Robotics and Autonomous Systems: Shaping the Future of Scotland

The impact of the next wave of robotics and autonomous systems is already emerging in Scotland. NHS Forth Valley Royal Hospital has dedicated robot corridors for transporting supplies, and by late 2020 more Edinburgh commuters will be transported by autonomous vehicles than any other global city. To ensure that such rapidly developing technologies will deliver both economic and societal benefits, a clear vision of the future is now required.

Robotics and autonomous systems have the potential to deliver important opportunities for upskilling, greater productivity, improved well-being and better workplace safety. Scotland can be a centre for technology development, growing the robotics businesses of the future whilst engaging with our citizens to ensure acceptance and support for these new technologies.

1. Background

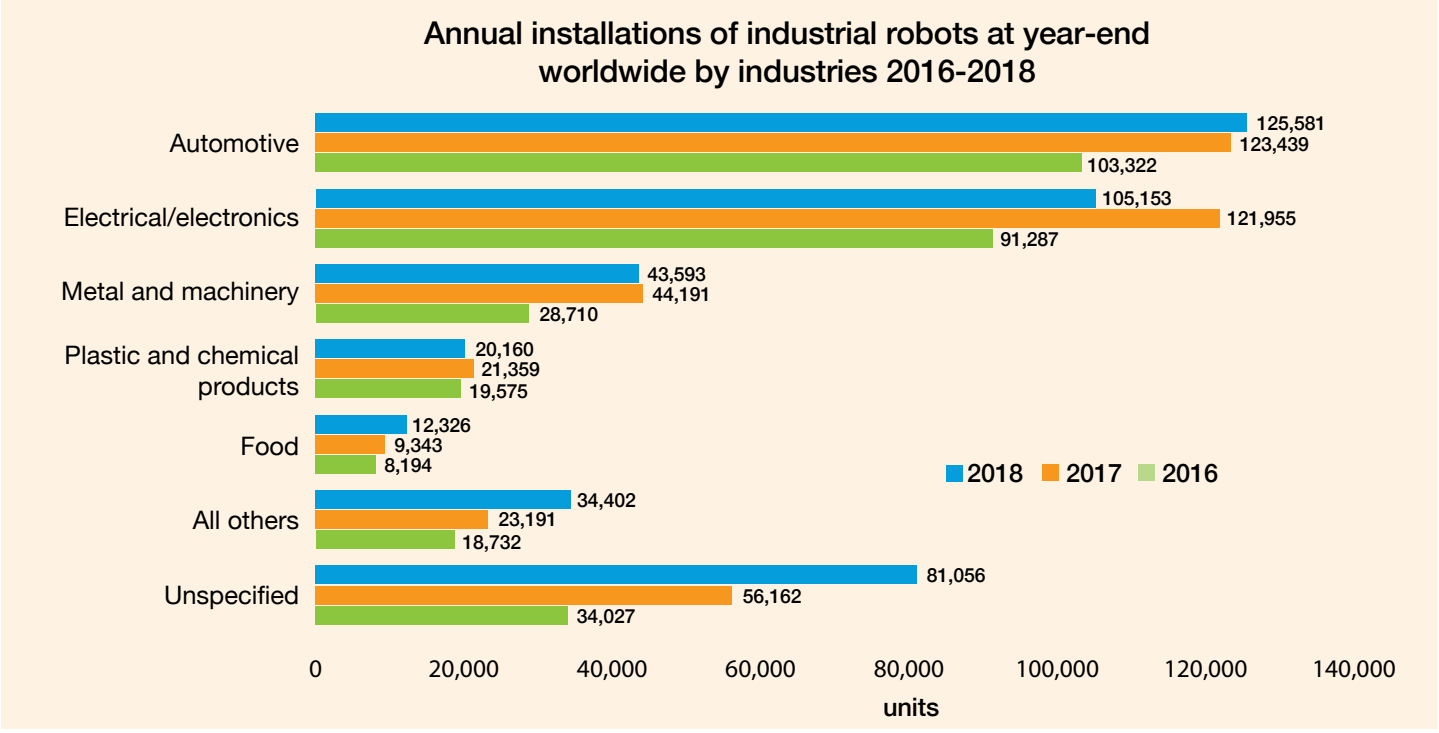
Robots have long been used in assembly line manufacturing, for example in the automotive sector, with industrial-scale machines separated from their human operators. However, robotics is also a collaborative activity, with interaction between humans and machines in the workplace and elsewhere. These developments offer a range of opportunities, freeing individuals to pursue more creative or people-centred work, improving productivity and displacing hazardous jobs. However, there are also key issues which need to be addressed: the risk of 'technological unemployment' (robots replacing human skills); the need to provide opportunities for re-training; and ensuring public acceptability.

This Briefing Note will address key issues associated with robotics and autonomous systems (autonomous machines), but will not directly address the broader question of machine intelligence algorithms in computing.

Globally, the International Federation of Robotics (IFR) notes that the annual turnover of the robotics sector is approximately $50B, including associated software and systems engineering. Industrial robots (mainly for manufacturing in the automotive and electronics sectors) represented an estimated 422,000 units sold in 2018 worth $16.5B. However, the IFR also notes that industrial collaborative robots[1] are at present still a niche product, with 14,000 units sold in 2018. Professional service robots (mainly autonomous vehicles for logistics and inspection robots) represented 271,100 units and low-cost domestic robots (for applications such as floor cleaning) represented 16.3 million units. Emerging applications such as human exoskeletons (to reduce manual loads) represented 7,300 units [1].

In order to understand the scale of robot utilisation, in 2016 the 'density' of robots (number of installed industrial robots per 10,000 employees in manufacturing) was 71 for the UK, but 488 for Singapore and 211 for Denmark [2].

It is clear that the robotics sector is currently dominated by the use of industrial robots in manufacturing, with the bulk of such activity in Asia. While the growth of industrial production line robots provides opportunities for manufacturing in Scotland, service and collaborative robots are expected to provide exciting new opportunities for the future across a broad range of sectors.



Source - World Robotics 2019, IFR

1 A collaborative robot is a robot that engages with humans in some way – either as an assistant in a task or process, or as a guide. Unlike autonomous robots, which work largely alone and without supervision, collaborative robots are designed to work with human instruction, or otherwise respond to human behaviors and actions.

2. Robotics and Automation in Scotland

Scotland already excels in robotics and automation research. Research ventures include the Edinburgh Centre for Robotics, a £120M collaboration between the University of Edinburgh and Heriot-Watt University. The Centre comprises 50 academic staff and 80 PhD students supported by two Centres for Doctoral Training. Uniquely, the centre hosts a NASA Valkyrie humanoid robot. As a sign of confidence, the UK's first National Robotarium will be opened in Edinburgh in 2021, as part of the £1.3B City Region Deal.

The use of underwater robots for environmental and climate research is being pioneered by the Scottish Association for Marine Science (SAMS) and Heriot-Watt University supported by UK Research and Innovation (UKRI), national capability funding of the Scottish Marine Robotics Facility and the NEXUSS Centre for Doctoral Training. Other activities include social robotics research at the University of Glasgow and the Space Mechatronic Systems Technology Laboratory at the University of Strathclyde.

Interestingly, the Agri-EPI Centre in Edinburgh is working with the University of Strathclyde on the AgriRover project to translate Mars rover space technologies to future smart farming robots which can autonomously monitor soil quality.

Specific innovation activities include the Data Lab Innovation Centre, which has supported Emotech to develop the world's first robot with a personality. The Construction Scotland Innovation Centre (CSIC) hosts a robot work cell with an industrial robotic arm to allow prototyping of new processes in a factory-like environment. A collaborative robot is also available to explore co-operation between humans and machines in the workplace.

The Offshore Robotics and Certification of Assets (ORCA) Hub[2] brings together 30 industrial partners to trial new robotic solutions for asset management in hazardous environments, while the National Manufacturing Institute Scotland (NMIS) is pursuing a vision for the Digital Factory 2050. The Scottish Research Partnership in Engineering is also supporting innovation through their Robotics and Autonomous Systems strategic leadership group of key experts from across Scotland's leading universities.

The commercial design, development and utilisation of robotics and automation is also widespread, from Ossur/Touch Bionics, developing robotic prosthetic hands, to Subsea 7, deploying submersible robotic inspection vehicles in the North Sea. These are examples of the use of robotics for life-changing medical interventions and removing people from potential harm in hazardous environments. Other examples include SP Technology which provides automation systems for a broad range of sectors from food and drink to pharmaceuticals. Start-ups are also prevalent including mobile robot companies such as ZIVA robotics and Adabotics.

As a practical technology demonstrator, the Connected and Autonomous Vehicles (CAV) Forth project will see bus operator Stagecoach, (working with a team including vehicle manufacturer Alexander Dennis, technology company Fusion Processing, Edinburgh Napier University and the Bristol Robotics Laboratory), deliver the UK's first autonomous bus service on a 14-mile route between Fife and Edinburgh via the Forth Road Bridge. The 30-month project will include a 12-month trial, beginning later in 2020. Importantly, as such autonomous systems begin to operate in less structured environments outside of factory settings, artificial intelligence can assist with their safe operation, particularly for applications such as transportation systems.

Credit: ORCA Hub and the Edinburgh Centre for Robotics

2 The ORCA Hub was launched in October 2017 along with three other Hubs as part of the UK government's £93m R&D funding on "Robotics and AI for Extreme Environments" through the Industrial Strategy Challenge Fund (ISCF).

3. Societal Issues

A key issue for the future deployment of robotics and autonomous systems is public trust, acceptability and a clear demonstration that such technologies will deliver societal benefits. Moreover, cybersecurity will be key to the integration of autonomous systems into public spaces. By engaging with the public early, Scotland can ensure that its citizens are well informed and that the future use of robotics and autonomous systems is co-created. Scotland can then articulate a clear vision of the future it wishes to be delivered through robotics and automation. This will require a dialogue on issues such as labour substitution, up-skilling, retraining the current workforce [3] and opportunities to displace hazardous jobs.

Such a dialogue will also need to temper expectations of how soon and how far robotics and automation will transform individual lives. Media coverage of the topic can create both apprehension and false expectations of the scale and pace of change. New technologies have always transformed the nature of work, displacing some jobs while creating new opportunities. Indeed, it has been noted that automation may impact mostly on individual tasks and so many jobs will evolve rather than be displaced [4]. A key issue for the future is to ensure that beneficial changes to the nature of work are an input to the deployment of robotics and automation, and that adverse outcomes are not left to be mitigated in future. Such transitions will need to be managed in a way that is consistent with Scottish Government aspirations for Fair Work and Inclusive Growth. While robotics will continue to change the nature of work, now and into the future, machine intelligence algorithms in computing are having earlier impacts. For example, PwC describes waves of global automation, from the current 'algorithmic wave' through to the early 2020s, impacting data-driven process such as finance, and a later 'autonomy wave' through to the mid-2030s, impacting manual tasks such as construction [5]. Combined, these waves will lead to significant change, although there is substantial uncertainty associated with such projections. Moreover, while it is anticipated that over 800,000 jobs in Scotland could be impacted both by machine intelligence and robotics [4], PwC estimates a potential net increase of 15,000 jobs by 2037 through these new technologies [6]. It is prudent to consider and plan now for the impacts of such technological change, particular since there will be highly uneven impacts across employment types. Understanding and responding to such changes through, for example, responsive and agile education and training will be critical to ensure that all can benefit from the future growth of robotics and autonomous systems [7].

In order to engage with public opinion, technology demonstrators deployed in public spaces can showcase examples of the use of robotics and autonomous systems. Importantly, while robotics is often seen as a tool for high technology manufacturing, exploring the use of robotics in more commonplace settings is important. Examples could include waste disposal, healthcare, and support and assistance for the elderly. Such a programme of public engagement would be distinctive for Scotland and also offer opportunities for commercial start-ups and their investors to trial new technologies at an early stage of development.

Credit : Edinburgh Centre for Robotics

4. Future Sector Opportunities

The intelligent application of robotics and autonomous systems offer new opportunities for Scotland across a range of key sectors including manufacturing, agriculture, construction, healthcare and the energy sector. For example, Scotland's goals for the growth of renewable energy can be assisted by the safer use of robots for the inspection and maintenance of offshore structures. Importantly, robotics and autonomous systems offer particular opportunities for existing SMEs to improve their productivity across many sectors [8].

In order to continue to attract and grow the robotics businesses of the future, national testbeds can provide a key focus; for example the use of driverless delivery vehicles for remote communities. Rural or island road networks are less congested than urban areas and a number of routes could be assigned for pilot projects. Moreover, since delivery costs are typically significant for remote communities, cost reductions could demonstrate tangible benefits to help reduce rural inequalities. Given Scotland's unique geography and the connectedness of government, opportunities to quickly respond to new technologies can be anticipated. Such robotics technology test beds can support recent calls to raise our ambition and ensure that innovation becomes a truly national mission for the future [9].

A pilot 'robotics village' could also provide opportunities to demonstrate a broad range of robot technologies and applications, as can the roll-out of Scotland's 5G mobile communications network. For other operating domains, assigning a volume of airspace could provide a testbed for autonomous drones, for example for monitoring forestry, inspection of remote infrastructure such as rail track and power lines, and drone delivery to remote locations. Moreover, future shortages in labour-intensive sectors such as agriculture (in particular seasonal labour) could be partly filled using robotic solutions.

For the public sector, robotics and automation could enable NHS Scotland to pioneer new ways of working, as is already evidenced by robotic delivery corridors at the Forth Valley Royal Hospital (see box below). Here, autonomous delivery vehicles are used to transport waste and supplies, while a robotic pharmacy has reduced the need for stockholding while improving dispensing accuracy. Other examples include new mobile robot technologies which could be trialled by the Scottish Fire and Rescue Service to reduce hazards to crews. Indeed, smart public sector procurement could allow government to act as an anchor customer for new robotics businesses, particularly those demonstrating clear societal benefits.

The team of 13 robots was a UK hospital first and came into operation in 2010 at the opening of the first phase of Forth Valley Royal Hospital in Larbert. They are operated by Serco who provide a wide range of support services at the hospital.

The self-guided vehicles, which deliver food and transport linen and medical supplies, operate in a specially designed, dedicated network of lifts and corridors around the hospital, separated from patients, visitors and the general public.

The robots help keep patient areas free from bulky trolleys and other clutter, help to reduce infection risks and free up support staff to focus on patients. By operating behind the scenes they also provide a calmer environment which improves the patient experience.

Other robotic systems in the hospital include a pharmacy system which sorts, retrieves and prints labels for medicines and a system in the mailroom which uses 'ibots' to sort mail at a rate of 3,000 items per hour.

Credit: NHS Forth Valley and Serco

5. Recommendations

Scotland excels in robotics and automation research, and has the potential to grow new and existing businesses developing and deploying the next generation of robotics technologies. In order to support such growth, a distinctive strategy for robotics and automation will help differentiate and position Scotland as a leader in intelligent automation for the Fourth Industrial Revolution (4IR). This can complement the forthcoming AI strategy for Scotland. In particular, given its geography, Scotland can be a living laboratory for a broad range of applications of robotics and autonomous systems across energy, agricultural, offshore and transportation. Scotland can also be at the forefront of a public dialogue to help co-create our future.

Credit: ORCA Hub and the Edinburgh Centre for Robotics

Recommendations:

- Form a government-led leadership team (academia, industry, trade unions, public sector and investors) tasked with delivering a distinctive strategy within 12 months, defining a roadmap for the next ten years and projecting the sector internationally
- Build technology testbeds to support Scotland's research base, underpin bids for UK initiatives, attract and grow robotics businesses and demonstrate the societal benefits of robotics and automation
- Work with Scottish Development International and the forthcoming Scottish National Investment Bank to position Scotland internationally and provide opportunities for co-investment in new technologies
- Ensure the availability of appropriate skills to support business development and ensure that robotics and autonomous systems can be integrated into the workplace through re-training
- Assess how Scotland can offer a distinctive regulatory environment through codes of practice to enable the safe and effective deployment of robotics and autonomous systems
- Engage with the public and wider economic interest in a dialogue on robotics and autonomous systems, for example through a Citizens Assembly, technology demonstrators in public spaces and participation in technology testbed activities

References

[1] 'Robot investment reaches $16.5B', International Federation of Robotics, press release, 18 September 2019

[2] 'Robot density rises globally', International Federation of Robotics, press release, 7 February 2019

[3] 'Upskilling Scotland: The future of skills and the fourth industrial revolution', Scottish Council for Development and Industry, January 2020

[4] 'Automatic…for the people? How Scotland can harness the technologies of the Fourth Industrial Revolution to increase economic and social prosperity', Scottish Council for Development and Industry, BT, Scotland IS, Royal Society of Edinburgh, March 2018

[5] 'Will robots really steal our jobs: An international analysis of the potential long term impact of automation', PwC, February 2018

[6] 'UK economic outlook: Prospects for the housing market and the impact of AI on jobs', PwC, July 2018

[7] 'Preparing for automation and aging: A successful 21st century skills system for Northern Ireland and Scotland', Institute for Public Policy Research Scotland, September 2018

[8] 'Automation and the Future of Work', House of Commons Business, Energy and Industrial Strategy (BEIS) Committee, 18 September 2019

[9] 'The Muscatelli Report: Driving innovation in Scotland – a national mission', Scottish Funding Council, November 2019

Acknowledgements

The Scottish Science Advisory Council acknowledges contributions from academia and industry through a Robotics and Autonomous Systems consultation workshop (October 2019).

Produced for Scottish Science Advisory Council by APS Group Scotland, 21 Tennant Street, Edinburgh EH6 5NA
(February 2020)

scottishscience@gov.scot