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Urze P., Rosas J., Camarinha-Matos L.M. (2021) Working Beside Robots: A Glimpse into the Future. In: Camarinha-Matos L.M., Boucher X., Afsarmanesh H. (eds) Smart and Sustainable Collaborative Networks 4.0. PRO-VE 2021. IFIP Advances in Information and Communication Technology, vol 629. Springer, Cham. https://doi.org/10.1007/978-3-030-85969-5_12

Working beside Robots: A Glimpse into the Future

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Abstract. Automation throughout history has caused profound changes in employment dynamics. With the advent of the fourth industrial revolution, a new threat may affect employability, as robots and AI-based processes can now assume tasks considered exclusive to humans. This position paper aims to motivate the study of the effects of AI and automation on employability, extending it into a collaborative network perspective. The problem is firstly observed from a historical perspective. The collaboration aspects are considered through the analysis of two case studies. Results suggest that a latent element of collaborative networks, complexity, may have effects in terms of employability.

Keywords: Employability, Artificial Intelligence, Automation, Collaborative Networks

1 Introduction

Since the end of the 19th century, humanity has witnessed several technological disruptive events with such a magnitude characterized as industrial revolutions. Now, it is said that we are currently going through the fourth industrial revolution (Industry 4.0). Meanwhile, there was progressive innovation with profound effects of technological, economic, and social nature, namely, the developments in the areas of Robotics and Artificial Intelligence. One of such profound effects was the transference of jobs between cross-industrial sectors, as many jobs were killed in some sectors, and new jobs were created in other ones. In this regard, researchers and history tell us that fears of job loss are unfounded, at least after some adaptation period, after which jobs transference succeeds. However, this time, things might be different, as Robots and Artificial Intelligence (AI) might effectively take a more significant proportion of our jobs at a faster speed. Or at least the impacts during the adaptation period might reach a different scale.

Two attitudes towards employability (or professional occupation) persist due to advances in automation and AI. In the 1980s, most publications were optimistic about technology and employment, and best-selling books announced the increasing amount of qualified work. Today, the vision is mostly pessimistic: job shedding, the rise of robotics and technological systems as synonym for the replacement of human workers; predictions of a dystopian future based on the aforementioned replacement and mass unemployment are now often put forward, as well as "intelligent machines" being considered driving forces in the dehumanization of work or the development of a cyber-proletariat [1].

In contrast with the gradual or linear evolution typical of previous technological revolutions, the fast diffusion of the digital economy represents an enormous challenge due to its intrinsic complexity, unpredictability, and dematerialization of processes, products, goods, and services [2]. In some way, it is predicted that information technology, robotics, and AI will have a dominant role in society. More recent forecasts even indicate that some "non-routine cognitive tasks" may be developed by robots, and that the service sector is subject to a widespread risk [3], [4]. For technological determinists, the question of whether machines will displace human labor "*will be answered by the nature of the technology that arrives in the future*" [5], [6]. Technological determinism regards technology as the key force shaping society and determining social change and progress. This notion of progress is therefore centered around technological growth and the conception that the problems of the social whole are solved by technological advances. There are, however, divergent approaches on the future of work that argue that there will not only be job distribution, but that new professions will also emerge from the process of social and technical transformation. Also, some traditional professions might be recreated and gain a new scope. In turn, from the social construction of technology's perspective, technology is socially constructed, and its trajectory is dependent on several social elements and pertinent social groups.

In this **position paper**, the two perspectives, the optimistic and the pessimistic, concerning the dynamics of Artificial Intelligence and Robotized Automation over employability / professional occupation are addressed. In addition, this problem is also addressed from the "collaborative networks" perspective. Since this is a position paper, our aim is not to present conclusive results but rather to provide arguments supported by existing evidence for the proposed problem and motivate inter-disciplinary discussion between social sciences and engineering.

2 The Impact of Innovation on Employability

In the past, automation was associated with machines and robots performing repetitive tasks in factories. Currently, thanks to the combination with certain disruptive technologies, such as AI, Robotics, Robotic Process Automation (RPA), and Machine Learning (ML), among others, machines are now able to perform operations that were previously unique to humans, for example, driving a car, landing a plane, writing news, predicting our behavior, and so on.

This capacity for machines / systems to now perform tasks known to be exclusive of humans has raised fears that automation could lead to a significant loss of jobs. As mentioned in a study from McKinsey in 2017 regarding the impacts of AI, Automation and Robotics on employability, 50% of existing activities are technically automatable [7].

From a historical perspective, whenever an industrial revolution occurred, there was subsequent massive destruction of jobs that became obsolete in some sectors. However, contrary to the fears and social unrest felt at those times, after a while job destruction was compensated by the creation of other jobs in new sectors. Fig. 1 illustrates the phases of employment transfer to other sectors.

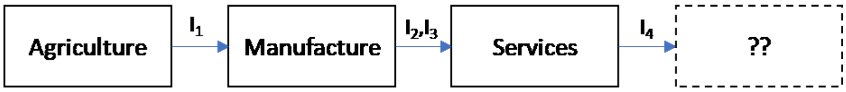

Fig. 1. Jobs displacement during industrial revolutions.

Instead of the feared jobs' loss during these transformation periods, there was a significant shift of employment to other sectors, briefly:

- **I1**: Transference of jobs from agriculture to manufacturing due to mechanization, steam power, …
- **I2**: Transference of jobs from manufacture to services due to electrical energy, mass production, assembly lines, …
- **I3**: More jobs transference due to automation, computers, and electronics, …
- **I4**: Due to Robots, AI, and other paradigms, many activities from the services sector can be taken by smart robots / smart systems. Will those lost jobs be transferred to other activities? Which ones?

More recently, society has benefited from the emergence of disruptive technologies, such as the Internet of Things (IoT) / Cyber-Physical Systems (CPS), Intelligent Robotics, and Artificial Intelligence / Machine Learning, which have allowed a deeper level of automation and robotization. By applying AI/ML algorithms, machines have been able to assume various roles and jobs that were previously exclusive to humans, e.g., non-predictable tasks requiring creative or intellectual effort. Therefore, contrary to previous disruptive events, these jobs' appropriation might be more challenging or even threatening, as it occurs across several activities sectors, including services, and encompassing non-repetitive, non-structured, more intellectual, and more creative tasks.

As stated by the authors of the study "*A Future that works: Automation; employment, and productivity*" [7], it is predicted that "50% of current work activities are technically automatable by adapting currently demonstrated technologies" and that "6/10 current occupations have more than 30% of activities that are technically automatable" [7]. According to the same authors, "Up to 375 M workers globally may need to transition to new occupational categories by 2030" [7]. Thus, there is increasing uncertainty about what might occur in terms of employability / professional occupation in the future. Still, as mentioned before, there are two types of attitudes or perspectives, optimistic and pessimistic, regarding the progressive innovation brought in by these technologies.

2.1 The Optimistic Perspective

Many researchers from several areas are optimistic that society will adapt to the higher levels of robotization and automation. Jobs' loss in some sectors will eventually be complemented by creating new work in other sectors. It happened before, it will happen now. They maintain that "*It is easy to see which jobs are being destroyed by technology, but difficult to imagine which jobs will be created by it*" [7]. As happened before, "*history would suggest that such fears may be unfounded: over time, labor markets adjust to changes in demand for workers from technological disruptions*" [7].

In fact, an optimist perspective could foresee:

- ***Recreation of professions in traditional sectors***. Several sectors (e.g., agriculture and fisheries) have suffered a marked loss of interest on the part of the new generations, even when they offer job opportunities. This is due to the harshness of traditional activities in these sectors and the low social prestige associated with them. The introduction of robotization and intelligent systems in these areas will make it possible to recreate the nature of the functions to be performed by humans, now more focused on planning, creativity (new products), management and participation in value chains. This naturally requires other levels of qualification and will likely lead to an increase in social prestige.
- ***Establishment of new professions and functions***. Robotics and its integration with intelligent networked systems will allow the emergence of new professions or a considerable extension of human capabilities (sensory, acting and telepresence) in areas such as support for active aging, security, entertainment, education, and training. It is also important to take advantage of such technological advances to compensate for the natural decline in capacities that comes with aging, allowing for a better integration in the socio-economic activities of the elderly and people with special needs.
- ***Promotion of new models of inter-generational collaboration***. The current and predictable demographic evolution requires new approaches for effective inter-generational dialogue and collaboration. Robotization, namely in terms of service robotics and extension to human sensory and action capabilities, should be used as a catalyst for collaboration between different age groups. In addition, AI and the growing hyperconnectivity of society, interconnecting organizations, people, and objects in the physical world (IoT/CPS) can enhance new network business models, where it is important to find suitable models of inter-generational integration.
- ***Enhance collaboration between humans and intelligent systems***. Human-machine collaboration (e.g., ongoing developments in collaborative robotics) and human-systems collaboration, namely exploring new forms of interface, computational models of emotions and creativity, etc., should lead to a redefinition of functions. This should allow not only a better use of the cognitive, creative, and emotional capacities of humans, but also an improvement in their professional achievement.

As mentioned in [8] and [9], "*alarmism is not justified, as the diffusion of artificial intelligence and robotics will not be as fast and accelerated as advertised. However,* *computers will replace routine tasks. But tasks requiring problem-solving, adaptability, flexibility, and creativity are the most resistant to innovation. Despite advances, there are limitations of current technology to perform non-routine tasks*." However, that statement was made more than five years ago. Progress and innovation run fast in areas like AI, robotics, ML, among others.

2.2 The Pessimistic Perspective

Until recently, robots were relatively limited, typically applied in routine and predictable tasks. However, as said by Elan Musk, "There will be fewer and fewer jobs that a robot cannot do better" [10]. Now, intelligent systems can take on increasingly complex tasks. An illustrative example is a system called Watson (IBM) which, supported by several AI functions, can beat humans in such a games as complex as "Jeopardy" [11]. AI-based processes and machines can now drive cars, write news, do trading in financial markets, impersonate humans in call centers as agents or chatbots, among others.

Around the beginning of the century, it was stated about the future of automation that activities, such as autonomous driving or natural language processing, would be quite challenging to perform by a computer [12]. However, such predictions were wrong. Some researchers believe that it is different this time. Intelligent processes and robots supported by AI and ML will be increasingly empowered to replace humans in a broader range of activities. As machines become more capable and sophisticated, there will be fewer and fewer tasks that they cannot do better.

AI and ML may therefore eliminate many jobs due to their unlimited potential for automating tasks. Any task can be the object of automation even faster than before, even if it involves complex work requiring human effort [13]. In addition, ML models can be replicated and reused at no cost, increasing this effect of eliminating human jobs. This certainly requires further multi-disciplinary discussion.

3 A Collaborative Networks Perspective

The influence of automation, robotics, and AI on employability can be addressed from a collaborative networks' perspective. For this, we will start by referring to the concept of network effects and the Metcalfe's Law. Then, for illustrative purposes, we describe two cases obtained from new media sources. The first one describes a system that can organize and coordinate a collaborative project involving a network of freelancers. The second case involves a supply chain dedicated to the manufacture of a "smart product."Afterward, we hypothesize that the determining factor for collaborative networks, versus robotics and AI, versus employability is related to the complexity of collaborative networks.

3.1 Network Effects

The "network effect" or "network externality" or "demand-side economies of scale" consists of the phenomenon by which the value or utility of a product is dependent on the number of users using that product or other compatible ones [14]. A network effect manifests, in a direct way, when the number of users increases, the value of the product also increases. It also manifests indirectly, as when the utility of the product for one group increases, the utility for other groups also increases. For instance, when people started to drive cars, road construction, gas stations, service areas, and other sectors became more important.

Metcalfe's law can characterize network effects [15]. This classical law establishes that the value of the network grows in proportion to the square number of elements participating in the network. The cost of a network increases directly proportionally to the size of a network. However, when a product reaches a critical number of users, network effects drive the subsequent growth of the network until it achieves a stable balance. From a certain point, due to saturation or congestion issues, which affect the network's ability to grow [16].

Some researchers have proposed more conservative formulations for Metcalfe's law in determining the value of a network [17]. In general, this law has been correct to explain the growth in telephone networks, faxes, web applications, social networks [18], and even Bitcoin [19]. Many companies began the transition from a traditional "business economy" to a "networked economy" to benefit from the strategic value of network effects.

3.2 Case-studies

The following two cases serve as an illustration and inspiration for the discussion that will be made afterward. The description of the cases is reduced to the minimum considered necessary for our purposes. The reader should consult the corresponding bibliography for more insights.

Freelancers' collaborative projects. We start with an example regarding collaborative projects management involving teams of freelancers. For the management of projects, a software called iCEO is used. "*iCEO is a virtual management system that automates complex work by dividing it into small individual tasks*" [20]. This software can significantly reduce project costs. This reduction is done in two ways. On one hand, the software eliminates and replaces "middle management". On the other hand, over the various projects, it tries to automate the tasks carried out by freelancers [20].

When the system is used in a new project, it firstly decides which jobs can be automated and which ones require human effort. Then, the system searches online for freelancers with the necessary skills. The system then distributes the tasks and manages the execution of the project. For this purpose, the system monitors every single task being developed by each freelancer. Meanwhile, it collects massive amounts of data, providing enough information to understand how each freelancer developed his/her tasks. Afterwards, ML algorithms begin to run through the collected data, obtaining models for task automation. What is happening is that the freelancers are effectively teaching the system how to perform their tasks.

Although the software eliminated the manager's role, in a first stage it helped create work for freelancers, which could be considered positive. However, as the system is used in posterior projects, it can significantly reduce freelancers' participation.

Supply-chain network. This case encompasses a company in a supply chain for assembling a "smart-product" [21]. It eloquently illustrates how network effects arise within a collaborative network.

The smart product brand company focuses on its core competencies (design, assembling, sales to the public). It outsources the other stages of product construction to better-qualified suppliers (manufacture, distribute, install, servicing). A generic representation of this network, expressing direct and indirect network effects in the supply-chain is illustrated in Fig. 2. To ensure product quality, the company needs to control critical logistics processes [21]. This requires a high-level of collaboration, which allows monitoring the product being manufactured at all stages, sharing demand plans, communicating changes in product design. That must be done in real-time. But as the customer base at the demand-side increases, there is a consequent increase in pressure and greater complexity of coordination on the supply-side. This happens in contexts where supply-chains can grow up to a global scale. According to Metcalfe's law, a level of congestion in the chain can be reached. To deal with the resulting complexity, it is necessary to automate chain coordination progressively. As described in the next section, this poses potential effects on employability.

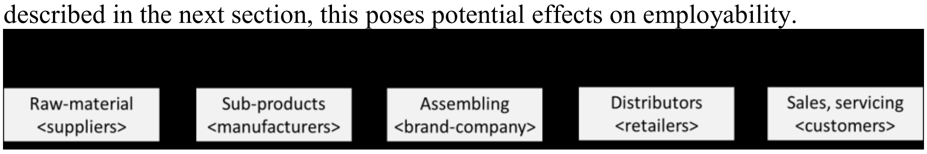

Fig. 2. Representation of the supply-chain focusing on the network effects.

3.3 Discussion

Regarding the described cases, the first one refers to an example of a system, which eliminates "middle-management" in collaborative projects. Eventually, using ML with data taken from freelancers' tasks monitoring, the system can even automate many of their tasks, reducing their need in subsequent projects. The case takes place in the context of networks. If there is a growing trend towards using this type of software for managing collaborative projects by itself, it poses a threat in terms of employability.

The second case is more interesting. When a supply chain comprises a small number of trustworthy suppliers, it can be managed and operated by humans and standard management processes. As the number of participants on the demand-side increases, supply-chain complexity also increases [22]. At a certain level, network growth can be hampered, not by lack of capacity, but by management complexity

[23], [24]. As such, many companies started to automate supply-chain management with Robotic Process Automation [25].

In this regard, the supply-chain automation with RPAs is accompanied by the digitalization of the entire chain, which, similarly to the previous case, allows recording massive amounts of data. That data is fed into Machine Learning algorithms to obtain mechanisms that improve network management. With this level of visibility, non-deterministic tasks performed by humans are subject to automation, which can free the human from repetitive tasks, but might also take jobs [25], [26].

Meanwhile, while finding the best suppliers, the RPAs try to identify the ones with the best price, quality, and delivery time. Eventually, the chosen ones might comprise suppliers who are involved in automation strategies on their own (as they were identified as the best ones). We can therefore stipulate, this self-organizing effect towards suppliers with more level of automation effects on employability.

From a taxonomic viewpoint, the first case resembles the PVC / VT network types. The second one comprises a supply chain. From related research, we know that complexity is a feature in collaborative networks [27]. We could therefore generalize this line of thinking to the other existing collaborative network forms. We could consider the utilization of RPA-based to implement, e.g. *X*-planners and *X*-managers, in which *X* belongs to {VE, VO, Extended Enterprise, …}, to deal with network complexity, as suggested in [28].

As mentioned before, since this is a position paper, our purpose is not to present definite research results but rather to present arguments to consider a new line of research or added concerns for current research streams. In this case, our hypothesis addresses the effects of AI and automation on employability from a collaborative networks' perspective. Having said that, we consider the hypothesis illustrated in Fig.3.

[redacted]

Fig. 3. CN Complexity and effects on jobs.

Therefore, we propose the hypothesis that collaborative networks complexity may pose positive or negative effects on employability. Further research work is necessary to confirm or refute this research premise and to devise promising directions for sustainable technological development. As this problem is complex and broad, other perspectives could be taken in consideration [29]. For instance, a more skeptical viewpoint could assume that complexity is a feature of many things and certainly would affect employability. Even considering the risks of this "unknown territory", it is the responsibility of researchers to also devise strategies that turn those risks into opportunities. As such, it is necessary to include such concerns in the research agenda. For instance, we could consider questions such as:

- What is an appropriate methodology to study the link between AI/ML/Robotics and employability, from a collaborative network perspective?
- Which socio-technical models for the development and integration of robotics and intelligent systems, complemented with organizational models in collaborative networks / business ecosystems, can enhance the recreation of professions and new functions in traditional sectors?

- How to explore and develop new technological possibilities to extend the human capacities, opening opportunities for new forms of professional occupation?
- How to explore and develop new collaborative models, contributing to peace, sustainability, and quality of life, including professional occupation?

Such challenges naturally require an interdisciplinary and socio-technical approach to research. The growing precariousness of labor relations, accentuated by some current socio-economic models, may constitute an obstacle to the social acceptance of new technologies. In addition to a strategy to raise awareness of new opportunities, it is also important to develop research into new models of "social security" for the "network economy" in a highly technological society.

4 Conclusions

This research work addressed the effects of AI, Robotics and automation on employability from a collaborative networks' perspective. We began addressing this issue from a historical perspective, looking at the effects of automation on job dynamics throughout the most significant disruptive events. Then, the perspective of collaboration was established, starting from two case studies, towards reaching our research hypotheses established in the previous sections. The question of whether AI and Robotics will lead to the loss of jobs is now even more uncertain. From a historical perspective, we most likely should not worry in the medium term. But things might be different now. The nature of innovation in the information age is different from what has happened before. This time, machines may significantly assume the work of humans. Either way, for the economy to survive as a sustainable ecosystem, it needs to adapt, as it has done before. And this calls us to design appropriate research agendas.

The next step, as future work, is to incorporate more aspects to the proposed research hypothesis. The problem is worth being addressed from a collaborative networks' perspective.

Acknowledgments. This work has also been partially funded by the Center of Technology and Systems (CTS) – UNINOVA, and the Portuguese FCT Foundation project UIDB/00066/2020, and by Interuniversity Center for the History of Science and Technology (CIUHCT) and the Portuguese FCT Foundation project UIDB/00286/2020.

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