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The Development of Manufacturing Industry Revolutions from 1.0 to 5.0

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Abstract
Industry 5.0 is a term used to describe how the manufacturing industry is being modernized and how human and machine collaboration is being fostered to increase efficiency and speed up results. By integrating digital technologies, this revolutionary transformation not only creates tailored goods that increase customer happiness but also establishes a new paradigm in supply chain management and manufacturing. Complex problems are addressed by using artificial intelligence and machine learning to the analysis of large amounts of manufacturing data. Gaining a competitive edge and promoting economic growth requires embracing IoT and the Industry 5.0 phenomenon in today's fast-paced corporate environment, which is defined by technical breakthroughs and globalization. Because they work in unison with human intelligence, robotics' contribution to this revolution enhances the accuracy of computation and prediction in industrial automation systems. In the age of technology, rapid changes are driving the development of mass customization and smart manufacturing, with robots playing a crucial role in enhancing human talents. This essay examines the historical background of industrial revolutions and the effects of Industry 4.0 and Industry 5.0 on society and manufacturing. It also highlights the salient characteristics and potential applications of these next industrial revolutions, culminating in a summary of the differences between Industry 4.0 and Industry 5.0.

Keywords: Industrial Revolutions; Industry 4.0, Industry 5.0, Industry 6.0, Internet of Things, Artificial Intelligence

Introduction

The advancement of digital technology, namely the rise of artificial intelligence systems, has been essential in tackling issues associated to production. These technologies enable mass customization and advanced industrial processes with minimal human participation. 2015 saw the launch of Industry 5.0, a revolutionary stage that uses cutting-edge technology to satisfy individualized customer requests. This was a huge turning point. Artificial intelligence is becoming a vital instrument for improving manufacturing precision and efficiency. This transformative change has the ability to redefine and reconfigure enterprises through the integration of intelligent technology (Xu, Xu, & Li, 2018; Haleem & Javaid, 2019a).

Even with the significant improvements from previous industrial revolutions, the industry is currently changing quickly. Industry 5.0 attractive to managers and engineers because it offers a way to do away with human labor in the production process. The Industrial Internet of Things (IIoT) plays a key role in the Industry 5.0 framework, promoting tight interaction between humans and machinery (Bryndin, 2020a).

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Industry 5.0 aims to provide specialized and improved job opportunities in the contemporary manufacturing category, enabling producers to provide customized products and services to fulfill specific customer demands (Lu, 2017a; Özdemir & Hekim, 2018; Reinhardt, Oliveira, & Ring, 2020). Examples of virtual technology tools used in labor training are virtual and augmented realities, which offer increased productivity and efficiency. Inventive solutions, covering programmable intelligent sensors, gadgets, devices, and equipment, enhance manufacturing value and are fundamental to this transformation (Da Xu, Wang, Bi, & Yu, 2013; Sachsenmeier, 2016; Doyle-Kent & Kopacek, 2019; Yli-Ojanperä et al., 2019).

The integration of technological know-how with the application of intelligent tools, automated systems, and artificial intelligence enables the creation and operation of Industry 5.0 (Bryndin, 2020b; Bryndin, 2014; Bryndin, 2017). In this paradigm, robots with cognitive capacities akin to humans expedite many activities concurrently, becoming important components of fully automated, large-scale industrial processes. To improve industry quality, accuracy, efficiency, and flexibility in response to changing market conditions, intelligent software enables human-machine collaboration (Z. Li & Da Xu, 2003; Da Xu, 2014; Ozkeser, 2018).

Industry 5.0 uses robots that improve human involvement in manufacturing while elevating the role of mechanical components, despite worries that they may replace human duties. By working together in a mutually advantageous way, people may concentrate on their creative endeavors while robots take care of repetitive and boring jobs. This division of labor improves the quality of goods and services by increasing human regulatory duties (Bryndin, 2020a).

Building upon Industry 4.0 and utilizing the 5G network, Industry 5.0 increases process flexibility and intelligence in manufacturing. In this sense, the 5G network is crucial, highlighting the significance of add-on technologies for the advancement of Industry 5.0 (Bryndin). With information technology playing a critical role in maximizing time and cost efficiency in many operations, from design to manufacturing, this industrial revolution is crucial in addressing tailored client needs (Da Xu, He, & Li, 2014; Xu et al., 2018; Haleem & Javaid, 2019b).

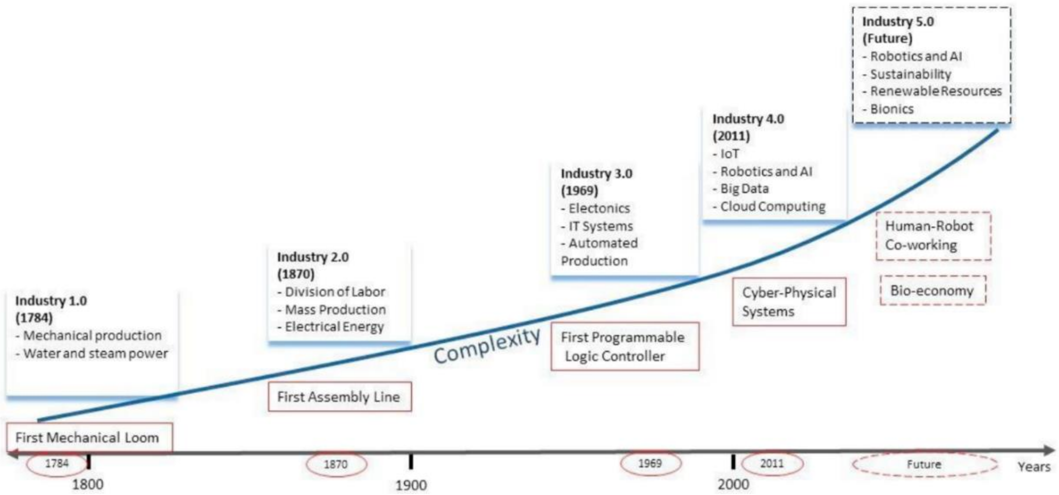


Fig.1.Industry Revolution Development (Demir, Döven, & Sezen, 2019)

Industry RevolutionDevelopment

For centuries, the primary means of producing products and services—which included necessities like clothing, food, and weapons—was human labor. But the beginning of the First Industrial Revolution (IR1.0) in the early 1700s brought about a significant change in the industrial environment and was a turning point that drove the growth and development of the industry. This analysis explores these mechanisms' evolutionary background.

During the First Industrial Revolution (IR1.0), manufacturing
Industry 1.0, which began in the early eighteenth century, was defined by the combination of mechanization and steam power. During this time, mechanization caused the spinning industry's production to expand eightfold. One of the main elements supporting the expansion and improvement of output was steam. In the spinning industry, steam power took the place of human force. As a result of its widespread application, steamships and steam locomotives were developed, revolutionizing long-distance transportation for both freight and passengers (GEORGE & GEORGE).

The Second Industrial Revolution's (IR2.0) Mass Production
When Industry 2.0 first appeared in the 19th century, electricity became the main source of power. Electricity was used in many kinds of equipment because it was easier to use than steam or water. During this time, there was a tremendous growth in management tools, which helped to increase industrial performance and efficiency overall. Higher wages resulted from the division of work being a distinguishing characteristic. Concepts like agile and pure production were developed in part by Frederick Taylor, whose contributions to the study of job processes and worker productivity were spurred by the advent of assembly lines and mass manufacturing. These developments sought to improve manufacturers' programs in terms of both production quantity and quality (GEORGE & GEORGE).

Production Automation is the Third Industrial Revolution (IR3.0).

Industry 3.0 began with the development of electronics and computer technology in the middle of the 20th century. During this time, manufacturing automation technologies were developed inside factories, which helped workers with a variety of jobs and changed the idea of mass production (GEORGE & GEORGE).

Industrial Revolution 4.0: The Shift to Digitization

Industry 4.0 differs from its predecessors in that it makes use of information and communication technology. Building on Industry 3.0's use of computer technology in production systems, Industry 4.0 connects these computer systems through networks. The concept of intelligent factories emerged as a result of the widespread connections between cyber and physical systems made possible by the development of the Internet platform. Production systems, parts, and employees are all interconnected in these intelligent factories (GEORGE & GEORGE).

"Smart manufacturing for the future," the central idea of Industry 4.0, started as a German project. Like its predecessors, Industry 4.0 seeks to use cutting-edge technologies to accomplish mass manufacturing and boost productivity. The Internet, the Internet of Things, robotics and artificial intelligence, cloud computing and big data, virtual and augmented reality, smart manufacturing, smart logistics, and environmental intelligence are just a few of the new technologies that have helped bring Industry 4.0 to life (Demir et al., 2019).

Industrial Revolution No. 5, or IR5.0:

Industry 3.0, which preceded Industry 4.0, focused on utilizing cognitive computing, incorporating smart buildings and the Internet of Things, and connecting production sites to cloud servers. But Industry 5.0 returns the attention to the importance of human participation in industrial processes. Collaborating harmoniously, humans and machines aspire to boost production and assure optimal resource use (GEORGE & GEORGE).
Industry 5.0 offers two different strategies. In the first, close coordination and communication between humans and robots are required at designated times and places. In this dynamic collaboration, people focus on creative work and supervisory duties, while robots handle a variety of jobs. The second technique of Industry 5.0, Bioeconomics, concentrates around the ethical and efficient utilization of biological resources. According to Demir et al. (2019), this viewpoint places a premium on sustainability while attempting to

reconcile industrial, economic, and environmental factors.

Industry 4.0

Important Features of Industry 4.0

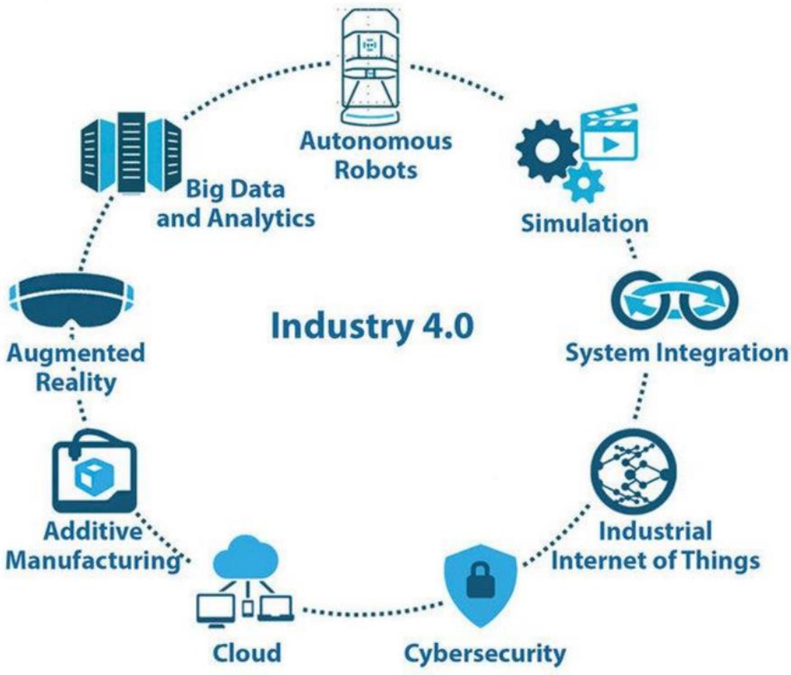
The fourth industrial revolution, commonly referred to as or Industry 4.0, is a fast-moving phenomenon defined by digital transformation that raises the value of products and services. Information and communication technology (ICT) policies are driving this revolution, which was started by the German government in 2011 to increase competitiveness. Its effects include new commercial services and products, a notable increase in productivity, and the transformation of business models (Blunck & Werthmann, 2017; Skobelev & Borovik, 2017; Tupa, Simota, & Steiner, 2017).

The integration of sensor networks, which include radio frequency identification (RFID), is a key component of Industry 4.0 as it allows for real-time communication amongst all parties involved in the production system. Advanced business models can now be implemented in smart factories because to this technology advancement (Niesen, Houy, Fettke, & Loos, 2016).

Symbiotic relationships between machines (M2M) and between machines and humans (M2H) are essential to the health of smart factories. Cyber-Physical Systems (CPS) are key technologies for Internet of Things (IoT) coordination and communication that are significantly relied upon in Industry 4.0. This calls for the usage of particular instruments and frameworks. Consumers benefit from personalized goods and services as a result of the smooth integration of the digital and physical worlds (Peraković, Periša, Cvitić, & Zorić).

Main Technologies of Industry 4.0

Industry 4.0 is heavily reliant on contemporary technologies, yet it's important to stress that no single technology drives the whole. Rather, the creation of intelligent goods and procedures is Industry 4.0's main goal. These procedures are described in the publication by Peraković et al., which is depicted in Figure 2. The integration of cutting-edge technology is emphasized. Industry 4.0 is centered on digitizing and integrating data across the entirety of value chain, which is accomplished by rearranging and combining different sectoral activities inside a smart factory (Peraković et al.).



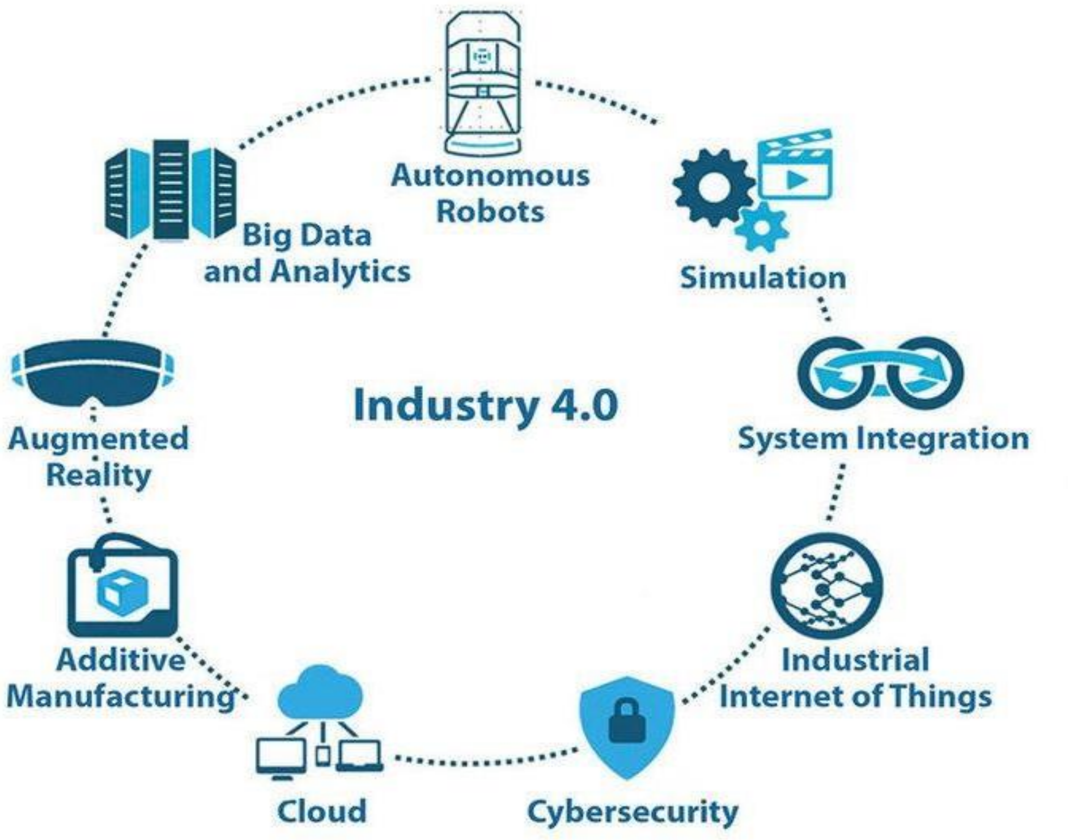


Fig.2. Main technologies of Industry 4.0 (Peraković et al.)

Key Objective of Industry 4.0

Given the worldwide trend and the vast terrain of innovation, technological advancement is essential to achieving Industry 4.0's goals and requirements. Simultaneously with technical developments, manufacturing automation must be implemented to accelerate operating procedures. Despite the current data-driven industrial revolution, a new trend characterized by the clever fusion of several technologies is beginning to take shape.

The digital revolution can lead to improved benefits in Industry 4.0 through a strategic classification and efficient use of the technologies outlined in Table 1, as noted by Dalenogare et al. (2018), Weyer et al. (2015), Qin et al. (2016), Wan et al. (2016), and Gorecky et al. (2014). By combining these technologies, industries can digitize more quickly, which helps Industry 4.0 objectives be realized more quickly.

Reaching these goals in a variety of sectors and companies is not just an aspirational goal, but a deliberate effort. As noted by Lasi et al. (2014), S. P. Singh et al. (2019), P. Singh et al. (2019), Das and Nayyar (2019), Jazdi (2014), and Lunn (1995), Industry 4.0 takes a specialized strategy to solve diverse difficulties in the political, social, scientific, economic, and technological domains.

Table1. Key Objectives of Industry 4.0

Technologies	Description
IIOT	The Internet of Things (IIoT) is one of the concepts in the virtual world. Lasers, global positioning systems and sensors are elements of connecting the virtual world to the real world.(Zhou, Liu, & Zhou, 2015)
Cyber physical system	Cyber physical systems are related to the real world.(Lu, 2017b) CPS and other digital technologies help to integrate the real world with the virtual world. These technologies create intelligent factories that accelerate energy production, logistics, transportation, and so on.(Lee, Kao, & Yang, 2014),(Zhou et al., 2015),(Lasi et al., 2014),(S. P. Singh et al., 2019)
Cloud computing	This technology is used as a computing solution to provide services on the Internet at an optimal cost. In fact, with this tool, users can share resources with the help of a dynamic memory and use software, hardware and other infrastructure to calculate data if needed.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Agility and sequencing	The current method is a mechanism that enables the system to make adjustments and send parts based on the appropriate sequence in the production system based on the customer's opinion and wishes. This method is based on the time and needs of the customer.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Additive manufacturing	The application of this technology is in the manufacture of parts with the help of 3D printing. The mentioned technology improves the production and manufacture of products based on the customer's order and wishes and strengthens personalization in the Industry 4.0.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Big data, data mining and data analytics	This concept is actually used to exploit and use large volumes of heterogeneous data on the Internet. This technology, along with data mining and data analysis techniques, improves data analysis and their use in production processes and leads to process optimization and cost reduction.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Artificial intelligence	Artificial intelligence is a science that uses adaptive and collective intelligence to extract useful information when needed. Applied tools in this technology are machine learning and innovative algorithms.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Cobot	A new generation of robots that has close cooperation with humans without security restrictions. These types of robots can be programmed to facilitate use in production.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Augmented reality	Augmented reality is used in cases such as the selection of warehouse parts and maintenance instructions for mobile devices and equipment. Augmented reality helps people to have the information needed to make the right decision at the right time.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
CAD/CAM	These programs are used to design and produce products using computer software.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
MES/SCADA	Manufacturing Execution Systems (MES) are computer systems used in manufacturing to track and document the conversion of raw materials into finished goods.(Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
Sensoring	This tool is used to improve the capabilities of robots and production processes such as measurement, reasoning and decision making. (Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)
On demand manufacturing	To stay in the world of competition, providing customer needs and wants is the first priority of product manufacturers and service providers, so organizations must achieve customer satisfaction based on dynamic patterns and considering the agility in responding and setting priorities. (Lee et al., 2014),(Lu, 2017b),(Zhou et al., 2015)

Main benefits of Industry 4.0

Customers are actively looking for better products and services in the present market. When looking at things from the customer's point of view, things like availability, price, and great quality are especially important. Because of this, businesses always work to improve and optimize their operations so that they meet the expectations of their clients. Table 1 presents the benefits of Industry 4.0 from a business perspective, as explained by Almada-Lobo (2017).

Table2. Main benefits of Industry 4.0 (Paschek, Mocan, & Draghici, 2019)

Benefits	Description
Efficiency	By using the automation system and using other elements of Industry 4.0, productivity increases. In Industry 4.0, using different tools, the need for people decreases, and on the other hand, the quality of products increases and losses are reduced.
Agility	In Industry 4.0, due to high standardization and production in lower circulations, flexibility increases and as a result, the agility of the organization in responding to customer needs improves.
Innovation	Due to the fact that industry 4.0 has a great variety and low volume of products, so it is a good space for innovation and introduction and testing of a new product.
Customer experience	Speed in responding to customer needs and having the right information about the needs of users makes manufacturers and service providers to introduce the right product to the market at the right time.
Costs reduction	In Industry 4.0, despite the initial investment made for transformation, costs continue to fall as quality discrepancies are reduced and less material is wasted, and staff and operations costs are reduced.
Revenues	By providing better quality products and services and lower costs, it increases the satisfaction of current customers and, as a result, facilitates entry into larger markets and more customers.

Even if cyber and physical systems are integrated into Industry 4.0, an appropriate organizational structure must be established to fully benefit from this transformation. As a result, according to Ustundag and Cevikcan (2017), the core values of the sector include strategic planning, participatory management, and the internalization of technology standards. Interestingly, most scientific studies on the Fourth Industrial Revolution have concentrated on technological features, paying less attention to important organizational and management factors (Mohelska & Sokolova, 2018).

On the other hand, this revolution's technological breakthroughs have created a knowledge and skill gap that prevents these tools from being used and implemented effectively. Concerns over job security have also been highlighted by the rise of automation and the use of robots in production processes during this time. Industry 4.0 is further complicated by problems relating to Internet usage, the Internet of Things, and worries about security and dependability on this platform (Lewis, 2017).

Industry 5.0

Important Aspects of Industry 5.0

It has been noted that in the context of Industry 4.0, the task of ensuring customer satisfaction by mass production customization is no longer sufficient in this new era. When mass production and customized manufacturing are combined, nevertheless, consumer satisfaction may increase—but only if humans are actively involved in the production processes (Østergaard, 2018). As a result, the need to create an Industry 5.0 environment is becoming more pressing. In order to improve product customization and increase production capacity, Industry 5.0 encourages human-machine collaboration and active engagement in smart factories (Johansson, 2017).

Innovation and creativity are greatly enhanced by Industry 5.0's incorporation of smart tools. During this stage, companies use machinery, gadgets, and smart materials to propel intelligent production, improving efficiency, quality, and flexibility. Better goods and services translate into higher levels of consumer satisfaction. In this industrial revolution, the use of tools and sensors increases the processing capability of systems, making them more capable of satisfying the demands of users. Modern software and technologies also simplify operations by making decision-making in complex processes easier (Chen, 2017; Demir et al., 2019). Table 3 goes into more detail on the four main components of Industry 5.0.

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Table3. Main characteristics of Industry 5.0

No.	Elements	Description	References
1	Intelligent materials	• Smart materials have changeable properties that change with temperature, humidity, light, etc. • These materials are used in various industries such as textiles, medicine and electronics and aerospace industries • In the 5.0 industry, smart material capabilities play an important role	(X. Li, Shang, & Wang, 2017),(Hakanen & Rajala, 2018),(Yang et al., 2019),(Haleem & Javaid, 2019a)
2	Intelligent devices	• Computing capabilities are a prominent feature of smart devices in the Industry 5.0. • Ability to connect in smart devices for effective management and monitoring. • Internet-connected cameras in smart devices improve the operation control system.	(Crutzen, 2005),(Derby et al., 2007),(Matindoust, Baghaei-Nejad, Abadi, Zou, & Zheng, 2016),(Shammar & Zahary, 2019)
3	Intelligent automation	• This element integrates different aspects of humans, software and machinery and improves their participation. • Automation system is effective for detecting process errors. • Machine learning in this system increases productivity in complex tasks and processes and is useful in reducing process time.	(Mekid, Schlegel, Aspragathos, & Teti, 2007),(Butner & Ho, 2019),(Pagliosa, Tortorella, & Ferreira, 2019)
4	Intelligent systems	• Intelligent systems can be used in various parts of the supply chain, such as transportation, logistics, research and development, etc. • In industry 5.0, this system increases the ability to interact and react to environmental changes • Intelligent systems allow the customer's personalized needs to be met at the required time	(Dragcevic et al., 2007),(Sykora, 2016),(Xie, Liu, Fu, & Liang, 2019),(Sakamoto, Barolli, Barolli, & Okamoto, 2019)

Industry 5.0 allows for the modification of manufactured product attributes to conform to certain standards and conditions through the use of smart materials. Software is the backbone of digital manufacturing, which highlights the importance of knowing this area as it is essential to producing complex and high-tech goods. The development of clever and inventive items is given priority during this transformative period, which lowers the need for inventory and physical storage (Haleem & Javaid, 2019a).

Crucial Components of Industry 5.0

The fifth industrial revolution uses intelligent machinery to improve quality, reduce waste, and increase safety while also encouraging innovation and creativity in manufacturing. In this transformation, artificial intelligence takes center stage and human interaction plays a smaller role. One benefit of using robots in the system is that they can facilitate smooth material and information flow and are less vulnerable to external factors that could affect processes (Lu & Da Xu, 2018; Özdemir & Hekim, 2018; Haleem & Javaid, 2019a). Table 4 lays out the essential elements of Industry 5.0.

		• With this tool, complex macro problems and issues can be solved in less time and at a lower cost	2019),(Lauterbach, 2019),(Narain, Swami, Srivastava, & Swami, 2019),(Lu, 2019a)
5	Smart Manufacturing	• The Internet connects machines and equipment and provides intelligent manufacturing with the automation system created • In intelligent production, equipment and machinery failures are identified to be remedied • Ordering raw materials to improve the distribution network plays an important role in intelligent production	(Al-Sayed & Yang, 2018),(Daudt & Willcox, 2018),(Torres, Pimentel, & Duarte, 2019),(Ghobakhloo & Fathi, 2019)
6	Smart Material	• Smart materials have changeable properties that can change to suit the situation, which plays an important role in the Industry 5.0 • By changing the temperature and pressure, the shape of the product can be changed and controlled • Control and deformation of products using smart materials based on the needs and desires of the manufacturer	(Bogue, 2012),(Chiodo & Jones, 2012),(Bogue, 2014)
7	3D Printing	• Using this feature, a physical 3D model is created based on computer models • This method is used to produce a test sample exactly according to the original product • By using easy fabrication of the test sample and modifying it if necessary, the efficiency of making the original product is increased	(Kanada, 2016),(Bai, Liu, Wang, & Wen, 2017),(H.-C. Wu & Chen, 2018),(Yuan, Zhu, Xu, & Chen, 2018),(Javaid & Haleem, 2018),(Ali, Batai, & Sarbassov, 2019)
8	4D Printing	• With this technology, product manufacturing is done with smart materials • By adding the fourth dimension to 3D, time, 4D technology is created • In this technology, environmental changes can change the shape of the product	(Pei, 2014),(Pei et al., 2017),(Javaid & Haleem, 2019)
9	5D Printing	• In 5D technologies, the product is made in the X, Y, Z axes, and on the other hand, the bed and head of the printer are movable. • 5D printing allows the product to be manufactured in several directions by reducing pressure and load • One of the applications of this technology is to make car parts that must have high reliability and strength	(Gillaspie et al., 2016),(Zeijderveld, 2018),(Haleem & Javaid, 2019a)
10	Virtual Reality	• One of the advantages of this technology in manufacturing is learning knowledge and establishing knowledge management and improving skills in production and automation systems. • It clearly shows the problems of the production system • Improves access to information and better decision making, thus helping the product development process	(Xia, Lopes, & Restivo, 2013),(Jung & tom Dieck, 2017),(Baxter & Hainey, 2019)

Table4. Critical Components of Industry 5.0

In the fifth industrial revolution, troubleshooting and improving system utilization become more frictionless thanks to enhanced advanced technology. In this day and age, big data is a highly valuable tool for system analysis. Software innovations that greatly improve research and development procedures are welcomed by Industry 5.0 (Lu, 2019b; Aceto, Persico, & Pescapé, 2020). Three-dimensional information is delivered through the widespread use of virtual reality, which produces an immersive, lifelike experience. With the aid of cutting-edge technological instruments, machines can work with a degree of autonomy that is comparable to that of human beings. This feature lets robots solve complicated issues and fix mistakes on their own. These elements stand out as essential instruments in the fifth industrial revolution, helping to accomplish a wide range of industry objectives.

Capabilities of Industry 5.0

Addressing consumer demands and preferences through mass customisation of goods and services is one of Industry 5.0's main goals. This entails adding features for product tracking that are automated, improving supply chain intelligence, and giving clients access to real-time data. Using cutting-edge technologies, information is analyzed and updated during the production of current items, which helps with the creation of new products (Lu & Da Xu, 2018; Nahavandi, 2019). Table 5 outlines the four major categories into which Industry 5.0's capabilities can be divided.

Table5. Capabilities of Industry 5.0

No.	Capabilities	Description	References
1	Digital decision making	• Using digital data and automation system, the desired decision is provided in complex situations. • Increases efficiency and productivity and improves product results with innovative decisions • Improves teamwork, creativity and effective communication between people	(Becker, Faria, & Duretec, 2014),(Yan et al., 2017),(Gürdür, El-Khoury, Seceleanu, & Lednicki, 2016),(Chatterjee & Kar, 2018),(Swan, Dahl, & Peltier, 2019),(Covaci & Zaraté, 2019)
2	Digital service	• Help develop a competitive strategy using digital information • To measure the performance and progress of people and empower them • For feasibility and deployment of new digital systems to improve the supply chain	(Uutoni, 2018),(Bolton et al., 2018),(Vannucci & Pantano, 2019),(Wanyan & Hu, 2019),(S. Li, Hao, Ding, & Xu, 2019)
3	Intelligent business	• Integrated data in new technology makes a significant difference in business • Employee, customer and stakeholder satisfaction is improved by using IT management systems • With the establishment of knowledge management in the areas of sales and process optimization, business growth is created	(D. D. Wu, Kapoor, & Sherif, 2012),(Aruldoss, Travis, & Venkatesan, 2014),(Ghouchani, Jodaki, Joudaki, Balali, & Rajabion, 2019),(Cao, You, Shi, & Hu, 2020)
4	AI-based sales and marketing	• Speed in data analysis in sales and marketing using artificial intelligence improves customer satisfaction • Artificial intelligence provides appropriate solutions and approaches to the sales department based on data analysis • Identify weak vendors and help improve them by analyzing data from top vendors	(Paschen et al., 2019),(Upadhyay & Khandelwal, 2019),(Weber & Schütte, 2019),(Narain et al., 2019)

In the fifth industrial revolution, ideas and creativity are elevated by the synergy of many technologies, which expands the scope of production and fosters advances in goods and services. Robots and humans work together to solve complicated problems and overcome hurdles by using digital technology for effective communication and shared decision-making (Javaid Haleem, 2020).

How Industry 4.0 and Industry 5.0 Differ From Each Other

In the context of Society 4.0, insufficient knowledge and information exchange have been identified as obstacles to efficient human-machine cooperation. The time commitment and intensity of executive duties increased, which had an especially negative effect on the aging workforce. However, according to Potočan, Mulej, and Nedelko (2020), Society 5.0 changes this dynamic by improving the interaction between humans and machines and fostering an easy transition between the actual and virtual worlds.

In Society 4.0, data from factories was gathered online via cyberspace, processed in the cloud using a variety of instruments and sensors, and accessed via multiple online platforms. An investigation of artificial intelligence in the manufacturing environment required cyberspace storage due to the large amount of data created and stored by multiple sensors. Once made available, this data helps to create value in goods and services by facilitating customized production in response to individual customer needs.

This strategy has a number of benefits, such as flexible and reliable production planning, optimal inventory management in line with customer demands, production cost savings, effective labor utilization, timely product or service distribution, and accelerated product delivery to customers, which minimizes shipping delays. Peraković et al. claim that putting these solutions into practice lowers costs, boosts industrial competitiveness, raises consumer happiness, and has a positive effect on the environment.

Industry 4.0 saw advancements in machinery and gadgets through knowledge dissemination, with a focus on customization enabled by intelligent manufacturing through technologies like the Internet of Things, artificial intelligence, physical cyber systems, the cloud, and cognitive computing (Rajput & Singh, 2019; Chen, 2017; L. Li, 2018). A major change is brought about by Industry 5.0, which emphasizes a stronger human link to production and more human involvement across the supply chain. This revolution increases automation systems' speed and accuracy by fostering critical thinking skills. A thorough comparison illustrating the differences between the two revolutions, 4.0 and 5.0, is given in Table 7 (Javaid & Haleem, 2020).

Automated device and equipment updates are essential to production system optimization and augmentation in Industry 5.0. Intelligent systems in this revolution contribute to careful tool selection, minimizing overproduction (L. Xu, 2000; L. D. Xu, 2000; Gürdür et al., 2016). Industry 5.0's intelligent system architecture places a high priority on data and information as essential elements of successful digital communication, enabling improved capabilities for research and development via intelligent data analysis. Additionally, this revolution's automated and networked factory internal systems build an intelligent network that promotes factory cooperation, enhances production support, and provides services that customers want (Kim, 2017; Demir et al., 2019; Gorodetsky, Larukchin, & Skobelev, 2019). According to Peruzzini and Stjepandić (2018), the supply chain's intelligence is improved by this integrated system, increasing its efficiency and competitiveness.

Conclusion and Discussion

The world has quickly changed due to technological innovation and revolutions, which have also affected customer satisfaction levels and opened up new markets. Industry 4.0, which is characterized by developments in Internet technology, the Internet of Things (IoT), big data, 3D printing, and artificial intelligence, emerged in the evolution from the early 2000s to the present. Since 2016, a new phenomenon known as Industry 5.0 has been developing. It is defined by attributes including IoT, robotics, artificial intelligence, smart materials, and 5D printing. The virtual and physical worlds work closely together in the upcoming Industry 5.0 revolution thanks to automated systems powered by artificial intelligence and intelligent agents.

The change from mass-customized to personalized production is symbolized by the shift from Industry 4.0 to Industry 5.0. The cooperation between humans and robots is a major shift that Industry 5.0 brings about in manufacturing. The fundamental innovation of this revolution is the merging of digital and human intelligence to speed manufacturing and prevent faults in systems.

Quantum superiority holds the key to the possibility of a Sixth Industrial Revolution (Industry 6.0). Quantum computing has applications in business analysis and physics that could improve prediction accuracy. It is anticipated that data science and machine learning will also make use of quantum computing's processing capability, especially when it comes to solving problems with machine designs, process optimization, and the development of novel materials with unique qualities. The combination of artificial intelligence and quantum computing has the potential to solve a wide range of challenging issues, from advanced disease modeling and material discovery to autonomous vehicles making decisions in real time.

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