[1.]Isak KARABEGOVIĆ

THE ROLE OF INDUSTRIAL AND SERVICE ROBOTS IN THE 4th INDUSTRIAL REVOLUTION – "INDUSTRY 4.0"

[1.] University of Bihać, Technical Faculty Bihać, BOSNIA & HERZEGOVINA

Abstract: As it is well known, the fourth industrial revolution, entitled "INDUSTRY 4.0" appeared for the first time at the Hannover Fair in 2011. It comes from the high-tech strategy of the German federal government that promotes automation and computerization of industry. Ever since 2012, the working group of the German government presented recommendations for the introduction of "Industry 4.0" in the production processes. The strategy consists of adjustment of industrial production to complete smart automation, which means the introduction of self-automation method, self-configuration method, self-diagnosing and removal of problem, knowledge and intelligent decision making. The central figures of "Industry 4.0" are industrial robots, as well as service robots. Their application in all production processes, with the support of information technology, will lead to "intelligent automation" and "intelligent factories". In the nearby future (expected by 2025), machines, devices, robots and humans need to be mutually connected, so that they can work side by side and communicate with each other via the internet platform (IOT). The paper states the role of robots in the fourth industrial revolution, as well as predictions of the development and implementation of robots in the industrial processes. Smart automation or smart factories will create a society in which the wealth, created through the strengthening of global competitiveness, would serve to meet social issues in the society.
Keywords: industrial robot, service robot, intelligent automation, industry 4.0, smart factory, robotic revolution

INTRODUCTION

In the past 20 years the development of digital technologies, new methods and new technologies in the world as well as their implementation in production, urged the companies worldwide to constantly monitor these developments and conduct modernization and automation of their production processes in order to stay competitive. The fourth technological revolution "Industry 4.0" (the term originated in Germany, and can in many ways be labeled as "smart factories", "smart industry" or "advanced manufacturing") refers to the implementation in production technologies, supported by a variety of digital technologies (e.g. 3D printing, Cloud computing, ICT, advanced robotics) and new materials. One of the reasons that above mentioned technologies are already partially available is constant decrease in costs, and it is expected that they will be fully represented in the production processes in the near future. The other reason why companies need to follow the development and implementation of these technologies is because customers quickly obtain information through ICT and expand their requirements, so that products they demand become more complex and complicated for a production process [1, 2, 3, 4, 5, 6, 7]. The application of these technologies, or the digitized production,provides a wide range of changes in the production process, greater flexibility in production process, and easier automation of production processes by using adjustable or collaborative robots, so that different products can be produced during the same production process. In this way, manufacturers will be able to produce very small series (one product if needed) because this technology provides a possibility of fast configuration of machines and production process, as well as their adaptation to customer requirements.In other words, we have the ability to produce rapidly without the installation of new production line. The application of digital design and virtual modeling of the production process reduces the time needed forthe production process from design of a product to the distribution to the customer. In addition, we have high improvement of the finished product quality and reduced level of production errors. With the implementation in the technology production process (such as ICT technology, sensor technology and robotic technology) we have the ability to record the production process of each element (instead of sampling and control) and detecting errors that occur during the process. When detecting errors, the machines can be adjusted in real time . The development of ICT technologies, sensor technologies and their application in robotic technology leads to the development of new industrial robots that can work together with the workers. For this reason, the companies are trying to introduce "intelligent automation "or use "smart machines" in the production processes that will be the product of the fourth industrial revolution "Industry 4.0". If we take into account the fact that large companies in the developed countries incorporate the application of "intelligent automation" in their business strategies, we come to the conclusion that in 10 to 20 years we will reach "smart factories", which will easily be able to satisfy all the needs demanded by the customers. Industrial robots are being developed in the sense of cooperation between robots and workers, simplification of use, industrial robots with multiple hands, robot integration with the existing systems, modular robots, compact and lightweight

robots, and their implementation in a production processes that is supported by the ICT technologies, and followed by the objective towards "smart factories". Intelligent robots will completely replace the workers in the production process, and at the same time the workers will work on more effective creative tasks [3, 16, 18].

THE ROLE OF DIGITAL TECHNOLOGY IN THE FOURTH INDUSTRIAL REVOLUTION "INDUSTRY 4.0"

As we already mentioned, the fourth industrial revolution is the result of digital technologies, and the participation of various digital technologies initiates the transformation of industrial production. In the next period, everything will depend on a number of new and innovative technological achievements. The application of information and communication technology (ICT), enable us to acquire information based on which we can carry out the integration of all systems in all phases of creating new products, both within the production process and outside of the production process (referring to the logistics and supply).Figure 1 outlines the key digital technologies (ICT) that enable digital transformation of the industrial production processes [1,3,15].

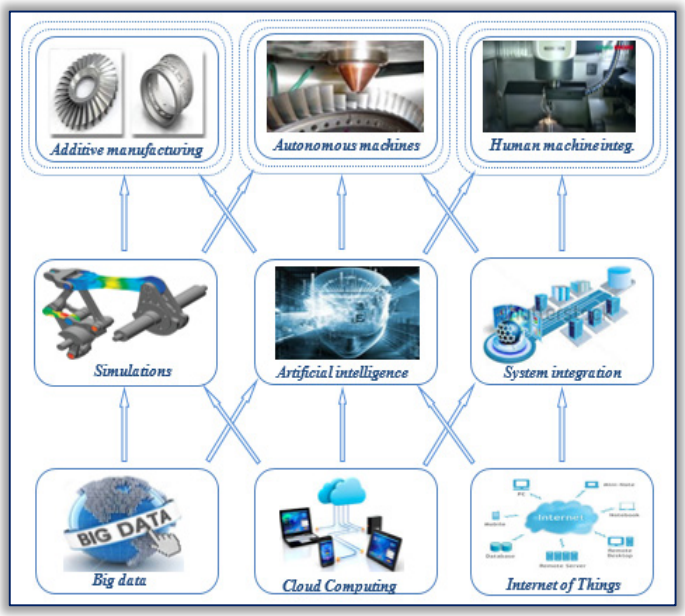


Figure 1. The transformation of production processes with digital technologies

The analysis of Figure 1 provides us with the conclusion that following technologies will lead us towards digital transformation of the industrial processes: Big Data, Cloud Computing, Internet, Simulations, Artificial Intelligence, and System integration, all representing support technologies on top of the Figure 1, such as Additive Manufacturing, Autonomous Machines and Human-Machine Integration. There are two reasons why digital technology will transform the production processes in the industry: the first is that their representation in the production processes is increasing every day, and the second is that the combination of various ICT technologies converges with other technologies. The main effect that influences the productivity in the production process is technologies depicted at the bottom of Figure that enable the work of technologies on the top of Figure 1. In order to use the above mentioned technologies and in order to achieve all that was not possible until now (for example, to control each piece during the production, follow the distribution, changing parameters during production, etc.), we have to implement all digital technologies shown in Figure 1. The best example of future technology is shown in Figure 2. It gives the scheme of fourth industrial revolution and the role of robots in the "Industry 4.0" [3,8,17,19,20].

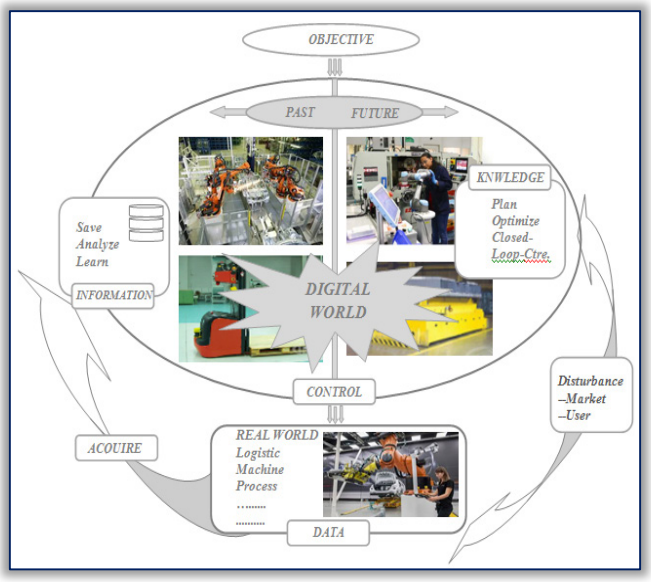


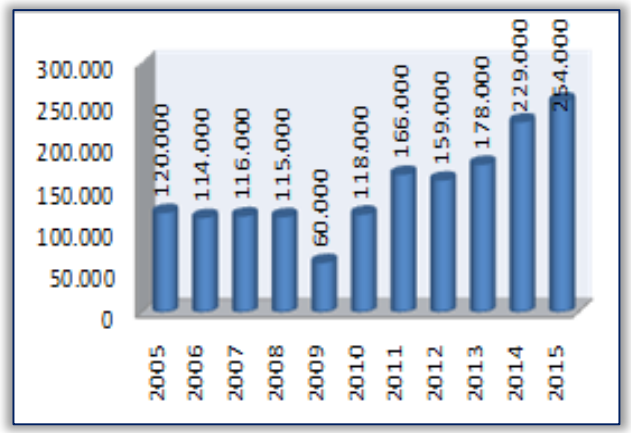
Figure 2. The basis of the fourth industrial revolution "Industry 4.0" are industrial robots and service robots

As Figure 2 shows, the current method of production is ever-changing and is being replaced by new productions methods, i.e. the transformation and production processes with the participation of digital technology in all processes of production, distribution and monitoring products throughout their life. It is impossible to automate the production processes with the "smart automation" without the participation of the industrial and service robots. Robotic technology and robots are one of the foundations of the fourth industrial revolution. The reason for this is that there has been the development of robotic technology owing to digital technologies, and above all, information technology and sensor technology, which led to the development and application of new types of industrial and service robots that make independent decisions and can work together with workers, but also take into account that they are not hurt during operation. In the period to come, i.e. future, it will not be possible to imagine any production process without the participation of the robots because they will be very flexible in order to perform any activity. In this way, robots significantly increase productivity, which is the objective of the companies engaged in the production. They produce faster, stronger and more consistent than workers with a combination of new sensors and actuators, and extensive data analysis. By using digital technology, such as Cloud Computing and Internet of Things, we get the ability to produce by independent production machines, that increase

productivity, they are automatically maintained, and maintain communication during the production process.

THE DEVELOPMENT OF ROBOTIC TECHNOLOGY WITH THE SUPPORT OF ICT TECHNOLOGY

Automation of production processes began in the 60s of the last century with the introduction of industrial robots in the production process in the automotive industry. The automation of production systems by introducing industrial robots is an ongoing process, and nowadays is performed differently because of the development of information technologies that affected its application in the automation because today they are performing multiple tasks, with the possibility of reprogramming. One of the disadvantages of the first-generation industrial and service robots is that they have to be programmed for every operation. The second disadvantage is that industrial robots were separated with barriers from the workers, so as not to hurt them during operation in the production process. Digital technology, sensor technology and new materials support the development of robotic technologies and their convergence enabled the development of second-generation industrial robots.



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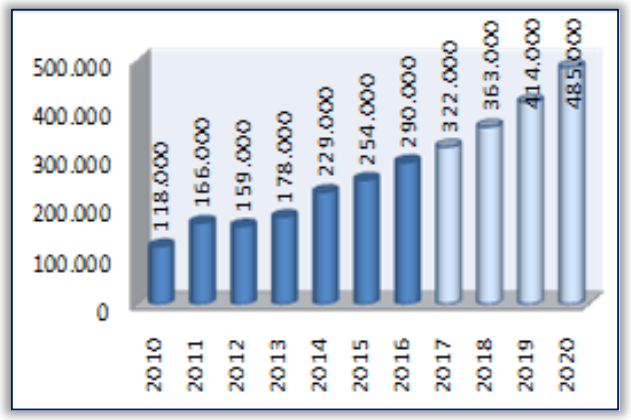
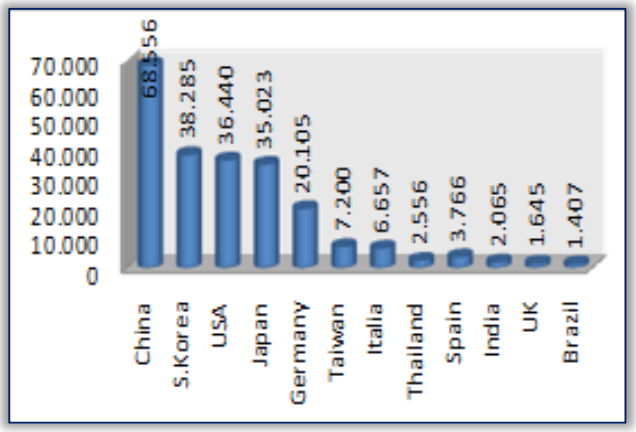


b)

Figure 3. The representation of industrial robots worldwide in the period 2005-2015 and the prediction of representation until 2020: a) Annual representation of robots; b) Prediction of representation

In order to understand the speed of convergence of digital and other technologies with robot technologies and their implementation in manufacturing processes in the industry, we have to conduct the analysis of the representation of industrial and service robots in the world in the last ten years. Statistical data were taken from the IFR (International Federation of Robotics) and shown in diagram in Figure 1 [9, 10, 11, 12, 13, 14].

Based on Figure 3a), we can conclude that the representation of industrial robots in production processes worldwide is increasing every year, so that in last ten years the representation of robot units increased from 120.000 robot units in 2005 to 254.000 robot units in 2015. This statement provides us with the assumption that the development of information technology and robotic technology and their implementation in production processes is increased by the automation and modernization of production processes, thus increasing the productivity.



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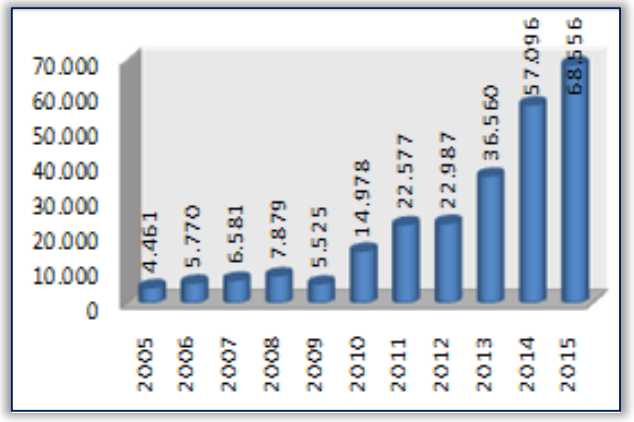


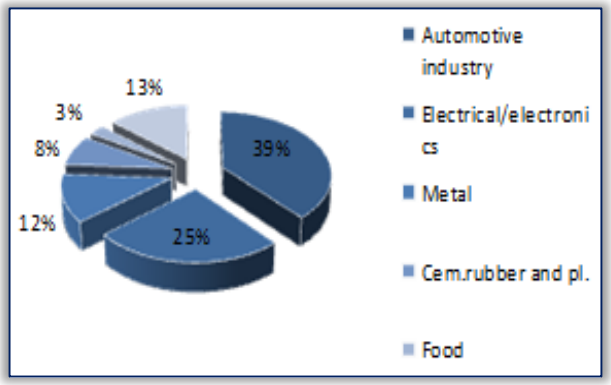
b)

Figure 4. The representation of industrial robots in top twelve countries in the world in the period 2005-2015 and the representation of industrial robots in China in the period 2005-2015: a) Representation of robots in top countries; b) Representation of robots in China

The predictions of representation of industrial robots in the coming period are given in Figure 3b). We can see that the increase of the representation is going to continue, and it will reach around 485.000 robot units in 2020. We need to conduct the analysis of the representation of industrial robots in top twelve countries in the world in 2015, as shown in Figure 4.

Among twelve countries in the world that have the highest representation of industrial robots in production processes in

2015 are the following: China, North Korea, USA, Japan, Germany, Taiwan, Italy, Spain, India, UK and Brazil. As we can see based on Figure 4a), the first place is held by China with 68.556 industrial robot units, followed by the countries in which the automotive industry is highly developed, such as North Korea, USA, Japan and Germany. If we look at the representation of industrial robots in production processes in China in the last ten years, Figure 4b), we see that it holds the first place in the last years, the reason being the strategy developed by China named "Made in China 2025", which aims to make China the leading technology country in the world. In order to determine the effect of such representation of industrial robots, we need to examine the percentage of the representation of industrial robots in the world in 2015 in different industries and vehicle production, which is shown in Figure 5 [6,13,14].



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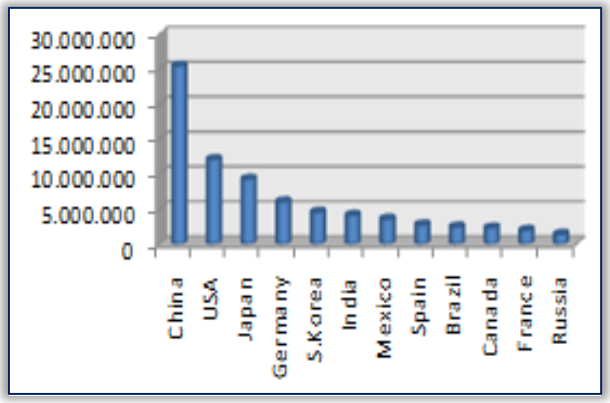

b)

Figure 5. The percentage of representation of industrial robots in different industries worldwide in 2015, as well as vehicle production in top twelve countries in the world in 2015: a) Representation of robots; b) Vehicle production

The first place by representation of industrial robots Figure 5a) is held by automotive industry with 39%, the second place is held by electrical/electronics industry with 25% and in the third place is metal industry with 12%.

Based on the image 3b), we conclude that China has installed most industrial robots in production processes in the automotive industry because they are the first in the world in vehicle production. In 2015 China produced close to 25 million vehicle units, followed by countries that are among top five countries in the representation of industrial robots in 2015: USA, Japan, Germany and North Korea.

In addition to development and increase of application of industrial robots in production processes, the development and increase of application of service robots in the production process is also growing. As an example, we take service robots for logistics in the production process, as shown in Figure 6 [3, 4, 17, 20].

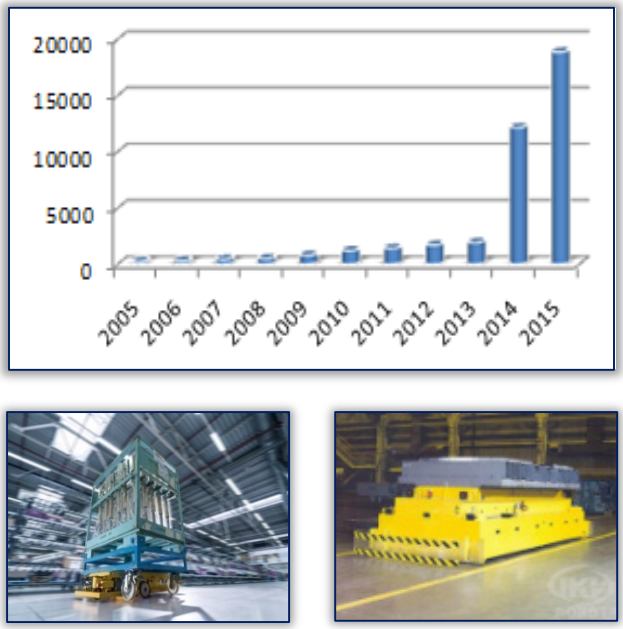

Figure 6. The representation of service robots for logistics worldwide for the period 2005-2015

The development of digital technology and the development of other technologies are contributing to the development of robotic technology, so that each year the representation of service robots for logistics in the production process is being developed and increased, as evidenced in Figure 6. It can be seen that in 2015 about 18.000 service robot units of different constructions and for different purposes are represented in the production processes. The convergence of digital technologies with other technology created the second generation of industrial robots, which will rapidly lead to the third generation of industrial robots that will be smaller than the current, less expensive, more autonomous, flexible and fully rendered, with simplified programming so that they can be programmed by workers.

The third generation of industrial robots is intelligent and autonomous robots and their improvement will be as follows: identifying specific objects, manipulation, knowledge, increase in computing performance, numerical remote controlling, working with miniature and complex products that require adjustment in the installation, reliability and precision that exceeds human capabilities.

For these reasons, industrial and service robots are presently at the center of automation of production processes, and in the future it will be impossible to create "intelligent automation" and "intelligent factory" without the participation of a new generation of robots, as shown in Figure 7.

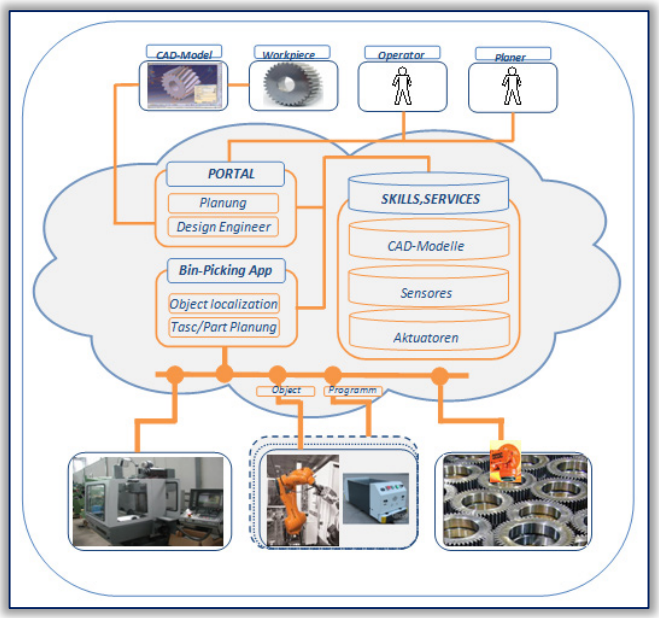

Figure 7. Intelligent production process of gear realized with digital and robotic technology

Digital technology and other technologies, which include robotic technology, are the foundation of every intelligent production, as is the case of production of gear shown in Figure 7. The advanced information technology enabled the design, simulation of actual plant at all stages of production (virtual reality), assembly, quality control, planning, management, diagnosis and optimization of production all from one place. This method leads to the highly productive production process, low cost and high quality of production.

CONCLUSIONS

The development of digital, sensor, and robotic technology with other technologies and new materials is introducing the intelligent industrial development leading to the "intelligent factories". This is the period of the fourth industrial revolution based on intelligent production processes that use network technology and equipment for monitoring technology in order to have the means to adjust the production. Production system has the ability to reason, predict, simulate, self-configuration of optimal production system, independent learning and maintenance (using saved files and updates), automatic error diagnosis, problem-solving and maintenance. The new production system will have the ability to communicate with the machine and be complementary at different levels. All the above is impossible to achieve without the application of industrial and service robots in the production process. It is well-known that robotic technology is developing rapidly, and the industrial robots of the second generation are already installed in production processes, where they work alongside with the workers, whereas in the past they had to be separated by compartments so that they wouldn't hurt workers. In addition, service robots for logistics are being installed in the production processes, that are completely intelligent and communication related to the production machines. Intelligent automation allows greater flexibility in the production, so that different products can be produced in the same production facility. Digital design and virtual modeling of production process enable us to reduce the time between the design of a product and its delivery to the market. In this way we acquire great improvements in product quality and a significant reduction of production errors. The fourth industrial revolution which includes digital and other technologies will lead us towards the "intelligent production'' in the next 10 years.

Note:

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