Internet of Things, Big Data and Simulation as a Competitive Advantage in the New Age of Industry 4.0

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Abstract

Innovation is an essential support for the organization's survival in the market. In this context, the advancement of technology can provide inputs for organizations to produce a consolidated position in a such competitive and technological world. Emerging technologies of Industry 4.0, like Internet of Things, Big Data and Simulation, arise in this context bringing terrific transformations in the mode of production and consequently in the management of production. The aim of this article is to make visible how these tools go far beyond technological innovations, providing aspects capable of assisting in the production management, offering, to managers, data that aid the decision making. For this, was analyzed a broad of scientific papers present in different journals of Web of Knowledge, Scopus, Scielo, Science Direct and Engineering Village. The results show that the use of these technologies can enable organizations to improve their processes, faster problem solving, increased productivity and improved process safety.

Keywords
Industry 4.0, internet of things, big data, simulation, management tools.

1. Introduction

Continuous advancement of technology is the driving force for innovation. Organizations that want to survive in a world so competitive and increasingly digital, seek refuge in technological advancement. The search for intelligent production, which will synthesize innovative and intelligent products and / or services, should be the main focus of any organization.

Over time, the industry underwent profound changes, which led to transformations in the manner of production, the size of production and consequently the way of managing itself. The First Industrial Revolution began in the mid-eighteenth century. Through the invention of the steam engine, mankind went from a manual production to a more technological and mechanical production. (Guangli et al., 2018) In this context the production had a size, volume and variety was considerably reduced. (Yin et al., 2017)

The Second Industrial Revolution took place between the mid and late nineteenth century and promoted a great technological leap for the industry, bringing the rise of energy technology and the promotion of revolutionary products. The Third Revolution was between the years 1970 and 2000 with the emergence of computers and the advancement of Computer Technology, provided new technologies through the internet. (Guangli et al., 2018) The dimensions present in the Second Revolution were volume and variety, while in the third there was an increase in the time-to-delivery factor. (Yin et al., 2017)

The modern world demands a more personalized, flexible and high-quality production. The Fourth Industrial Revolution, or simply Industry 4.0, has a huge capacity for growth, because, through intelligent manufacturing, is possible to profitably manufacture the most individual desires of customers, as it provides a flexible production capable of responding quickly to any unforeseen, and even production changes. (Caruso 2017).

Inevitably, there was a transformation of the way of managing the industries in the realities of each Revolution, and consequently through the emergence of new technologies also generated changes in the production processes, thus requiring new management tools.

Faced with this and similar fact in industry 4.0, there are tools that go far beyond technological innovations, which are capable of potentially interfering in decision making. These generate data, which, synthesized, become useful information, becoming important management tools in this new scenario that arises. The present article aims to show, through a bibliographical research, how the tools of industry 4.0, internet of things, big data and simulation can become important tools in the decision making and consequently, important factors in the management of the organizations.

2 Methodology

A bibliographic research was done and analysed a broad of scientific papers present in different journals of Web of Knowledge, Scopus, Scielo, Science Direct and Engineering Village. Used the keywords "industry 4.0", "internet of things", "bigdata", "simulation", "software", "management" and "productivity". A boolean search logic was used and the keywords were allocated with the connectors "AND" and "OR", according to table 1.

Table 1. Keywords and correspondence at each scientific base

Keywords	**Databases**				
("big data" OR "bigdata") AND ("productivity")	Scopus	Web of Knowledge	Scielo	ScienceDirect	Engineering Village
("Big Data" OR "bigdata") AND ("productivity") AND ("management")					
("IoT" OR "Internet of things") AND ("big data" OR "bigdata") AND ("management")					
("IoT" OR "Internet of things") AND ("business management")					
("industry 4.0") AND ("productivity") AND ("management")					
("simulation") AND ("productivity") AND ("management")					
Articles Founded	505	671	4	159	900

Through this process it was possible to obtain 2239 articles, of which 505 were from the Scopus database, 671 from Web of Knowledge, 4 from Scielo, 159 from Science Direct and, finally, 900 from the Engineering Village database. After capturing the articles, EndNote software was used to catalogue them into a library.

The first filter applied on the library base was the exclusion of the duplicate articles, thus eliminating 376 articles, reaching a base of 1863 articles. The focus of the research is to evaluate the potential of IoT, Big Data and Simulation as decision-making agents assisting the management of data and information. In order to achieve the expected result, filters were applied to conduct content aimed at the business and management area, looking for effects of the application of these technologies on the performance of organizations. Regard to management and efficiency from this process, the final basis of articles that composed the present work was reached.

A lexical analysis was performed to evaluate the word frequency of the articles base, and to verify if the content was in agreement with the expected, using the software QSR Nvivo 10. TreeCloud 1.3 software was also used to assess the proximity relationship between the words of the base. With this, was possible to analyze the main attributes involved for each technology and the main aspects that they add to the business.

3 Innovation and Competitiveness

The world has become more and more dynamic, processes flow at an unbelievable speed. The advancement of technology, especially the new technologies from the new era of industry, is generating great transformations in the work processes and giving rise to new business models. As is said in this new scenario is Industry 4.0, its potential provides more efficiency processes, increased productivity and the generation of innovative products and services. (Bauer 2018)

The modern era of technology enables significantly expand business opportunities, creating competitive and innovative advantages. In this reality of modern business with intensive use of technology, companies are provided a greater maintenance of their competitiveness. (Sotnyk and Zavrazhnyi 2017) Organizations need to use innovation to survive, that is, make use of new technologies to reduce production costs and adapt to new markets, creating differentiated products and services.

In this complex scale, where consumer demand, organizational interests and technology are aligned, industry 4.0 has become an unquestionable reality, owing obviously to the great advancement of technology, which is present in the life of almost the entire world.

3.1 A Industry 4.0

Through the use of "Cyber-Physical Systems", Internet of Things and Cloud Computing, is possible to obtain a greater level of communication and cooperation between the production systems. This context is known as "Intelligent Factories" and is provided from the Industry 4.0, which relies on physical and digital interaction (Gorecky et.al 2014). This scenario brings new means of production, business perspectives that allow an improvement in processes and, through the benefits of the internet, is possible to revolutionize data processing, which is an important basis for modern industry. (Nagy et.al 2018).

The data, themselves, can not generate major changes, if they are not well collected, analyzed and used in support of decision making. They must be well founded in order to be assertive generating a competitive advantage that is visible through the interconnection of production. There are beneficial interactions for the organizations, such as the machine to predict the occurrence of failures and indicate the part needed to perform the maintenance, or, if possible, to avoid production stoppages by monitoring the operating conditions of the machine in order to react faster to problems. (Nagy et.al 2018)

The new manufacturing era, with the intensive use of communication and interaction technologies in industrial processes, has achieved great success in sharing and collecting data, because the machines are connected in a collaborative community (Li et.al 2016). This new data treatment present in this collaborative machine community is aided by another great technology that makes all this interaction possible: the Internet of Things.

3.2 Internet of Things

Internet of Things (IoT) deals with the interaction of the physical with the virtual from addressable objects with virtual representations similar to what occurs in the structure of the Internet.These objects can be linked to information about them, or even share such information.Tthis information is collected from real-time sensor data on its conditions, properties or any other useful aspect related to the object (Aggarwal et al. 2014).

Basically, the architecture of IoT is composed of sensors, actuators and controllers, and, of course, the "things" that are embedded in all these mechanisms. For there to be harmony among all these factors, it is also necessary to command computers or logical devices that guide and dominate all this architecture (Negash et. Al. 2018). It is worth mentioning that during this process an immense amount of data is generated, which have a very large production speed coming from several devices.It is worth mentioning that during this process an immense amount of data is generated, which have a very large speed producion coming from several devices. These devices need to

receive a treatment and be stored to become useful and attend this demand. This whole process counts with the participation of another technology: the Big Data.

The data generated in this process are critical for organizations. The informations are of utmost importance for decision making, since such are everywhere, embedded in a network and their management becomes essential to generate business efficiency (Altendorfer-Kaiser 2017). The data received can be varied. Information about the condition of equipment, production rates, energy consumption, maintenance rates (such as temperature, for example), if not properly treated will be useless. When are treated, all these factors generate knowledge and begin to be part of the decision support system.

3.3 *Big Data*

From the need to make quick decisions, the challenge of storing a large amount of data in a safe and viable way has inevitably been generated, and these electronic data will occupy a significant space, beyond the care of being processed safely. Big data can provide this by processing this data, however, it should be noted that the big data is not restricted to only a large mountain of data (data alone can not generate transformations). They need to be analyzed in order to find explanatory variables in order to generate a response or a useful result, that is, data management is an analytical matter that incorporates business intelligence (Baesens et.al 2016).

Is necessary to have a set of analytical and decision support applications to structure a Business Intelligence (BI). This structure is based on the collection or mining of data, systems that support decision, knowledge management systems and online analytical processing (Abuosba 2015). Therefore, the organization of information, access to information and analysis are fundamental for obtaining assertiveness in decision-making and good performance management. Big data and their analysis create a propitious ground for the collection of greater perceptions about the process, its automation and judgments that provide benefits to the organizations (Akoum and Mahjoub 2013).

Many organizations use the Big Data features to process the data generated primarily from the Internet of Things. Considering that these data are being formed at a tremendous speed and size, this task becomes complex, but such data must be transformed into knowledge. This process is possible even with a great apparent challenge. Companies that want to generate competitive advantages and become smart businesses must use these technologies appropriately in order to generate benefits for them. (Arass et.al 2018).

Given the above, the interaction between the Internet of Things and the Big Data can be extremely efficient in regards to data collection and processing, which provide great benefits with regard to decision making. In the new era of industry information is the key to success, yet much more than information alone, but rather the good use of it for generating values and advantages for the organization.

3.4 Simulation

Simulation is an approximate reproduction of a behavior or object of a given system in a virtual way, this reproduction is called a simulation model, that is based on a mathematical model with a virtal representation in a computer program. Through this process, it is possible to evaluate the behavior of variables of a system in a simple and inexpensive way, without compromising the real system. It is impracticable, in relation to project execution, to imagine the application of several possibilities to later evaluate its performance in the actual production system, in addition to demanding high costs and jeopardizing the system itself in the occurrence of failures. (Kikolski 2017).

As a modern and flexible management tool, simulation has been used by many industries around the world. It is used to evaluate various aspects of the manufacturing system, without using the actual system, with the great complexity of current systems. It is also used to evaluate the performance of possibilities to be applied in the system in order to predict and evaluate decisions before they are effectively implemented. With this feature, the organization has the power to mitigate risks in evaluating the measures to be used. (Dargi et.al 2011).

Industries have many advantages with the use of simulation, among them are: saving of investments, increase in the use of resources, reduction of time in the cycle of processes, increase of the income, besides the easiness to make decisions to solve problems or to look for improvements in the management of production. Computational simulation is applied and proposed to deal with the problems of manufacturing systems, also because it is easier to handle than the usual mathematical models (Zahraee et. Al. 2014).

4 Analysis of results

4.1 Lexical Analysis

From lexical analysis, the evaluation of the frequency of words was used to search for the terms that are most relevant in the results of the bibliographic research. For this, the QSR NVivo 10 software was used. After this process, the result was presented below in figure 1. Information Technology is a driver and facilitator of digital transformation. Emerging technologies of the new manufacturing age have proved to be disruptive to the achievement of knowledge and information that raise their commercial value (Zimmermann et. Al 2015), bringing diverse benefits to organizations and society.

The concern of having data available in organizations is evident, more and more efforts have been made to save data, but access and availability to the data alone is not relevant to the business. Smart companies make their decisions based on analyzes of the available data, look for information that will help them understand the market and their consumers, as well as increase their area of activity and consequently their profits. It is important to analyze and choose the best way to gain competitive advantage over your competitors. (Niraj and Aditya 2019).

Nowadays, great data generation has made it challenging to manage them. These data can be generated from a variety of sources, and can add significant value to organizations; well-managed data analysis can bring diverse benefits and increase their competitiveness by providing real and accurate information about their customers' preferences and generating self-knowledge, this considerably increases the assertiveness of decisions guaranteed more efficiency, reducing risks and losses and generating more profit for the companies (Alyoubi and El Emary 2016).

Figure 1. Tag Cloud resulting from lexical analysis (using the QRS Nvivo 10 software)

4.2 Content analysis

From the analysis of the content, the evaluation of relationship between the words to search for an understanding of the results of the bibliographical research, using the software TreeCloud 1.3, after this process the result presented in figure 2 .

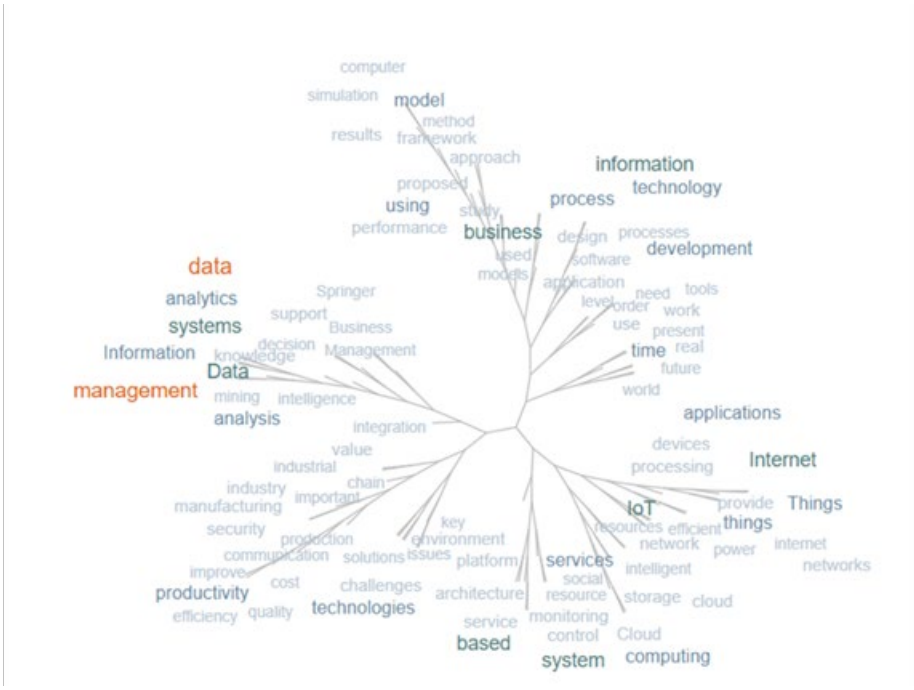

Figure 2. Tree cloud resulting from content analysis (using the software TreeCloud 1.3)

The results indicate that the data analyzed and the integration of the systems generate information of great relevance for the support to the decision making and consequently potentially interfere in the management of the business. Knowledge is the driving force behind decision assertiveness and problem minimization.

Communication in manufacturing is a value-generating agent capable of improving productivity, efficiency and quality of processes and throughout the production chain through the use of technology. This communication is generated from the use of technologies such as IoT that creates a collaborative network in the factories, in which the machines form a community that shares and collects relevant information about its states through sensors. This architecture provides a greater control over the processes and facilitates monitoring, as a consequence there is a faster response to problems involved in the process.

The computational simulation is an important tool in the new industrial era, from the modeling of real situations. It is possible to predict failures and evaluate the performance of the analyzed structure, in addition to predicting possible results, without using the actual structure, allowing to study the business from the model created to actually apply the method evaluated in the model.

4.3 Analysis of results

4.3.1 Using the Internet of Things in a company in the agricultural area

The customization of services in bulk products is a challenge for organizations, but more and more is demanded this issue in the market. In the agricultural area it was identified that the producers had the need of a greater interaction between their equipment and the environment, because through this interaction it would be easier to observe and identify aspects that directly interfered in the production, without the use of other specific equipment. (Cedeño et.al 2018).

According to this perspective, the company Tractor Co, which has its area of operation in the sale and maintenance of tractors, sought through the use of the technology to offer its customers relevant and safe information on the equipment used by them. From an internet-based architecture, it was possible to monitor the tractors in order to predict production, failures and maintenance needs without complications. This system is possible with the integration of devices to tractors that provide conditions of use information, such as tracking the average

temperature, oil check and pressure of operations, this information is processed and accompanied in software, to offer customers beyond sale of tractors their maintenance. (Cedeño et.al 2018).

With this database, the customer is offered a customization of services. The service is given quickly and efficiently because it was possible to predict the failure before it occurred, and if for any reason the failure time occurs correction is faster because the causes are more likely to be known through monitoring. With this, the organization besides offering the product, offers its clients a completely personalized and differentiated service, generating value before their customers and loyalty. (Cedeño et.al 2018)

4.3.2 Using Big Data in a company that monitors oceans, atmosphere and climate

The National Oceanic and Atmospheric Administration (NOAA) is an organization owned by the US government, which through cutting-edge research and high-tech tools offers citizens, planners, emergency managers and other decision makers reliable information on weather forecasts . To arrive at these forecasts are collected various data from satellites, radars, ships, weather models and other sources. All these data are generated throughout the country and in an absurd amount to be processed in order to generate useful information to the population. (NOAA).

Faced with this situation, the organization has a great challenge of using these data to generate meteorological knowledge to all stakeholders in an accessible and safe way. This information is extremely important in the field of safety, because, for example, they can predict drilling. Another use is support in the choice of business location, as occurs with farmers who care about the climate conditions in a given locality to evaluate the impacts on their production, and with workers who have fishing activities, who in this case need the monitoring of oceans. All this is possible through the Big Data. (NOAA).

4.3.3 Using Computational Simulation in an Airline Company

Embraer (brazilian aerospace conglomerate that produces commercial, military, and agricultural aircraft and aircraft) was facing a major challenge due to the large number of antennas distributed over the aircraft jets that caused an increase in fuel consumption due to generation of aerodynamic drag. The organization then sought the most viable way to resolve this situation. In this case, the creation of prototypes would not provide conditions that met the requirements sought by the company, then used the computational simulation of the electromagnetic field to obtain the most efficient evaluation of projects of alternative installations of antennas in their aircraft. (ESSS 2017).

The antennas are needed to meet the demands of security and radar tracking, as well as being able to offer customers services such as Wi-fi and live television for passengers. If the company made prototypes for every possible location of the antennas, they would require time and money for construction, in addition to the field tests, to arrive at an evaluation and decision on the case. Faced with this situation, the computer simulation, through a software, proved to be the most efficient and fastest solution to solve the problem. From the creation of virtual models it was possible to evaluate the performance of each location of the antennas, arriving in a faster way the optimal solution for the situation. Through the use of this technology, it has generated resource savings, design time and execution. (ESSS 2017).

4.3.4 Use of Innovative Technologies in cities

In intelligent houses, all electronic devices (refrigerator, television, air conditioning, among others) are connected to a central network (internet) so that it is possible to monitor the whole environment, forming domestic systems that generate services such as home security, medical care home, comfortable life support and optimization and energy savings. Through the sensors are generated a huge amount of data, which are used to manage the house, solve problems remotely and, immediately, optimize the use of resources. All these aspects provide users with a higher quality of life, reduced costs, reduced environmental impact (as it optimizes waste generation), more safety and comfort in homes (Bogatinoska et.al 2016).

It is possible to transfer, share and access data through a cloud infrastructure that enables smart cities to exchange data between the most diverse sectors, such as transportation, energy, health and agriculture, generating optimization and increasing efficiency in these cities. Sensors are the key point for this architecture to capture such data. The internet works as a network and for process control you also need a device such as a cell phone, for example, that functions as the system interface (Bogatinoska et.al 2016).

5 Conclusion

The key point for decision making is knowledge. Technologies provide, through tools, the basis for these decisions to be made. The internet of things works with a great integrator of objects, capable of interacting, communicating and sharing various information. Big data is capable of storing a large amount of data and the simulation has attributes that facilitate beneficial choices for the organization. The integration of these technologies also bring diverse benefits to society, contributing to its development and efficiency.

Today, the information base has a huge variety and amount of data. All of these factors contribute to an even greater share of technology. The formation of intelligent factories creates a collaborative network of machines capable of rapidly exchanging information autonomously. Is it possible that in the future machines alone make decisions? Analysis at this point is the starting point for a possible response.

Technology, with its attributes, can become much more precise and assertive, but the human factor is necessary to perform information analysis and make the right decisions. These competences encompass aspects that mathematical and logical algorithms can not learn and reproduce, such as consciousness, empathy, and creativity. Of course more technologies will come. New skills and learning will be demanded. Therefore, the new challenge will be the definition of these new competencies for the professional of the future.

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Biography

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