Social aspects of automation: Some critical insights

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Abstract. Sustainable development has been recognized globally as one of the major driving forces towards the current technological innovations. To achieve sustainable development and attain its associated goals, it is very important to properly address its concerns in different aspects of technological innovations. Several industrial sectors have enjoyed productivity and economic gains due to advent of automation technology. It is important to characterize sustainability for the automation technology. Sustainability is key factor that will determine the future of our neighbours in time and it must be tightly wrapped around the double-edged sword of technology. In this study, different impacts of automation have been addressed using the ‘Circles of Sustainability’ approach as a framework, covering economic, political, cultural and ecological aspects and their implications. A systematic literature review of automation technology from its inception is outlined and plotted against its many outcomes covering a broad spectrum. The study is more focused towards the social aspects of the automation technology. The study also reviews literature to analyse the employment deficiency as one end of the social impact spectrum. On the other end of the spectrum, benefits to society through technological advancements, such as the Internet of Things (IoT) coupled with automation are presented.

1. Introduction
To have a secure future it is very important that modern technologies should be properly analysed in terms of their sustainability aspects. The main reason to practice sustainability is to ensure harmony between humans and the environment we live in. In this economic race to the top, people and governments often concentrate only on the economic gains and disregard the impacts of decisions taken to enhance economic gain on the environment or/and society. Governments all over the world have endorsed initiatives to promote sustainability in all their activities. EPA (environmental protection agency, USA) has implemented initiatives to endorse the executive order 13693 released to reduce greenhouse gas emissions by 40% from the 2008 levels in the next decade [1]. The World Bank has launched many sustainability driven programs such as ‘Shared Infrastructure for Solar Parks’ [2] and several projects under ‘Global Environment Facility’ (GEF) [3–5] to ensure and promote sustainable development throughout the world. Further, many organizations, academics and researchers around the globe have developed sustainability measurement indices to help us analysing region’s sustainability status. Happy Planet Index (HPI) [6], Quality of Life Index (QLI) [7] and Environmental Performance Index (EPI) [8] are few of the well-known sustainability measuring Indices.
Automation is one of the current modern innovations, and undoubtedly it can be referred as future’s technology. At this stage, it is particularly important to define the framework to assess the sustainability aspect of this technology. Starting with the invention of computers that revolutionized human work, inundated many clerical positions, today, the automation and robotics industry has only become smarter and more complex. We have become so used to automation and no longer realize that most of our interactions are with autonomous machines and automated control systems. Society is evolving to accommodate autonomous machines and this necessitates the study of their impact on our social life.

The aim of this study is to analyse the social effects of automation on the society. Sustainable development is discussed and ‘Circles of Sustainability’ approach [9] is further utilized to establish a framework of the current analysis. The social impact is studied by analysing cultural and ethical concerns associated with the automation and reviewing its effect on the human employment opportunities. Further, paper also provides review and discussion on the coupling of other modern technologies with automation such as internet of things (IoT) and outlines the associated future implications.

2. Framework

The World Commission on Environment and Development (WCED) defines sustainable development (SD) as “A process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations” [10]. To analyse the sustainability of a technology or a system, it requires a huge amount of data and can only be approximated as it is impossible to measure all the dimensions of sustainability simultaneously. Among the many philosophies that provide us a framework for measuring sustainability, three pillars approach also known as triple bottom line (TBL) approach is the most basic and widely accepted. In this study, a new derived form of three pillars approach is used that is termed as ‘Circles of Sustainability’. The approach was developed by Paul James and outlined in the book ‘Urban Sustainability in Theory and Practice’ [9].

In literature, the ‘Circles of Sustainability’ approach is mainly utilized to assess the urban sustainability profiles of different regions and the outcomes are focused more towards the social aspects of sustainability. Figure 1 shows the schematic illustration of the ‘Circles of Sustainability’ approach. The approach assesses sustainability using four dimensions of ecology, economics, politics and culture. Each of the four major domains are further divided into seven subdomains as shown in the Figure 1. In order to examine sustainability of each subdomain a nine point scale has been introduced, where lower point reflects critical sustainability and highest point reflects vibrant sustainability as shown in the legend of Figure 1 [9]. The major difference between the TBL approach and the circles of sustainability approach is the division of social aspects into two weighted parameters of politics and culture. Since this study is more focused towards analysing the social impact of automation, so ‘Circles of Sustainability’ approach has been preferred over the TBL method.
Figure 1. Schematic illustration of Circles of Sustainability Approach (adopted from ref. [9])

3. Synchronizing circles of sustainability approach for automation
Based on the above-mentioned framework, selective subdomains from the major four domains of ecology, economics, culture and politics, have been selected to characterize social implications of automation technology. These subdomains have been selected based on the availability of literature data. The selected subdomains have been represented in the Figure 2 as shown below.

Figure 2. Selected subdomain to reveal the social impact of automation using circles of sustainability approach.
3.1. Ecology
The fact that automation based technologies are the major advancements in science and the most promising technologies of the future, it is imperative that one should take the necessary measures to limit its effect on the environment. These effects are mainly discussed under ecology domain. The literature about the selected subdomains of materials and energy, and emissions and waste has been discussed as under.

3.1.1. Materials and energy
The idea of automation is to maximize the profit margins by increasing the production rate. The idea also supports the economic concern as for the bulk production rate automation reduces the cost as compared to the manual production. At the same time, it should be kept in mind that automation based technologies consumes electricity as input energy and the associated electricity consumption cannot be neglected [11]. It is also well understood that energy consumption in automation should be reduced or optimized to attain sustainable future. Several researchers have focused their work to analyse and optimize the energy consumption in automated based technologies. Vergnano et al. [12] explored the energy optimization in an automated manufacturing system using an embedded approach that incorporates energy evaluation of the system into the scheduling model of the system. The study reveals an enormous energy saving potential using this schedule driven modelling approach. In another study, Paes et al. [13] studied the energy efficient path planning of an industrial automated robot. The study reveals that intelligent energy efficient trajectory planning can save time and energy consumption. The study provided that the most efficient trajectory saved 4\% of the energy consumption and 3\% of the time. Nilakantan et al. [14] examined the energy optimization potential based on the cycle time of an automated automobile body paint assembly line. The study provided models for the energy balancing using cycle times and revealed good potential.

3.1.2. Emissions and waste
As automation requires electricity as main input source of energy, the associated emissions cannot be neglected when it comes to the sustainability evaluation. As per International Energy Agency (IEA), 24\% of the total direct CO$_2$ emissions came from the industry that appears to be the second largest source of emission [15]. The waste generation due to the automation is very industry specific topic. For example, the waste generation rate is different for an automated automobile industry than the semiconductor based electronic industry. However, when it comes to the waste management, automation technology has provided benefits to deal with the recycling opportunities of the waste.

3.2. Economics
There is no doubt that automation based technologies have provided the economic gains to the industry. However, the economic social subdomains such as labour and welfare, and wealth and distribution have been discussed further.

3.2.1. Labour and welfare
Economic sustenance is important to ensure welfare of a community. Employment is the source of financial input to many families and hence an important criterion to analyse and assess sustainability. Literature on the effect of automation on the employment opportunities was abundant up to late 1980’s but since then has been only rarely evaluated. The effect of automation on society has been discussed in view of available literature. The integration of automation technologies into the workplace has changed the job requirements and division of work are no longer the same. The boundary for this change in work division can be best plotted to the introduction of computers to work spaces [16].

Literature is divided on whether the overall effect of automation is negative or positive but there is a consensus that automation is ‘job killer’ for repetitive simple tasks and ‘job creating technology’ for everything beyond that [17]. Guteri [18] illustrates examples where the number of people required for certain jobs reduced due to the introduction of automated systems in the Industry. Automation in the logistics and inventory systems has significantly reduced the number of people required to maintain storage and retrieval mechanisms in the respective industries. Further, levels of automation have
continuously evolved leading to the smarter technologies and consequently much lower employment opportunities in that sector [19]. Flexible manufacturing lines also help in performing different tasks with minor modification to assembly lines and provide better productivity [18]. In contradiction to the former claim that automation reduces the number of employees, Frey and Osborne [16] discusses the idea of technology favouring the highly skilled workers is a twentieth century phenomena. In the beginning, automation served the purpose of deskilling activities and splitting them to number of low skill repetitive tasks. Frey and Osborne [16] have conducted a numerical study to analyse how susceptible are jobs to Automation. Three important characteristics on which probability of automation is dependent were identified for the analysis. These characteristics were perception and manipulation, creative intelligence and social Intelligence. An algorithm was developed using O*NET software used by the US department of labour to evaluate 702 job descriptions based on the above three characteristics. Inputs such as finger dexterity, originality for each job were given as inputs to the algorithm and results were presented as high, medium or minimal risk of susceptibility to automation. The results attested some of the claims in literature such as decreased job opportunities in logistics and transportation related sectors whereas the high cognition related jobs such as engineering where in minimal risk category. A surprising result observed in the analysis was that number of jobs in the service sector was classified under high-risk category.

Another prevalent point of view is that the aggregate jobs has remained the same even though there have been changes in the focus area of human labour [20]. The study supporting this claim, states that even though certain job identities have been taken over by automation and robotics, that has alternatively given rise at least equivalent amount of middle level “blue collar” jobs but with a different identity. The study presented in [20] also discusses an example of the advent of motor vehicle. In 1920 due to the advent of motor vehicle the number of equestrian modes of transport slowly became non-existent but at the same time, market was generated for more number of street vendors. In the modern day, job titles such as radiology technicians, phlebotomists are described as the new middle level blue collar jobs. Though the average employment numbers would remain the same, the problem is in identifying where the labour requirement is now focused, as the evaluation of the same is only accurately possible after a certain period. Another aspect associated with new job creation is the educational level associated with the job. It becomes very difficult for working adults to revisit their educational capacities in order to re-qualify for a new job.

3.2.2. Wealth and distribution
An important characteristic of automation technologies is that in most cases these technologies increase productivity, therefore increasing the economic gain. Governments all over the world are pushing industries towards automation to increase the production capacity and improve their economic status. Hence, it is a definite fact that wealth will increase with the introduction of automation technologies [21]. The first industrial revolution witnessed in the UK was a very good example of the economic gains initiated through automation technologies. However, the question of wealth distribution is quite debatable. Even though the cost of automation technologies is reducing, the initial cost is still higher for many entrepreneurs with few resources. Further, since automation has led to deskilling of works, the wages for these works are also reduced. At the same time, high skill jobs such as engineering and design, as a by-product of automation, are associated with higher wages paid, as discussed in [22]. Overall, even though the wealth generation is guaranteed, equal distribution among the members of the society is a definite problem.

3.3. Culture
Keeping in view the cultural domain of sustainability, following subdomains of ‘performance and creativity’ and ‘health and wellbeing’ have been discussed under the context of automation.

3.3.1. Performance and creativity
Automation provides better and more efficient way of doing specific tasks but automation hardware and software will take time to replace the human cognitive skills. It means that boundaries of creativity have been extended with the introduction of automation to the society but still it has
limitation when it comes to the human cognitive skills for critical thinking [23]. In the current form automation aids extending the limits of creativity but requires human interaction or collaboration.

3.3.2. Health and wellbeing
Health and wellbeing of the people is an important criterion for evaluation and it is impossible to ignore the benefits of automation in this sector. Apart from the many developments in the field of medicine and surgery, automation and robotics have replaced humans in many dangerous job titles such as underwater operations [24]. In harmful and harsh operations such as welding the robots can help the humans in performing the job faster and thereby reducing the operating time of these jobs. Similarly, automated robots can handle harsh environments where human interaction is very difficult such as space exploration, deep ocean exploration, radioactive facilities and toxic environments. In addition, automated robots are also being used to perform the domestic tasks such as cleaning and washing related activities. Automated robots are also being used for the surveillance applications and activities to ensure safety of the community [25]. Further, the entertainment related automation would add to the job market and contribute towards welfare of the society.

3.4. Politics
Keeping in view the political domain of sustainability, following subdomains of ‘ethics and accountability’ and ‘security and accord’ have been discussed under the context of automation.

3.4.1. Ethics and accountability
Healthcare sectors are gearing up to introduce automated robots as primary care personnel at hospitals and clinics. Many robots have already been employed to work as care robots in hospitals. Technology has bred automated robots that can help the elderly to move and cater their important needs [26]. Beran et al. [27] employed robots as companions to children undergoing vaccination. Though the children cried as much as without the robot, the parents attested that the children recalled the robot more than the needle and encouraged clinics to include such distractions. Robots are currently in development to serve functions such as surgical robots, care robots, service robots and in the development of prosthetics [28].

In a study sponsored by the European Commission, the ethical concerns associated with robotics and automation was tackled by applying logical reasoning and experimental study [29]. Ethicists express concern regarding accountability, quality of care, privacy and morality issue associated with the use of robots in the field of healthcare. The cases of liability and supervision in the healthcare field are primary reason for division of opinion regarding robots in healthcare. ‘Who is accountable for the decisions made by the robot’? is the question that ethicists demand answer [29]. Another major issue associated with the use of robots is the quality of care. Could robots truly replace the care one human can provide another? The people opposed to the use of robots have termed robotic care to ‘Mechanical’ and missing the warmth of human care. The claim is made on the basis that since robots cannot feel or sense the feelings of its patients, a vital component of human care contributing to a patient’s recovery is missing in robotic care. Robots inability to make moral decisions is another factor highlighted by many ethicists. Decisions are not all mathematical and the lack of moral reasoning in robots is another issue discussed in the ethics of healthcare robotics.

3.4.2. Security & accord
In the subdomain of security and accord, the issues related to the trust and security aspects of automation are addressed. In the study [29] the researchers, through questionnaires, find that people do not trust the robots. In the case of domestic service robots, majority of people do not opt of automated robots due to the lack of trust and false misconceptions that robots will overpower humans. Further, people find the use of robots as a breach of privacy and find it difficult to let robots into their private life. People also fear working with fast, powerful machines as companions since there exists a lack of trust. The study presents the need to educate people about the technology of robotics and clear the misconceptions prevalent in the minds of people. When working with powerful machines, the study recommends appropriate safety must be implemented. Security robots are the future being discussed.
by the current world leaders but proper guideline for data protection is cited as a requirement in the study.

Today’s world is driven by the internet and almost every service in the world today is made possible through the IoT. The coupling of automation and other modern concepts such as internet of things (IoT) should be discussed when addressing the security related issues of automation. To date, security frameworks for the implementation of IoT across industry verticals is generally lacking. IoT devices have gathered pace at the expense of security best practices in a race to deploy solutions as the first in the market, usually funded by venture capitalists looking for quick return on investment. Areas of focus in the future will need to consider securing the operating systems that the automation tasks are executed on as well as the wireless communications environment needed in the world of automation through IoT.

4. Conclusions and future recommendations

This study is aimed at reviewing the social impacts of automation on our society. The study utilized ‘circles of sustainability’ approach as a framework to analyse the technology of automation. Following conclusions can be drawn from this current study:

- Automation delivers improved and effective way of doing specific tasks but automation will take time to replace the human cognitive skills for critical thinking. This means creativity is facilitated through automation but requires human interaction.
- Ethical aspects of automation revealed several concerns such as inability to make moral decisions, accountability of medical related decisions, and lack of human feelings.
- It was observed that many life cycle analysis (LCA) studies do not exist on automation. Research must be encouraged to study the environmental effect of automation technologies through LCA analysis to better understand the environmental impact.
- Circles of sustainability has several social subdomains present, however in the current study only few of the subdomains are covered. More detailed studies are required to gather data and conduct complete analysis.

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