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Research Article

Use of Artificial Intelligence in Smart Production in the Industrial 4.0 Era

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Article Info	ABSTRACT
	Businesses have undergone many changes and transformations in their production systems from past to present in order to survive in a competitive environment. The common purpose of all of these transformations is to deliver the products and services the customer wants at the desired quality, at any time, and at a low cost. Especially with Industry 4.0, which is called the Fourth Industrial Revolution, companies have started to analyze large amounts of data obtained from their systems by using advanced technologies. Thus, they turned their production systems into smart production with very little human intervention. Artificial intelligence techniques play a key role in making smart production. Production efficiency and product quality are improved by analyzing large production data, which is difficult to obtain with traditional methods, in real-time by techniques such as deep learning and machine learning used in artificial intelligence. Due to these advantages, artificial intelligence has been widely used in almost every sector today. Here, it is aimed to examine the use of artificial intelligence, which has become more important with industry 4.0, in smart production. In the study, firstly, the relationship between industry 4.0 and smart production was explained, then the use of artificial intelligence in smart production and the benefits obtained were emphasized. Finally, some suggestions were presented to companies for the use of artificial intelligence in production systems.

1. Introduction

When we match the social stages of businesses with the industrial revolutions, we can say that the industrial society includes the first and second Industrial Revolution, and the information society emerged with the Third Industrial Revolution. Today, the doors of a new era led by digitalization have been opened. This concept, which enters all areas of our lives, is the source of an industrial revolution. This period, which is expressed as Industry 4.0 or the Fourth Industrial Revolution, creates a radical change in production methods[1]. Because the production systems used today are faced with uncertain demands, high product variety, and rigid delivery times. Therefore, production systems/methods need to perform their duties more flexibly and without the need for human intervention by using the technologies that emerged with the industry 4.0 revolution in order to overcome such difficulties [2].

Industry 4.0 optimizes production in real-time and facilitates vertical, horizontal, and end-to-end integration [3]. When doing so; It uses technologies such as Internet of Things (IoT), Cloud Computing (CC), Big Data Analytics (BDA), Cyber-Physical System (CPS), Simulation, Additive Manufacturing (AM), and Autonomous Robots (AR) [3-5].

These technologies are the foundation of Industry 4.0 and enable the manufacturing industry to be smart and able to meet current challenges such as adapting to individual customer requirements, improving quality, and responding more quickly to market demands [6]. Industry 4.0 and its technologies play an important role in making industrial processes autonomous and thus collect instant data from industrial machines/components [7]. With the development of Industry 4.0, the machines used in the production processes will be able to make decisions without human intervention by communicating with each other [8].

One of the goals of Industry 4.0 is to turn today's factories into smart ones. Smart factories are factories that can provide flexibility in all processes with the help of information technologies in the face of the increasing complexity of products, manufacturing processes, and supply chains. In smart factories, where information technologies, telecommunications, and production are combined, production tools become more autonomous and factories that can organize themselves without the need for human intervention emerge. With this integrated system, every stage of production can be monitored and problems in the processes can be intervened immediately [1].

In this study, the use of artificial intelligence in smart production, which emerged with the use of industry 4.0's key

technologies in production, was examined. In the second part of the study, smart production is explained, in the third part, the use of artificial intelligence in smart production and its benefits are emphasized, and in the last part, a general evaluation is made.

2.   Smart Production

Over the last century, the production industry has gone through a series of paradigm shifts. At this stage; There were eras of Ford Assembly Line (1900s), Toyota Production System (1960s), flexible manufacturing (1980s), reconfigurable manufacturing (1990s), and agent-based manufacturing (2000s). In the processes carried out in these periods, the common goals of their businesses are; further improving the performance of production machines and processes, improving the level of automation and product quality, reducing operational downtime, and responding to dynamically changing customer demands on time. In order to do this, they used various technologies and methods. Recently, the use of data and communication capabilities from sensors has come to the fore. Accordingly, various countries have developed various strategies to take advantage of data science. For example, Germany introduced Industry 4.0, also known as the fourth industrial revolution, in 2010 [9]. Thus, the automation-based production that emerged in Industry 3.0 has left its place to smart production in smart factories in Industry 4.0 [1].

Smart production means using data analytics from various sciences to improve the performance of systems and decision-making. Smart production refers to a new production paradigm in which production machines are fully connected via wireless networks, monitored by sensors, and controlled by advanced computational intelligence, using technologies such as IoT, CC, and CPS [10]. A smart production system is a human-cyber-physical system in which physical systems and cyber-physical systems cooperate to achieve optimized production goals [11]. Smart production is also defined as a new production model and new information and communication technology, intelligent science and technology, large production technology (including design, production, management, testing, and integration), and systems engineering technology [12]. Technologies used in smart production aim to create production intelligence in companies. Thus, it reduces costs while increasing product quality, system productivity, and sustainability [9].

In today's production, a wide variety of data is collected from many different areas, including product line, production equipment, production process, labor activities, and environmental conditions [9]. In addition, businesses obtain large amounts of unstructured data from sensors in machines, production lines, production execution systems, enterprise resource planning systems, systems outside of production (customer feedback, supply chain), and other different sources [13]. Real-time analysis of this data is an important component of smart production [9]. Large amounts of data produced in daily life and technologies developed based on this data contribute to activities such as automating the production process, optimizing products, and reducing energy waste, leading to the production of higher quality products and services at lower costs [8]. Researches show that 82% of companies that use big data analytics in their processes experience an increase in productivity and a 45% increase in customer satisfaction [9].

For smart production, Industrial Artificial Intelligence is required, which can optimize the production process and thus significantly improve the economic and social benefits. Smart production benefits from both Industry 4.0 technologies and artificial intelligence algorithms. Thus, it monitors the production systems in real time, increasing the quality of the products and reducing the costs [11].

3.   Use of Artificial Intelligence in Smart Production

Artificial intelligence (AI), image processing, natural language processing, robotics, machine learning, etc. It is a cognitive science with rich research activities in various fields [14]. AI refers to the intelligence displayed by machines. It is a set of algorithms that enable a machine to perform complex tasks by sensing its operating environment and taking actions to maximize the probability of successfully achieving predetermined goals [15].

AI has entered the Industry 4.0 era, has taken a place in the production industry, and has become an integral part of the digitalization of businesses [13, 15]. It can be said that in the Industry 4.0 revolution, production and factories cannot be "smart" without artificial intelligence [15]. Therefore, it is considered one of the key technologies for Industry 4.0 and smart production [13, 15, 16]. With the spread of production data, artificial intelligence using this data makes production smart by transforming unprecedented volumes of data into comprehensible information, as shown in Fig. 1 [9].
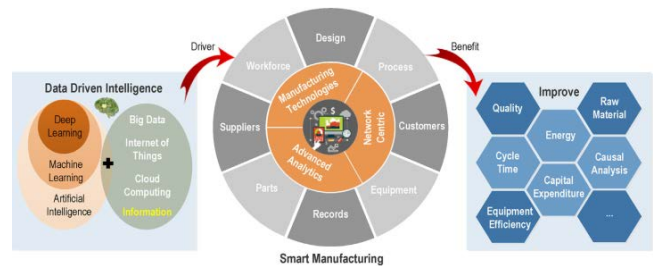

Fig. 1. The role of data-driven intelligence in smart production [9].

In smart factories desired by the modern production industry, the use of AI facilitates rapid decision-making based on both real-time and historical data with the minimal human intervention [17].

AI technology facilitates the development of new models, tools and forms, system architecture, and technology systems in the field of smart production. Deep integration of the implementation of these models, tools, and formats will create a smart production ecosystem as shown in Fig. 2.
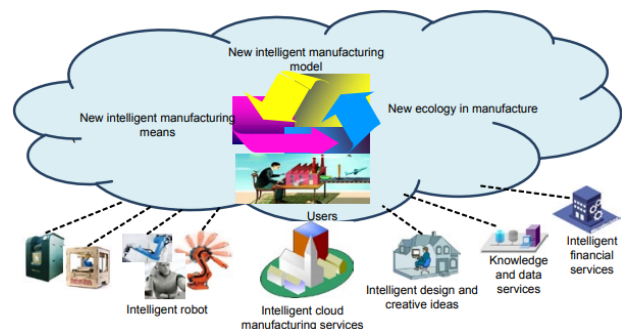

Fig. 2. New models, means, and forms of smart production [12]

AI paired with key digital technologies is expected to change production, just as the steam engine changed production years ago. Because artificial intelligence solutions can monitor and analyze the activities in the production process to solve even the problems that people are not aware of [18].

With the development of AI techniques, our private life and all engineering processes were affected by development [15, 16, 19, 20]. Today, the term artificial intelligence is encountered in many areas such as manufacturing, industrial design, monitoring and control, product testing and evaluation, automatic robot design in industrial production, decision making, monitoring and programming of the production process, predictive maintenance, repair of industrial assets [15, 16, 19, 20]. They simplify and automate complex processes in a wide variety of industry applications. Thus, they improve production efficiency and product quality [21].

Big data volumes are analyzed in real time by leveraging the analytical capabilities of artificial intelligence; It also contributes to areas such as reducing downtime, increasing production efficiency, automating production, forecasting demand, and optimizing inventory levels [22].

The use of AI tools and techniques for smart production is fairly new. Manufacturers began to realize the importance of these tools and techniques and equipped the devices in their companies with sensors that collect/share large volumes of data[22]. This large amount of data collected contains very useful information that can increase the overall productivity of production processes and system dynamics and can be applied to decision support in various fields [7]. Techniques such as deep learning (DL) and machine learning (ML) used in AI, on the other hand, offer the analysis of this large production data, which is difficult to obtain with traditional methods and analytical tools to process this data [19, 23].

Today, with the great development of cloud computing and computing power, ML and DL models used in AI have started to be used in all areas of the industry such as automotive, manufacturing, textile, financial services, health, and supply chains [8, 13, 19, 23]. It has also begun to be used in traditional manufacturing industries, but also emerging strategic industries such as high-tech equipment manufacturing and robots[21].

With the use of smart technologies in production, production activities are carried out at lower costs. In addition, these technologies, which take over the duties of human resources who do labor-intensive work, enable people to focus on more creative works, enable them to think innovatively, and do value-added works that can improve their companies [24]. AI models have also been used effectively in maintenance and repair departments, which have recently become important for companies. Used here, it provides many advantages such as reducing maintenance cost, reducing repair stoppage, reducing machine failure, increasing spare part life and inventory, and improving operator safety [7]. Figure 3 shows the use of AI in various sectors of the production industry.
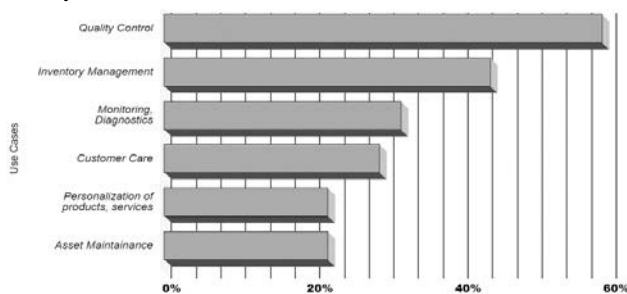

Fig. 3. AI use cases in various sectors of the production industry [24]

In Fig. 3, it is seen that AI models are used in non-value-added activities such as quality control, stock management, and monitoring. Thus, it can be said that it prevents the use of labor in these areas and also prevents the waste of the labor force.

4. Conclusion and Evaluation

In today's world, since production processes are based on both information and data, rather than just information, data is constantly produced by various networks such as sensors, machines, systems, and smart devices in modern production, and this data is analyzed comprehensively by the key technologies of the industry 4.0 revolution. As a result of these analyzes, production systems started to transform into smart production.

AI techniques play a key role in smart production. AI becomes the heart of Industry 4.0 and attracts attention from all segments, as it optimizes the performance, quality, controllability, and transparency of production processes by using Industry 4.0 technologies such as Industrial Internet of Things (IIoT), and Big Data. Production monitoring has an important

place in smart production as it enables businesses to detect anomalies in production lines in a timely manner and then reduce waste.

Companies that want to use AI in their companies in order to use their capacities effectively in order to meet the increasing product demands due to the increasing population all over the world are faced with a significant financial expenditure at the beginning. However, companies that make their production smart by using AI models in their processes increase their productivity tremendously and also contribute to the increase of the GDP of the countries they are connected to. On the contrary, it can be said that irregularities and errors are inevitable in the processes of companies that do not use AI in their production. In this context, it is emerging that companies that want to monitor their production systems in real time, increase their performance, increase the quality of their products and reduce their costs, need to adopt and use products and digital technologies equipped with AI.

Declaration of conflicting interests

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