Industry 4.0: Technologies and Applications

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Abstract

This work presents a synthesis of Industry 4.0 theme, pointing out the main historical characteristics of its development. The principles on which this industrial revolution is based. The auxiliary technologies involving its phenomenon.

Keywords

Industry 4.0; IoT; 4th Industrial Revolution, Physical Cyber.

1. Introduction

The internet is currently the main agent that makes possible the communication from people to people, machine to machine and machine to people on a large network, this interaction is called Physical Cyber System (FRAÇA, GIOCONDO, p. 35). The term Industry 4.0 emerged on a plan developed by Germany to promote high technology, it is also known as Advanced Manufacturing, IOT (internet of things) and Intelligent Industry. (CAVALCANTE; ALMEIDA, 2017)

According to Rodrigues et al. (2018, p. 13), the industry 4.0 is understood as the integration between the digitalization and the industry, sensors and equipment connected through the network, merging the virtual and the real world.

This digital transformation is being responsible for the 4th Industrial Revolution and it has three pillars, that when integrated, constitute a foundation within industries, they are: Automation Systems, Information Systems and Physical Cyber Systems (RODRIGUES et al., 2018, p 13)

This research carried out is exploratory document referential methodologies, such as: articles, scientific magazines of various nationalities, in order to comprehend the theme’s international state.

2. Historical Content

The Industrial Revolution has had great developments in industry over the history, through three Industrial Revolutions, which have brought changes to the way that people live; beginning with the steam engine and the mechanization in the XVIII century, followed by the intense usage of the electric energy (2nd Industrial Revolution - 1880) and culminating with the generalized digitalization (3rd Industrial Revolution - 1972), these have generated various challenges and industry changes, currently the 4th Revolution shows the progress of technology bringing the different innovations, new business models which integrate the technology with the people. (PEREIRA et al., 2018).

The differential about the Industry 4.0 towards the other three revolutions, (Schwab, 2016) wrote a definition of the revolution scope we are inserted in:

> The 4th Industrial Revolution, however, does not only refer to systems and intelligent machines which are connected. Its scope is much wider. Many new discoveries occur simultaneously in areas ranging from Genetic Sequencing to nanotechnology, renewable energy to Quantum computation. Which makes the fourth Industry Revolution fundamentally different from the passed ones, is the merge of these technologies and the integration between the physical domains, digital and biologic. (2016, p19)

3. Principles And Competencies

The following principles are identified on the Hawaii International Conference on System Sciences (HICSS) research document, Mario Hermannet et al. (2017), these principles help defining technologies and approaches which are part of Industry 4.0.

Interconnection: With the wireless communication technology and the IoT resources, you could connect machinery, sensors and various devices to people responsible to monitor its progress, in order to obtain efficiency and effectiveness.

Information transparency: transparency provided by Industry 4.0 provides a wide quantity of necessary and useful information for the Operators to make decisions properly. The interconnectivity allows Operators to collect a huge quantity of data and information from all sections of the manufacturing process, this way, helping the functionality and identifying the main areas which may benefit from the innovation and improvement.

Decentralized decisions: the interconnection and the information transparency allow the Operators to make decisions in and out of the production’s installations. The capacity of combining local and global information at the same time, helps to improve making decisions and increase the productivity in general.

Technical assistance: The Industry 4.0 transfers the human's job of operating the machines to a problem resolution and a decision maker. The Assistance Systems are projected to support operators that need to make informed decisions to resolve urgent problems in a short period of time.

There will be mainly social impacts, with labor changes, employability and in people’s need to improve their skills, that’s why the risk analysis is necessary, as well as for opportunities for progress and the social innovation, the Industry 4.0 will not only affect the machines, but mainly the people. (SCHWAB, 2016).

The required skills, according to Tessaniri and Saltorato (2018): Functional Skills: Complex problem solutions; Advanced IT knowledge, coding and programming included; Processing capability, analyzing and protecting data and information; operating and controlling systems and equipment; Math and statistic knowledge; great comprehension on the manufacturing activities and process.

Behaviors skills: Flexibility, Creativity, Judging and making decisions capability; Time self-management; Emotional intelligence; Mentally oriented for learning.

Social skills: Ability to work in a team; Ability to communicate; Leadership; Knowledge transferability; Persuasion capability; Communicating in different languages capability.

The enforces on the Industry 4.0 usually try to establish a conceptual structure to explain what is the phenomenon. There are also some continuous enforces in the universities and knowledge institutes structure, so that its search and education activities may easily support this eminent transition to the Industry 4.0.

Industry 4.0 is considered as a natural development in transition from traditional to modern manufacturing processes. Because the transitions happen with the technology help, the university’s organizational structure is crucial for the Industry 4.0 to reach its goals. The role of computer science and software technology is unquestionable, once the industry 4.0 success depends very much on the efficiency and effectiveness from the applied computer systems.

4. Industry 4.0 Technologies

Various technologies or techniques may be used to implement Industry 4.0. These Technologies include, according to Xu, Xu and Li (2018): CPS, IoT, Cloud Computing, industrial integration information and other related technologies. In this section, it is presented the selected technologies which are particularly significant for Industry 4.0.

4.1. Internet Of Things

When the term, Internet Of Things (IoT), emerged for the first time, it was referred to uniquely identifiable interoperable objects using radio frequency (RFID). When Connecting the RFID program to the internet, the reader may identify and track, in automatic and exclusive ways, the attached objects in real time. Posteriorly, the IoT technology was used with other technologies, such as sensors, actuators, GPS and mobile devices which are operated through Wi-Fi, Bluetooth, cell phone networks or NFC (ASHTON, 2009)

> A global dynamic network infrastructure, with autoconfiguration resources based on standardized and interoperable communication protocols where the virtual and physical identity, physical attributes and the virtual personalities use smart interfaces and are perfectly integrated to the network information. (Van Kranenburg, 2018)

The Industry 4.0, also known as smart and cognitive manufacturing, offers new opportunities for the manufacturing companies to analyze and use project data, production, supply and inventory to help them to accomplish their vision of modernization. The Industry 4.0 uses cognitive computing as well as IoT industrial applications. Scientific and analytics models are applied to analyze data in real time in multiple machines, processes and systems, and then, combines the manufacturing automatically. Until now, many manufacturing industries have applied IoT to promote production, distribution, transport, service and maintenance on the manufacturing process. (TAO ET.AL, 2016)

As a result, the Industry 4.0 is capable of developing a new manufacturing system generation which integrates and synchronize data in real time between the physical objects and the shorter computational space. Cai, Xu and Xu (2014) created a flexible information model, as well as a opened and configurable software platform, for IoT based applications that covers all the product's life cycle to integrate heterogeneous and distributed products information to manufacturing inside and between companies. These applications also offer a base for other smart integrations.

4.2. Radio Frequency Identification

RFID is one of the IoT's pillars, a concept based on tracking and identification technologies, activated by RFID. For 1980 decade, the RFID has been used to identifying and tracking objects, and applied widely in various departments, manufacturing included. (ZAI ET.AL 2016).

A RFID system may provide enough information about the objects in real time in IoT. RFID is a technology that uses wireless communication. Even though it had been initially developed for tracking and identification purposes, the growing interest in many other possible applications, has led to the development of a new range of technology-based wireless sensor devices. In many cases, the automatic and continuous RFID's capability of detection may eliminate the human labor in the data collection process and to make data automation possible. (Li et al, 2018)

4.3. Wireless Sensors Network (WSN)

A WSN is a system composed by radio frequency transceivers (RF), sensors, micro-controllers and power-source. Various hardware and software systems are available for the WSN's Internet Protocol version 6 (IPv6), provides unlimited number of device connections; Wireless provides cheap and fast communication; Bluetooth and RFID provides a slow and local communication; A mobile platform provides anywhere, anytime and about anything communication. (ALQHATANI; MOSTAFA, 2018)

4.4. Ubiquitous Computing

It is also known as omnipresent computing, environmental intelligence and distributed electronic. In IoT, a virtual computer model may be perfectly integrated to physical object networks (DING ET. AL, 2013).

According to Ding et al (2013), the omnipresent computing is activated by the smart devices. These devices are capable of integrating other devices, organizations and information systems for sharing and exchanging data; real time monitoring; and using anything, anywhere, anytime, without communicating, capture, measure and transfer data. Its performance was, considerably improved for individual smart devices. It is powerful, versatile and smart enough to deal with changes and complexity. For the network system, it is possible to integrate simple devices, without superior computing resources, in order to the information may accessed for in real time decision making.

4.5. Cloud Computing

The virtualization technology provides cloud computing with resource sharing, dynamic allocation, extension flexibility and many other advantages. A great volume of data might load in a cloud computing center for storage and information processing. Which makes faster and easier the decision make. (MITRA et al. 2017).
Mourtzis and Vlachou (2016) discussed the CPS cloud-based for manufacturing systems. The cloud manufacturing, similar to cloud computing, uses a resources network, in a highly distributed way. The Manufacturing-as-a-Service (MaaS) is attracting the manufacturing industries. The cloud design allows that anyone may do it.

4.6. Cyber Physical Systems (CPS)

The CPS are projected systems created and dependent of continuous computing algorithm integrations and physical components. The CPS advance will allow the capability, adaptability, scalability, resilience, security and usability, which will exceed in many simple embedded systems that exist nowadays. (NSF, 2017).

The traditional analyses tools are able to deal with the CPS's total complexity or to predict properly the system behavior. For example, as IoT reaches billions of connected devices - with the capability of detecting, controlling and interacting with the human world, virtual and physical. An issue for the progress is the lack of proper science and technology to conceptualize and project the deep interdependencies between the planned systems and the natural world. Therefore, the CPS's challenges and opportunities are significative. New relationships between cybernetic and physical components require new architectural models, that define the form and function. It integrates the continuous and discrete, composed by the opened environmental uncertainties. The traditional in real time performance guarantees are not enough for the CPS, when the systems are large and spatially, temporarily or hierarchically distributed in configurations that might change quickly. With the autonomy and cooperation possible through the CPS, greater guarantees of safety, security, scalability and reliability are required, putting a high award in opened interfaces, modularity, interoperability and verification.

4.7. Industrial, Architectural, Cooperative and Cooperative Applications Integrations.

In the first half of the 2000 decade, the TIC (Information and Communication Technology) impact upon the industries were beyond the traditional paradigm. It affects the industrial and manufacturing processes in an unprecedented way (Kaynak, 2004).

Kaynak provided an example of industrial integration through the electronic industrial journey to the industrial computing:

> If we had a look for the industrial developments that occurred in the 90 century, the first half could be considered strong, in a sense that better productivity and product quality were mainly due to the hardware improvement. [...] The lasts century's decades, in other hand, are characterized by the merge of different technologies, whose first example perhaps was electronic, optoelectronic, mechatronic, biocomputing and so on. As a result, the limits between industrial departments and academic subjects have worn out very quickly. In the new millennium, it is very difficult to establish clear boundaries between the industrial departments, products and services, product and user, IT, communication, media, consumable electronic products and even IT department and other departments. The industrial automation and control also contributed to the changes.

5. Final Considerations

The industry proposal is to improve drastically the production efficiency and effectiveness through the advanced TIC concepts. It is concerned that the Industry 4.0 movement is causing a great milestone on the technological revolution history.

Even though some technologies and applications introduced in this document might not be totally used in Industry 4.0, they are expected to have great potential for future important roles. The Industry 4.0 success relies on the available technologies sophistications and mainly their capability of intercommunicating. The technologies will act as a facilitator in the Industry 4.0 for the future most efficient industrial ecosystems.

Currently, concentrated efforts are needed to combine the proposed capabilities of Industry 4.0 and emerging technologies. With this combination, Industry 4.0 will be able to make use of the power of the current and emerging technologies to dramatically improve complex ecosystems adopting new technologies.

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