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Article · February 2020

DOI: 10.35940/ijrte.D8764.018520

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Industry 4.0 and Society 5.0: Opportunities and Threats

Andreia G. Pereira, Tânia M. Lima, Fernando Charrua-Santos

Abstract*: *Industry 4.0 promises to revolutionize industrial production with increased operational efficiency, the development of new business models, services and products. It enables real-time production planning and dynamic optimization in contrast to conventional forecast.

The tools and technological advances developed by Industry 4.0 will have a significant role to improving the quality of life in society in order to enable a happier, motivated, and satisfied and with more time for leisure. As a consequence, it will increase productivity and the mankind will choose the direction and the kind of society we want to create in the future to promote equal wealth distribution. As consequence of Industry 4.0 emerges Society 5.0, beginning in Japan, due to the concern of the ageing population.

Society 5.0 focuses on the use of tools and technologies developed by Industry 4.0 to benefit the humankind. Intelligent systems, developed by Industry 4.0, could be seen by society as a beneficial rather than as adversaries.

Future society could benefit from advanced technology in solving problems and economically. Society 5.0 has a special focus to position the human being at the centre of innovation, technological transformation and industrial automation, stimulated by Industry 4.0. This new Society 5.0 paradigm will play a predominant role in creating a happier, satisfied, fulfilled and consequently more productive society. Society 5.0, also called the super intelligent society, intends to use advanced technology of Industry 4.0 for enjoyment of humankind, in order to promote an interconnection between people and systems in cyberspace with optimization of results by artificial intelligence.

***Keywords*: *Industry 4.0, Society 5.0,* Cyber-Physical Systems**

I. INTRODUCTION

Industry 4.0 is a planned industrial revolution, communicated by German government in 2011, with focus on strengthening the competitiveness of manufacturing through high technology strategies [1].

The fourth Industrial revolution, named Industry 4.0, enables a significant impact on manufacturing environment with radical changes in the performance of production operations [2]. The economic impact of this fourth industrial revolution is expected to be significant since it promotes a substantial increase in operational efficiency as well as the development of business models, services and products completely new [1].

Revised Manuscript Received on January 15, 2020

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In contrast to conventional forecast production planning, Industry 4.0 allows real-time production planning simultaneously with a dynamic optimisation [2]. Industry 4.0 enables the implementation of autonomously controlled and dynamic, optimizing the value chains and could combine the Lean philosophy with the integration of information and communication technologies [3]. The creation of intelligent factories with advanced information, communication and technologies oriented for the future are promoted by this fourth industrial revolution [2].

The main potentialities of Industry 4.0 are: specialized solutions for each sector and personalized customer interaction, the facility of manufacturing specific products with low production volumes, increase competitiveness and flexibility with adjustment to constant value chain changes, accelerated growth in productivity and operational efficiency [4], work-life balance and reduced energy costs [5].

The implementation of Industry 4.0, in specific cases, demonstrate that connections between humans, systems and objects allow for an optimized, complete, dynamic and real-time network [6].

The concept of Society 5.0 complements Industry 4.0 and promises to revolutionize society for a greater good, the mankind [7].

This new society acts as a social development and aims to promote a major impact on societies at all levels, such as quality of life and sustainability [8].

The main goal of this paper is to understand the interaction and synergy between Industry 4.0 and Society 5.0 and the pertinence of how advanced technologies from Industry 4.0 could contribute to the organization of a new society called 5.0. This research contemplates a quantitative methodology focused on responding to a cause-effect relationship.

II. INDUSTRY 4.0

Industry 4.0 is characterised like a network in real time, intelligent and digital for equipment, objects and mainly for people concerning the industrial management [9], enables increased digitalization of the whole value chain and the interconnection between people, objects and systems through the data exchange in real-time [10].

Modern information and communication technologies could be implemented in machines, workers in production and logistics processes, in order to promote the better communication among all participants in the product development process, analyse data according to defined algorithms and control production flows to promote continuous improvement [9].

Industry 4.0 could be described by three paradigms:

- Intelligent Product where it is possible to solicit the required resources and coordinate productions processes, since the products have a memory to save operational data and standards individually.
- Intelligent Machine where the traditional production hierarchy is replaced by decentralized self-organization, allowing for a flexible and modular production line.
- Augmented Operator with knowledge automation in order to promote a flexible and adaptive part on production system [5].

In Industry 4.0, the main components include the Cyber-Physical Systems (CPS), Internet of Services (IoS) and the Internet of Things (IoT) [11], which will be an important tool in the implementation of Industry 4.0 [12]. The heart of Industry 4.0 structure is the CPS system and consists of integrating hardware and software into a mechanical or electrical system projected for a goal [11].

A. Smart Factories stimulated by Industry 4.0

Industry 4.0 enables the use of smart objects that promote adaptability, resource efficiency and process integration [13].

The expression "Smart" refers to Industry 4.0 applications namely: Smart Factory and Manufacturing, Smart Product and Smart City [13]. Intelligent factories operate with a platform able to execute commands, data transmission and other information between equipment and clouds with inclusion of machines and products [12].

Industry 4.0 encompasses numerous technologies and emergent standards which include Industrial Internet of Things (IIoT), cloud-bases manufacturing and social product development [4]. Industrial Internet of Things (IIoT) will be one of the major contributors of the correct functioning and performance of a factory with Industry 4.0 implementation and results from the convergence of industrial systems with advanced programming, sensors and communication systems [4]. Furthermore, the allocation of resources such as materials, energy and water could be realised more efficiently based on intelligent interconnected modules [14].

The complexity and management challenges in industrial really need to be solved in order to take advantage on potential opportunities developed by Industry 4.0 and in smart production could offer [4].

B. The challenges set by Industry 4.0 for companies

The high level of competition in the current market forces the companies to overcome new challenges regarding the best prices/costs, quality and delivery time [9]. Industry must be the ability to respond to innovation and bring new products to market within a short time due to current competition around the world [10].

In order to guarantee process competitiveness along the value chain, it is mandatory to design productive, efficient and flexible methods [9].

The main aspect to promote the fast adaptation to changes in production is the connexion between processes, products and equipment with artificial intelligence [10].

Companies will include storage systems, machines and productions plants from Cyber-Physical Systems (CPS) in a global network [15]. CPS is considered as a high-tech technology to handling systems where could integrate computer skills and physical resources [16]. Furthermore, CPS integration with production, logistics and services in current industrial practices will promote evolution in the implementation of Industry 4.0 in factories with significant economic impact [16]. The life cycle of a mutable product could be managed with a dynamic production and delivery by a challenge of digitization and automation of production processes and promotes a creation of new opportunities for industries [10; 13].

Control applications and production control centralized and monolithic will originate solutions that could support production processes and supply chain processes in a decentralised manner [17]. The process will be dynamic, efficient and effective concerning the changes, decentralization, self-optimization and automation [13].

In a factory environment, CPS´s include intelligent machines, storage systems and production facilities capable of autonomously exchanging information, triggering actions and independent control [15]. The continuous growth and evolution in the industry has promoted the implementation of high-tech methodologies [16].

According to [18], Industry must learn first to walk before it could dream of flying.

III. SOCIETY 5.0

Society 5.0 is focuses on positioning the human being at the centre of technological and innovation modification for the benefit of humanity and it is considered a quiet revolution started in Japan that promises to revolutionize society [19]. The main purpose of Society 5.0 is to enhance people's quality life with the use of potentialities acquired by Industry 4.0 [8].

Japan is already moving towards Society 5.0 with the implementation of new methodologies such as autonomous trucks for orders delivered or drones. In the meantime the rest of the World is adapting to the challenges promoted by Industry 4.0 [20].

A. Movement initiated in Japan

Japan foresees, in 2050, the oldest society with about 40% of population has more than 65 years old [21]. In order to face today´s society´s dilemma should be use advanced technology like big data, robotics, artificial intelligence, drone deliveries and autonomous trucks [20].

The future growth plan promoted by Japan includes a training to meet sustainable development goals and the creation of a super-intelligent society [22]. In order to coordinate cooperation between academia, government and industry, Japan will promote a Society 5.0 services platform. [22].

Therefore, Japan moves courageously calling for future development as a Society 5.0, with changes that will influence aspects of society and industrial production [21]. Europe will also be an integral part of this movement [19].

B. Computer technologies adapted to this new Society

Society 5.0 is defined by parallel intelligence, where traditional artificial intelligence theories are extended to emerging cyber-physical-social systems (CPSS) [23].

Nowadays, advances through innovation in science and technology,

mainly in computer science, contribute to the improvement of business and society [24].

Parallel intelligence enables to handle effectively with socially and engineeringly complex issues and aims to find agile, focused and convergent solutions to understand uncertain, diverse and complex issues [23].

In the meantime, the world is facing global challenges such as global warming, scarcity of natural resources, terrorism and economic divergence [24].

Following the great advance in mechanization, electrification, information and networking technology, modern society entered a new era of technological development, which is the parallel era of virtual-real intelligence technology [23].

The connection between people and things and between the real and cyber worlds will enable the effective and efficient resolution of societal issues, create more quality of life for people and sustain healthy economic growth [24].

The key techniques of Society 5.0 follow the idea of automation, which is the direction for the next development of artificial intelligence technology and the general structure to deal with management and control of CPSS systems [23].

The Japanese Society expect the formation of a Super Smart Society, with the creation of sustainable society where the various types of values are connected through CPS and people could live in safety, security and comfort [24]. Intelligent society is a system that utilize the potential of digital technology, digital instruments and networks to improve the quality of human life [25].

CPS could connect different sectors, countries, regions and societies [24].

A complex analytical approach to the development of virtual artificial systems use a system namely ACP: (A) Artificial systems, (C) Computational experiments, (P) Parallel execution [26].

The evolution and development of the information society originated Society 5.0, focused on improving enterprises and individual strengths and solving social problems [25].

C. The Future and Society 5.0

Employment, public administration, people´s privacy and industrial structure are all aspects of society that are undergoing drastic changes and digital information must respond to current demands [27]. Society 5.0 has to be implemented considering the integration of various dimensions such as Entrepreneurial Skills, Entrepreneurial Spirit and Innovation Policy [8].

Technological development allows the possibility to improve living standards, but it could also negatively impact employment, unequal distribution of wealth and information [27]. Society 5.0 enables the use of advanced technologies such as IT, IoT, robotics, artificial intelligence and augmented reality in people´s lives, health and other spheres of activity while Industry 4.0 restricts technology advances only in industrial sector [28]. Thus, it depends on mankind which direction we want to choose and what kind of society we want to create in the future, with the innovative technologies we have a tour disposal [27].

The diversity of technologies for the benefit of humanity such us increased production, mitigation of costs related with ageing society, equal distribution of wealth, reduction of greenhouse gases, reduced food products, the correction of regional inequalities and other could solve the social problems and the economic growth [22].

Society 5.0 combines digital transformation with the creativity of different people for sustainable development through problem solving and value creation and enables it to meet the goals proposed by United Nations for sustainable development [27].

IV. RESULTS

The table I presents the main aspects related to the Industry 4.0 and the Society 5.0.

Table- I: Industry 4.0 and Society 5.0

INDUSTRY 4.0	SOCIETY 5.0
End of 20th century	21st century
Information Society	Super smart society
Automation, information (computer, internet)	Digital transformation
Cloud	Big Bata

V. CONCLUSION

The fourth industrial revolution or Industry 4.0 emerged in 2011 with new technological developments and digitalization of full supply chain and the network connection between systems, objects and people.

Reducing costs, energy, improving production process efficiency, responsiveness to customer needs and product quality are all promote by the evolution of production systems with the latest technology and tools developed by Industry 4.0.

Industrial companies go through digital transformation in order to join with the constant evolution and to react to the challenges imposed by society.

Nowadays, production industries are undergoing a huge digital transformation so that they can keep up with the constant evolution and respond to the challenges imposed by society itself. There is a growing network of products, machines and people with the massive use of the internet.

The new technologies of Industry 4.0 could be use in benefit of humanity. Recently Japan encountered with the ageing of its population and felt the need to create a system to improve the quality life of society and adopt immediate actions to promote advantages with this high technology. The use of technology to benefit the society has promoted a new industrial revolution called Society 5.0.

Society 5.0 focuses on application of technology in constant development and innovation stimulated for Industry 4.0 to solve mankind problems such as population ageing, natural disasters, social inequality, security and improving people's quality of life. The integration of technology with society will be crucial as it is relevant to use drone deliveries, artificial intelligence, big data, autonomous trucks and robotics in the near future for the benefit of humanity.

ACKNOWLEDGEMENT

The authors were funded in part by Fundação para a Ciência e Tecnologia (FCT), under project UID/EMS/00151/2013 C-MAST, with reference POCI-01-0145-FEDER-007718.

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Andreia G. Pereira obtained her Master´s degree in Chemical Engineering in 2011 at Faculty of Engineering of the University of Porto (FEUP). She worked from 2012 to 2013 and from 2014 to 2015 as a commercial assistant in a Bank. From 2013 to 2014 she perform a professional internship in Portuguese Mint and Official Printing Office (INCM - Imprensa Nacional – Casa da Moeda) and obtained the status of effective engineer in the Portuguese Engineers Order with the ID number 70924. Currently, she works as Project Manager in R&D Department at Automotive Compounding Industry (ACI). Simultaneously, she is PhD student in Industrial Engineering and Management at the University of Beira Interior (UBI) and collaborator researcher of the Center for Mechanical and Aerospace Science and Technologies (C-MAST) Research Group.

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