

Robotics and artificial intelligence

A response to the House of Commons Science and Technology Committee inquiry into robotics and artificial intelligence

April 2016



This evidence is submitted by the Royal Academy of Engineering and has been compiled with the input of our Fellows working in relevant fields. As the UK's national academy for engineering, we bring together the most successful and talented engineers from across the engineering sectors for a shared purpose: to advance and promote excellence in engineering.

Key messages

1. While it is convenient to position robotics and artificial intelligence (AI) together, they are different topics utilising different technologies and will develop at different rates. Although both AI and robotics can, and probably will, be used together, combining them poses challenges that make policy impact difficult to predict. Both may be interdependent but this response does not use the terms interchangeably.
2. It is difficult to imagine a sector, technology or part of public life that will not be affected by robotics and AI. The Academy would welcome continued support by government and the encouragement of leadership across the UK to help maintain UK competitiveness.
3. The key implication for the UK workforce is the need for a shift in the skills base. Productivity is likely to increase as technologies are introduced to both manufacturing and service industries with the need for human users to manage and collaborate with them. Robotics and AI could provide new employment opportunities by opening up new fields of activity. The Academy would like to see government taking a role in preparing and supporting a shift in the skills base to ensure that new employment opportunities are exploited.
4. AI systems, including robots, will only function in very narrow areas for the foreseeable future. Some members of the public will continue to have misconceptions on how narrow that expertise is, and will be tempted to overestimate it. Ongoing dialogue with the public by government, supported by industry and academia, will be essential for the public acceptance of robotics and AI technologies.
5. The Academy has previously looked at robotics and autonomous systems in its 2009 report [Autonomous systems: social, legal and ethical issues](#). While robotic and AI technologies may have progressed, many of the social, legal and ethical issues raised in the report are still relevant. In 2015, the Academy held a conference looking at [Innovation in autonomous systems](#).
6. A clearer timeline may be needed to address each question. The response below reflects on the 2020 horizon. If looking beyond 2020, further issues could be raised.

The implications of robotics and artificial intelligence on the future UK workforce and job market, and the Government's preparation for the shift in the UK skills base and training that this may require.

Workforce and job market

7. Often seen as a normal part of commercial and industrial progress, robotics can represent a threat to some current jobs. Historically, the use of robotics reduces the need for traditional manual skills and replaces it with the need for systems management skills as, in all but a few cases, human oversight will be required. The opportunities for employees to work with new technologies and the creation of new jobs will depend on the design of the new technologies and their human-machine interfaces, and retraining of staff.
8. Some traditional jobs may be replaceable by autonomous systems; however, new robotics and AI technologies have the potential to increase productivity providing companies with a competitive edge and allowing them to grow. New technologies will also bring about new employment opportunities compare, for example, the fact that the computer could have been seen as a replacement for human activity and a threat to employment yet it has created whole new industries such as the successful gaming industry in the UK.
9. Additionally, robotics will allow activities to be undertaken that are either too dangerous or too difficult for people. The result, if properly supported, could be to increase employment opportunities through new businesses. SMEs have been created to exploit small drones for commercial activities from agriculture to filming. These are not substitution activities but have come out of being able to do things from the air that previously would not have been considered due to cost or danger. The UK should aim to capitalise on new opportunities rather than importing it.
10. AI technologies are expected to affect some employment sectors; for example, AI advising call centre operatives how to answer customers' questions greatly reduces the length of calls and so the number of workers employed. However, AI is also predicted to affect 'information professions' in the service industry including legal and financial services.
11. Rigorous engineering processes should be applied when designing and testing any robotics and AI systems. Human factors and ergonomics will also be important to ensure that they take proper account of the interaction between them and the people who use them.

Shift in the skills base

12. The Academy would like to see government prepare for and support a shift in the skills base to ensure new employment opportunities are exploited. Skills will need to adapt and a lack of investment in the exploitation of robotics and AI will lead to the UK experiencing job losses as other nations become more competitive.
13. The UK workforce will need skills to enable them to work with the new technologies, both in the manufacturing and service industries.

14. As highlighted in the Academy's report [Connecting data](#), increased levels of digital skills will be needed in general throughout the workforce, not least if the opportunities arising from robotics and AI are to be realised. The required combination of skills is challenging, drawing on engineering, computer science, machine learning, mathematics and informatics and it is unlikely that any single individual will have all these skills. As a result, it is likely that teams will be needed that encompass all the necessary skills in order to integrate robotics and AI systems into wider systems.

The extent to which social and economic opportunities provided by emerging autonomous systems and artificial intelligence technologies are being exploited to deliver benefits to the UK.

15. A meeting in 2015 held by the Academy, [Innovation in autonomous systems](#), heard examples of where robotics and AI technologies could provide social and economic opportunities:
- use of drones in dangerous situations such as mapping radiation leaks and other environmental phenomena from the air
 - autonomous surface vehicles for use in research and surveying, oil and gas, offshore renewable energy, military and security sectors
 - assistive technology to tackle the problem of an ageing population
 - robotics handling of products in logistics chains.
16. Several enablers are needed before social and economic opportunities can deliver benefits in the UK. Non-technical aspects such as investment, skills and regulation are a prerequisite for market development and capability.
17. Another key enabler is insurance; it is not clear, for example, how autonomous vehicles will be insurable. The airline industry could be considered an interesting parallel here. The Warsaw Convention caps liability for accident claims in the airline industry that would otherwise be uninsurable. An insurance and liability framework is needed, an endeavour that requires government involvement.
18. The need for non-technical enablers such as regulation can create a 'catch 22' problem. Taking aerospace as an example, most major and high risk innovations have been developed through military funding and trials in protected environments. As defence funding has been scaled back, industry is less able to test technologies in this protected environment and, therefore, is looking for regulations in advance of risking major investment into design and development. The regulators, on the other hand, are reluctant to develop regulation in anticipation of product development. The [ASTRAEA programme](#) attempted to bridge this gap for unmanned aircraft systems but lost the support of government funding.
19. International regulations dictate the technologies which can enter large markets. It is essential that UK government, in partnership with UK industry, takes a leading role in writing them so that UK technologies are not frozen out by other nations.

20. In 2015, Innovate UK's Robotics and Autonomous Systems Special Interest Group (RAS-SIG) published a roadmap [*The UK Landscape for Robotics and Autonomous Systems*](#) which identifies sector clusters where social and economic opportunities will be seen. These include manufacturing and agri-food, healthcare and consumer, transport and cities, energy supply, utilities and the environment.
21. However, it must be noted that robotics and AI applications are being developed independently. Although applications may be widely different, there are underlying similarities that would benefit from a cross-sector approach to some level of standardisation and regulation. Even within the transport sector, the air, land and sea sectors are going their separate ways – a clear opportunity for joined-up thinking. An integrated approach should result in cost savings. At the very least we need to encourage cross-sector learning.

The extent to which the funding, research and innovation landscape facilitates the UK maintaining a position at the forefront of these technologies, and what measures the Government should take to assist further in these areas.

Funding

22. Funding, including that from government, is important. Funding and support for the innovation landscape for the robotics and autonomous systems sector began to gain momentum in the last government, which identified them as part of the UK's industrial strategy. The strategy encouraged academia and industry to come together to plan what steps were needed to keep the UK competitive in this sector. The Academy would recommend the government continue to support robotics and AI sectors as a high priority. More recently, the EPSRC UK-RAS Network was set up to coordinate some of this activity but with no significant government funding. The Aerospace Technology Institute model might have more impact, focusing government and industry investment.

Research and innovation landscape

23. Robotics is not a new technology but the UK has been late in embracing it, particularly for manufacturing. The majority of manufacturing robots are imported. The UK's robot industrial base is largely dependent on SMEs producing specialised robots. While the previous government recognised it as one of the 'Eight Great Technologies', the UK still stands to miss out on the next generation of technologies if there is not the government and industry support to transition these technologies to market.
24. Despite relatively low levels of investment over the last 20 years, UK industry is well placed to develop robot technology for nuclear sites, autonomous vehicles and subsea developments for oil and gas. Recent EU funding and government recognition of the sector have encouraged UK academia to become increasingly active in this area and the UK is in a position where with the correct encouragement this could be a major economic growth sector.

25. A focus on funding is important but, as evidenced in the [Dowling Review](#), UK entry arrangements could be simplified. This should include more consistent international terminology wherever possible.
26. To ensure the UK remain competitive, government and industry should take a role in defining international standards in robotics and AI. Standards will be developed for different scales or types of applications but again, it must be recognised, as mentioned in paragraph 21, that there are exploitable similarities between applications. Robotics and AI applications will reach into most, if not all, sectors so it is vital that clear definitions exist for robotics that do not constrain innovation. The international standards bodies need to work together to learn from each other.
27. It is important that UK initiatives are seen as centres of excellence. Working across Europe and with other international leaders requires a focused approach within the UK with clear ownership. This in turn will help export potential.
28. One example is autonomous cars. The UK is in good position to host real-world trials of next generation autonomous cars. The UK's existing legal and regulatory framework is not a barrier to the testing of automated vehicles on public roads. Real-world testing of automated technologies is possible in the UK today, providing a test driver is present, takes responsibility for the safe operation of the vehicle and that the vehicle can be used compatibly with road traffic law. However, with other countries pushing ahead with this also, the UK must continue to address challenging environments inhibiting current research and trials.
29. Government should continue to support and facilitate the funding, research and innovation landscape through appropriate investment and enabling legal and regulatory frameworks. Robotics and AI technologies will impact the productivity and growth of other sectors as new applications and use of AI decision making emerges and, therefore, qualifies for a higher priority if the UK is going to remain competitive in all, or any, of its industrial (in its broadest sense) sectors.

The social, legal and ethical issues raised by developments in robotics and artificial intelligence technologies, and how they should be addressed.

30. Social, legal and ethical issues may be quite different for robotics compared to AI.

Social

31. AI systems, including robots, will only function in very narrow areas for the foreseeable future. Some of the public will continue to have misconceptions on just how narrow that expertise is, and will be tempted to over-estimate it. Misconceptions lead to false expectations of what AI systems can do; for example, that AI systems will work correctly outside their narrow expertise. Those working in these fields do not believe it is a threat to humanity.
32. The engineering community is primarily concerned with robotics and AI technology working safely within their designed scope. A critical aspect of this is

to ensure that such systems can recognise when they are straying outside their scope and warn their human users that they need assistance or should not be used in a situation. Beyond this, engineers also recognise that AI potentially presents wider societal concerns and the Academy is currently looking into these issues.

33. Rigorous engineering processes should be applied when designing and testing any AI system, particularly those designed for use in safety or security critical situations.

Legal

34. It is likely that, for many sectors, autonomy will generate a fundamental change in current business models. For example, driverless cars are likely to change vehicle ownership models. Consumers may start to view mobility as a service rather than a vehicle. The insurance sector, dealing with risk, will need to adapt and change for when autonomous vehicles are used.

Ethical

35. Ethical issues must be addressed in the design and development of robotics and AI technologies so that wrong assumptions about users and their behaviour are avoided.
36. The increasing use of 'intelligence' in machines is shifting the responsibility for safe operation from the operator to the designer, with consequent legal and ethical implications. There may be a need to mandate chartered status as a legal requirement to practise in this field. Any discipline involved in robotics and AI needs to consider the ethical implications of their work. Ethics training could be a requirement for engineering. The Academy has looked at [engineering ethics](#) and produced a [Statement of Ethical Principles](#). To bring the statement to life, a [set of case studies](#) has been developed to show the relevance of the ethical principles to engineering practice.
37. One of the most widely debated uses of full autonomy is in the military. While it is widely acknowledged the ethical issues of removing the human user from a lethal weapon system, it should not be ignored that there may be potential ethical benefits as well. The Academy would welcome a more balanced debate.
38. Part of a balanced debate is appropriately engaging the public. Government could do more to open dialogue with the public on these issues so that concerns about social, legal and ethical issues are addressed in a timely way. A good example of this is the current dialogue sponsored by the Department for Transport and Ministry of Defence on drones, with support from Sciencewise. This is currently touring the country engaging a cross-section of the public in their local areas.