A REVIEW ON THE FUTURE OF WORK: ROBOTICS

1 Introduction

Machines have been a part of human reality for a long time, however the industrial revolution marked a major breakthrough in the use of machinery and machines. At that time, their significance and importance was recognised generally, but people reacted in very different ways: some viewed machines as a threat, while others saw promising opportunities in them. Today, in the era of ubiquitous technology and in the middle of a transitional phase, a similar situation is presented, but this time as regards smart machines and processes.

As will be described below, the ‘ubiquitous r/evolution’ will usher in an era where machinery and equipment can be installed anywhere - even in the human body; robots will become human assistants and, in the long-run, they will become co-workers.

2 What is a robot?

According to its intended application, a robot can be classified as an industrial or as a service robot:

- The International Robot Association defines an **industrial robot** as an "automatically controlled reprogrammable, multifunctional manipulator with at least three programmable axes which may be either fixed in place or mobile for use in industrial automation applications." (as defined in the standard ISO 8373: 1994)
- **Service robots** are designed to support, accompany and nurse humans, sharing the human environment and exhibiting basic intelligent behaviour to accomplish assigned tasks. They fall into three classes: Class 1 robots replace humans at work in dirty, hazardous environments and tedious operations, Class 2 robots operate closely with humans to increase comfort, such as entertainment, assisting the elderly, carrying patients or working together with humans, Class 3 robots operate on humans, e.g. medical robots for diagnosis, surgery, treatment and rehabilitation.

Robots were initially built to carry out simple work tasks, but increasingly they are also being built to think, using **artificial intelligence** (AI).

There are two types of AI: weak and strong. Weak AI refers to a machine that depends on software designed for a specific problem to guide its investigation or response. It does not reach consciousness, but is essentially a problem-solver in a limited field of application (e.g. text and image recognition, expert systems and chess computers). In contrast, Strong AI refers to a hypothetical machine that exhibits behaviour at least as skilful and flexible as that of humans.

The relative advantage of robots and intelligent machines is associated with their ability to perform a variety of movements and to ‘think’ endlessly and tirelessly. Today, when designing robots, the focus is on the robots’ ability to follow patterns and as a result, they are generally highly specialized. In the not too distant future, this is set to change and there will be robots able to work on a broad range of tasks and to imitate and paraphrase humans. In part, this development will be possible thanks to an immense increase in the memory capacity of robots and AI apps, allowing huge amounts of data to be accessed and used for a variety of operational tasks.

3 Extent of robotics and future projections

In general, society is moving from an information society to a knowledge society and from a knowledge society to a ‘ubiquitous-knowledge’ society. In a ‘ubiquitous society’, the role to be played by smart and autonomous machines will be a key issue for policy-makers. Attention will have to be focused on ‘technology waves’, such as digitalization, information and communication technology and robotics, which are all crucial elements in the development of this new ubiquitous society.

The EU Robotics Strategy 2020 outlines current developments in the following way:

"*Robotics Technology will become dominant in the coming decade. It will influence every aspect of work and home. Robotics has the potential to transform lives and work practices, raise efficiency and safety levels, provide enhanced levels of service and create jobs. Its impact will grow over time as will the interaction between robots and people*."

Between the 1960s and the 1990s, most robots and robotics in general were limited to industrial applications. Nowadays, robots are reaching exceptional capabilities and robustness and robotics and AI will have huge implications for a range of sectors such as military industry, security services, health care, transport and logistics, customer service, and home maintenance. In the field of service robotics, recent developments in medical and personal health care have been remarkable and an even higher degree of autonomy and system complexity is not far off, along with more human-centred applications.

As now, in the ubiquitous world, people will communicate with each other (man-man) and machines with people (man-machine), however, machines (including robots) will also communicate with each other (machine-to-machine). The number of devices involved in machine-to-machine communications is expected to grow exponentially until, by 2020, the number of 'smart objects' able to talk to each other and to inter-operate with humans will reach around 50 billion.

These developments in communication will lead to the widely anticipated '**Internet of Things'** (IoT), which describes a system that relies on autonomous communication between physical objects. Robotics will be linked in many ways to IoT and this linking process will change the "old" network society in many ways. The way in which mobile phones and wearable computers, such as 'life-trackers' have become part of our everyday lives implies that human beings will soon live in a 'ubiquitous world' in which all devices (including robots) will be fully networked. In the ongoing IoT revolution, the steady spread of robots into many activities of everyday life makes IoT-aided robotics applications a tangible reality.

In the future, advances in robotics will lead to the development of partners, assistants, household robots, healthcare robots, construction robots, pet robots, tele-presence robots and toy robots. These robot applications will imitate human and animal behaviour and IoT and ubiquitous applications will enable them to communicate with each other.

All of these quantitative changes will give rise to qualitative changes, which are almost impossible to predict because of the complexity of the issue. High-speed computing systems have already seen opportunities for faster, more reliable and more precise decision-making and action, whilst threats and risks deriving from this rapid development can also arise, such as the stock market spikes caused by high-frequency trading. Is development going perhaps too fast? Might the increasing speed of ubiquitous and other technological progress cause greater risks to the economy and society?

4 Robotics and the future of work

Considering the future of work, it is important to consider how far robots can replace or complement and enhance human work. A future where robots continue to be developed mainly for a complementary role would be the least challenging for society as humans would not have to compete with robots and automats and traditional roles would be largely preserved. However, economic and productivity pressures are likely to result instead in a substitution approach whereby individuals and groups are replaced in their jobs by robotics and automation. Overall, fewer workers will be needed for jobs that are routine or have clearly definable tasks, as they will be done instead by industrial and service robots. A result of this technical change will be a relative increase in the demand for highly educated workers and a reduced demand for less educated workers traditionally carrying out jobs consisting of routine cognitive and manual tasks. This so-called 'hollowing out' of mid-skilled workers could lead to the loss of around one third of all current jobs in the coming decades.

This complementarity - substitutability dilemma and the balance between job conservation and technology-driven unemployment is a challenging issue for policy-makers, business and wider civil society. The broader implications of how robotics will change labour market, economy and society, raises difficult social and political issues. The discussion on intelligent machines and the impact of robotics and ubiquitous technology on society, economy and employment has so far been rather passive and there have been few well-structured ideas elaborated on how far a robotised and automated society can be developed.

The fear of technology-driven unemployment is at least as old as the protests of 19th century English textile workers, the Luddites, against the loss of their jobs to the new technology of the industrial revolution. However, the fears that developing technology could replace a large proportion of human labour and lead to permanent structural unemployment has been proved wrong time and again and for many economists it represents an almost unthinkable idea. In fact, technological progress has generally meant an increase in wealth and more jobs, at least in the long term and new technology and scientific inventions have generally been seen very positively. However, the new era of robotics and artificial intelligence may represent change on a scale not experienced before; and under this scenario the possible impact on employment, job destruction and the economy has been discussed very little. Many conventional economists believe that market mechanisms will again be able to balance the problems in the long-run. But will this really always be the case?

5 Occupational safety and health implications of robotics

As discussed above, the spread of robotics innovations has important implications for the future of work. Robots offer the possibility of maintaining high levels of industrial production in countries with high labour costs. They will also allow productive activities and tasks to be carried out that cannot be performed by humans, such as analysing, auditing and editing massive data, or working in environments that are too difficult or dangerous. Furthermore, in the present context of an ageing population, robots hold out a solution to the increasing scarcity – and value – of manual work labour.

From the point of view of occupational safety and health (OSH), the spread of robotics presents both opportunities and challenges.

The greatest OSH benefits stemming from the wider use of robotics should be substitution for people working in unhealthy or dangerous environments. In space, defence, security, or the nuclear industry, but also in logistics, maintenance and inspection, autonomous robots are particularly useful in replacing human workers performing dirty, dull or unsafe tasks, thus avoiding workers' exposures to hazardous agents and conditions and reducing physical, ergonomic and psychosocial risks. For example, robots are already used to perform repetitive and monotonous tasks, to handle radioactive material or to work in explosive atmospheres. In the future, many other highly repetitive, risky or unpleasant tasks will be performed by robots in a variety of sectors like agriculture, construction, transport, healthcare, firefighting or cleaning services.

Despite these advances, there are certain skills for which humans will continue to be better suited than machines for some time to come and the question is how to achieve the best combination of human and robot skills. The advantages of robotics include heavy-duty jobs with precision and repeatability, whereas the advantages of humans include creativity, decision-making, flexibility and adaptability. This need to combine optimal skills has resulted in collaborative robots and humans sharing a common workspace more closely and led to the development of new approaches and standards to guarantee the safety of the "man-robot merger". Some European countries are including robotics in their national programmes and trying to promote a safe and flexible co-operation between robots and operators to achieve better productivity. For example, the German Federal Institute for Occupational Safety and Health (BAuA) organises annual workshops on the topic "human-robot collaboration".

In future, co-operation between robots and humans will diversify, with robots increasing their autonomy and human-robot collaboration reaching completely new forms. Current approaches and technical standards aiming to protect employees from the risk of working with collaborative robots will have to be revised in preparation for these developments.

There are other OSH challenges related to the future emergence of autonomous robots and service robotics that will have to be addressed:

- Robotics plays an important part in healthcare innovations and in providing care for the elderly (including older workers). Robotics technology is closely associated with developments in prosthetics and implant technology and these two areas in turn rely heavily on neuro and information science. Brain–computer interfaces (BCIs), prostheses coupled to the nervous system, artificial vision, ICT implants and even neuro-chips (still at an early stage) are among the latest developments.

These and other advances in robotics allow the development of human enhancement technologies, which not only address disability, but also improve the capabilities of healthy individuals. For example, exoskeletons or 'wearable robots' augment the capacity of workers to carry loads, but are also used as rehabilitation or assistive devices that enable access or return to work for people with disabilities. The introduction of human enhancement technologies raises new demands on health and safety management to monitor emerging risks, but also poses new legal and ethical questions.

- The vast majority of people have no experience of interacting with robots, but this is set to change as machine-man interaction at work increases. The indirect impacts of machine-machine communication are not widely known, but could be significant. Ergonomic and logistical arrangements of autonomous robots need new testing and piloting regimes in industries and the service sector and tailored training programmes should be provided to workers who will be programming, operating, maintaining or sharing the workplace with these robots.
- The effects of robotics on workers' and managers' motivation and wellbeing are not widely known. Psychosocial factors related to robotics will require more attention in the field of safety and health.
- Because of a difference in maturity between application areas, it is not possible to provide uniform guidelines of security and risk management. In some applications, security and safety issues have been managed professionally, but there are some robotics applications that may be less safe. There should be more analyses to identify risky and unsafe activities of autonomous robotics, in particular in the agro and food industries, care services, domestic services, manufacturing branches, professional services and transportation.
- Given that professional service robotics is a relatively new area, issues of legal liability in case of accidents in a public area is not clear. More legislative analyses concerning liability issues need to be undertaken before the technology is launched.

Thus there are thematic needs to develop a safety framework for autonomous industrial robotics and service robotics. Key strategic themes are (1) technology management, (2) regulation and good governance, and (3) user interfaces and experiences. There is a need for a more widely shared European knowledge base of safety methods for less-intelligent systems (e.g. vehicles and cars) to adapt them to service robotics and autonomous robotics, which in future will be much 'smarter'.

6 Concluding remarks

History has shown us that new technologies provide not only new benefits and new possibilities, but also new costs and novel threats. There is a general consensus that change is speeding up and that the future will become unfamiliar to us at a faster pace, especially in the field of robotics and AI where new inventions and innovations are introduced almost every week. Some of the benefits of these advances are enhanced health, convenience, productivity, safety, and more useful data, information and knowledge for people and organizations. The potential downsides are challenges to personal privacy and data protection, over-hyped expectations and increasing technological complexity.

There is a need for increased European co-operation in the following fields: (1) Safety requirements of robotics (sets of requirements, norms of safe operation and best practices), (2) design guidelines for ergonomics of robotics, (3) methods to improve safety and health applications of robotics, (4) validation and verification techniques (methods to test whether the requirements and guidelines are applied properly), (5) user-driven experiences and behaviour with robotics, (6) educational models to train workers to work with robots, (7) best practices of regulation in field of industrial (especially autonomous robots) and service robotics (especially care and welfare robots) and (8) technological possibilities to create safe systems by eliminating or reducing possible risk of robotics.

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