The rise of the robots

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The Rise of the Robots

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Mechanisation, automation, robotics

There is no widely accepted definition of what robots are or robotics is about. The word 'robot' originates from science fiction and denoted a humanlike machine that could do all a human could do, but without emotions and a conscience.
In a historic perspective robotics could be seen as the latest development in the consecutive series of mechanisation, automation and autonomous robots. In the early stage mechanisation replaced animal and human muscle power; next, automation reduced the need for continuous human sensing; and most recently robot autonomy will replace the need for direct human control and requires only human monitoring.

It is interesting to compare internationally where the UK stands in terms of automation and robotics.

Asia

In the industrial robotics area Japan is the leading producer of systems. It also has a reputation for leading service robotics research, the commercialisation is poor. South Korea actively facilitates robotics and aims to become the 3rd largest producer of industrial robots. China manufactures most of the world's lower costs domestic robots. Though China is a late starter, it is making headway: there have been more robotic brain surgery operations performed in China than in the rest of the world combined.

USA

In the USA the Department of Defence heavily spends on robotics and autonomous systems; put by some to be well in excess of $5Billion. Research on service robots has until recently had little support. The Obama administration have launched the National Robotics Initiative (NRI) with a strong emphasis on "reshoring" manufacturing to the USA but also positioning robotics as a key technology for future growth.

Europe

In terms of industry, Europe is the largest producer of civilian professional service robots and produces about 25% of the world's industrial robots. While Europe is leading, the UK is staying behind (refer to Figure 1). Acknowledging this the UK government (TSB) has set up a Robotics and Autonomous Systems- Special Interest

Group to define a vision for an emerging (UK) industrial Robotics and Autonomous Systems sector.

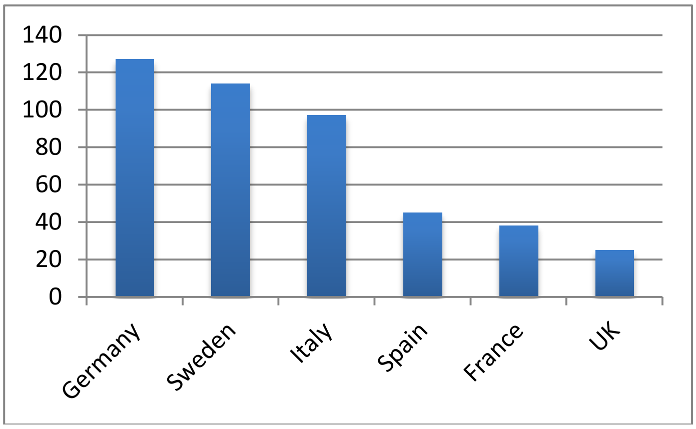

Figure 1, Robots per 10,000 employees in non-automotive sectors (International Federation of Robotics - World Robotics 2010)

Despite the industrial lag, UK robotics research is recognised internationally; the minister for Universities and Science (Willetts) has clearly identified the importance of Robotics. The most significant strategic investment in robotics in Europe is being made by the European Commission, which has spent €500 Million on the robotics programme running from 2007 to 2013. The UK academic participation in this programme has been high. For 2014-2015 another €300 Million has been earmarked for robotics.

Latest development in robotics

The conventional distinction is between *Automation* and *Industrial* robotics and *Mobile* and *Service* robotics. Industrial robots are typically applied in work cells, that is, largely static and controlled environments. Mobile and service robots are designed for unknown or partially unknown environments.

Industrial robots

Industry is still the key application for robotics. Industrial robots are high precision machines working at high speeds. However, the gripping of ill-defined objects such as vegetables or food or lightweight materials (foil etc.) is still a hurdle; robots cannot match the flexibility of a human worker. For safety reasons, workspaces for industrial robots are separated and inaccessible for human workers.
Enabling human to collaborate with industrial robots requires a new setting. The key lies in creating situational awareness both for the robot and the human co-worker: a very prominent in service robotics.

Mobile and Service Robots

Mobile and Service Robots can be applied in many sectors such as agricultural, military or search and rescue but also in everyday human environments for instance as caretaker. Autonomy in navigating unknown and dynamically changing environments (3D navigation) is a core research and R&D topic with widespread potential applications. However, robot autonomy also induces questions about how humans interact with robots over which they do not have (full) control.

(UGV/AGV) Autonomous ground vehicles

UGVs come in many varieties, wheeled and tracked vehicles are the most common but there are also legged robots and snake-like robots. Providing robots with autonomy is still challenging. Autonomous or driverless trains and subways are already in operation for decades; autonomous agricultural tractors are already commercially available and in operation. Driverless road vehicles are currently being trialled. In the UK, trials will be carried by Oxford University.
A major problem with the driverless vehicles is the legal liability in case things go wrong. Most of the driverless systems therefore have a human supervisor on board (trains, tractors) or are permanently remotely supervised.

(UAV/UAS) Autonomous Aerial Systems

Military applications have driven the recent development of UAVs and the UK rapidly gaining ground. However, UAVs are also being increasingly applied to civilian applications, including law enforcement; forest fire support; search and rescue; inspection of pipelines, powerlines, railways and offshore wind farms and environmental monitoring.
UAVs are normally classified into micro, mini and then larger scale UASs; they range from a few centimetres in size to aircraft such as the Global Hawk with a wingspan of over 35 meters. Both rotary and fixed wing UASs have been developed and are in operation; fixed wing UASs are also known as 'drones'.

(UUV/AUV) Autonomous Underwater Vehicles

Autonomous **U**nderwater **V**ehicles (AUVs) are robotic submarines, which are used to explore the world's oceans or laying and maintenance of underwater pipes and cables. Communications with the AUV are limited to using acoustics (sound) when the AUV is underwater; satellite communications can be used when the AUV is floating on the sea surface. Energy supply is a challenge for AUVs: lacking supply of oxygen from the atmosphere, combustion engines are not practical. Accurate navigation is also a challenge as satellite signals (for instance GPS) don't penetrate sea water.

Application domains

Agricultural robots

Dairy farming has been transformed by the introduction of commercially available automatic milking systems. The robot is available 24 hours a day and the cows can decide themselves when they feel ready for milking; the robot provides the particular animal with additional food supplies, food supplements or medication.

Arable farming is largely mechanised and robots are being introduced, for example driverless tractors. Mechanisation introduced blanket treatment of crops to achieve economy of scale. Autonomous robots and smart control allow scaling down treatments to plant or even leaf level; there is potential to reduce the use of plant protection products by 95% or more. The future is for (small) robots designed for individual plant care.

Robots interacting with humans

European countries and Japan are feeling the pressure of the ageing populations; this is a strong incentive to develop robots that interact with humans in everyday life situations.

Rehabilitation Robotics

Rehabilitation engineering tries to assist disabled people by providing a technological solution to everyday problems; solutions may include walkers, gloves, hearing aides, and other assistive objects. *Rehabilitation robotics* aims to augment rehabilitation by applying robotic devices; besides building therapy aids, it also includes development of robotic therapies.

Assistive Robotics

While rehabilitation has a therapeutic focus, assistive robotics is very much concerned with living. Assistive robots can provide significant increases in the autonomy of disabled users, raising their quality of life; they also have the potential to reduce the burden of caring for the growing numbers of disabled people in ageing populations. The fundamental point in developing assistive robotics is that assistive systems should not always and unconditionally assist the patient, but attempt to balance the needs of the patient with providing challenges that the patient can learn to overcome

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Social robot companions

Robot companions are typically service or healthcare robots that fulfil a dual function: they are able to provide physical, cognitive or social/emotional support, and they perform these tasks in a social manner. Socially interactive robots may use a variety of modalities including speech, gestures, body movements, facial expressions etc. to express social cues in their interactions with their users.

Ethical Issues in robotics

There arise many questions about social and moral responsibility related to robotics: concerns about safety but also legal questions about liability for any errors or damage created by robots. Privacy issues have been raised in the context of CCTV, but mobile robots and airborne drones extend the reach of the police, the paparazzi, or just nosey neighbours. With robots developed to monitor the health and safety of people, there are important questions to be answered about who should be able to view the images and data that they have access to.

Additional ethical issues arise if robots are able to direct or control people, or restrict their freedom certainly if the robots are operating autonomously without direct human control. In a military context the possibility of autonomous lethal weapons is becoming a reality, but ethical questions also have to be dealt with in domestic situations.