational repertoire is that of automated telephone services. How many times have you telephoned your bank or electricity company and have been asked to press a number to select the option you require? A system such as this is possible because the problem is 'closed': there are a limited number of options at any point in the conversation. To be more exact, the conversation is highly structured and can be represented using what is known as a *decision tree*.

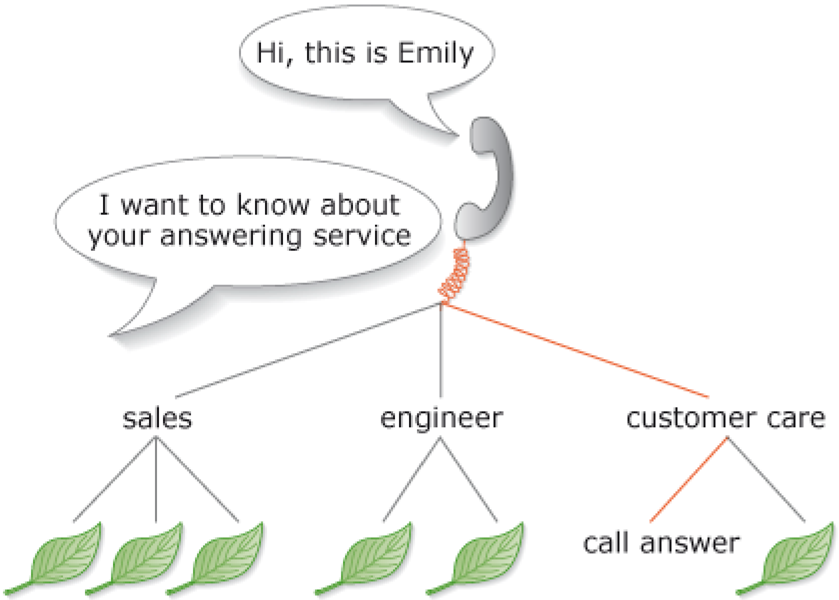

Figure 3.2 A decision tree

Show description

A decision tree is a particular sort of logical structure. The *root* of the tree is a question that has two or more possible answers, or options. Each option provides a *branch* to another question or node in the tree. Each of these questions has several possible answers, each with its own associated branch.

Take the example of an automated telephone customer management system. On dialling the customer helpline, you may be asked to 'press 1 for billing enquiries', 'press 2 to report a fault', and so on. Each of these options leads to another point in the tree. At the bottom of the tree are *leaf* nodes. These nodes are where actions might occur, such as completing a request for a billing statement, or finally getting to speak to someone. Conventionally, the root of the tree is drawn at the top and the branches flow down the diagram, with the leaves at the bottom. By designing the conversation as a tree, you can make sure that the caller will eventually reach a meaningful leaf. What you want to avoid are loops whereby the answer from one option takes you back up to a higher node in the tree ('but I just did that …').

3.2 Current uses of chatbots

While chatbots continue to be used as automated telephone customer management systems, their uses now go far beyond this, in areas of our lives we wouldn't necessarily think about.

Activity 3.2 Listen

Listen to the following podcast from the BBC about how the chatbot is one of 50 innovations that have helped make the modern economy.

> Think about your own experiences of interacting with chatbots. Do you find them frustrating as they don’t understand you, or efficient as you don’t have to observe the same manners as when interacting with a person? How much personal information would you be willing to disclose to a chatbot compared to a person?

One of the main areas in the development and use of chatbots is healthcare. This is a development from a long history of *expert systems* – computer programs that can act as experts in particular domains. Healthcare is an ideal domain for chatbots: it has a well-established boundary of evidence, scales very easily, and allows healthcare professionals to triage patients with little input from a human.

> ### Activity 3.3 Research
>
> There are many health-related chatbots on the Internet; we have decided to demonstrate the Microsoft Healthcare Bot.
>
> Visit the Microsoft Healthcare Bot. Select ‘Try a demo of an example end-user experience’
>
> Take a moment to pretend you are ill. As you talk through your symptoms with the bot, what differences do you notice compared to how you interacted with Eliza?

Given the safety-critical nature of healthcare, you have probably noted that, unlike Eliza, the Microsoft Healthcare Bot does not ask you a series of open-ended questions; having started with an open-ended question, you are likely to see a series of multiple-choice questions. Using this technique allows the designers to map out every pathway of the decision tree, ensuring that the advice being given is medically accurate.

If you think about the variety of chatbots you have conversed with, then you may find the number surprising. As different industries have moved online, they have increasingly found chatbots an efficient tool to answer questions and relieve pressure on support staff. Whether it is undertaking your personal banking, having a university companion, or ordering something through Amazon Alexa, you probably interact with chatbots more than you think.

However, this popularisation of chatbots has not been without issues. Ikea were an early innovator with the release of ‘Anna’, a virtual guide for their website. Anna was closed down in 2016 for undisclosed reasons, although customer frustrations were reported as one possible cause. Similarly, concerns have been raised by the Children’s Commissioner for England about two chatbots designed to support children’s mental health which were found to struggle with handling indications of child sexual abuse. As with many technologies, while there is enormous potential in the use of chatbots, care must be taken that they support the needs and desires of end users in a safe manner.

3.3 Computers with personality

Byron Reeves and Clifford Nass, at Stanford University, wrote *The Media Equation: How people Treat Computers, Television and New Media Like Real People and Places*, first published in 1996. The book presents a series of fascinating psychological studies which the authors argue demonstrate that humans treat media devices as though they were real people.

As an example, let us focus on synthetic voices. If you have a satellite navigation system for your car or on a smartphone, then you may be familiar with the range of synthetic voices that are commonly available today. To hear several examples of commercially available synthetic voices, try visiting the Microsoft or Google websites.

Nass discovered that people read personality into a synthetic voices even when they know that it comes from a computer:

> The present research suggests that a simple manipulation of synthetic speech characteristics to match the personality of the user, … can dramatically increase the persuasiveness of content at essentially no cost.
>
> (Nass and Lee, 2001)

In other words, it is worth a company changing the speech synthesiser to suit what the listener is likely to find friendly – a man from Edinburgh may hear a different speaker than a woman from Southend, for example.

If you are interested in Nass's research, you can find a list of his publications on his Google Scholar profile page.

SAQ 3.2

Clifford Nass says:

> It seems to be impossible for the human brain to turn off its attempt to figure out 'who is this person I am speaking to?'
>
> (Nass, cited in Hermida, 2001)

Do you think this makes the Turing test easier or more difficult?

Reveal answer

3.4 Reading the signs

When human beings interact they take in and process lots of information about each other. The gestures, body language and expressions people use when they communicate are major sources of this information. Next time you are in a crowd, look at the way people interact. Do they remain in the same position? Do their heads stay in the same place? Are their facial expressions constant?

You will probably observe that people move a great deal when talking to each other. Some people almost perform small subconscious dances, shuffling from foot to foot or throwing their arms around. Many people have a wide repertoire of expressions and use them constantly as they speak.

Robots that can express some of these cues could make human–robot interaction richer, allowing much more 'natural' interactions with people. An expressive robot could make conversation as a human does, giving the nods and smiles that keep conversation flowing, and taking turns in the way that people do. It could also express and respond to emotions.

One of the first robots developed to explore facial expressions was Kismet, shown in Figure 3.3.

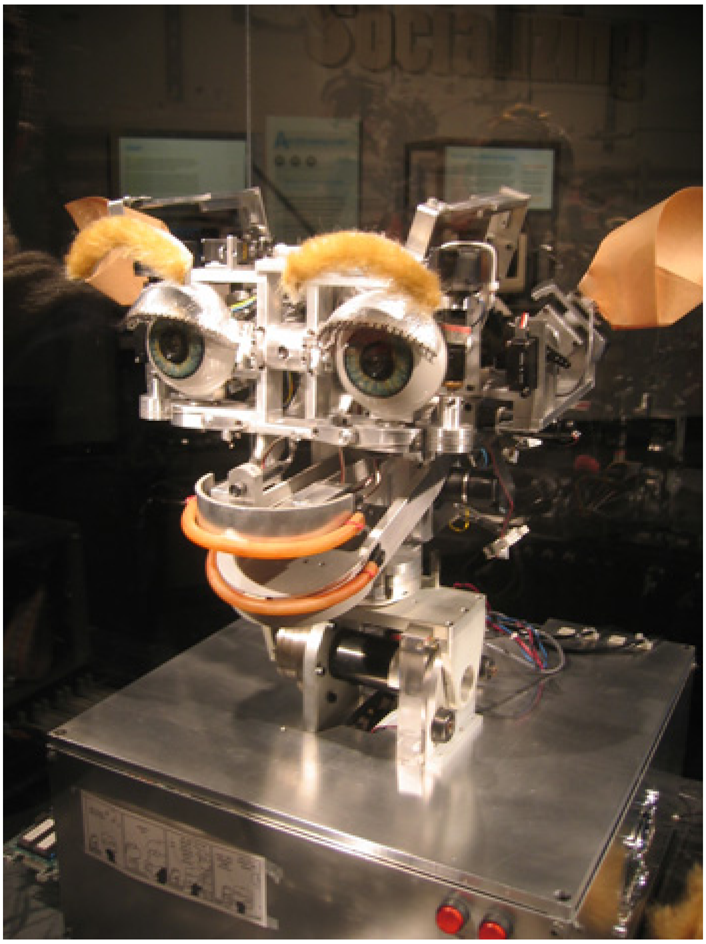

Figure 3.3 Kismet

Show description

Activity 3.4 Read

> Read the first section, ‘Social amplification’, of this description of how Kismet interacts with people (MIT, no date).

In the web page you read in Activity 3.4, there was a reference to Kismet’s ‘personal space’. When we interact with other people, there is a part of their space that we don’t enter. For example, if you put your face close to the face of a stranger then they may be embarrassed or offended and withdraw. Do you think robots have any need for personal space like this? Or is this just something that has to be programmed in to keep humans happy?

Progress in the development of affective robots has been startling. Sophia, pictured in Figure 3.4, is a more recent example of a robot that expresses emotions. Developed by Hanson Robotics, Sophia can make 60 facial expressions including smiling, frowning, displaying amusement and even scowling and sneering. While some experts have criticised the hype surrounding Sophia, particularly with regards to how advanced her AI systems actually are, her ability to display emotions is widely recognised.

Figure 3.4 Sophia

Show description

Robots such as Kismet and Sophia show that it is possible to create robots that can display emotions. In fact, building a robot that can display emotions is a relatively easy task since we are so adept at recognising expressions in simplified images – think of a cartoon. Kismet and Sophia have expressive faces even though they are no more than caricatures. What is more contentious is whether a robot can actually have an emotional state, which would require a state of consciousness. Certainly with technology as it currently stands, a conscious robot that can experience feelings rather than emulate them is many years away.

Getting a robot to recognise the emotional state of a person is challenging: humans have very expressive faces which can signal a range of subtle emotions. There is a standard coding system, the Facial Action Coding System (FACS) produced by psychologists Ekman and Friesen (1978), by which any facial expression can be encoded by a trained observer. Some progress has been made on equivalent computer analysis. Simply recognising faces in an image is now relatively straightforward as a result of research into surveillance and also into consumer photography (many smartphone cameras now recognise faces to focus on them). This allows computers to identify the main features – eyes, eyebrows, mouth – and track their positions, and thus can make FACS encoding possible. But the FACS system identifies 32 ‘action units’ (which roughly correspond to some particular facial muscle) and 16 changes in head orientation and gaze. Their combination leads to a very large number of possible expressions, each of which would need to be mapped to an emotional state.

There are increasing numbers of commercial companies that offer emotion recognition. A review from 2021 identified several ways in which such technologies might be adopted. While useful, this is a long way from the deep understanding of emotions that humans have.

3.5 Anthropomorphism

Perhaps one of the most important factors that influences the way we interact with computers and robots is the extent to which we expect them to behave – or interpret them as behaving – in a human-like way.

As mentioned in Section 2, anthropomorphism (from the Greek *anthropos* – ‘human’, and *morphe* – ‘form’) refers to the way we ascribe human qualities to objects or other living things. This is perhaps most noticeable with pets. For example, people often ascribe personality traits to their pets, describing them as happy, loving or mischievous, all of which are human characteristics. Pet owners often give their pets names that could easily be a person’s nickname, and often treat a pet as a member of the family.

Anthropomorphism does not just apply to pets. For example, how many times, perhaps when you are programming, have you screamed ‘you stupid thing’ at your computer, when your code has done something wrong or unexpected?

Humans use theory of mind to predict the behaviour of other people, which might explain why we are led to anthropomorphise things around us. We try to understand these things on our own terms, in our own likeness or as caricatures of ourselves. Thus anthropomorphism suggests that we have expectations about the way things behave that are often couched in human terms.

As robots take on more explicit human features – a humanoid form, a face that displays human facial expressions, eyes that track us around a room – then it becomes easier to ascribe ever-more human characteristics to these machines. We also raise our expectations about how robots interact with us, and this in turn may influence the way in which the technology evolves, and the techniques researchers and technologists develop to allow us to interact with robots.

The uncanny valley

It would be easy to expect that the more lifelike a humanoid robot becomes, the more comfortable humans would feel when interacting with them. However, Masahiro Mori (2012 [1970]) suggested that the emotional response of humans to robots might be more complex than that. His argument can be summarised in the following graph.

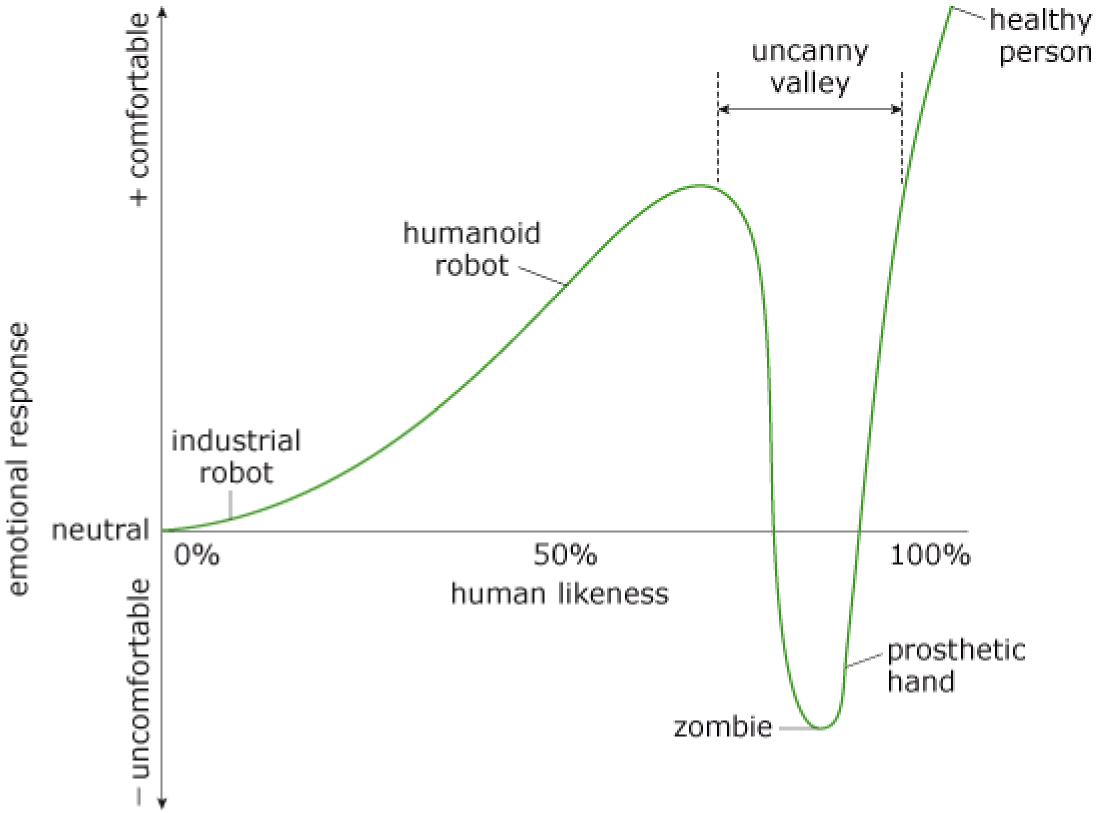

Figure 3.5 The uncanny valley

Show description

The more human-like a robot appears to be, the more positive the emotional response of the observer, and the more comfortable we feel interacting with it. However, when the robot looks nearly human, the observer can be unnerved by an appearance that is lifelike but wrong in some subtle respect. The positive feelings are suddenly lost and may even be replaced by revulsion. Mori called this the ‘uncanny valley’ effect; it has also been called the ‘zombie effect’.

Mori introduced this idea in the 1970s when robots were not very lifelike at all. Despite the huge progress that has been made in developing more lifelike robots, many people argue that no robot has yet been developed that does not sit within the uncanny valley.

Activity 3.5 Watch

Watch this clip from the BBC series *Hyper Evolution: Rise of the Robots* of an interview with Professor Ishiguro’s robot Erica.

Do you think the interview demonstrates the uncanny valley? How did you feel while watching the interview?

Reveal discussion

You may also be interested in visiting Hiroshi Ishiguro's robotics lab website.

4 Healthcare robots

One of the best ways of illustrating the many different ways of interacting with robots is to explore current robot systems. We have chosen to focus on health-related robots, as the range of different functions these robots perform demonstrates the wide range of potential interactions.

If you think back to the discussion on chatbots we had earlier in this topic, you should realise that we have already encountered a text-only interaction. Discussing your health concerns with a chatbot in order to receive health advice was an interaction driven entirely through typed text.

This is a relatively constrained problem. The majority of health-related tasks we would like robots to help with occur in the physical world, requiring richer interactions. For example, as the population ages, robots are being seen as a possible solution to the problem of caring for older people. The intention behind most of these robots is not to replace human carers, but to remove the mundane repetitive aspects of caring so that a human carer can focus more on tasks that are more meaningful and socially relevant to the person being cared for.

Some research has suggested that robots can be particularly valuable to children who have special educational needs. Providing the assistance that these children need is challenging.

Robots can be non-judgemental, can be available all of the time and will not get bored with completing repetitive tasks.

Activity 4.1 Watch and discuss

The following two clips are from the BBC documentary *Six Robots & Us*. The clips demonstrate two households trialling different robots, both of which have similar interaction abilities.

The first clip is about Carebot from the University of Salford. Neil and Linda are trialling the use of Carebot. Linda has chronic MS, making her constrained to her wheelchair. Linda has very little independence, and Neil struggles to leave the house. Carebot is a prototype assistant that can recognise voices, provide medication reminders and call an ambulance in an emergency.

The second clip focuses on TutorBot, a NAO robot that has been programmed by the University of Westminster to help children with special educational needs. Isaac has got a learning delay, affecting his speech, reading and concentration levels. This has caused Isaac to have confidence issues. TutorBot uses speech and facial recognition, and speech output to try to help improve Isaac’s confidence.

Spend ten minutes thinking about the approaches to interaction taken by the designers of Carebot and TutorBot. Would you change how they interacted with their users? You might like to think about:

a. the purposes the robots were designed for
b. the practicalities of using those interaction techniques in the real world.

Discuss your ideas with others in your Cluster group forum.

Similar to Carebot, the development of nursing robots has focused on non-clinical tasks such as gathering supplies or delivering lab samples. Diligent Robots have developed Moxi to achieve these tasks, allowing nurses to focus more on patient needs.

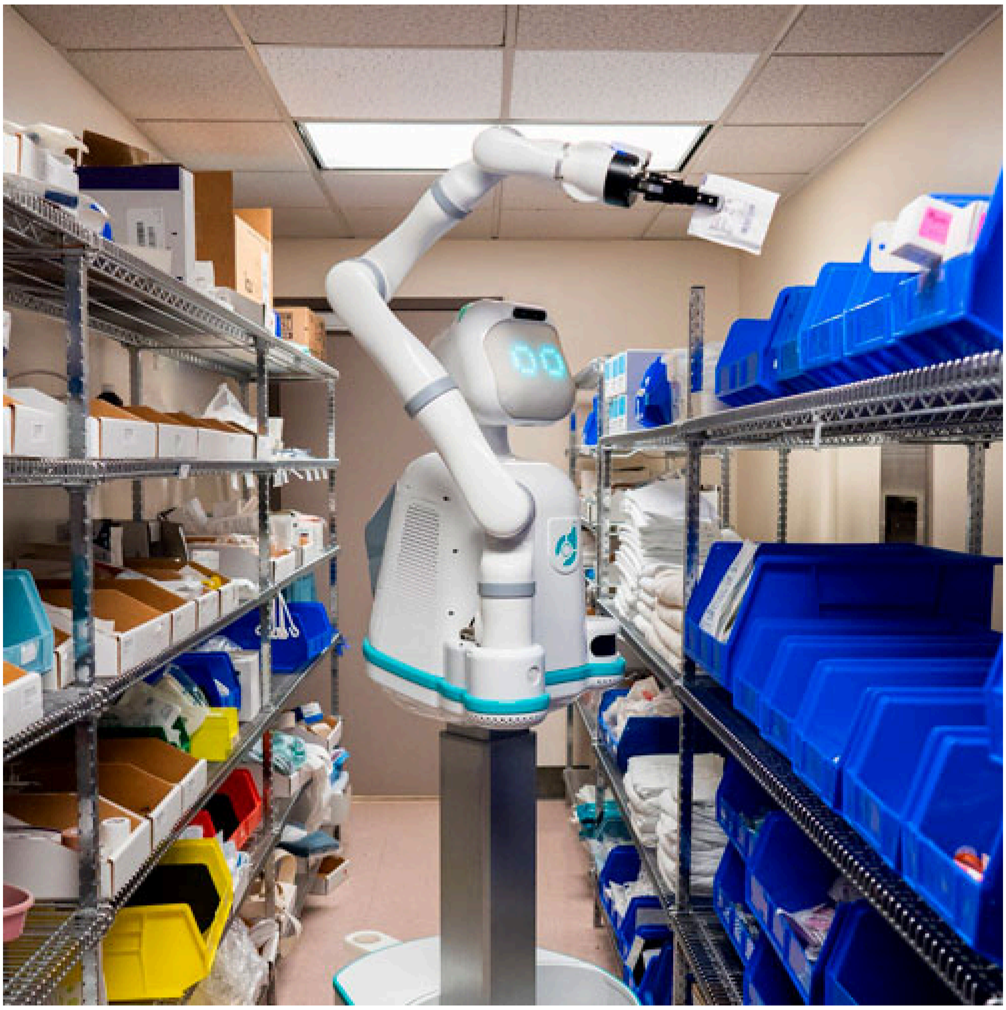

Figure 4.1 Diligent Robotic's Moxi robot

Show description

Exact details of how nurses interact with Moxi are hard to establish, but they appear to be similar to Carebot: primarily verbal inputs, supplemented with an app to help teach Moxi specific tasks.

Not all robots require such a large amount of interaction. The classic example is probably Paro – a robotic seal for people with dementia. The intention was to provide patients with something to care for and which could help sustain social interaction while creating a sense of purpose and joy amongst users. Unlike a real pet, Paro will not come to any harm if a patient forgets to look after it.

Figure 4.2 Paro, the robotic seal

Show description

The interaction features are relatively minimal. Paro has some speech recognition and is meant to be able to recognise its own name. Paro coos and moves its head in response to being spoken to or petted. Even with this minimal set of interactions, some studies have found that Paro can reduce stress amongst users (Aminuddin *et al*., 2016).

Moving from a simple set of interactions to a highly complex set of interactions, some forms of surgery are increasingly making use of robots. The da Vinci robotic surgery system from Intuitive is currently probably the most popular robotic surgery system.

Figure 4.3 The da Vinci surgeon console

Show description

The da Vinci surgery system consists of many parts. Our focus is more on the surgeon console (shown in Figure 4.3) which allows a surgeon to control the robot that is performing the surgery.

The console allows the surgeon to see what the da Vinci surgical unit can currently see through the viewing area at the top of the console. Of more interest are the two complicated-looking hand controls, with multiple degrees of freedom. These allow the surgeon to control the movements of the da Vinci surgical unit. This is the first example we've presented where the robot is being directly controlled by an individual, and is controlled through physical movement (sometimes referred to as *haptics*, which uses the senses of touch and motion).

Haptics is being increasingly used as a means of human–robot interaction. This is partially due to an increase in our understanding of how to engineer haptic technologies, and partly due to an understanding that some physical movements are essential for some of the tasks that we are asking robots to complete.

Physical therapy is a necessary step in recovery for many medical conditions. Sometimes this requires a person to make repeated movements which are uncomfortable – for example, if a person has broken their arm, then they may need to make certain movements with their arm to regain full use of it. While exercises are provided by trained physiotherapists, generally patients are left to complete these exercises on their own.

To assist with this, researchers at Ben-Gurion University of the Negev in Israel have developed a robotic arm that will play tic-tac-toe (noughts and crosses) on a vertical board, forcing patients to make upper body movements to play the game. You can read more about the robot, and see a video of it working, in this article from the *IEEE Spectrum* magazine (Ackerman, 2018). The tic-tac-toe robot is an interesting case study as the interaction between the robot and the human is so minimal: the robot primarily uses a haptic output (the movement of the cup) as a signal to the human that it is their go; other than that, there is little communication.

Staying with the theme of therapy, you may be familiar with electronic wheelchairs that provide mobility for people who cannot walk. Fascinating progress is being made to move beyond this. Human exoskeletons are artificial skeletons worn by individuals to support them. We are now at the point where researchers have developed an exoskeleton that allows a person to move all four of their paralysed limbs using an implant in their brain.

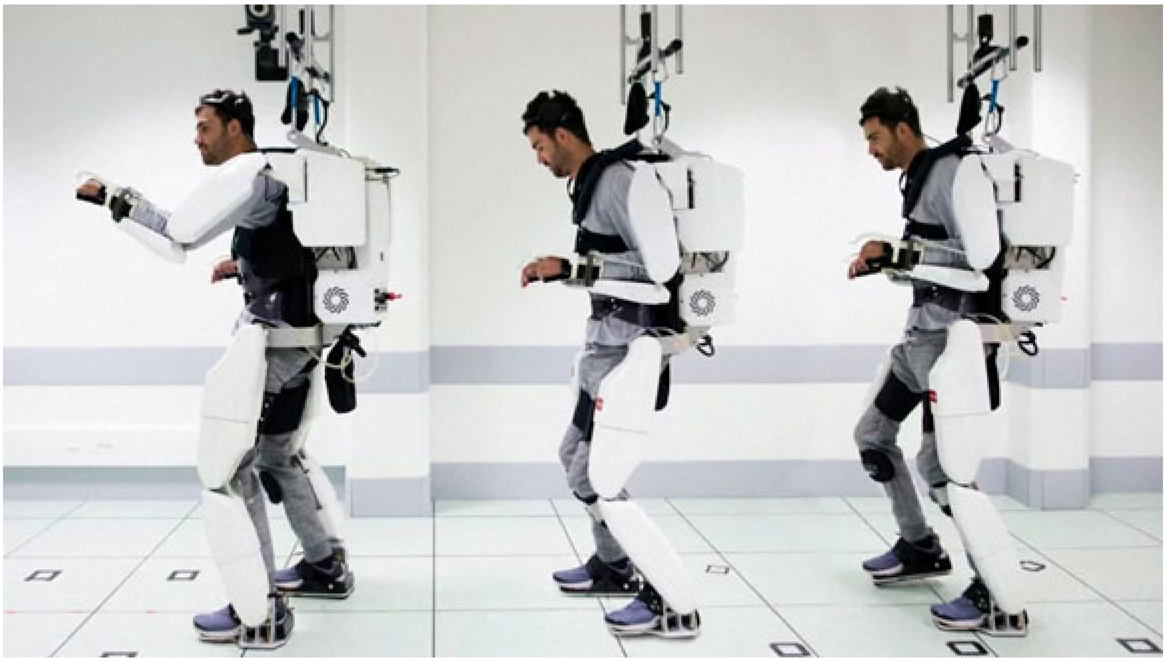

Figure 4.4 A mind-controlled human exoskeleton

Show description

You can read more about this research in this BBC article (Gallagher, 2019), or consult the journal paper in the *Lancet* (Benabid *et al*., 2019).

This is an excellent example of a brain–computer interface. In this particular example, the man has had two implants placed on the surface of the brain. These implants monitor brain activity then send them to a nearby computer where they are processed into movements for the exoskeleton. Other methods for monitoring brain activity for use by computer systems exist, including externally-worn caps. However, the long-term applications for many of these interfaces – which are commonly used for mobility systems – means surgical solutions provide an interface that can be used while the mobility system remains useful.

Activity 4.1 Research

The robots we have discussed in this section have generally used three of the main human senses – touch, vision and sound.

Spend 30 minutes exploring the IEEE robotics website or other websites, looking for examples of robots that use the other two main human senses – taste and smell. Do not feel constrained to looking only at robots being used to support healthcare.

If you find an interesting example that is not in the Robopedia wiki, please add a short page describing it.

5 Open questions in human–robot interaction

The field of human–robot interaction is relatively new, so many questions remain open. Some problems are inherently hard to understand and solve; others emerge as new robots are developed for unanticipated application areas. Here are some of the broad areas where research questions are currently being asked:

Methods for exchanging information between humans and robots

Interaction requires both parties to be able to exchange information. In human–robot interaction, this can involve robots perceiving humans or humans perceiving robots. While some of the basics have been established – particularly in the area of speech recognition – many areas remain under-explored. Whether it is robots having a better understanding of non-verbal signals (such as gestures), or developing more refined models of robotic eye gaze, this area of research will continue to develop.

This will have applications in all areas where humans and robots interact, including everything from autonomous vehicles better understanding the social signals of human drivers through to people being able to monitor industrial robots more effectively.

Long-term impact of healthcare robots

As we have discussed in Section 4, affective robots have been an area of great promise for healthcare. Areas where pilot projects are ongoing range from companion robots for the lonely, assistive robots for children with special educational needs and home-help robots.

In each of these cases we remain in early days, and much more research is needed to understand how such robots might operate at scale in the real world. Outstanding questions remain as to the long-term effectiveness of the robots, how to customise them to best fit with the individual needs and preferences of their owners, and how adaptive the robots are as an individual's needs change over time.

Coordination between humans and robots

The coordination and collaboration of complex social activities requires an understanding of the goals, abilities and communication patterns of everybody involved. This is not trivial: how to best design technology to support coordination and collaboration between *people* is a huge area of research; imagine how much harder it is for humans and robots to collaborate together.

One of the big open research questions is exploring how to better use mental models in human–robot interaction. For our purposes, we can understand mental models as what a person understands about someone they are working with – including what they think their collaborator is thinking and what their collaborator knows. (We referred to theory of mind in Section 2.) If two people are trying to work together but have different mental models, then the outcome is rarely positive. Research in human–robot interaction is exploring how to improve the mental models that robots have of their human collaborators. Another avenue of research is how to communicate to humans what their robot collaborator is thinking. Both of these areas need to improve if humans and robots are to collaborate more effectively.

Group interactions

As a final point, during this topic we have mainly considered a single human interacting with a single robot. Of course, the world is more complicated than that. One person may be trying to interact with a whole host of robots (such as a drone swarm, or the assorted robots in a smart home). Alternatively, a group of people may be trying to interact with a single robot (such as in robot-assisted surgery, or in a classroom). In either case, much more research is needed to better understand how to structure the interaction between groups of humans and robots.

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 3 we have looked at human–robot interaction and at robots that display human emotions. We have explored a number of example robots in the context of healthcare, demonstrating the wide variety of interaction techniques, and how different modalities (e.g. touch) can be used in different ways for different purposes. We finished this topic with a brief look through some of the bigger open questions around human–robot interaction which are likely to be the main focus of research over the next few years.

I hope you appreciate what a tremendous range of ideas we have covered. You aren’t expected to remember the detail of everything that you’ve read: but you should recognise that robotics covers many different areas of specialist knowledge, from robot mechanics to the human mind.

Where next

This is the end of Topic 3.

Topic 4 examines how relationships between humans and robots may change in the future, and the implications this has.

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Further Reading

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