The Impact of Robotics and Automation on Working Conditions and Employment

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The IEEE Robotics and Automation Research and Practice Ethics Committee (RARPEC) is intended as a platform to exchange ideas and discuss the impacts and practice of robotics and automation (R&A) technologies in research, development, and deployment that appear to pose ethical questions for humanity. With increased awareness and controversies surrounding R&A, RARPEC is publishing a series of opinion pieces that will focus on separating hype from reality by providing an objective and balanced treatment of technological, ethical, legal, and societal perspectives. Second in the series, this piece focuses on topics related to robots, jobs, and workforce development. Please send your feedback and suggestions to the chair of the committee, Raj Madhavan, at raj.madhavan@ieee.org. We look forward to your comments!

As roboticists, we like to think that the fruits of our research—robots that are faster, more efficient, more agile, and more intelligent—can only benefit humanity. While this is certainly true for exploratory or disaster intervention robots, the case is more controversial for other types of robots such as those used for military purposes, as discussed in the previous article in the series [7]. In this article, we provide a quick overview of the concerns raised by the accelerated introduction of robotics and artificial intelligence (AI) technologies in all economic sectors and, in particular, its effects on working conditions and employment.

Robotics and Automation in the Workplace

Robots, like any machines introduced into the production process, have contrasting effects on workers. On the one hand, they can eliminate some harsh, unhealthy, or dangerous tasks. Consider for instance, the welding process in car manufacturing. Welding is certainly a hazardous activity for workers to perform, with deleterious short- and long-term effects ranging from irritations of the eyes, nose, ears, throat, and chest to pulmonary infections, heart diseases, and lung and throat cancers. The robot-based automation of welding in modern car manufacturing lines has significantly reduced health problems caused by welding. On the other hand, precisely because robots can automatically perform some tasks, they render the workers who previously performed those tasks "redundant" for production processes. This has multiple adverse effects for workers.

For example, workers rendered redundant by robots face the risk of being laid off. Since the first machines were introduced on a large scale at the beginning of the 19th century (the First Industrial Revolution), the layoff of redundant workers has been a common practice. An early and particularly tragic episode was the introduction of power looms in the United Kingdom during the first few decades of the 19th century. Skilled weavers were suddenly put in competition with machines that could weave better and faster. Facing wage reduction or replacement by machines operated by cheaper, unskilled workers, desperate weavers (later known as *Luddites*) waged a campaign of destruction targeted at the newly introduced machines. The response by the owner class was harsh: seventeen Luddites were hanged, many others were imprisoned, and the movement was quickly dispelled.

These days, even though strict labor regulations and strong workers' organizations in most developed countries may offer some protection against or procure compensation in the event of layoffs, such technological layoffs and their adverse effects on the lives of the concerned workers seem inevitable. Indeed, when the management of a company considers introducing robots, its chief concern is not whether the robots are based on a fancy new technology or whether they will improve workers' welfare; it is profitability. In this view, keeping redundant workers simply does not make economic sense.

Additionally, workers who retain their jobs alongside robots might not always see their working conditions improve. Consider, for instance, the Amazon warehouses into which robots have been introduced on a massive scale over the past few years; because the robots are so fast and so consistent, their pace can be set arbitrarily and is, in fact, imposed on the workers. A journalist working undercover in an Amazon warehouse testifies:

> Alone in a locked metal cage, ten feet from my nearest colleague,

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> a robot approaches from the shadows and thrusts a tower of shelves toward me. I have nine seconds to grab and process an item to be sent for packing, a target of 300 items an hour, for hour after relentless hour. As I bend to the floor then reach high above my head to fulfill a never-ending stream of orders, my body screams at me [8].

Far from the image of robots serving humans, the reality is, in fact, the other way round: "…(human) staff are just cattle, there to serve robots" [8].

But would the increased work intensity be compensated for by higher salaries or shorter working hours? In fact, a detailed study of the effects of robot densification in 14 industries across 17 developed countries during the period of 1993–2007 shows that low- and middle-skilled workers actually suffered salary reduction with the introduction of robots, as illustrated in Table 7 in [5]. The same study shows that there was no significant reduction in the number of working hours.

Global Effects of Robotics and Automation: Toward a Jobless Society?

As discussed in the "Robotics and Automation in the Workplace" section, the impact of robotics and automation on the welfare of individual workers is far from entirely positive, but what are its long-term effects on all of society, particularly with regard to employment?

Interestingly, only a few decades after the Luddite revolt, the perspective of entirely automatic production, without any human intervention, started to be formulated. Andrew Ure, an early business theorist, thus contemplated "the most perfect manufacture […] which dispenses entirely with manual labor" [9]. That perspective has not, however, materialized. As more tasks became automated, an even larger number of new tasks, made necessary by new products or entirely new economic sectors, was created that required human labor.

Yet, due to the rapid progress of robotics and AI technologies in the past few years, the perspective of a jobless society, in which all work is performed by robots and no jobs are left for humans, has begun to capture considerable attention from the general public. Alarmist articles about a jobless future abound in the mainstream media, based significantly on scholarly literature. For instance, a widely cited report by Oxford economists predicts that up to 47% of total U.S. employment is at risk of being taken away by automation [4]. In a recent and well-documented book, technologist Martin Ford argues that, contrary to the development of automation up until now, automation today, because of its cognitive capability, carries an actual threat of massive job destruction over the coming decades [3]. However, there are also studies that make much less dramatic predictions. In fact, as highlighted in a recent *MIT Technology Review* survey, there is no consensus among economists and technologists about the degree and timeline of job eliminations resulting from automation [10]. Furthermore, the effects of robotics and AI on the norms of work and employment, and the associated concerns in developing economies (the so-called global south), are even less well understood because their societal acceptance and assimilation differ significantly between developed and developing economies. In labor-intensive economies (for example, the BRICS countries, i.e., Brazil, Russia, India, China, and South Africa), the effects of automation would be felt much more steeply in the coming decade. While labor may still be cheap in developing economies, automation in developed countries will offset this advantage, thereby possibly resulting in significant adverse effects on workforces in developing countries.

The number of robots in factories has been rising quickly, and robotics technologies have been introduced into many sectors beyond manufacturing, e.g., surgical or rehabilitation robots in hospitals, service robots, self-driving cars, and so on. However, from a roboticists' perspective, there is still a very long way to go before robots can totally replace humans. For example, outside of the structured environments of factory assembly lines, robot locomotion and manipulation capabilities are still very limited. During the 2015 Defense Advanced Research Projects Agency Robotics Challenge, robots (teleoperated by humans and so not even autonomous!) from the best research labs around the world had trouble performing tasks that most humans would find trivial. Even the simple task of grasping and manipulating a previously unknown object in-hand is still the subject of intense academic research. Moreover, the robots already deployed in factories still require an enormous amount of reprogramming when facing a slightly different task. They are far from being able to automatically learn to perform new tasks by themselves or from human demonstration.

Finally, the discussion of automation and employment should not be centered only on the number of jobs lost; it should also deal with the changing nature of work because of the automatability and functional description of tasks. In the Fourth Industrial Revolution, the emphasis is on how machines and humans can work together so that repetitive and dangerous tasks can be relegated to machines and automated systems. This augmented collaborative workforce is the wave of the future and has enormous implications for employment in the automation age. It will redefine the relations between workers, their crafts, and their working environments. On the one hand, workers can focus on aspects that require creativity, social skills, and emotional intelligence; on the other, this could also have a dehumanizing effect if workers' activities are subjugated to robots' behaviors.

Proposed Solutions to Address Unemployment Caused by Automation

Although the degree and timeline of job eliminations caused by automation are still debated, there is a consensus that, in the present global context of stagnant and interdependent economies, automation will inevitably take away a significant number of jobs. This means that, in the next few years and decades, many workers will lose their jobs to robots, while those keeping their jobs will experience

increased physical and psychological pressure and still more will face unemployment due to the lack of jobs. A number of solutions have been proposed to address these problems.

An important consideration is to raise the level of workers' education (both initially and continuing) so that they can undertake the higher-level jobs required by automation. Training programs to develop new, requisite skill sets available across the spectrum of the workforce, and not just for low-skilled workers, could be mandated. Such programs could be funded by public–private partnerships and made available for workers who are still employed and those who are in between jobs.

Universal basic income (UBI) is another concept proposed to address technological unemployment, with all of a country's citizens or residents unconditionally receiving sufficient regular amounts of money that will enable them to live. Additionally, there would be no requirement for people to work or look for work. There are many versions of UBI, differing widely in terms of the proposed income amount and the funding source. In any case, for such a system to provide decent living conditions for everyone in a country (and, beyond, in every country), the amount of funding required is likely to be very significant. As a result, there is a significant and complex debate about how UBI could be funded, whether such a system could be sustainable at all, and the effects it would have on the economy.

The notion of robot taxes has been proposed as another alternative to deal with the potential unemployment created by automation. The basic idea, as suggested by Bill Gates [1], is to tax corporations and entities deploying robots that cause job losses. The tax income could then be used to offset the economic hardships experienced by laid-off workers or retrain them so that they can be reassimilated into the workforce. In that vein, a motion (eventually rejected) in the European Union Parliament in 2017 proposed "levying tax on the work performed by a robot or a fee for using and maintaining a robot should be examined in the context of funding the support and retraining of unemployed workers whose jobs have been reduced or eliminated" [2]. Robot taxes have certainly met criticisms from a number of economists. For instance, Larry Summers [6] argued that there are no fundamental differences between robots and any technologies that may cause job losses (including Bill Gates's software); yet there are no specific taxes on such technologies. Thus, taxing robots would amount to another tax on capital, which most capitalists would oppose.

More generally, socioeconomic, political, and resource constraints should be carefully considered when emerging technologies are deployed because there is a potential for unintended consequences such as tilting economic and power structures to unduly benefit certain segments of society, resulting in new gaps and/or exacerbating existing inequities. There are time-sensitive challenges regarding how developing nations, with their potentially low-technology classroom-centric curricula, can be provided with the technical expertise that would allow for the introduction and absorption of these cutting-edge technologies.

Robotics and automation carries the wonderful promise of liberating humanity from toil. In an ideal society, most of the repetitive, unhealthy, and uninteresting work would be fulfilled by robots, while humans would spend a limited amount of time every day on work (including deciding what the robots should do) and the rest of the time on creative activities. From a technical viewpoint, this future is certainly possible, yet both the current situation and the outlook pictured by many reports are gloomy. Robots now tend to be perceived by a portion of the general public as a threat, instead of as a fantastic liberation tool. Why is this so?

In the current economic system where robots are owned by a minority, the gains in productivity they permit (e.g., higher wages and fewer working hours) are not likely to be shared by the working majority; rather, robots would be seen as the reason for humans' job losses. Therefore, to reach the ideal society that most robotics researchers have in mind, the notion of who owns the robots, the working majority or a minority of capitalists, might just be the decisive question.

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