THE FUTURE OF WORK AND ROBOTICS

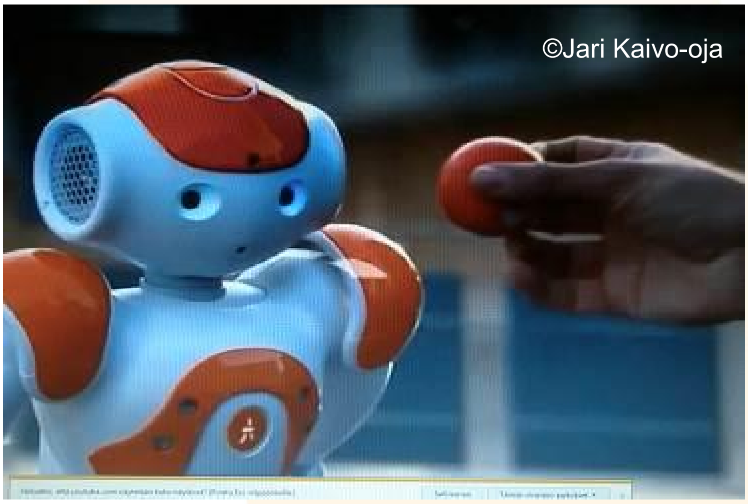
This review article is undertaken on behalf of the European Agency for Safety and Health at Work. The review article examines key questions concerning robotics and artificial intelligence (AI). The article informs European decision-makers of current challenges of safety, health and welfare issues in the changing work life.

1 Introduction

In this article we shall discuss the futures of work and robotics. The key idea is to evaluate current trends of European work life and present some diagnoses and prognoses as well as a policy prescription of European robotics strategy with special attention to human welfare, health and safety issues. Focus in European economic and social policy has been "jobs and growth" and "social inclusiveness". These two policy priorities are still relevant but many on-going changes and transitions in European economy and civil society require more attention. One of them is robotics and artificial intelligence (AI) developments.

Robotics 2020 report explains European robotics strategy in many ways. The summary of Robotics 2020 report 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."



In this article we want to underline that robotics is not only an issue regarding science, technology and innovation policy but also a social and health issue. As US Robotics outlines, moving from Internet to robotics will include many social and cultural challenges. Achieving open innovation and creating a strong component market place are important strategic objectives for the European policy-makers. Many important aspects of robotics and AI developments include great social challenges and health and safety risks, which need political attention. European societies are currently facing important challenges. Robotics can be an integral part of wider solutions to these challenges, but also entails important ethical, legal, and societal (ELS) impacts. Addressing these impacts needs to go hand in hand with the deployment of technology. In EU Robotics strategy, a key issue is to underline that building early awareness of the inevitable ethical, legal, and societal (ELS) issues will allow timely legislative action and societal interaction. Of equal importance is the need to ensure the industrial and service designers of robot systems are aware of these issues and are provided with guidance to create compliant and ethical systems. Addressing the ELS issues will help support the development of new markets by building confidence.

This article includes following sections, which elaborate different key aspects of robotics and future of work life.

In Section 2 history of robotics and key learning of history are outlined. In Section 3 key future trends in the field of robotics are evaluated. Especially futuristic insights to modern ubiquitous knowledge society are provided for readers.

- Section 4 includes various scenarios regarding the futures of human beings and work life. This section includes evidence-based insights concerning key changes in work life and human welfare.
- Section 5 presents a roadmap of robotics, which covers key aspects of industrial and service robotics.
- Section 6 provides some technology foresight insights and inter-linkages to robotics. There are three critical technology roadmaps (1) the technological future of robotics, (2) digitalization and (3) ICT technologies.
- Section 7 identifies the key challenges of future work life and labor policy in the European Union: economic, social and political.
- Section 8 informs readers about some important strategic projects of the European Union, especially about European robotics strategy. In Section 9 summary is outlined.

2 History of robotics and key lessons learned

2.1 Short historical introduction and current insights

Machines have been a part of human reality for a long time. The Industrial Revolution marked a major breakthrough in the use of machinery and machines. Machines, at that time, were associated with a number of human fears and threats. The significance and importance of machines were assessed in different ways: some viewed machines as threats while others saw promising opportunities in them. Today, in the era of ubiquitous technology and right in the middle of a transitional phase, the situation is similar with smart machines and processes everywhere.

The ubiquitous r/evolution would mean that machinery and equipment could be installed anywhere - even in the human body. Robots could become human assistants and, in the long-run, they would become co-workers. Man would gradually be released from the shackles of time and space with the help of ubiquitous applications and technological solutions. The man-machine relationship would become more and more integrated and interactive as smart machines come to the help of man in the most diverse contexts at work and in the free time. Changes in the social, cultural and economic sphere would occur.

It is essential to emphasize how now is the time to consider what we demand from robots and robotics. We need to find novel models of man-robot cooperation and interaction, but also new rules of the "game" in postmodern societies. We have to perceive where we are, and navigate to where the world is going to in the future.

Robotization is not a new thing for humankind. In 1738, Jacques de Vaucanson had already built the Flute Player, an automaton, or the first functioning robot, which could play the flute. De Vaucanson built also a mechanical duck that imitated the motions of the live bird, but also its motions of drinking, eating, and "digesting." His most important invention was the automation of the loom, albeit ignored by his contemporaries. This tells us how, at an early stage in the history of automation, a man built an automaton to entertain but also to educate his contemporaries about the possibility of working objects. A robot can be a good partner in work and play. However, we can also identify a long-lasting phenomenon that advanced technologies, digitalization, robotics and the philosophy of lean production, management and government will finally result in the production model of more and more goods while involving less and less people (Brynjolfsson & McFee 2011, Way 2013, Pistoni 2014). Technological unemployment is unemployment primarily caused by technological change.

Jeremy Rifkin has noted that the middle class is disappearing, the richest are getting richer and policy makers do have no idea how bad the situation truly is (Rifkin 1995, 2010, 2011). Early concern about technological unemployment was exemplified by the Luddites, textile workers who feared that automated looms would allow more productivity with fewer workers, leading to mass unemployment. While automation did lead to textile workers being laid off, new jobs in other industries were developed. Due to this shift of labor from automated industries to non-automated industries, technological unemployment has been called the Luddite fallacy (Pettinger 2013). Typical *personal strategies* to fight against technological unemployment are: (1) Investments in education, training and life-long learning, (2) stop searching work and retire/depart labor force, (3) increase work searching activities, (4) increase entrepreneurship and innovative Do-It-Yourself activities, (5) create social entrepreneurship activities, (6) start working in the public sector, (7) start downshifting in work life and allocate personal time to leisure time and (8) reject a middle-class lifestyle and work career planning.

According to recent studies (Pew Research Center 2014) robotics and artificial intelligence will permeate wide segments of people´s daily life by 2025, with huge implications for a range of industries such as health care, transport and logistics, customer service, and home maintenance. According to this study people are deeply divided on how advances in AI and robotics will impact the economic and employment picture over the next decade. In the report of Pew Research Center (2014) the *key reasons to be hopeful concerning robotics were*: (1) Advances in technology may displace certain types of work, but historically they have been a net creator of jobs, (2) people will adapt to these changes by inventing entirely new types of work, and by taking advantage of uniquely human capabilities, (3) technology will free us from day-to-day drudgery, and allow us to define our relationship with "work" in a more positive and socially beneficial way and (4) ultimately, we as a society control our own destiny through the choices we make.

In the report of Pew Research Center (2014) *the key reasons to be concerned* were identified:

(1) Impacts from automation have thus far impacted mostly blue-collar employment; the coming wave of innovation threatens to upend white-collar work as well, (2) certain highly-skilled workers will succeed wildly in this new environment—but far more may be displaced into lower paying service industry jobs at best, or permanent unemployment at worst, (3) our educational system is not adequately preparing us for work of the future, and our political and economic institutions are poorly equipped to handle these hard choices.

The history of industrial robots apparently started in 1954 in the United States, when George C. Devol applied for patent for a programmable manipulator. In 1959, the first such robot was sold for industrial use. In 1960, Devol with Joseph F. Engel Berger developed a robot named "Unimate", which was submitted to General Motors to help a casting machine in 1961. This was the beginning of the robot revolution in industry, which still continues today. Key robotics issue of today and in the future will be service and personal robotics. The development of robotization is, or was, concentrated in Japan and Europe, because American industries used to follow the logic of analogical technology. The key technical advances were digitalisation and the transition to PC-control in the application of robotics.

Robots and robotics as a social issue is not an isolated island of technological development. Ideas and inventions must be connected to the broader innovation ecosystems. This will not happen within closed systems and isolated departments. Definitions, designs and build production systems are continuously evolving on the digital frontier. The key issue in the current technological and social transformation period revolves around the dynamics of organizational agility. Because of this, we need change makers with dynamic capabilities and forward-looking abilities in the change process. Figure 1 shows key elements of the ubiquitous r/evolution. It also offers a cogent view of the complexity in current technological and social changes.

Figure 1: GRIN-waves and cross-fertilization linkages of innovation ecosystems.

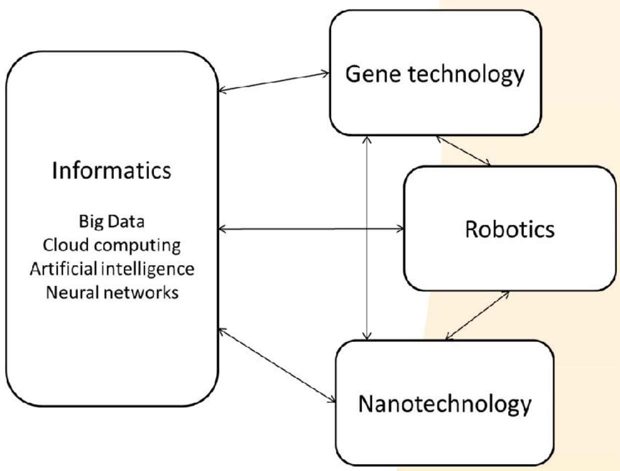


Figure 1 describes key technological waves and inter-linkages of technology waves. These linkages may very well produce many wild cards of technological development. Please, fasten your seat belts!

A human being or a robot? Or both?

Robots can replace or supplement people in a variety of tasks. Osaka University professor Hiroshi Ishiguro, who has made robot copies of his family members, says that in Japan, robots are considered as human friends (Guizzo 2010). Considering the future of work, it is important to take into account how robots can complement and enhance man's work in the future. What kind of a team would a man and a robot, or men and robots, constitute? This question is highly relevant for the future of manufacturing industries and service economy.

What is the desirable future of robotics for humankind? Admittedly, the vision of the future where robots are being developed mainly from a complementary perspective would be the best bet for human beings. In this development framework/scenario man would not have to compete with robots and automats. The Bohemian change makers set greater hope on the complementary than the substitution perspective. From an economic and productivity point of view, development would most likely aim toward the substitution approach. This would mean that individuals and groups are replaced by robotics and automation. It is understandable that a complementarity - substitutability dilemma is challenging for trade unions and political decision-makers alike. How will robotics change economies and societies? This question displays a very thorny social and political issue.

2.2 What is a robot?

A standard definition of a robot is that a robot is a mechanical or virtual agent, usually an electro-mechanical machine guided by a computer program or electronic circuitry. Man has to define robots in many different ways. Another definition, from 1993 according to Standard EN 775, defines the robot as "automatically controlled, re-programmable, multi-purpose processing device, which has several degrees of freedom, and which may be either stationary or mounted to be movable, for the use in industrial automation systems."

The International Robot Association, in turn, defines the robot, in accordance with ISO 8373: 1994, as an "automatically controlled reprogrammable, multifunctional manipulator with at least three programmable axes." The term "robot" refers to forced labour, to a human unilaterally controlled to work according to rules; it usually means a mechanical device or a machine that knows how to act in certain ways in the physical world. Thus, humans have initially forced robots to forced labour, to slavery. Man has forced the robots also to thinking, to the use of artificial intelligence.

Behind Artificial Intelligence, we find the French Age of Enlightenment thinker René Descartes and his idea of mathematical modelling. As a research field AI was separated from the development of computer science in the 1950s. The science of AI is a multidisciplinary combination of mathematics, technology, psychology, cognitive science, philosophy and medicine.

There are two types of Artificial Intelligence: weak and strong. Weak AI refers to a machine that uses the software for some specific problems to investigate or respond. Strong AI refer to artificial general intelligence, a hypothetical machine that exhibits behavior *at least as skillful and flexible as humans do*, and the research program of building such an artificial general intelligence. AI machines´ cognitive abilities are not as extensive as humans have. Weak AI does not reach consciousness, but it is essentially a problem-solver in a limited field of applications. As an example of weak AI we can mention text and image recognition, expert systems and chess computers, such as the legendary Deep Blue, which topped many of the world's chess masters.

The etymology of the word "robot" stems from the Czech robotnik "slave," from robota "forced labor, compulsory service, drudgery," from robotiti "to work, drudge," from an Old Czech source akin to Old Church Slavonic rabota "servitude". The adaption of the word "robot" into English does not imply that any automatic machine is a robot, rather than the robot ought to have some human-like features. Man built a robot after his/her image. Possibly, that is why robots have raised a variety of strong emotions, both negative and positive, and are seen at the same time as friends and enemies.

The relative advantage of robots and intelligent machines is associated with their ability to play a variety of movements and thinking endlessly and tirelessly. When planners are engineering and re-engineering robots, it is important for them to focus on the design of the robots' ability to follow patterns. Because of this basic planning and engineering principle, robots are mainly specialized – at least initially. At a later stage, we might see generalized robots, which would work extensively to imitate and paraphrase humans. In the future, the memory of robots and AI apps would become very extensive, allowing huge amounts of data storage and their utilization in a variety of operational tasks. Extended memory would expand the potential use of robotics.

2.3 Welfare benefits and advantages of robotics

Robots can free people to focus on the creative process by taking care of unpleasant physical and mechanical work. The greatest benefits of robotics should be meant for people working in unhealthy environments, such as mines and deep waters. Using robots, industrial production could be maintained in countries with high labour costs – especially for small scale batch production. The third domain for robots would be confined to productive activities and tasks that a man cannot perform. Robots planned to analyse, audit and edit massive data are in the business interest of companies and private experts. The majority of data collected in the world has been gathered in recent years; approximately 90 per cent of it all in the past two years. Thus, the "Big Data" are real-time data and up-to-date; in their analysis, attention is paid to the volume of data stream, variances, and to the velocity of data. When big data is analyzed on the basis of these criteria, businesses and other stakeholders will identify new opportunities in crowds, markets and networks. Crowdsourcing, the practice of obtaining needed ideas, services, or strategic content by soliciting contributions from a large group of people, and especially from an online community, rather than from traditional employees or suppliers, is gaining importance in various business fields. Applying crowdsourcing techniques of BigData will be a key issue for companies and corporations.

At present, the main challenge of robotization lies in combining human and robot activities, guaranteeing the safety of the "man-robot merger". The key aim is to find the best human-robot match. The advantages of robotics include heavy-duty jobs with precision and repeatability; the advantages of humans include creativity, decision-making, flexibility and adaptability. On the basis of co-operation of humans and robots, companies and the public sector would increase efficiency and capacity, as well as improve quality and industrial working conditions. In particular, co-operation of humans and robots would enhance the production of small series manufacturing. The so-called 3D-printing would revolutionize many industrial production processes. 3D printing or additive manufacturing is a process of making a three-dimensional solid object of virtually any shape from a digital model. Additive manufacturing would provide novel opportunities for agile production designers, architects, and for the creative class and Bohemians as well. In the future, co-operation of robots and humans will be diversified with their co-operation reaching completely new forms.

2.4 Welfare, health and safety challenges of robotics

Health and safety experts have a long historical experience with industrial robotics. There is a broad knowledge base of safety and health sciences. Especially research in occupational and organizational risk assessment is still very relevant. However, the changing nature of work, organizational structures and rewards systems will define when robotics and AI are introduced to modern organizations. Most likely, key challenges will include the emergence of autonomous robots and service robotics. Robotics and technological changes will change work environment stressors such as job scope, social roles, career management and organizational changes and rewards (see e.g. Sapolsky 2006). Autonomous robots and service robotics should be studied from risk and safety perspectives.

Key European robotics challenges as regards welfare, health and safety will be:

- People are not used to interacting with robots. Machine-man interaction will increase in work life. Further, the indirect impacts of machine-machine communication are not widely known. Ergonomic and logistical arrangements of autonomous robots need new testing and piloting activities in industries and the service sector.

- Motivational effects of robotics among workers and managers can be surprising. This issue has been recognized in the medical sector in some empirical studies (Pink 2009). The effect of robotics on motivation and work welfare are not widely known. Stress factors of robotics require more attention in the field of safety and health. Direct and indirect effects of stress factors of robotics should be studied more. Psychological, physical, behavioral and organizational outcomes should be studied more.
- The use of robotics in dangerous tasks (especially in defense and security fields, but also in logistics, maintenance and inspection) need special attention from safety and health experts. Safety of autonomous robotics in various industries needs more attention of health and safety professionals.
- Because of a difference in maturity between application areas, it is not possible to provide uniform guidelines of security and risk management in the European Union. In some applications, security and safety issues have been managed professionally, but there are some robotics applications, which may be more risky and less safe. There should be more analyses to identify such risky and unsafe activities of autonomous robotics. In particular, health and safety experts should analyze agro and food industries, care services, cure services, domestic services, manufacturing branches, professional services and transportation from this perspective.
- Because all robots are particularly useful in replacing dirty, dull or dangerous work, there should be active inventions and interventions to increase robotics in such tasks. These special invention areas include defense, security, nuclear industries, harsh arctic work conditions and repairing operations.
- Because professional service robotics is a relatively new area, the liability in case of accidents in a public area is not clear. There should be more legislative analyses concerning liability issues.
- 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 healthy applications of robotics, (4) validation and verification techniques (methods to test whether the requirements and guidelines are applied properly), (5) user-driven experiences and behavior 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.

Thus there are thematic needs to develop a safety framework for autonomous industrial robotics and service robotics. Key strategic themes are (1) technology, (2) regulation and (3) user interfaces and experiences.

We should have a more widely shared European knowledge base of previous safety methods for less-intelligent systems (e.g. vehicles and cars). These safety methods should be adapted to service robotics and autonomous robotics, which are going to be a lot more intelligent.

3 Key future trends in the field robotics: futuristic insights to modern ubiquitous knowledge society

3.1 New phase of European knowledge society policy

In the European Union the robotics Public Private Partnership (PPP) is the agent for implementing robotics strategy in Europe. Its purpose is to connect the science base to the marketplace, a connection that ultimately benefits the society as a whole. Its vision is to attain a world-wide leading position in the robotics market across all domains.

The on-going societal transformation takes multiple forms. Different aspects of this development have been given a multitude of names, depending on the viewpoint and focus of attention; *information society* (see e.g. Machlup 1962; Porat 1977), *knowledge society* (see e.g. Stehr 2002), *service society* (see Malaska 2003; Kuosa & Koskinen 2012) *super-industrial society* (Toffler 1970), *post-industrial society* (see Touraine 1971; Bell 1974), *network society* (see Castells 1996) *participatory economy* (see Hahnel 2005), *telematic society* (see Nora & Minc 1981), and *ubiquitous society* (see Greenfield 2001; Stappers 2006) have been used, alongside an array of other more or less descriptive key words, to highlight the ways in which our societies have changed and continue to change. Albeit each of these concepts describes a slightly different sphere of the society or a different point along a chronological line of development, the terms are definitely not mutually exclusive.

Discussing the technological and business aspects of this development, we are faced with yet another array of concepts: *everyware* (Greenfield 2001), *anywhere revolution* (Green 2010), *Web 1.0, Web 2.0 (*see e.g. O'Reilly 2009; Gehl 2011), *Web 3.0* (see Berners-Lee et al. 2009; Antoniou & van Harmelen 2008), *Web 4.0* (see e.g. [Kiehne 2012), pervasive computing (see Hansmann et al. 2004), *ambient intelligence* (see Weber et al. 2005), *Semantic Web* (see e.g. Berners-Lee et al. 2009), and *ubiquitous computing* (see e.g. Weiser 1991) belong to the relevant vocabulary. Even further, discussing the objects of the ubiquitous world brings forth another list of terms: *the Internet of Things* (see Ashton 2009), *things that think*, *computer haptics* (see e.g. Massie 1993), and *physical computing* (see O'Sullivan & Igoe 2004), to name but a few.

Ronzani (2007) has done interesting research into the usage of the terms 'ubiquitous computing,' 'pervasive computing,' and 'ambient intelligence' in mass media. His study "suggests that by and large the three concepts are described by the same attributes." (Ronzani, p. 9).

3.2 Information society and ubiquitous knowledge society

In general we can claim that we have been moving from information society to knowledge society and from knowledge society to ubiquitous knowledge society. In ubiquitous society the role of smart and autonomous machines will be a key issue. Technology waves like digitalization, information and communication technology (ICT) and robotics are crucial elements of the new ubiquitous society.

Wikipedia defines information society as a "society where the creation, distribution, diffusion, use, integration and manipulation of information is a significant economic, political, and cultural activity." On first glance, this definition seems sound, but if we look at the past development of human societies and civilizations this has been the norm: the exchange of ideas and technology, i.e. exchange of information through cooperation and competition has always been the driving force of the humanity as a whole (see McNeill & McNeill 2003). This definition does not seem to provide a sound basis for comparison with other key terms. Indeed, in the contemporary discussion the term is mostly applied to the manner in which technologies have impacted society and culture.

Network society, on the other hand, has been used to describe a society that increasingly organises its inner relationships in media networks that by and by replace or augment the social networks based on face-to-face communication (van Dijk 1991) or as Manuel Castells put it in an interview (Kreisler 2001), the network society is "a society where the key social structures and activities are organized around electronically processed information networks." Even though van Dijk (1991) and Castells (1996) differ in their approaches to what counts as the basic unit of modern society – for Castells it is the network, for van Dijk the individual – their definitions of network society provide a framework that enables even casual readers to understand what it means. For the purposes of this article, it is perhaps wise to use the term information society to stress the importance of information instead of the structure, the network wherein the information flows. It is probable that robotics will be in many ways linked to the Internet of Things in the future. Thus, *robotics meets Internet of Things and this linking process changes our understanding of the "old" network society*. In this process ubiquitous robots are going to be more and more popular. Ubiquitous robot is a term used in an analogous way to ubiquitous computing. Software products useful for integrating robotic technologies with technologies from the fields of ubiquitous and pervasive computing, sensor networks, and ambient intelligence are key elements of change. Emergence of mobile phone, wearable computer and ubiquitous computing predicts human beings will live in a ubiquitous world in which all devices (including robots) are fully networked.

Economic history since the early stages of the first Industrial Revolution has been characterized by an increasing dematerialization of individual human work and immaterialization of consumption (more demand for services). Industrial revolution was made possible by the substitution of machines for manual labour, then by the development of services and, finally, the advent of the virtual during the digital revolution. Developments in the field of robotics follow this kind of logic. The contemporary modern world is filled with data and information, neither of which is sufficient enough to create any great value without the knowledge of how to apply said data and information. Also ideas, inventions and innovations depend on knowledge base of human beings.

This article leans towards a broader definition of knowledge society because a limited focus on the economics of knowledge is better described as the knowledge economy, which can be viewed as the economic counterpart of information society.

However, it is wise to point out that the "broader social, ethical and political dimensions" entailed by UNESCOs outline below are all, at least to some extent, dependent on the economy and the ways in which we do business. According to UNESCO´s report "Towards knowledge societies: UNESCO world report" (UNESCO 2005, p. 27): "Knowledge societies are about capabilities to identify, produce, process, transform, disseminate and use information to build and apply knowledge for human development. They require an empowering social vision that encompasses plurality, inclusion, solidarity and participation".

UNESCO has emphasized in many contexts that concept of knowledge societies is more all-embracing and more conducive to empowerment than the concepts of "technology" and "connectivity", which often dominate social and political debates on the information/knowledge society. In international debates on technology and connectivity emphasize infrastructures and governance of the network planet. Technology and connectivity should not be viewed as ends in themselves. The global information society is meaningful only if it favors the development of knowledge societies and sets itself the goal of "tending towards human development based on human rights". This kind of human emphasis is good to remember also in discussions about robotics. For UNESCO, the construction of knowledge societies "opens the way to humanization of the process of globalization" (UNESCO 2005, p. 27).

In this respect, it is perhaps also relevant to refer to the increasingly knowledge-driven nature of business; one topical theme being knowledge-intensive businesses (Toivonen 2004, Strambach 2008). Key processes of knowledge-intensive business are codification, abstraction, and diffusion. Knowledge assets are created in these processes. Embodied knowledge has a very low level, narrative knowledge has a higher level, and finally, formal knowledge has the highest possible level of codification and abstraction (Boisot 1995, Boisot 1998). Embodied, narrative, and formal knowledge can be stored, exchanged, and sold in various markets and businesses.

It can be stated that the prerequisites of knowledge society include 1) the availability of information and networks, 2) the ability to exploit information, and 3) respect for different ways of knowing. The emergence of robotics r/evolution deepens these developments.

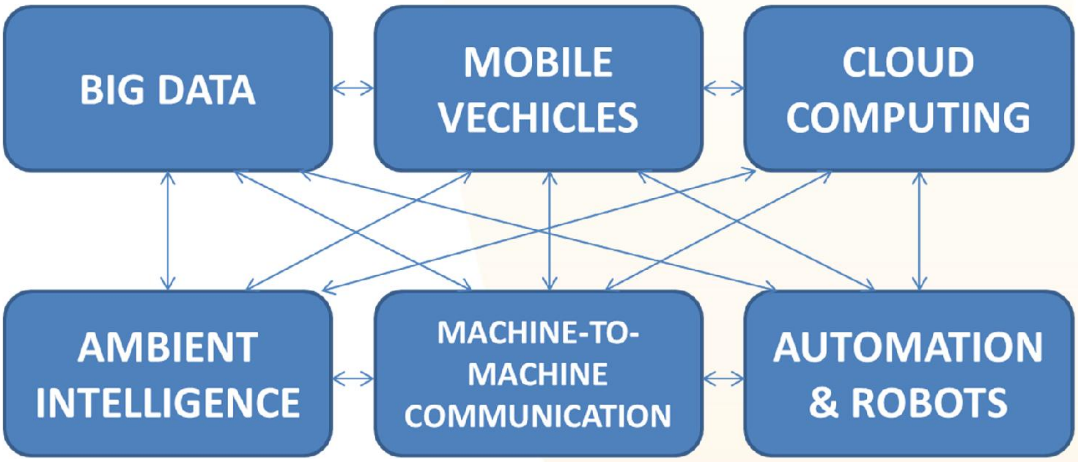
Ubiquitous society is a term describing a world where computing is present everywhere simultaneously, where it exists everywhere at the same time. In this context, it is wise to note that computing does not necessarily equal computers as we know them. In other words, the ubiquitous society is a future where computing is everywhere but nowhere in particular.

The possibilities and risks related to the ubiquitous revolution can be attributed to (almost) every sphere of human activity. However, it is easy to underline two main questions dominating the contemporary debate: future business models and the relationship between the individual and the society at large.

In the ubiquitous society, things are going to be connected. Not only are networks, markets, and crowds connected, but also human beings, machines, robots, and media are going to be interconnected in complex ways. Ubiquitous society includes elements of a trans-mediated reality. It is noteworthy that ubiquitous computing and the ubiquitous society takes, at least technologically speaking, many forms. Greenfield (2006, 15) explains: "The many forms of ubiquitous computing are indistinguishable from the user's perspective and will appear to a user as aspects of a single paradigm" (…). He goes on and explains that it "appears not merely in more places than personal computing does, but in more different kinds of places, at a greater variety of scales" (ibid., 46). Hunter (2002, xxii) paints a scarier picture of ubiquitous computing: "[W]e'll be living in a man-made environment of intelligent machines that are capable of seeing, hearing, and understanding most of what we do. Everything's recorded. Nothing's forgotten." Ubiquitous computing and ubirobots will drastically change our societies – that much is certain. We should not let technological development dictate this development. Instead, we should concentrate on building such a knowledge society that is capable of producing a preferable ubiquitous tomorrow instead of a dystopian one.

Fig. 2 visualizes complex systemic elements of ubiquitous r/evolution. These elements are in close technical interaction. Thinking carefully about this Fig. 2 reveals many uncertainties and risks of ubiquitous r/evolution. Robotics and AI automation are key aspects of the risks.

Figure 2: Complex systemic elements of ubiquitous r/evolution



The capabilities of many digital electronic devices are strongly linked to Moore's law: sensors, processing speed, memory capacity, and even the number and size of pixels in digital cameras. All of these are improving at roughly exponential rates. The speed of developments and new tech apps is amazing. Ubiquitous r/evolution involves a lot of challenges. High speed gigabit switches are already up and running. Cloud services will continue to evolve, increasing the greening of IT technology and the accessibility of applications, which in turn strengthens the democracy of the market economy in many countries.

The emergence of new pervasive computing terminals, new computers apps in cars and mobile services, new navigation positioning apps used in a variety of new ways are changing our way of life. Care robots, surgical robots, robot cleaners, and many other new robotic applications are a growing segment of the consumer market, the blood vessels in 3D printing, and artificial intelligence will be helpful for many professionals and occupations. Also engineers, doctors and lawyers can be helped by new technology and applications. New inventions of robotics and automation will be adopted in the field of military industries and security services. Future wars will be won with air, maritime and field robots. Technological advances and robotization continue accelerating in many areas of human activities, at peace and in war.

Ubiquitous technologies affect fundamental human activities: labour, leisure, housing and transportation. We do not have an area that won't be affected by this r/evolution. Therefore, many countries, Japan a case in point, have already established ubiquitous strategies to secure their competitiveness and built a variety of technology platforms to ubiquitous applications.

Large quantitative changes give rise to qualitative changes, which are almost impossible to predict because of the complexity of changes. High-speed computing systems have already seen opportunities for faster, more reliable and more precise decision-making and action, whilst threats and risks stemming from this rapid development are identified. Is development going perhaps too fast? Might the increasing speed of ubiquitous and other technological progress cause greater risks to the economy and society?

In the coming ubiquitous society, major problems might be connected to (1) speed blindness, (2) ill-considered decisions and, possibly, (3) the fact that the necessary decisions are not made at all. We must still live in a society of bounded rationality, in spite of all smartness of new technologies, scientific breakthroughs and innovations.

3.3 Ubiquitous robotics and changes in our realities

Now ubiquitous, both mundane and ubiquitous technology are gaining a variety of applications. In the ubiquitous world, people communicate (1) with each other (man-man), (2) machines communicate with people (man-machine), but also (3) machines (including robots) communicate with each other (machine-to-machine). Communication (4) between robots can be seen as an area of its own (robot-to-robot). The media turns ubiquitous and uses more machines and robotics (media–machine, robots-media), and communicating with people (media-man).

This technological change in communication ways changes our culture dramatically. We can talk about trans-media and hypermedia. The borderlines between virtual world and real world are becoming fuzzy, when ubiquitous r/evolution goes on. Ubiquitous technology r/evolution creates many open windows and business opportunities for start-up companies developing apps for smart media, for smart vehicles and for smart machines.

New tech apps are a very big opportunity for many companies renew society and make life easier. New forms of digital media applications will change media culture drastically. Co-creation and crowdsourcing, as well as a number of consumer and citizen media activities will emerge as key challenge for the media, which have in many cases quite conservative actors.

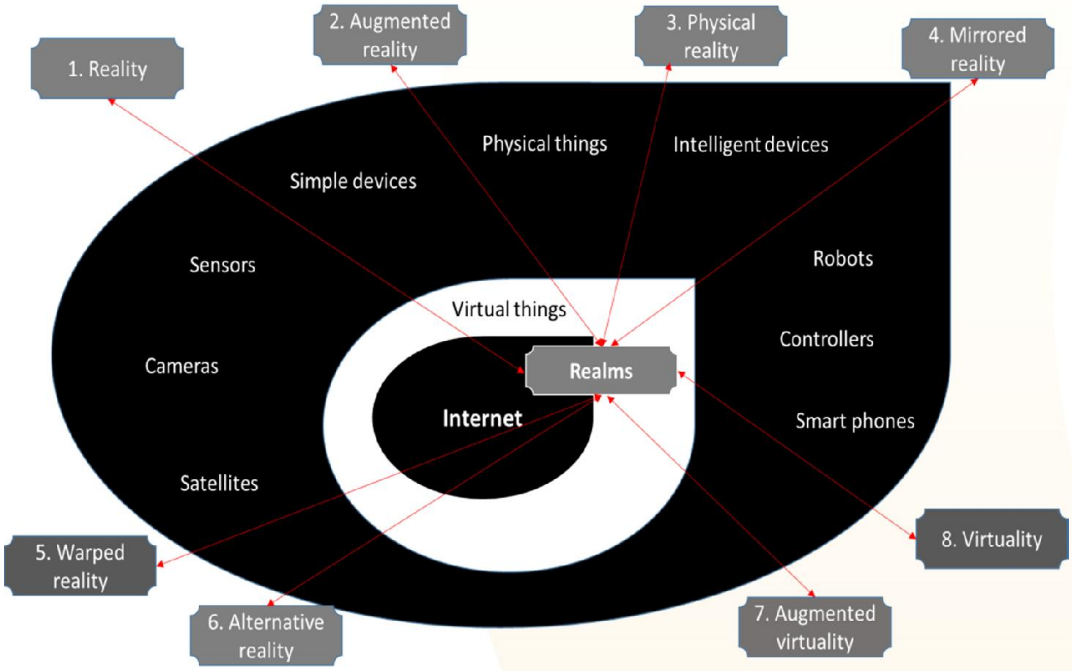
Development has not yet been brought to us by "power of the brain" but the Internet and computer networks provide us a huge amount of information, knowledge and culture, which is within everyone's reach. Michael Choros (2011) sees in his book “World Wide Mind. The Coming Integration of Humanity, Machines, and the Internet” that human activities, machines and the Internet will integrate together into the future. According to Mr Choros, ubiquitous global integration process leads to the creation of the global mind (worldwide mind).

In spite of cold logic and calculative decision-making we use our computers for social communication, for transactions, and for online social community building. The threats presented in past have changed: now we are afraid of losing the privacy and threats created by cyber criminals and cyber terrorists. We fear cyber conflicts and cyber wars, which, of course, are technological threats, which should be eliminated by excellence, by technical safety/security information and by effective training. The ubiquitous society is very vulnerable, and this should be taken into account in the development of digital technologies and new web applications.

4 The future of work and robotics: a scenario analysis of human work

The Internet of Things (IoT) is a system that relies on autonomous communication of a group of physical objects. IoT is an emerging global Internet-based information architecture facilitating the exchange of services and goods. Atzori et al. (2010, p. 2793) evaluated that the main domains of IoT will be: (1) Transportation and logistics, (2) healthcare, (3) smart environment (home, office and plant) and (4) personal and social. In Figure 3, key elements of IoT with key realms of multiverse are illustrated.

Figure 3: Internet of Things, devices and realms of multiverse (modification from (Chen & Hu 2013, p. 161, Pine II & Korn 2011).



In Table 1 the realms of ubiquitous society are figured out. This entity is called the multiverse. Table 1 tells to us that leaders, managers, planners – people responsible for running business – must understand the fundamental nature of the three elements of reality: time, space and matter. New service designs, architectures and business models are needed in the multiverse, not only in the universe. What is obvious is that managers must work in order to manage these critical eight realms of ubiquitous society. Challenging issues of ubiquitous society will be multidimensional scales of time, matter and reality. In particular, the increasing importance of virtual reality is a currently challenging issue. Also robotics has this aspect of virtuality (see Table 1).

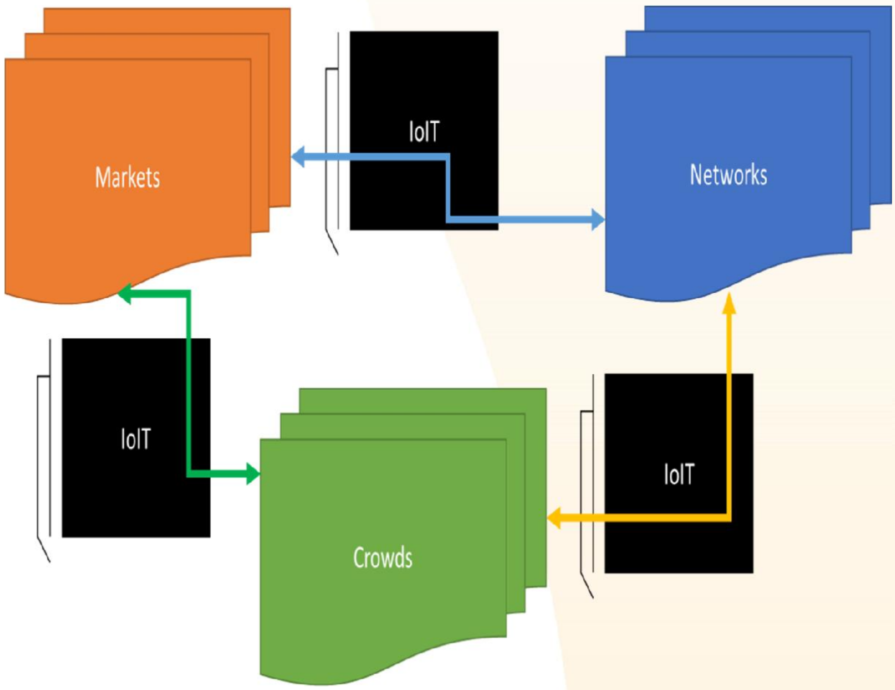
Table 1. Realms in the ubiquitous society and in the multiverse (Pine II & Korn 2011, p. 17).

Variables			Realm
1. Time	Space	Matter	Reality
2. Time	Space	No-matter	Augmented reality
3. Time	No-space	Matter	Physical reality
4. Time	No-space	No-matter	Mirrored reality
5. No-time	Space	Matter	Warped reality
6. No–time	Space	No-matter	Alternative Reality
7. No-time	No-space	Matter	Augmented Virtuality
8. No-time	No-space	No-matter	Virtuality

The applications of IoT are numerous, basically meaning smart things and smart systems such as smart homes, smart cities, smart industrial automation and smart services. IoT systems provide better productivity, efficiency and better quality to numerous service providers and industries. IoT is based on social, cultural and economic trust and associated trust management skills, which broadly speaking mean developed security services and antifragility operations. Critical issues of IoT security field are (Sicari et a.l. 2015, King & Raja 2012): trusted platforms, low-complexity, encryption, access control, secure data, provenance, data confidentiality, authentication, identity management, and privacy enhancing technologies (PETs).

Security of IoT requires data confidentiality, privacy and trust. These security issues are managed by distributed intelligence, distributed systems, smart computing and communication identification systems. (Sicari et a. 2015, King & Raja 2012). Finally, in Figure 4 we have figured out the functioning pattern of markets networks and crowds. IoT can be found between these key systems of global economy. There is probably a lot of potential for smartness between these key systems. Data, information and knowledge about communication and interaction of these systems will be vital issues for the future of management.

Figure 4. The functioning pattern of markets, networks and crowds.



Especially IoIT, Internet of Intelligent Things, as some experts emphasize smart Machine-to-Machine communication, provides much potential for crowdsourcing of markets and networks. IoIT provides also much potential for smart networking (between markets and networks and between various networks). We expect that one obvious consequence of IoIT will be the broader scope of deliberate democracy. Finally, the legal framework of IoT/IoIT is very vague or non-existing. Issues such as standardization, service design architecture, service design models, data privacy and data security create management and governance problems, which are not totally solved within current service architectures. IoT has also become subject to power politics because of risks of cyber war, cyber terror and cyber criminality (see e.g. Robinson et al. 2015).

In Fig. 5 a global reference scenario for IoT-aided robotics and AI applications is presented. We can see that IoT will be central for the collection of Big Data. Big Data will be collected from the (1) environment, (2) from human beings and (3) from robots and AI applications.

Figure 5: A global reference scenario for IoT aided robotics and AI application (a modification of Grieco et al. 2014, p. 34).

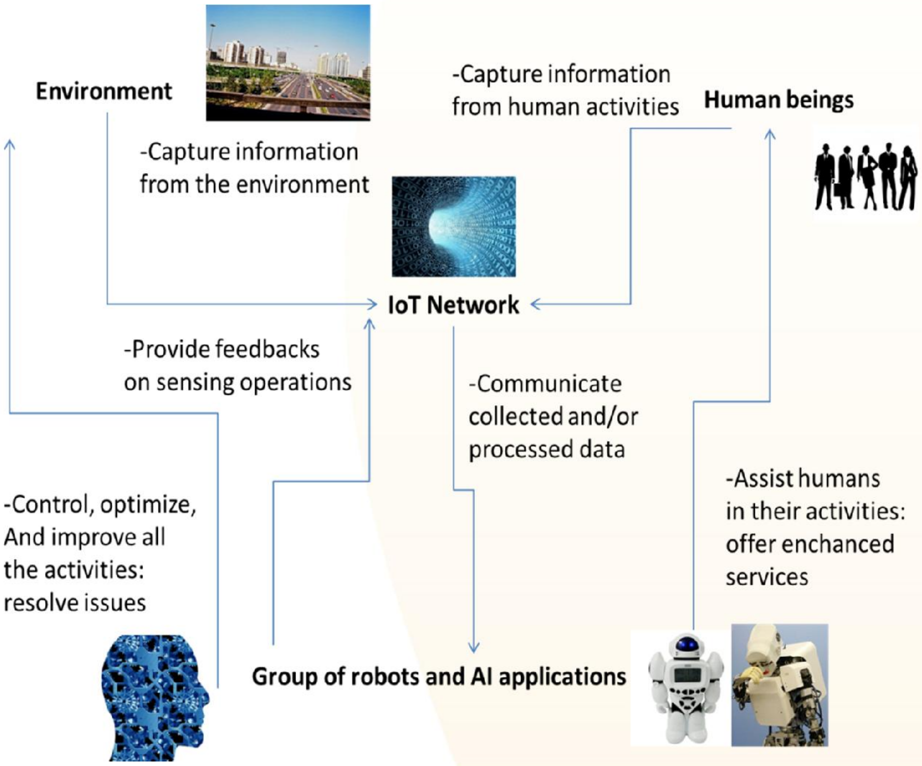


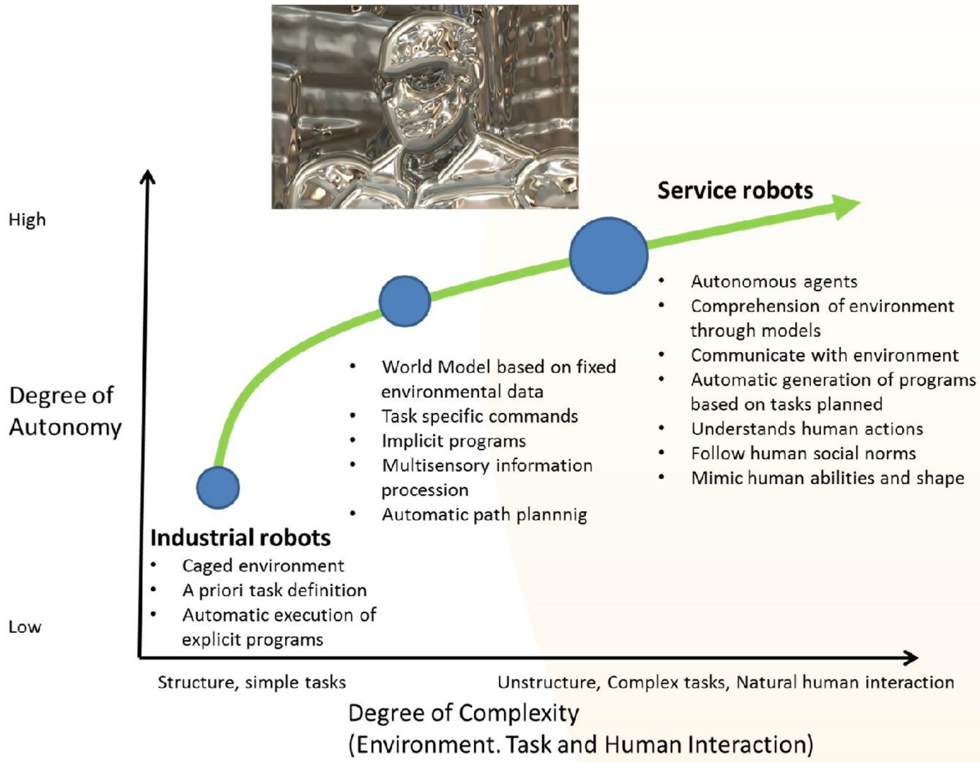
Fig. 5 describes key elements of future management system. Robots and AI application can assist and help managers and leaders in many ways.

5 Framework of roadmap of robotics: from industrial robotics to service robotics

Between the 1960s and the 1990s, most robots and robotics in general were related to industrial applications. The key challenge was to rationalize production at manufacturing sites. Now robots are becoming ubiquitous, reaching exceptional capabilities and robustness. Service robots support, accompany and nurse humans. Robots will be helpers in healthcare and personal life. Service industries develop many new service robot applications. Service robots share the human environment and exhibit basic intelligent behavior to accomplish assigned tasks. We can expect that degree of autonomy and system complexity along with human-centered applications.

In the future service robotics will play a bigger role. Service robotics is an emerging application for human-centered technologies and the service economy. Recent studies imply that the rise of household and personal assistance robots forecast a human-robot collaborative society. In Fig. 6, a 3-phase model of robotics is presented. This model illustrates key phases of robotics.

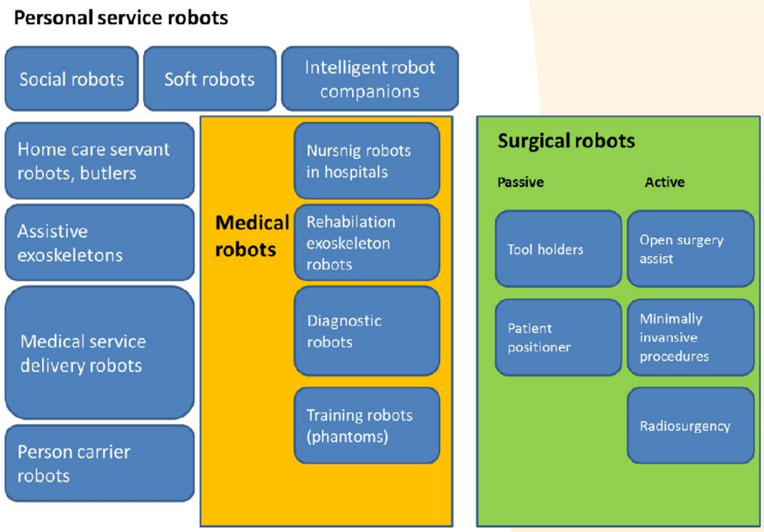
Figure 6: Evolution of robotics:



In Figure 6: Current trends are leading towards more complex, more personalized and autonomous systems and robot services. This implies flexible systems that are able to perform tasks in an unconstrained, human centered environment. (Haidegger et al. 2013, p. 1216).

In the field of service robotics we can identify three classes. Class 1 robots replace humans at work in dirty, hazardous environments and tedious operations. Class 2 robots operate closely with humans to alleviate incommodity or to increase comfort, such as entertainment, assisting the elderly or carrying patients or other things. Class 3 robots operate humans, e.g. medical robots for diagnosis, surgery, treatment and rehabilitation. In the field of service robotics, recent developments in medical and personal health care have been outstanding. In this specific field, the following robot applications can be identified (Fig. 7).

Figure 7. Categories of medical/non-medical personal service robots. (Haidegger et al. 2013, p. 1217).

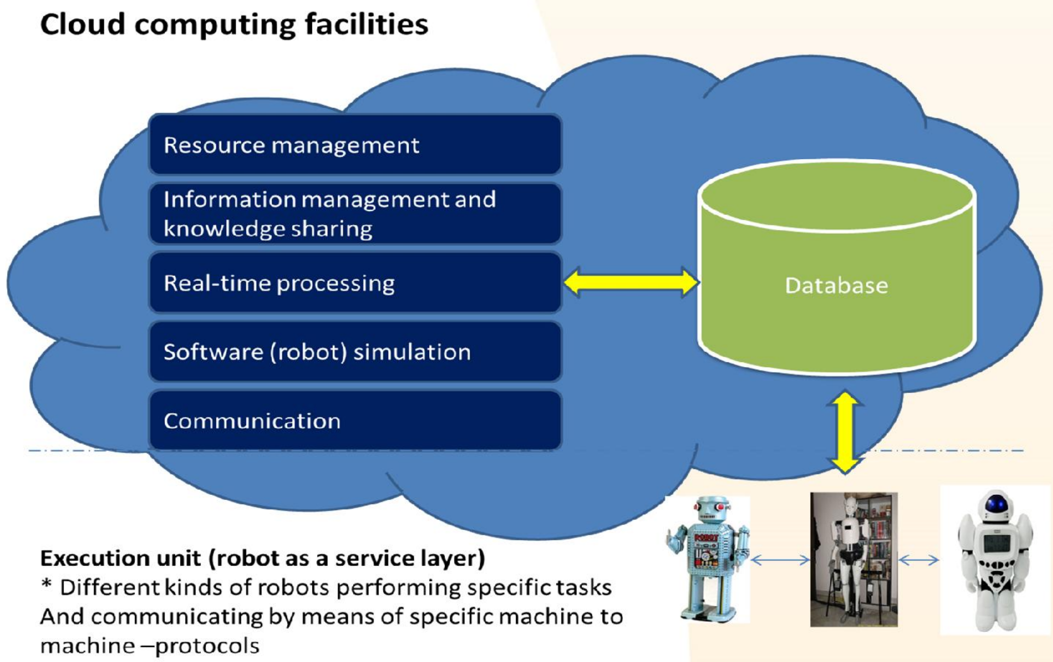


In other service industries similar kinds of "robot families" will emerge during the next years and next decade. Technological transformation will bring robots as personal and social helpers to the European service economy. The "robot families" will change European work life in many ways. Especially, many innovative robotics developments will happen in urban and service economy context (see Lee, Phaal & Lee 2013).

6 Technology foresight insights and inter-linkages to robotics: Three critical technology roadmaps, the technological future of robotics, digitalization and ICT technologies

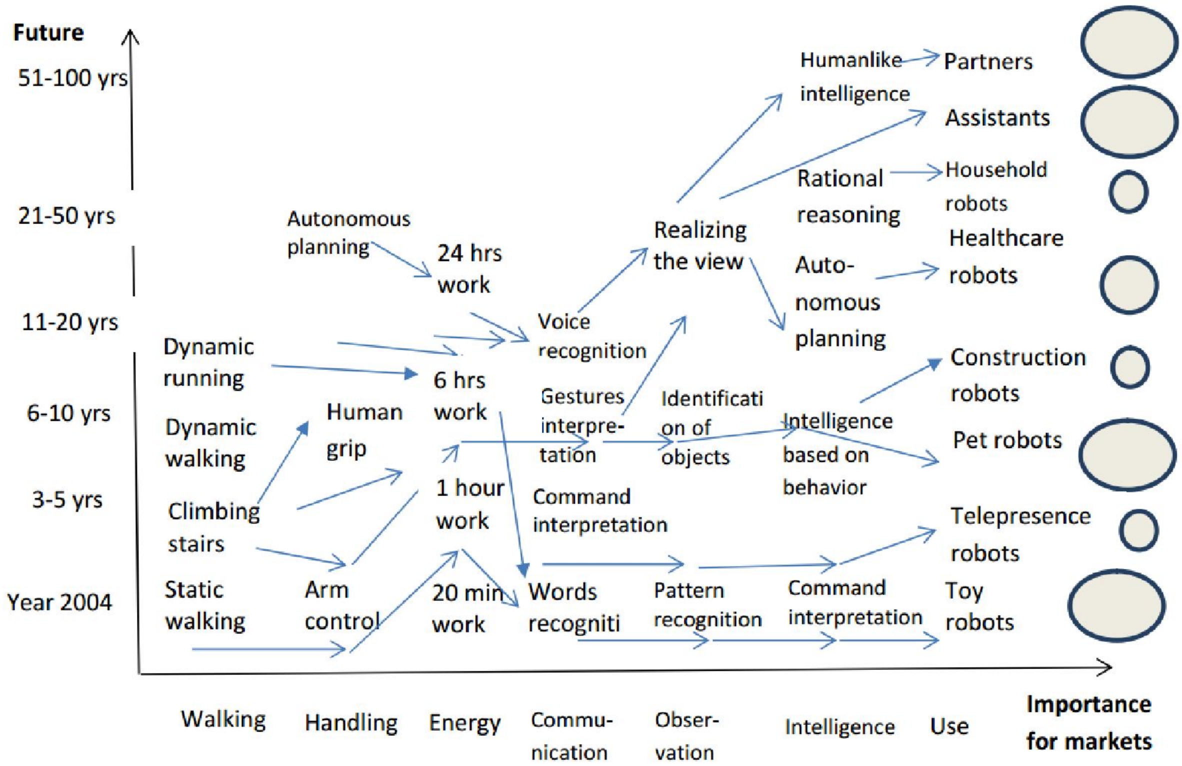
The number of devices involved in Machine-to-Machine (M2) communications is expected to steadily grow till 2020. In 2020 the number of smart objects able to talk to each other and to inter-operate with humans should be around 50 billion. This development will lead to the era of Internet of Things (IoT). In the ongoing IoT or Internet of Intelligent Things (IoIT) revolution, the growing diffusion of robots in many activities of everyday life makes IoT-aided robotics applications a tangible reality of our future. The interplay between robots and "things" will probably help humans in many ways. In Fig. 8 robotics based on cloud computing facilities is visualized.

Figure 8. Robotics based on cloud computing facilities (Chibani et al. 2013).



In Fig. 9 a roadmap for robotics developments (Euron 2004, 2012) is visualized. There will be partners, assistants, household robots, healthcare robots, construction robots, pet robots, telepresence robots and toy robots. These robot applications imitate human and animal behavior. IoT and ubiquitous applications will enable these robot applications to communicate with each other.

Figure 9: Roadmap for Robotics developments (Euron 2004, 2012).



Figures 10 and 11 visualize roadmaps of digitalization, robotics and manufacturing and information technology. These three technology waves are interlinked by IoT applications. What is for certain is that these technology waves change the ways people work and spend their time.

Figure 10: Technology roadmaps of Digitalization and Robotics and manufacturing (TechCast 2014).

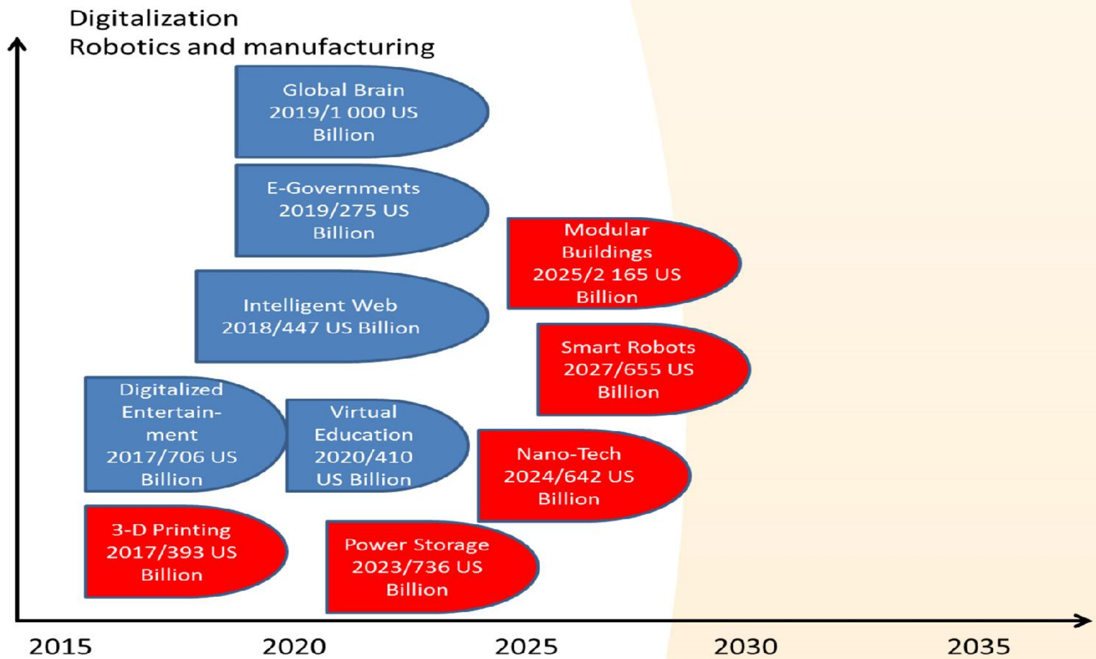
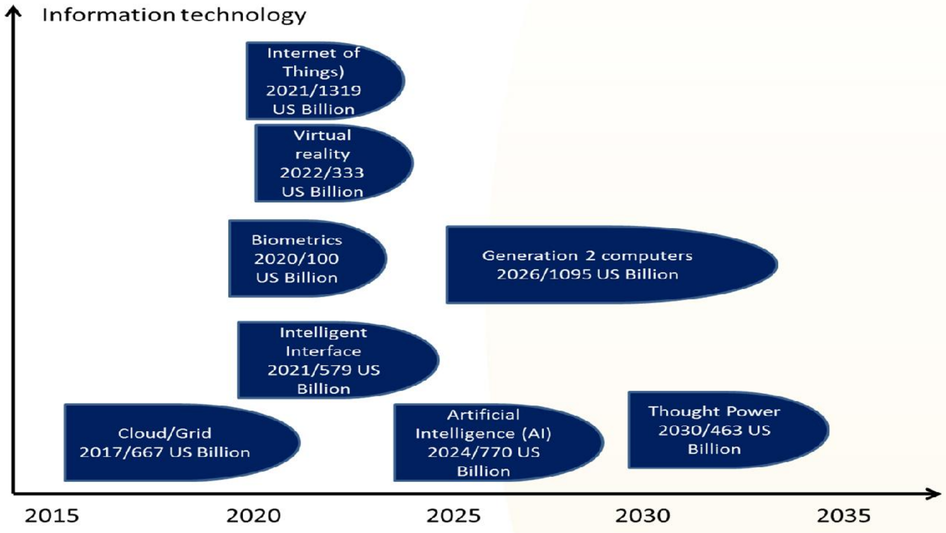


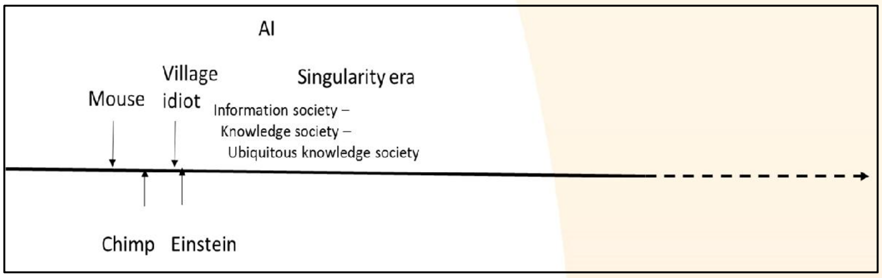
Figure 11: Technology roadmap of Information Technology (TechCast 2014).



One of the key development aspects of robotics is linked to artificial intelligence (AI). Some authors talk about *the second machine age* (Brynjolfsson & McAfee 2014) or *the age of superintelligence* (Bostrom 2014). All these technological changes will lead to a smaller volume of routine work. Technical change increases the relative demand for highly educated workers while reducing demand for less educated workers whose jobs include routine cognitive and manual tasks.

In Fig. 12 the intelligence explosion is placed on a time line. Key issue for the future is how the intelligence explosion is managed and how policy-makers make intelligence explosion survivable. Probably many systemic conflicts will emerge and some technological development includes disruptive elements (see e.g. McKinsey Global Institute 2013).

Figure 12. The evolution of intelligence explosion (Modification of Bostrom 2014, p. 70).



7 Challenges of future work life and labor policy in European Union: Economic, social and political

7.1 The challenge of technological unemployment

The concern over technological unemployment is hardly a recent phenomenon. Throughout history, the process of creative destruction that follows technological inventions has created enormous wealth, but also undesired disruptions. As stressed by Schumpeter (1962), it was not the lack of inventive ideas that set the boundaries for economic development, but rather powerful social and economic interests promoting the technological status quo. The idea of status quo is relevant also in the context of robotics and AI discussions. The balance between job conservation and technological progress, therefore, reflects to a large extent the balance of power in society, and how gains from technological progress are being distributed among citizens and stakeholders.

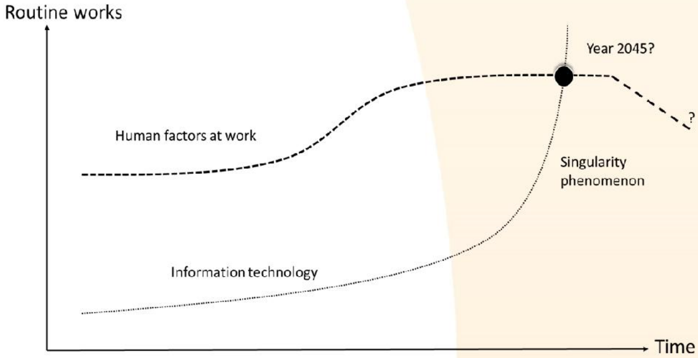
Technological developments have direct and indirect effects on the labour market. For example, on average fewer workers will be needed because industrial and service robots will replace many routine jobs and clearly definable tasks. In the future, the average employee is only the robot's deputy. The human role is to take care of planning, coding and occupying creativity and innovation to services and production. This change increases the need for creativity and creative change agents of creative class.

7.2 Work and singularity hypothesis

The extreme scenario of robotics was presented by Raymond Kurzweil in the form of singularity hypothesis, according to which computer intelligence will exceed human intelligence in the coming decades (see Fig. 13). Kurzweil predicts that by 2029, technological progress has advanced to a stage where computers and ambient intelligence override human abilities. According to Kuzweil this kind of scientific and technological transition to a technological singularity takes place around the year 2045 (Fig. 13). This implies that the robots and other smart artificial intelligence applications can do same things as normal people do. We can certainly disagree, and we can be skeptical of Kurzweil's estimates. Maybe it is possible to find a Golden Rule between the extremes, between technological optimism and technological pessimism? In the history of futures studies and predictions Raymond Kurzweil has been quite a successful and visionary expert. From this viewpoint it may not be wise to adopt technological pessimism as regards the singularity hypothesis.

What is certain, however, is that machines, computers and robots will be much more capable and flexible in the future. The question lies in the direction and speed of technological development and their meaning and significance for a man and mankind's fate? One way to deal with Kurtzweil's scenario is obvious: robots and avatars do not change our society in any way, but everything continues linearly as before. It's just a stage of technological development, just as well as the invention of the steam engine was during the industrial revolution. According to this paradigm we propose a hypothesis, which we may call the Martin Ford's first hypothesis (2009). The hypothesis is as follows: Technology will never evolve to the point where average human being's work can be automated. The economy creates and produces in all circumstances and all times new jobs for people with an average human knowledge and skills.

Figure 13: Singularity scenario and future of work.

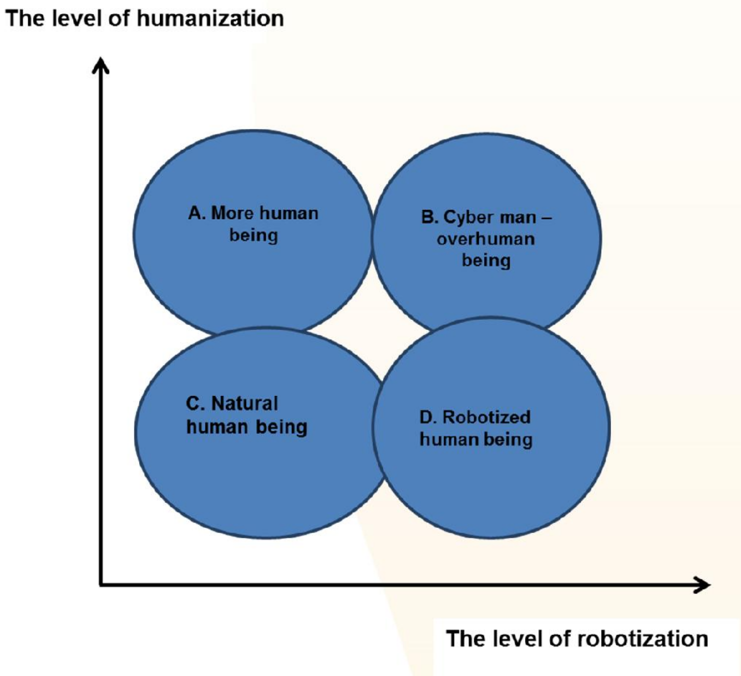


The role of routine works will decrease when singularity scenario is realized. This change means drastic changes in safety and health policies. The safety of routine work will not be such an important policy issue in the world of singularity. There would also be serious consequences for education policy and life-long learning if the singularity scenario will be our future development path.

7.3 The future of human beings and work

In our scenario analysis, the analysis of human future is based on two developments, humanization and robotization. These two drivers are relevant for the future of human beings as shown in Figure 14. Figure 14 presents four alternative scenarios of robotics about human development. Social and welfare policies should carefully consider the aspects to emphasize in economic and robotics strategy. Private business interests might lead to the selection of a robotics substitution strategy, while, from a broader socio-political point of view, the aspect of complementarity in robotics strategy should be emphasized. In this context, the aspects of value rationality should be considered carefully. This means that a target rationale or approach is inadequate. The basic ethical question of whether one wants to allow robotics to increase economic growth or well-being can prove very difficult for decision-makers.

Figure 14: The future of human beings: The impact of robotics.



In Fig. 14 one can see the futures of human beings. One scenario (scenario A) is that real human beings become more and more human and cultivate their inborn human characteristics to an extreme level. Another scenario (scenario D) depicts a more robotized human being. In this scenario human beings are machined and robotized. A third alternative, scenario B, is that of a cyber-man – a super-human being. In this scenario humans are very smart and intelligent, combining a high level of humanness and a high level of robotics and artificial intelligence.

Estimated from a global perspective it is clear that in the future everyone would have access to the same high level of technology, but the usability of technical solutions will have large regional differences. From this perspective, it is impossible to estimate that all the people would come into a cyber-people class. Probably we will find human beings in all the four scenario categories. This fact should be kept in mind when discussing robotics and its importance for the economy and the world of work. Today, the digital divide is a reality in the global context. The future of humankind and its cultural evolution will depend on how well we use technologies and take advantage of innovations and technical opportunities.

7.4 Trends in the workplace and work life

Professor Christopher Freeman and other scholars (Freeman 2001, Freeman & Soete 1994, Freeman & Loucã 2001) have identified seven qualitative trends in the workplace. Freeman speculated on the nature of future employment in the United States and Europe. He identified the following trends:

- increased employment of women in higher-paying jobs
- increase in average skills and age of workers
- global shift in world labour force towards countries that are considered developing (BRICSA)

countries today

- shift in manufacturing employment to these developing countries
- continuing decline of manufacturing employment (but not necessarily output)
- growth of employment in health care and personal services
- nearly universal use of ICT at the workplace and in the markets.

The impacts of these trends on the work place and the future of work are not straightforward. Probably we shall see great variety of work cultures and working conditions in the future. In many European countries unemployment has become a structural phenomenon resulting from fast technical progress and massive productivity increase. A divide is developing throughout Europe, a split between those who are still employed and those who are not. The ratio of those deprived of a job is increasing. Some scholars speak of a two-third society with two-thirds of people living in “well-lit” conditions and one-third living on the “dark side”. This is despite the irony that our societies still define themselves as “work societies”. (Wilbert 1997, 79). In the long run many occupations and work places are at risk. According to an Oxford study, about 47 percent of total US employment is at risk (Frey & Osborne 2013). The impact of computerisation on labour market outcomes is well-established in academic literature, documenting the decline of employment in routine intensive occupations – i.e. occupations mainly consisting of tasks following well-defined procedures that can easily be performed by sophisticated algorithms. For example, work market studies by Charles et al. (2013) and Jaimovich and Siu (2012) emphasise that the ongoing decline in manufacturing employment and the disappearance of other routine jobs is causing the current low rates of employment. If these trend estimates hold in the future, we will face a growing mass unemployment problem in Europe.

Futurist Marja-Liisa Viherä (2010) has estimated that human **M**otivation, **A**ccess to technological systems and created training **S**kills (MAS capabilities) are crucial to how well the benefits of technology can be realized in the workplace (see Viherä 1999). Growth of income inequalities and the digital divide may also influence people's motivations, access to information networks and skills in sharply diverging ways. The differences of opportunities between rural and urban areas can be huge. The future of the Internet is presented with very different estimates. The Internet created and creates entirely new opportunities for open innovation and networking. On the other hand, regulation can change the future direction of development.

It would be a mistake to assume that the structures of society remain unchanged when future technological developments, globalization and demographic changes occur. In this case decision-makers can find new opportunities and open windows. Most likely there will be new social movements and non-governmental organizations, whose importance will be on a completely different level than the influence of existing political organizations. In the field of futures research there has been much discussion about so-called micro-trends that are strongly associated with changes in the structure of societal trend factors. In structural factors of societies, the main future changes are (Gratton 2010):

1. **Re-organized Families:** The traditional family will be re-organized and families rearranged. In the norm, families have previously been the core units of society. In post-industrialised countries there has been an increase in the number of reconstituted families - as well as single households and single-parent families.
2. **Ultra-individualism:** People are becoming more self-aware as their reflection power increases. Ultra-individualism will become more common. When families organize themselves in a new way, and demographic structures change – the individuals' way of thinking about social relations will also change. Friendships are very important if not more so than family relations or kinship. Interpersonal depth and authenticity are key sources of human well-being. People make more and more bold decisions with regard to their own relationships, consequently non-functional backdrop relations are reduced.
3. **The Power of Women**: The social role of women is changing. There will be an increase in the number of influential women, especially within the general level of education and in the labour market. Women will become more active, contributing politically and economically. Also, women will play a more prominent role in the management and leadership of companies and

entrepreneurial businesses, with some joining the top echelons of the corporate elite. This change will affect the rules concerning working life but also life outside the workplace.

4. **Re-defined Roles of Men**: Men will have a more balanced role. Men's attitudes and practices are changing, as is their position in the workplace and in society, due to the change in the status of women. They are looking for a new, more balanced role in society: their big issues being leisure time and the time spent on relationships, the quality of relationships and career choices at different stages in their career. Debate on the role of men in the new social models will increase.
5. **Trust**: Trust is an important factor in the functioning of society. There is growing distrust towards institutions. Professor Francis Fukuyama introduced the concept of confidence into the wider international debate. He sees trust as a key issue of the political system and its credibility. People's faith and trust in big institutions and systems, policy initiatives and corporate responsibility have been seriously eroded during the last decades. Lack of confidence in leadership and policies does not remain without consequences in the social system.
6. **Economic Growth is not enough**: People's happiness and well-being are not unambiguously correlated with economic growth. There is a decline in happiness. In many societies we can observe a negative correlation between welfare indicators and economic growth. This change has given rise to an animated discussion on economic growth, de-growth strategy and downshifting in the work place.
7. **Passive daydreamers**: Passive leisure is increasing in many societies. People are spending more and more time reverting to a passive life-style, playing simple games, getting involved in more social activities, focusing on hobbies and watching TV. Passive time spent following the media is also increasing. Social media can change this trend to promote a more active lifestyle, but not everywhere. In order to involve citizens, it should provide a broad variety of services, and be truly socially oriented.

We can see many worrying trends in social and work life issues. Social upheaval and radicalisation of the youth is possible in many societies – especially in economies with high unemployment rates. Forecast for the future foresee many disrupted families, people's condescending confidence in the basic institutions of society and loss of the feeling of happiness. On the other hand, we can see a number of promising opportunities to improve these worrying trends. We can focus ourselves on development and control. Policy-makers should require more responsible business practices and support social entrepreneurship.

7.5 The problem of structural unemployment

Intelligent machines are not a new thing for humankind. Yet the discussion of intelligent machines and social impacts of robotics and ubiquitous technology on the society and the economy has been passive, perhaps almost non-existent. It appears that the theme has been avoided even in the field of policy. Policy-makers like success stories of technology and science, but they do not like to critically analyze the side-effects of technological progress. Well-structured ideas and thoughts on how far robotized and automated society can be developed have been quite few.

The hypothesis that developing technology could replace a large proportion of human labor and lead to permanent structural unemployment has been for a large part of economists an almost unthinkable idea. The few economists who have discussed the subject have simply been labeled old-fashioned machine haters. Also a concept of neo-Luddite has been presented in such discussions. Automatisation and robotics are very sensitive topics in the field of economics.

For the representatives of conventional economics, technological progress has generally meant an increase in wealth and more jobs, at least in the long term. The new technology and scientific inventions being developed by engineers and scientists have generally been seen as very positive issues. Economists are enthusiastic about the new technology and novelties and they have been viewed to have high potential for societal progress and development. But the real impact of new technologies on employment, job destruction and the economy has been discussed very little. Many conventional economists believe that market mechanism balances the problems in the long-run.

It has been typical to think that technological trajectories are following the logic of economic cycles and associated positive employment effects. A second key idea in economics has been that developing technology always increases people's well-being. In economics it is normal to think that the free market economy really takes care of things - at least with some time lag markets are in balance again (See scenarios of Fig. 15). Wealth and progress, of which we enjoy today in the industrialized countries, would not have taken place without the capitalist logic. In the Western industrial era, technological development and market economy have evolved in parallel. We can think about, is this the case in the future? Should we really leave the discussion of robotisation and automation exclusively in the hidden arms of market forces?

Still today, a key mechanism by which income and purchasing power is distributed to citizens, is to have a job whether in companies or in the public sector. If it happens that at some point of time smart machines, and in particular, intelligent machines take care of most of the work, this kind of mechanism and thinking does not function anymore. Such a change is undoubtedly a great threat to the current economic system and to its financial foundation, and it should raise serious social reflections and broad public debate.

Society based on work ethos can no longer be taken for granted. How do people make work in the future and receive income from their work? If they do not receive income from work, we need to think about how income and wealth are formed in the future. Globalization does not automatically lead all countries and economies to enrichment and better welfare. The consequences of globalization may surprise us in a negative way. It is quite possible that the global financial crisis will continue for too long if we do not pay enough attention to automation and robotisation. These processes can be seen as a “slow revolution” which brings about structural changes in the long run.

Modern research shows that technological development is not only progress in small steps, it is moving forward at an accelerated pace in many areas and technical development can really surprise us in a radical way. Our laws, our culture, our attitudes and our social mechanisms have not evolved to meet the changes of technology waves. Maybe we are not ready for ubiquitous revolution and fast robotisation? Unfortunately, this does not mean that changes will not take place in the future.

7.6 Pessimistic scenario: Ford’s automation hypothesis II

How wealth creation logic changes if ambient intelligence and robots took care of an autonomous industrial production processes, and perhaps also to a large extent, social services? What may be result for workers and for the economy in general? One answer is Ford's (2009) II hypothesis:

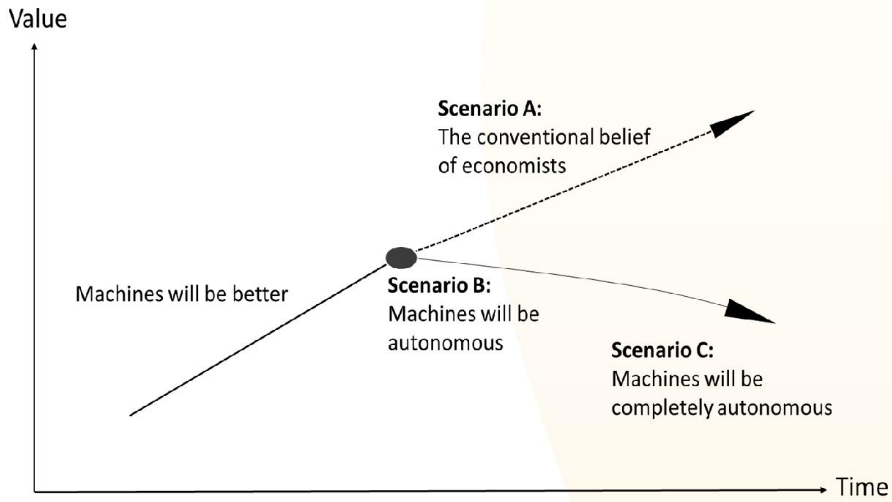
At some point in the future - perhaps after many years or after decades later - machines can perform a large part of the average workers´ works and the consequence is that these average workers will never find a new job.

It is clear that many experts do not agree with this hypothesis. They like to believe that in the economy we can at all times and under all circumstances create new jobs. The extent to which Ford’s hypothesis II can become a reality, it is a challenge for modern economics. Scholar Martin Ford (2009) has presented hypothetical calculations that the potential job loss could be 50-60 per cent of the working population. In practice, these are the people who drive cars, repair machinery and equipment, work as sellers in shopping malls, do office work, and are common in industrial units and plants, whose work can be given to robots and machines. They are so-called average workers.

The work is punctuated by the everyday life of many people, as well as it provides the essence of success and rich experience. Loss of employment can mean great human suffering. If 50 to 60 percent of people cannot find work, it is, of course, also a big drop in consumer demand in the market. Many mass markets loss their demand and this process can lead societies to possibly deeper recession. The changes associated with Ford’s hypothesis II (2009) also mean that people can no longer afford to spend on expensive products and services. Worst of all, the change can mean a serious threat to the capitalist market economy. Final consequence can be disequilibrium of supply and demand as production is increasing, but demand decreasing. On the contrary, the consumer demand may decrease dramatically, leading to structural economic problems in many societies.

Only a small part of the world's population is very prosperous, and the purchasing power of global market is limited. Typically, the prosperity has been achieved in business or by saving. In developing countries people are saving, but in post-industrial countries people still focus on consumption. The global economy can grow only in such a way that the global middle class is growing. If robotisation and automation will take work into the bottom, a lot of people in the mass consumer market will lose most of demand. This can, in the worst case, derail the global economy for long-term depression, which has never been experienced in the past history.

Figure 15. The potential effects of robotics: Three alternative scenarios of work life. Source: modification of Ford 2009).



Such a future image represents the future of large-scale problems in society. In particular, social problems will grow and civil peace is threatened. We have seen already pretty strong signals about this type of development in Europe, where many countries have a large segment of young people at the margins of the labor market. Is this a reasonable situation and outcome we like to have in the future?

The above-described worst-case scenario of Martin Ford (2009, 2015) does not seem reasonable. But still we have too much wishful thinking and we build our planning on hope and good wishes. If we understand current problems and challenges, this fact creates a positive pressure to move towards a better path of the future. This kind of future includes elements of genuine communal encounter, human accountability, peer support, and a strong civil society.

8 Pathfinder examples, programmes and projects of European robotics

In a globally competitive environment, Europe and EU member countries are not only competing against low-wage developing economies, but also highly automated economies and as the decade progresses robotics usage will increase around the world. In the competitiveness, productivity and sustainability battle, leadership in robotics technology will be the key strategic differentiator. In the US Robotics Strategy “A Roadmap for US Robotics. From Internet to Robotics” this is a key starting point for strategic analyses (see Robotics-VO 2013, SPARC 2014).

In current situation, Europe starts from a strong position in robotics, having 32 % of current world markets. Industrial robotics has around one third (1/3) of the world market, while in the smaller professional service robot market European manufacturers produce 63% of the non-military robots. The European position in the domestic and service robot market represents a market share of 14 % and, due to its current size, this is also a much smaller area of economic activity in Europe than the other two areas.

Thus, service robotics is a strategic question for member countries of the European Union. There are needs to anticipate disruptive technology roadmaps, because service robotics will show far more disruptive effects on the competitiveness of non-manufacturing industries such as agriculture, transport, healthcare, security and utilities. The growth in these clusters over the coming decade will be much more dramatic. From what is currently a relatively low base, service robots used in non-manufacturing areas are expected to become the largest area of global robot sales. The role of service robotics will be stronger than before in the history.

One key activity in the field of robotics is the European Robotics strategy which has the title "euRobotics AISBL - Promoting Excellence in European Robotics" (http://www.eurobotics-project.eu/). This project aims to develop robotics field inside European Union. This activity is closely connected to SPARC – the Partnership for Robotics in Europe (SPARC 2014a, 2014b, http://www.sparc-robotics.net/). In Fig. 16 estimates on the world robotics market developments and reachable European market shares are visualized below.

Figure 16. Estimates on the world robotics market developments and reachable European market shares. (SPARC 2014b, Robotics in Europe. Introduction, Web: http://www.sparc-robotics.net/robotics-in-europe/).

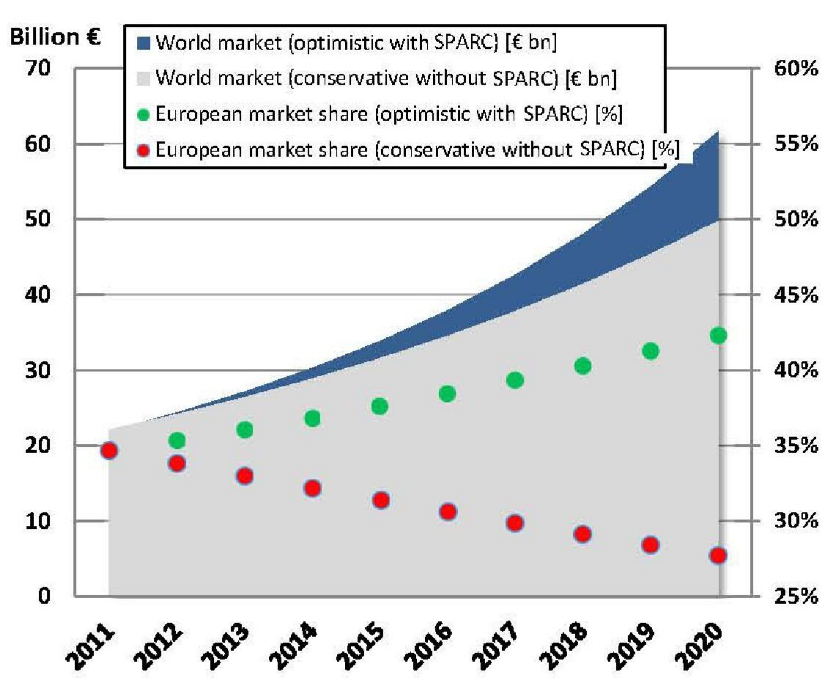


Figure 16 illustrates also that the effects of SPARC are noticeable in a significant uplift of the European market share (plus 14%) and a resulting additional turnover of approximately €44bn (cumulated over years 2014-2020). Growth rates and market shares of robotics are cumulated for the entire robotics domain from industrial, professional (without defence-related applications) and domestic service robotics. This figure motivates stakeholders to invest in the fields of robotics, especially in manufacturing robotics and service robotics. The Horizon 2020 program is also including many elements relevant for robotics. AISBL´s and SPARC´s main missions are (1) to collaborate with the European Commission (EC) to develop and (2) implement a strategy and (3) a roadmap for research, technological development and innovation in robotics, in view of the launch of the next framework program Horizon 2020 (EU Robotics AISBL 2014). Towards this end, euRobotics AISBL was formed to engage from the private side in a contractual Public-Private Partnership with the European Union as the public side. It is important to note that *euRobotics AISBL* (Association Internationale Sans But Lucratif) is a Brussels based international non-profit association for all stakeholders in European robotics (SPARC 2014a, 2014b).

9 Summary

New technologies are promising us many upsides like enhanced health, convenience, productivity, safety, and more useful data, information and knowledge for people and organizations. The potential downsides are challenges to personal privacy, over-hyped expectations and increasing technological complexity that boggles us.

As presented in this article, robotics and AI with ongoing ubiquitous r/evolution will have impacts on safety and health issues. Robotics is not problem-free from this angle of human welfare. In this article a list of key challenges of robotics and AI were presented. An underlined issue was the demand European co-operation in meeting these big challenges.

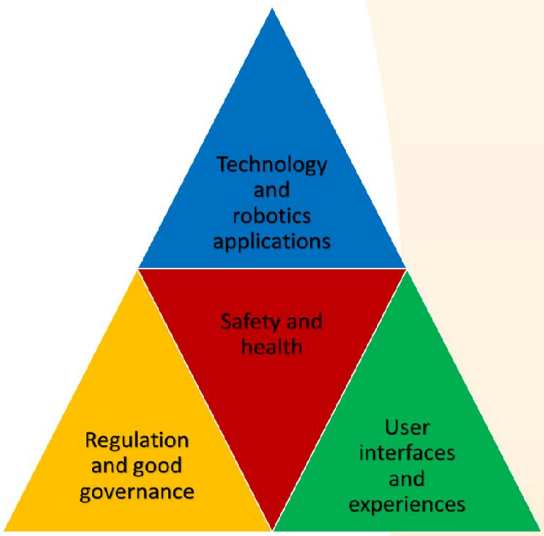
The challenges of robotics and AI revolution require scientific discussion from the viewpoint of management, leadership and organizations – that is, it is time to discuss the meaning of these challenges seriously also in terms of existing traditions of management and safety sciences, bearing in mind their importance already today. Digitalization, robotics, AI, IoT and Big Data are most definitely key factors affecting societal development in the future.

Private and public organizations have begun to gain critical insights from Big Data, robotics and ubiquitous technology through various management systems. Basically, the issue at stake here is that it is not just a question of how to manage and control the technological possibilities. The development also concern leadership functions. A robotized and automated society needs new kinds of management and leadership styles and organizational culture. Education and training need to be developed to meet these big challenges.

Taking the Internet of Things, robotics and ubiquitous technology seriously may lead towards a revolution of digitalization which affects management processes in organizations. The deployment of on-going key processes call for strong leadership in the fields of safety and health. Both the utilization and the development of technologies as well as eliminating negative side effects of new robot applications are the key challenges in ongoing technological transition period.

If the consequences of robotics and AI are taken seriously and professionally, special attention must be paid to (1) technology management, (2) user interfaces and experiences and (3) regulation and good governance. These three critical themes will require many European joint actions and development of good governance (see Safety and health triangle in Fig. 16).

Figure 17: Safety and health triangle.



When we adopt new technologies, the elements of safety and health triangle need more attention. There will be new technologies and applications of robotics and AI. New technologies provide new benefits, new costs, new possibilities and novel threats as history has shown. The widely held notion is that change is speeding up and the future will become weirder at a faster pace that we can easily track. It does seem harder to keep up with new developments, especially in the field of robotics and AI where new inventions and innovations are introduced almost every week.

One key question is to what extent European citizens can trust themselves in managing big technological transformations and how much support they can expect from public institutions and governments. If governments take a very minimal role in the management of big technology transformations this approach leads to minimal state policy. If we adopt public-private partnership, the other approach, as European Union has done in the European robotics strategy, citizens can expect more from governments and other agencies.

10 References

Antoniou, G. & van Harmelen, F. (2004) A Semantic Web Primer. 2nd Edition, The MIT Press, Boston.

Ashton, K. (2009) That 'Internet of Things' Thing. Web: http://www.rfidjournal.com/article/view/4986 Retrieved 13-03-29, 2015.

Atzori, L., Iera, A. & Giacomo Morabito, G. (2010) The Internet of Things: A survey. Computer Networks, Volume 54, Issue 15, 28, 2787-2805

Bell, D. (1974) The Coming of Post-Industrial Society, Harper Colophon Books, New York.

Bostrom, N. (2014) Superintelligence. Paths, Dangers, Strategies. Oxford University Press, Oxford.

Brynjolfsson, E. & McAfee, A. (2011) Race Agains Machine. How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy. Digital Frontier Press, Lexinton, Massachusetts.

Brynjolfsson, E. & McAfee, A. (2014) The Second Machine Age. Work, Progress, and Prosperity in a Time of Brilliant Technologies. W.W. Norton & Company. New York and London.

Castells, M. (2000) The Rise of the Network Society, Blackwell, Oxford.

Berkhout, F., Smith, A., Stirling, A. (2004) Socio-technological regimes and transition contexts. In: Elzen, B., Geels, F.W., Green,K. (Eds.), System Innovation and the Transition to Sustainability: Theory, Evidence and Policy. Edward Elgar, Cheltenham, 48–75.

Berners-Lee, T., Hendler, J. & Lassila, O. (2001) The Semantic Web. Scientific American. May 17, 2001.

Boisot, M.H. (1995) Information Space: A Framework for Learning in Organizations, Institutions and Culture. Routledge, London, 1995.

Boisot, M.X. (1998) Knowledge Assets. Securing Competitive Advantage in the Information Economy. Oxford University Press, Oxford, 1998.

Charles, K.K., Hurst, E. & Notowidigdo,M.J. (2013) Manufacturing decline, housing booms, and non-employment. Tech. Rep., NBER Working Paper No. 18949, National Bureau of Economic Research.

Chibani, A., Amirat, Y., M., S., Matson, E., Hagita, N. & Barreto, M. (2013) Ubiquitous robotics: Recent challenges and future trends. Robotics and Autonomous Systems, Volume 61, Issue 11, November 2013, 1162-1172.

Van Djik, J. (2006) The Network Society. Originally published in Dutch as De netwerkmaastchappij. Second Edition. Sage, London.

EU Robotics AISBI (2015) Robotics 2020- Strategic Research Agenda for Robotics in Europe. Years 2014-2020. SPARC. The Partnerships for Robotics in Robotics. Web: http://www.eu-robotics.net/cms/upload/PPP/SRA2020_SPARC.pdf

EU Robotics AISBL (2014) Robotics 2020 Multi-Annual Roadmap nFor Robotics in Europe. Call 1 ICT23 – Horizon 2020. Initial Release B 15/01/2014. Web: http://www.eu-robotics.net/cms/upload/PDF/Multi-Annual_Roadmap_2020_Call_1_Initial_Release.pdf

European Robotics Research Network, EURON (2004) Key Area 1 on "Research Coordination" – KA1. Robotics. Roadmapdiagram, s. 60. Verkkosivu: http://www.org.id.tue.nl/IFIP-SG16/robotics-roadmap-2004.pdf

Feather, J. (2002) The Information Society. A study of continuity and change. Third Edition. Facet Publishing, London.

Ford, M. (2009) The Lights in the Tunnel: Automation, Accelerating Technology and the Economy of the Future. USA: Acculant Publishing.

Ford, M. (2015) Rise of the Robots: Technology and the Threat of a Jobless Future. New York: Basic Books.

Freeman, C. (2001) Long-Term structural changes: a re-appraisal, in P. Petit and L. Soete (eds.), Technology and the Future of European Employment, Edward Elgar, Cheltenham, 2001, 23-45.

Freeman, C. & Soete, L. (1994) Work for All or Mass Unemployment? Computerised Technical Change into the Twenty-first Century. Printer, London.

Freeman, C. and Louçã, F. (2001) As Time Goes By. From the Industrial Revolutions to the Information Revolution. Oxford University Press, Oxford.

Frey, C.B. & Osborne, M. (2013) The Future of Employment: How Susceptible Are Jobs To Computerisation? Oxford Martin School. Oxford. Web: http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

Gehl, R. (2011) The Archive and the Processor: The Internal Logic of Web 2.0. New Media and Society. 13(8) (2011), 1228–1244.

Geels, F.W. (2011) The multi-level perspective on sustainability transitions: Responses to seven criticisms. Environmental Innovation and Societal Transitions. Volume 1, Issue 1, June 2011, 24-40.

Gratton, L. (2010) The Shift: The Future of Work is Already Here. Collins, London.

Green, E.G. (2010) Anywhere. How Global Connectivity Is Revolutionizing the Way We Do Business. McGraw-Hill, New York.

Greenfield, A. (2006) Everyware: The Dawning Age of Ubiquitous Computing, New Riders, Berkeley, CA.

Grieco, L.A., Rizzo, A., Colucci, S., Sicari, S., Piro, G., Di Paola, D. & Boggia, G. (2014) IoT-aided robotics applications: Technological implications, target domains and open issues. Computer Communications, Volume 54, 1 December 2014, 32-47.

Guizzo, E. (2010) Hiroshi Ishiguro: The Man Who Made a Copy of Himself. IEEE Spectrum. Web: http://spectrum.ieee.org/robotics/humanoids/hiroshi-ishiguro-the-man-who-made-a-copy-of-himself

Hahnel, R. (2005) Economic Justice and Democracy: From Competition to Cooperation. Routledge, New York.

Haidegger, T., Barreto, M., Gonçalves, P., Habib, M.K., Ragavan, S., Kumar V., Li, H., Vaccarella, A., Perrone, R. & Prestes, E. (2013) Applied ontologies and standards for service robots. Robotics and Autonomous Systems, Volume 61, Issue 11, 1215-1223.

Hansmann, U., Merk, L., Nicklous, M. & Stober, T. (2004) Pervasive Computing. Second Edition. Springer, Berlin.

Haidegger, T., Barreto, M., Gonçalves, P., Habib, M.K., Ragavan, Sampath K.V., Li, H., Vaccarella, A., Perrone, R. & Prestes, E.(2013) Applied ontologies and standards for service robots. Robotics and Autonomous Systems, Volume 61, Issue 11, November 2013, 1215-1223.

Ingrand, F. & Ghallab, M. (2015) Deliberation for autonomous robots: A survey. Artificial Intelligence, In Press, Corrected Proof, Available online in Science Direct, 28 November 2014.

Jaimovich, N. and Siu, H.E. (2012) The trend is the cycle: Job polarization and jobless recoveries. Tech. Rep., NBER Working Paper No. 18334, National Bureau of Economic Research.

Kern, F. (2012) Using the multi-level perspective on socio-technical transitions to assess innovation policy. Technological Forecasting and Social Change, Volume 79, Issue 2, February 2012, 298-310.

Kiehne, A. (2012) Web 4.0 - The web has grown up. Are we ready? Web: http://blog.ts.fujitsu.com/face2fujitsu/index.php/web-4-0-the-web-has-grown-up-are-we-ready/

King, N.J. & V.T. Raja, V.T. (2012) Protecting the privacy and security of sensitive customer data in the cloud. Computer Law & Security Review, Volume 28, Issue 3, 308-319.

Kreisler, H. (2001) Identity and Change in the Network Society. Conversation with Manuel Castells. UC Berkeley, Conversations with History; Institute of International Studies. Web: http://globetrotter.berkeley.edu/people/Castells/castells-con4.html Retrieved 2015-03-27.

Kostoff, R.N., Boylan, R. & Simons, G.R. (2004) Disruptive technology roadmaps. Technological Forecasting and Social Change, Volume 71, Issues 1–2, January–February 2004, 141-159.

Kurzweil, R. (1999) The Age of Spiritual Machines: When Computers Exceed Human Intelligence. Viking Adult, USA.

Kurzweil, R. (2005) The Singularity is Near: When Humans Transcend Biology. Viking Adult, USA.

Lee, J.H., Phaal, R. & Lee, S-H. (2013) An integrated service-device-technology roadmap for smart city development. Technological Forecasting and Social Change, Volume 80, Issue 2, February 2013, 286-306.

Machlup, P. (1962) The Production and Distribution of Knowledge in the United States, Princeton, NJ, Princeton University Press, 1962.

Malaska, P. (2003) Synchronic – diachronic system analysis. In Rune Höglund, Markus Jäntti, Gunnar Rosenqvist (eds.), Statistics, Econometrics and Society: Essays in honour of Leif Nordberg, Statistics Finland Research Report 238, Statistics Finland, Helsinki.

Massie, T.H. (1993) Design of a Three Degree of Freedom Force-Reflecting Haptic Interface. SB Thesis, Department of Electrical Engineering and Computer Science, MIT.

McKinsey Global Institute (2013) Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy. May 2013. McKinsey & Company.

McNeill. J.R. & W. McNeill, W. (2003) Human Web. A Bird's Eye View of World History. W. W. Norton & Company, New York.

Nora, S. & A. Minc, A. (1981) The Computerization of Society: A Report to the President of France. Originally published in French in 1978 as L'informatisation de la société: rapport à M. le Président de la République. MIT Press, Cambridge, MA.

O'Reilly, T. (2009) What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software. Web: http://oreilly.com/web2/archive/what-is-web-20.html Retrieved 12-06-27, 2009.

O'Sullivan, D. & Igoe, T. (2004) Physical Computing: Sensing and Controlling the Physical World with Computers. Thomson Course Technology, Boston, MA.

Pajarinen, M. & Rouvinen, P. (2014) Computerization Threatens One Third of Finnish Employment. ETLA Brief No 22. Web: http://pub.etla.fi/ETLA-Muistio-Brief-22.pdf

Pettinger, T. (2013) The Luddite Fallacy. Economics. Web: http://www.economicshelp.org/blog/6717/economics/the-luddite-fallacy/

Pew Research Center (2014) AI, Robotics, and the Future of Jobs. Digital Life in 2025. Web: http://www.pewinternet.org/2014/08/06/future-of-jobs/

Pine II, B. J., Korn, K.C. (2011) Infinite Possibility. Creating Customer Value on the Digital Frontier. Barrett-Koehler Publishers: San Francisco.

Pink, D. (2009) The Surprising Truth About What Motivates Us. Riverhead.

Pistoni, F. (2014) Robots Will Steal Your Job But That´s OK. ©Federico Pistoni.

Porat, M. (1977) The Information Economy. US Department of Commerce, Washington, DC, 1977.

Rifkin, J. (1995) The End of Work: The Decline of the Global Labor force and the Dawn of the Post-Market era. Putnam Publishing Group, New York.

Rifkin, J. (2010) The Empathic Civilization: The Race of Global Consciousness In a World in Crisis. Jeremy P. Tacher, Australia.

Rifkin, J. (2011) The Third Industrial Revolution: How Lateral Power in Transforming Energy, the Economy, and the World. Palgrave Macmillan, New York.

Robinson, M., Jones & Janicke, K.H. (2015) Cyber warfare: Issues and challenges. Computers & Security, Volume 49, 70-94.

Robotics-VO (2013) A Roadmap for US Robotics. From Internet to Robotics. 2013 Edition. Robotics in the United States of America. USA. Web: https://robotics-vo.us/sites/default/files/2013%20Robotics%20Roadmap-rs.pdf

Sapolsky, R.M (2006) Why Zebras Don´t Get Ulvers: An Updated Guide to Stress, Stress-related Diseases, and coping. The Norton Psychology reader. Edited by Gary Marcus, W.W. Norton & Company, New York.

Sicari, S. Rizzardi, A. Grieco, L.A. & Coen-Porisini, A. (2015) Security, privacy and trust in Internet of Things: The road ahead. Computer Networks, Volume 76, 146-164.

SPARC (2014) Strategic Research Agenda for Robotics in Europe 2014-2020. © euRobo(cs aisbl 2013 & 2014. Web: http://www.eu-robotics.net/cms/upload/PPP/SRA2020_SPARC.pdf

SPARC (2014) Robotics in Europe. Introduction, Web: http://www.sparc-robotics.net/robotics-in-europe/)

Stappers, P.J. (2006) Creative connections: user, designer, context, and tools. Personal and Ubiquitous Computing. 10(2–3), 95–100.

Stehr, N. (2002) Knowledge & Economic Conduct, University of Toronto Press, Toronto.

Stenmark, M. & Malec, J. (2015) Knowledge-based instruction of manipulation tasks for industrial robotics. Robotics and Computer-Integrated Manufacturing, In Press, Corrected Proof, Available online 6 September 2014.

Strambach, S. (2008) Knowledge-Intensive Business Services (KIBS) as drivers of multilevel knowledge dynamics. International Journal Services Technology and Management, 10 (2/3/4) (2008), 152–174.

TechCast (2014) Technology Forecasts. December 2014. Web: https://www.techcastglobal.com/documents/10193/0/Tech+Forecasts/0a4363df-2287-4da1-821e-05d9ec984c42

Teece, D. (2007) Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. Strategic Management Journal. Volume 28, Issue 13, 1319–1350.

Toffler, A. (1970) Future Shock. Random House, New York.

Toivonen, M. (2004) Expertise as Business. Long-term Development and Future Prospects of Knowledge-intensive Business Services. Dissertation. Helsinki, Helsinki University of Technology, Department of Industrial Engineering and Management, Helsinki.

Touraine, A. (1971) The Post-Industrial Society. Tomorrow's Social History: Classes, Conflicts and Culture in the Programmed Society. Random House, New York.

UNESCO (2005) Towards Knowledge Societies. UNESCO World Report, UNESCO Publishing. Paris. Web: http://unesdoc.unesco.org/images/0014/001418/141843e.pdf

Viherä M-L. (1999) Ihminen tietoyhteiskunnassa. Kansalaisten viestintävalmiudet kansalaisyhteiskunnan mahdollistajana. [People and Information Society. The Citizens' Communication Skills and the Opening of New Prospects for the Civil Society]. Turun kauppakorkeakoulu. Turun kauppakorkeakoulun julkaisuja. Sarja A-1: 1999. Turku.

Van Djik, J. (2006) The Network Society. Originally published in Dutch as De netwerkmaastchappij. Second Edition. Sage, London.

Way, B. (2013) Robocalypse: The End of Human Jobs And How Robots Will Replace Them. ©Ben Way.

Weber, W., Rabaey, J.M. & Aarts, E. (eds.) (2005) Ambient Intelligence. Springer, Berlin.

Weiser, M. (1991) The computer for the 21st century. Scientific American. 265(3) (1991), 94–104.

Wilbert, B. (1997) Cultural meanings in transition: a crisis at work. P. James, W.F. & Wright, S. (Ed.) Work of the Future. Global Perspectives. Allen & Unwin, Australia, 79-87.

Yasunga, Y., Watanabe, M. & Korenga, M. (2009) Application of technology roadmaps to governmental innovation policy for promoting technology governance. Technological Forecasting and Social Change. Volume 76, Issue 1, January 2009, 61-79.

Authors: Research Director, Dr, Adjunct Professor Jari Kaivo-oja,

Turku School of Economics, University of Turku