12

The Future

What is covered in this chapter:

- Current attitude of the general public toward robots and how this may change in the upcoming years;
- Possible shifts and developments in the nature of human–robot relationships, specifically companion bots;
- Further development of the technology of human–robot interactions (HRI), specifically artificial intelligence (AI);
- The inherent issues with predicting the future ("crystal ball problems").

As with other technologies that have become commonplace in everyday use, such as personal computers, smartphones, or the internet, we expect robots will sooner or later become assimilated into society. They may even be accepted into our personal, and even intimate, spaces. Robots are currently being designed to be co-workers, tutors, and assistants in the medical field and to provide services in care settings, in education, and in people's homes. Sony, evidencing the renewed interest of the company in social robots, has recently released a new AIBO robotic dog (see Figure 3.2).

Technological advancements make this vision increasingly conceivable but are not sufficient to ensure a rosy future in a society equipped with robots. Recent polls in the United States and Europe suggest that the broader public is not very willing to accept social robots for everyday use, particularly in areas such as eldercare and other socially assistive and interactive applications (Smith, 2014; European Commission, 2012). Human–robot interaction (HRI) studies have also shown that people report high levels of robot anxiety and other negative attitudes toward robots and a low willingness to interact with robots in their personal space or workplace settings (Reich-Stiebert and Eyssel, 2013, 2015).

One solution to this issue may be to just wait it out. As technology advances, people will have more opportunities to interact with robots and may become more accepting of them through that exposure. As we mentioned in our discussion of nonverbal cues, direct interaction with

This material has been published by Cambridge University Press as Human Robot Interaction by
Christoph Bartneck, Tony Belpaeime, Friederike Eyssel, Takayuki Kanda, Merel Keijsers, and Selma Sabanovic.
ISBN: 9781108735407 (http://www.cambridge.org/9781108735407).

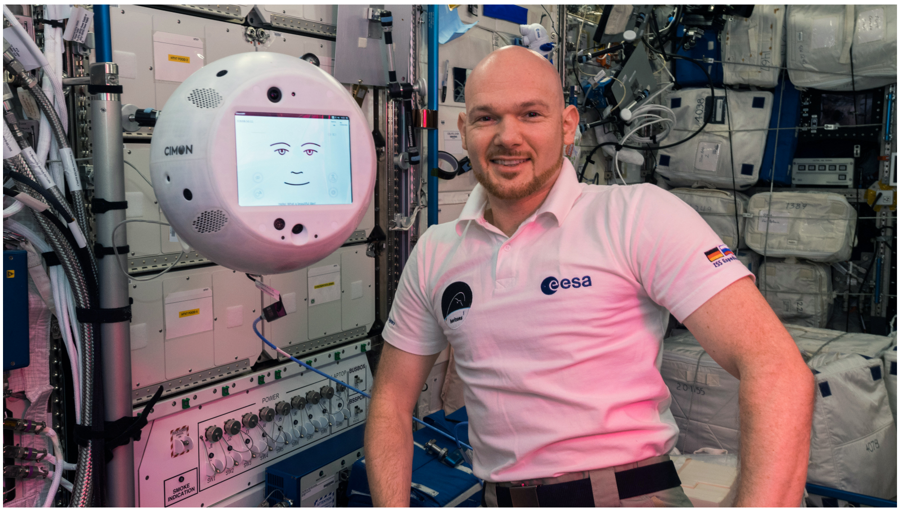

Figure 12.1 The Cimon robot (2018–present) assists astronauts on the International Space Station. (Source: National Aeronautics and Space Administration)

members of another social group—in this case, robots—changes attitudes and decreases anxiety related to that group (Crisp and Turner, 2013; Pettigrew et al., 2011). Wullenkord (2017) showed that just imagining collaborative interaction with a Nao robot prior to actually interacting with it improved attitudes and reactions toward the robot and increased the perceived quality of the interaction. We can therefore expect that as people have increased contact with robots, be it directly or through the media, attitudes will grow more positive, and the willingness to use robots will increase over time.

As we have seen in the rest of this book, however, advances in HRI research can significantly speed up this process. By better understanding the sources of people's concerns about robots and the types of societal needs and desires that robotic capabilities can address, we can create interactions that will be positive and beneficial to people, which can lead to a positive feedback loop for familiarizing people with robots and create more support for the broader adoption of new robotic technologies.

We also need to consider that the media frequently portray robots negatively or unrealistically. For example, there has been much talk of robots, instead of people, looking after those in need of assistance in our aging societies. This is not a pleasant thought for many, who are reasonably concerned by the wide-ranging implications of this scenario for HRI and, more fundamentally, for human–human relationships. The way this future scenario is portrayed by the media, however, is unrealistic. This manner of framing robotics in society creates fear in the general public and distracts us from the work we need to do and the choices we need to make to create our preferred future.

Facilitating an open mind about novel developments in technology and science might be a step toward achieving a more positive view and

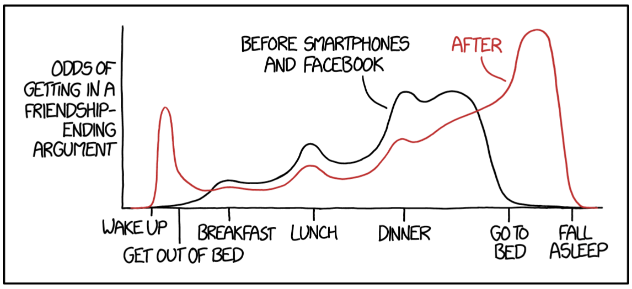

Figure 12.2 Odds of getting into a friendship-ending argument before and after the introduction of smartphones. (Source: XKCD)

a stronger sense of acceptance by the general public. These changes can only be observed through longitudinal studies, and HRI scholars must work together with the communities they seek to serve to consider how technological developments can come together with societal structures to produce positive change. There is no quick "technological fix" for societal problems, such as demographic change. Besides developing much-needed technologies, it is also crucial to take on a human-centered approach that focuses on the actual psychological, social, and emotional needs of the people using and being affected by robots. A more human-centered view coupled with technological advancement will together create robust and socially appropriate robots that can benefit us all.

12.1 The nature of human–robot relationships

When waiting to check in at the airport, a machine handles the check-in process. In Japan, Pepper robots greet us when we enter a bank or a shop. When care is provided mainly by machines rather than humans, this has strong implications for the development and maintenance of human relationships. Even currently, some technologies, such as social networks and online games, have resulted in less direct contact between people. Instead of writing letters or meeting in person, people communicate via posts on Facebook. Our patterns of when we talk to whom about what are changing (see Figure 12.2), as are the ways we begin and end our romantic relationships—by smartphone. Robots may contribute to further estrangement among people, as is argued by Turkle (2017), or robots could be designed to support and even increase interaction among people. This effect has been seen with the seal-like robot Paro in a day home, in which older adults ended up meeting and talking more to others when the robot was put in a public space (Wada and Shibata, 2007).

Clearly, as social robots and artificial intelligence (AI) are developed further, they will likely play an increasingly larger role in our everyday lives and society. Because the nature of human–robot relationships is a product of the robots' capabilities and the users' preferences, these developments are inevitably tied to the question of what issues we consider ethical and desirable to address with robots and AI.

For example, one major societal issue at the moment is loneliness. Feeling socially connected to others has an almost incredible list of benefits for individual mental and physical health (Vaillan, 2015). This will become increasingly relevant as the populations of developed countries continue to age in the upcoming decades. An increasing part of the population is in need of care, not just for attending to their physical needs of feeding, bathing, and clothing but for emotional care as well. It might be that the younger generations are neither willing nor competently able to serve these dual needs on their own. Particularly, the emotional needs of seniors or people with cognitive or physical impairments have to be taken into account, but all people are in danger of growing more and more lonely and disconnected (American Osteopathic Association, 2016).

The lack of social connection can have serious impacts for our psychological well-being and health. The "need to belong," a key motivation of human nature (Baumeister and Leary, 1995), can easily become frustrated. To illustrate, research by Eisenberger et al. (2003) has shed light on the neuroanatomical underpinnings of reactions to social exclusion, whereas Williams (2007) has documented the negative social consequences of exclusionary status. That is, when the need to belong is violated, people feel a lower sense of belonging, self-esteem, and control and even regard their existence as less meaningful than when their inclusionary status is not under threat. In addition, the risk of developing Alzheimer's disease is doubled in lonely people compared with socially connected individuals, and loneliness is a predictor of a decline in cognitive abilities (Shankar et al., 2013). In light of the detrimental effects of loneliness on quality of life and psychological and cognitive functioning, robots could play an important role in mediating these effects.

Figure 12.3 Not everyone is charmed by the idea of strong AI. The late theoretical physicist Stephen William Hawking, and the inventor and engineer Elon Musk are both vocal critics against the development of strong AI.

A few commercial start-ups have been offering artificially intelligent "companions," although so far with only modest success, such as Gatebox's Living With Project. If AI and robots are developed to the point where they can reliably imitate human interaction patterns, they could be extremely helpful in relieving feelings of boredom and loneliness.

What remains to be seen is how comfortable people are with the different potential roles that AI may take on. As the quest for strong AI continues, the question of whether such an AI is desirable is being raised on a daily basis. Whereas the most spectacular version of this question considers how we can ensure that such an AI would remain benevolent to the human race, it is at least as interesting to consider the issue of whether people would be comfortable with handing over power in the first place. Assume that strong AI is developed, the sole purpose of which is to enhance the well-being of society while adhering

This material has been published by Cambridge University Press as Human Robot Interaction by
Christoph Bartneck, Tony Belpaeime, Friederike Eyssel, Takayuki Kanda, Merel Keijsers, and Selma Sabanovic.
ISBN: 9781108735407 (http://www.cambridge.org/9781108735407).

to a set of rules that keep it from harming humans (e.g., Asimov's Laws of Robotics; see Section 11.2). Can one throw out of the window all the doubts about self-interest, bias, and hidden political agendas that arise with human leaders and, instead, fully trust that the AI would take proper care (see Figure 12.3)? Would users agree with such a setup?

This is an important point in robot and AI development. Just as we ask ourselves, "Just because we could, does that mean we should?" to balance out all the rational possibilities with moral and ethical skepticism, the reverse, "Just because we should, does that mean we would?" holds true as well. Robots are logical, but humans—the people who create robots—are not. Simply because something might be beneficial from a logical point of view does not mean that people are comfortable with it.

12.2 The technology of HRI

HRI is lifted on the tides of technological progress. New sensors and actuators and continuous developments in AI are quickly adopted into HRI applications. Given the steady progress in AI and its applications, there is every reason to believe that a number of technological problems that currently still require the smoke and mirrors of Wizard-of-Oz (WoZ) control will soon be delivered autonomously by the robot.

Progress in HRI is not so much held back by a lack of development in robotic hardware but, rather, by a lack of progress in autonomous control and AI. A testament to this is the ability of human operators to hold a meaningful interaction through a robot. It is clearly not the limited view through the sensors and the limited expressivity of the actuators that hinder the interaction. Rather, it is the artificial cognition—substituted by real cognition in the case of WoZ control—that is lacking. There is, of course, room for improvement in robot hardware: the speed and power of actuators need work, and the energy autonomy of robots needs to improve drastically. Furthermore, robotics and social robotics in particular have always taken a "Frankenstein approach" to hardware, building robots from whatever technology is readily available rather than developing radically new hardware solutions. But at this point, breakthroughs in HRI are most likely to come from progress in robot control and AI. Machine learning holds considerable promise here. However, there are fundamental barriers to the use of machine learning in HRI. Because machine learning requires vast amounts of annotated data and computational time, it comes to its own in domains that allow offline learning and for which huge amounts of training data are available or, when not, can be generated. Although there is plenty of human interaction going on in the world, these interactions run in real-time. As opposed to machine learning of the game of chess or Go, where the learning can run as fast as computers will

This material has been published by Cambridge University Press as Human Robot Interaction by
Christoph Bartneck, Tony Belpaeime, Friederike Eyssel, Takayuki Kanda, Merel Keijsers, and Selma Sabanovic.
ISBN: 9781108735407 (http://www.cambridge.org/9781108735407).

allow, machine learning of HRI strategies inherently runs online. No matter how fast the computer is, the interaction pace is dictated by the human interaction partner, and the evaluation and updates of the machine learning will run in "human time" rather than in computer time. One solution for facilitating machine learning for HRI might be to use more robots and data from more interactions: pooling interaction events could be a solution to the dearth of HRI data and could speed up the evaluation of learned interaction strategies. It is unclear what the next technological breakthroughs will be in AI and robotics, but one thing is clear: HRI will readily absorb them.

12.3 Crystal ball problems

Predicting the future is hard to do, and especially in the field of HRI, it seems as if every stance imaginable is defended with passion by a small army of experts (and a large group of those wishing to be experts), ranging from doomsday predictions to nirvana forecasts. It proves to be nearly impossible to gain consensus on the far future of HRI and even on small and concrete predictions of how long it will take to develop a specific capability or what we actually want from a robot. Here, it is fitting to mention two predictions related to developments in HRI that have not panned out as expected.

First, we can perhaps take some lessons from developments in AI, which have been rapid yet unable to adhere to initial expectations. When the fundamentals of AI were developed in the 1950s, it was expected that strong AI could be designed within the upcoming decade (McCorduck, 1979; Russell and Norvig, 2009). Half a century later, AI still struggles with understanding human sentences. As long as the rules of a behavior are strict and can be operationalized, AI can keep up with humans easily and often even outsmart them. This was famously shown by the Deep Blue computer program beating the human world champion Kasparov in a game of chess in the late 1990s (Campbell et al., 2002). The recent victory of an AI over the world champion on a game of Go (Murphy, 2016) was considered a milestone because Go is more complex and has a larger emphasis on strategics, whereas chess is more tactical and has a less extensive set of possible ways to win.

Similarly, the world has seen a sharp increase in the number of start-ups and initiatives for new social robots. A popular way of obtaining funds for these kinds of projects is through crowdsourcing because many people prove to be willing to invest. They predict that the robot will be a success. However, for some reason, few of the funded projects actually take off. Usually, they start up, continue for a year or two, and then die out. This raises the question of whether humans are capable of realizing what they want from a robot. Obviously, even when we think some social robot is a brilliant application for an everyday problem,

This material has been published by Cambridge University Press as Human Robot Interaction by
Christoph Bartneck, Tony Belpaeime, Friederike Eyssel, Takayuki Kanda, Merel Keijsers, and Selma Sabanovic.
ISBN: 9781108735407 (http://www.cambridge.org/9781108735407).

when we actually get the robot, we are not quite as sold as we were on the idea. Although, as we've shown in this book, there are people from many different fields involved in developing robotic applications for society, we would likely benefit from expanding the range of perspectives that participate in discussion and decision-making about the kind of future we want with robots.

These two examples of predictions gone wrong may, of course, be part of the whole problem of expectation management and the tendency of users to overestimate what robots are capable of. But in addition, the second example indicates that humans are adept at predicting how much they would like to have a robot for certain tasks. We imagine robots taking over all kinds of jobs, but it remains to be seen in which areas we prefer the (messier) human way of doing it.

Questions for you to think about:

- Which technological developments, and related social developments, have surprised you the most in your lifetime?
- What kind of future would you want to see with robots? What kind of future would you be afraid of or concerned about?
- How much time do you spend interacting with people face to face versus in mediated environments (e.g., Facebook, conference call)? What about nonhuman agents—do you interact with them at all? In what circumstances and how much?
- Who is caring for your grandparents or parents? What kind of community do they live in? Do you live close to them? Who do you think will take care of you in the future? What kind of community might you find yourself living in?

Further Reading:

- Future of Life Institute. An open letter—research priorities for robust and beneficial artificial intelligence, January 2015. URL `https://futureoflife.org/ai-open-letter/`
- Illah Reza Nourbakhsh. *Robot futures.* MIT Press, Cambridge, MA, 2013. ISBN 9780262018623. URL `http://www.worldcat.org/oclc/945438245`
- Daniel H. Wilson. *How to survive a robot uprising: Tips on defending yourself against the coming rebellion.* Bloomsbury, New York, NY, 2005. ISBN 9781582345925. URL `http://www.worldcat.org/oclc/1029483559`
- Jo Cribb and David Glover. *Don't worry about the robots.* Allen & Unwin, Auckland, New Zealand, 2018. ISBN 9781760633509. URL `http://www.worldcat.org/oclc/1042120802`

This material has been published by Cambridge University Press as Human Robot Interaction by
Christoph Bartneck, Tony Belpaeime, Friederike Eyssel, Takayuki Kanda, Merel Keijsers, and Selma Sabanovic.
ISBN: 9781108735407 (http://www.cambridge.org/9781108735407).