# Current Technologies and Tools Aiding Industry 5.0 Development

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Edited by

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# SUMMARY

This book discusses the integration of product, process, machine, software, and industrial robots in realizing Industry 5.0. It covers the dual integration of human intelligence with machine intelligence and reviews the results of making use of the Industrial Internet of Things (IIoT) and artificial intelligence (AI). The creation of a new category of robots named "collaborative robots" (Cobots) specifically designed to speed up the manufacturing process and increase profitability is explored. There will be a revolution in industry and society as a result of Industry 5.0. Robots who work with humans, also known as 'cobots', are a key component of Industry 5.0. Industry 5.0 will overcome all the limitations of the previous industrial revolution. Humans and machines will work together in this revolution to increase the efficiency of processes by utilizing human brainpower and creativity. Thus, this book intends to provide a quality publication with unique insights and methods of application for current scholars and users. This book offers a great overview of how artificial intelligence (AI) transforms organizations and organizes innovation management.

Implications of Industry 5.0 discusses the little-known effects of the Fifth Industrial Revolution and contributes to the lack of knowledge about this topic by looking at the various opportunities and challenges. This reference book is ideal for business owners, managers, industry professionals, researchers, scholars, practitioners, academicians, instructors, and students.

## Coverage

The many academic areas covered in this publication include, but are not limited to:

- Artificial Intelligence
- IoT
- Business strategy
- Manufacturing
- Renewable Energy
- Robotics

- Cobots
- Social Media

# About the Book

This book focuses on the next stage, Industry 5.0, and the steps needed to take automation to the next level by reducing workforce size and improving operational and process efficiency. The business and consumption models, as well as industrial processes, promise significant shifts in Industry 5.0. Two major players are at the heart of this shift: consumers and manufacturers. The evolution of industry from Industry 4.0 to Industry 5.0 and its impact on the manufacturing, education, HR and engineering research industries are the primary topics covered in this edited book.

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We would like to first and foremost express our gratitude to God. We realized how true this gift of writing is as we put this book together. You empowered us to pursue our dreams and believe in our passions. Without your trust, we could never have accomplished this. We wish to acknowledge the help of all the people involved in this project and, more specifically, the authors and reviewers that took part in the review process. Without their support, this book would not have become a reality. We thank God for the opportunity to pursue this highly relevant subject at this time, and each of the authors for their collective contributions. My sincere gratitude goes to all the chapter authors who contributed their time and expertise to this book. We wish to acknowledge the valuable contributions of all the peer reviewers regarding their suggestions for improvement of quality, coherence, and content for chapters. Some authors served as referees; we highly appreciate their time and commitment. A successful book publication is the integrated result of more people than those persons granted credit as editor and author.

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# PREFACE

With Industry 4.0, technology has provided manufacturing industries with novel new opportunities and has contributed to the manufacturing sector's expansion. This book focuses on the next stage, Industry 5.0, and the steps needed to take automation to the next level by reducing workforce size and improving operational and process efficiency. 5.0 Industry: The integration of product, process, machine, software, and industrial robots in achieving Industry 5.0 is discussed in this book. It examines the outcomes of utilizing the Industrial Internet of Things (IIoT) and Artificial Intelligence (AI), as well as the dual integration of human and machine intelligence. Collaborative Robots (Cobots) are a new category of robots that are specifically designed to speed up the manufacturing process and increase profitability. This book also looks at ways to reduce waste in the design and manufacturing of products and provides customers with products that are more individualized and customized.

The business and consumption models, as well as industrial processes, promise significant shifts in Industry 5.0. Two major players are at the heart of Industry 5.0: consumers and manufacturers. Manufacturers focus on real-time improvements to the business model with the assistance of data science and Internet of Things (IoT) technologies. They could concentrate on creativity and problem-solving. Products that are personalized, a significant shift from mass customization to personalization, will be beneficial to customers. During the design phase, customers could specify their preferences, and the production line could be adjusted accordingly without incurring additional costs.

The evolution of Industry 5.0 from Industry 1.0 to Industry 5.0 and its impact on the manufacturing and medical research industries are the primary topics covered in this edited book. This book will be interesting to practicing professionals as well as design, manufacturing, industrial, and mechanical engineers. This book, which covers everything from Industry 4.0 to Industry 5.0 and beyond, will also be helpful to academics, management executives, chief information officers, CEOs, and IT professionals etc.

# ORGANIZATION OF THE BOOK

The book is organized into 10 chapters. A brief description of each of the chapters follows:

**Chapter 1**

The Industry 5.0 opportunities, limitations, and prospects for future research are all discussed in this paper. Industry 5.0 shifts the paradigm and brings the solution because it places less emphasis on technology and assumes that human-machine collaboration is the foundation for progress. The use of personalized products is increasing customer satisfaction thanks to the Industrial Revolution. Industry 5.0 is essential for the factory's economic growth and competitive advantage in today's technologically advanced business environment. The purpose of the paper is to examine Industry 5.0's potential uses.

**Chapter 2**

Next, we talk about AI-based tools, edge computing, various AI-based technologies that are integrated into the Internet of Things, and trust models for IoT appliances. AI-based systems are the core of the Internet of Things in the Industry 5.0 paradigm. Through precise manufacturing automation and critical thinking abilities, Industry 5.0 demonstrated a significant connection between intelligent systems and humans in the majority of applications. Additionally, Industry 5.0 includes a number of useful tools that assist businesses in working at a low cost and undergoing rapid change without requiring a major investment.

**Chapter 3**

The arguments for Industry 5.0 and a brief critique of Industry 4.0 are presented in this paper. In addition, we emphasize that the next industrial revolution ought to be fueled by environmental sustainability and information technology, regardless of its form. Industry 4.0 is criticized for not being able to meet all foreseeable future requirements in discussions about Industry 5.0. While mass production is the focus of Industry 4.0, sustainability is the focus of Industry 5.0.

**Chapter 4**

Businesses are undoubtedly being affected by modern technology. Companies are increasing profits, enhancing production quality, or developing new products as a result of successive advancements. From the point of view of Industry 5.0, the paper discusses the possibilities of using cobots to complete manual tasks in human-cobot collaborative teams to cut waste in manufacturing systems. The work is done together by humans and machines.

**Chapter 5**

The world is undergoing a tsunami of change, transformation, digital society, and industrialization, all of which are having an impact on society in a variety of ways, including employment, public administration, industrial structure, and individual privacy. The Vision of Industry 5.0 Leading to Society 5.0 is the subject of this paper. A new version of education and educators 5.0 will be available to the intelligent society, which is likely to lead the world. In order for the humans to effectively complete the tasks that have been assigned, they will be outfitted with smart, collaborative, and cooperative robots. Personalized "Human Touch" goods will enrich the new super-smart society. The new horizons of the educational system from an indological perspective will also be discussed in this paper.

**Chapter 6**

The fifth modern upset, which is otherwise called Industry 5.0, includes the cooperation of human insight and mental registering to convey customized items. With the "Personalization of Automation and Efficiency," Industry 5.0 builds on the fundamental elements of the Industry 4.0 revolution.

**Chapter 7**

The impact of Industry 5.0 on business owners is the subject of this article's analysis and evaluation. The findings of the Industry 4.0 analysis are based on conversations with practitioners and sales representatives. The objective of the article's main section was to identify gaps, opportunities, and threats in the business environment. In addition, this analysis explains the most effective strategy for transformation during the upcoming industrial revolution.

**Chapter 8**

We have chosen to use five of these questions to frame our claims, and we have tried to be unprejudiced when selecting data sources and having discussions about the main questions. We anticipate that this article will stoke interest in and encourage further discussion of these topics. We have chosen to use five of these questions to frame our claims, and we have tried to be unprejudiced when selecting data sources and having discussions about the main questions. We anticipate that this article will stoke interest in and encourage further discussion of these topics.

**Chapter 9**

The principles of human centrality, sustainability, and resilience have been used to define Industry 5.0. This paper looks at the most important technologies that will be needed for Industry 5.0. It comes to the conclusion that the capabilities of current Artificial Intelligence must be drastically improved. As the key technology to bring Industry 4.0 into the fifth industrial revolution, we propose the emerging concept of augmented intelligence.

**Chapter 10**

This paper aims to provide a succinct explanation of the concept of Industry 5.0 as well as an explanation of how it will alter the skills that will be in high demand in the coming years. Researchers hope that the study will serve as a guide and a resource. In addition, it is anticipated to be beneficial to workers, managers, and job candidates in all fields, but HR departments in particular.

# CHAPTER 1

# INDUSTRY 5.0 POTENTIAL FOR SOCIETY: HUMAN-CENTERED CHALLENGES AND SOLUTIONS AND POTENTIAL AREAS FOR RESEARCH

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## Abstract

*This chapter addresses the attitude of collegiate teachers towards innovative techniques and computer proficiency in relation to teacher effectiveness. For the past ten years, the industry has received Industry 4.0 to address its shortcomings. Finally, the time has come for Industry 5.0. The productivity of businesses is rising thanks to smart factories; Industry 4.0 therefore has limitations. The Industry 5.0 opportunities, limitations, and prospects for future research are all discussed in this chapter. Industry 5.0 shifts the paradigm and brings the solution because it places less emphasis on technology and assumes that human-machine collaboration is the foundation for progress. The use of personalized products is increasing customer satisfaction thanks to the Industrial Revolution. Industry 5.0 is essential for the factory's economic growth and competitive advantage in today's technologically advanced business environment. The purpose of the paper is to examine Industry 5.0's potential uses. The definitions of Industry 5.0 and the advanced technologies required for this industry revolution are discussed at the beginning. Additionally, applications like healthcare, supply chain, manufacturing production, and cloud manufacturing, among others, are discussed. Big data analytics, the Internet of Things, collaborative robots, Blockchain, digital twins, and potential 6G systems are the technologies discussed in this paper. In addition, the study included difficulties and*

*issues that this paper examines in order to comprehend the issues brought on by organizational differences between assembly line workers and robots.*

***Keywords:*** *Human-machine collaboration, the supply chain, disaster recovery, smart healthcare, cognitive systems, and eco-friendly manufacturing are all part of Industry 5.0.*

## Introduction

The first industrial revolution, also known as Industry 1.0, occurred in the eighteenth century and marked a pivotal moment in history. During this time, new methods and procedures were developed, and they were made possible by machines. It began in England in 1760 and by the end of the eighteenth century had spread to the United States. Industries like mining, textiles, agriculture, glass, and others were affected by Industry 1.0, which marked a shift from the handicraft economy to one dominated by machinery. Between the years 1871 and 1914, there was a second shift in the manufacturing industry known as Industry 2.0, which made it easier to move people and new ideas around more quickly. As machines replace factory workers, this revolution is a time of economic expansion that boosts business productivity and raises unemployment rates (Pathak (2021)).

Industry 3.0, also known as the digital revolution, began in the 1970s with the automation of computers and memory-programmable controls. The use of digital logic and integrated circuit chips in mass production is the primary focus of this phase; computers, digital mobile phones, and the internet were among the derived technologies. The technological advancements are altering both conventional products and business practices. Technology is being transformed into digital format by the digital revolution. The combination of physical assets and cutting-edge technologies like artificial intelligence, the Internet of Things, robots, 3D printing, and cloud computing is known as Industry 4.0. Organizations that have adopted 4.0 are adaptable and prepared to make decisions based on data. The next generation of technology known as Industry 5.0 is intended for efficient and intelligent machines. From industry 1.0 to Industry 5.0, the industry revolution is depicted in Figure 1 (HeD et al. 2017).

## The Reasoning Behind the Development of Industry 5.0

Humans and machines are cooperating in the Industry 5.0 revolution, enhancing industrial production efficiency. The manufacturing sector is seeing an increase in productivity as a result of both human workers and universal robots. The manufacturing company's executive teams must first define the production line, then adhere to the key performance indicators and check that the processes are efficient.

The manufacturing of robots and industrial robots is Industry 5.0's future direction. The manufacturing industry is moving at breakneck speed thanks to the development of cognitive computing and artificial intelligence technologies. Industry 5.0 also benefits sustainability because it aims to create a sustainable system powered by renewable energy, in addition to the manufacturing sector. In order for businesses to adopt Industry 5.0, employees must have proper interactions with operators and machines. It is expertise in fields like artificial intelligence and robotics (Nahavandi et al., 2019).

The business organization's role is to make decisions based on advanced factors. Virtual education necessitates employee training in order to reduce costs for businesses because it does not necessitate production interruption. It offers secure training, preventing employees from being exposed to unnecessary issues during sessions. Interactive knowledge environments improve communication and employee motivation. Artificial intelligence and robotics system communication are related to these employment positions. The purpose of collaborative robots' design is to facilitate natural human interaction. In Industry 5.0, the technology that is required is the expansion of digital twins. Better comprehension and testing will be made possible by visual models of the production, processes, and products. The software that is required to drive the transformation of the industrial business in Industry 5.0 is Te Nexus Integral platform. It is an integrated system for managing industrial assets on a large scale, enabling businesses to move quickly toward digital transformation. Previous generations adapted their lives to the capabilities of machines. However, because humans are now at the center of production processes, Industry 5.0 differs from all previous resolutions (Vinitha et al. 2020).

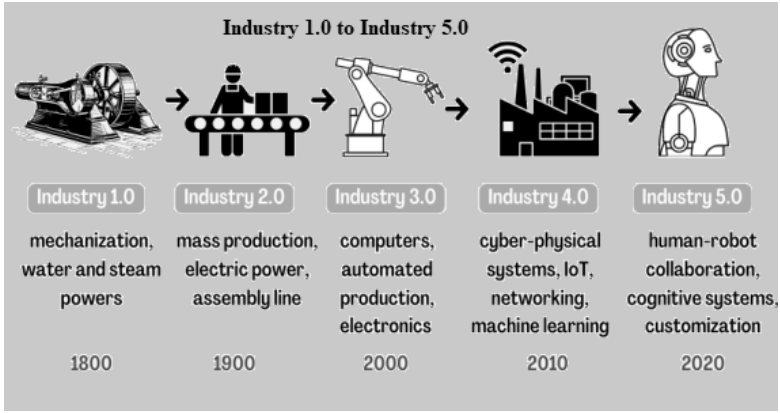


Figure. 1.1 Industrial Evolution from Industry 1.0–5.0

## Enhancements to Industry 5.0

Industry 5.0 is replacing previous enhancements and is an efficient procedure due to its highest level of perfection and the fact that machine work saves human workers time and effort. A few features, in addition to the difficulties, encourage business organizations to implement Industry 5.0. For instance, experts in the medical field are working toward the creation of a synthetic pancreas. The project is still in its infancy. Patients who have been diagnosed with Type-1 diabetes have been given a device to monitor their blood sugar levels. There is a connection between this device and another device that can inject insulin into the body. In terms of providing a patient with a dependable and user-friendly control system, this is one of the innovative technologies that has been developed and customized for patients. With Industry 5.0, doctors can now provide their patients with an application that they can install on their smartphones so that they can be tracked by their lifestyle and daily route and a personalized plan can be created for them. Because the implemented technologies are based on artificial intelligence (AI) systems, this would have a profound impact on the lives of people with type 1 diabetes. These artificial intelligence (AI) systems are able to recognize and respond to various body reactions (Madsen (2016)).

Enhance the maintenance strategy: Smart sensors, IoT, and custom software all require predictive maintenance because it is necessary to properly

monitor and maintain smart device failures. A maintenance plan will prevent these machines from malfunctioning.

**Sustainability:** Industry 5.0 promises to use resources tailored to the manufacturing industry's current needs. Flexible business models are the result of human and machine collaboration. To get rid of waste and overproduction, they must be reduced. Local production makes economics sustainable, along with new efforts. Corporate technologies are altering the trend with Industry 5.0. It results in the development of sustainable policies, such as waste minimization and management, which have the potential to make businesses as productive as possible. Industry 5.0 is designed to be useful by deliberately focusing on innovative research and placing knowledge at the forefront of the evolution. It is thought to be characterized by a determination that goes beyond just producing products for commercial use (Rada et al. 2022).

The following are the fundamental tenets of Industry 5.0: resilience, human-centeredness, and sustainability.

**Human efficacy and productivity:** People are brought back to the production center by cutting-edge technology.

While humans concentrate on innovation and cost-effective business solutions, collaborative robots carry out dangerous and repetitive tasks. Because of these skills, business productivity rises, and employees are more motivated to work hard and see results. Human needs are prioritized over the manufacturing process in a human-centered methodology. Instead of focusing on how technology can adapt to the requirements of workers, producers must recognize what technology can do for people. Technology must address issues of autonomy and privacy (Skobelev et al., 2020).

**Control of the environment:** A real-time predictive overview of the climate, temperature, and energy consumption, among other things, is provided by specialized software and smart and connected sensors. Businesses can benefit from this by cutting costs and increasing output. It is necessary to enhance iterative procedures that repurpose, recycle, and recover assets in order to maintain the manufacturing process's sustainability. The influence of the environment must be reduced. The developed technologies, such as artificial intelligence, can be utilized by sustainable manufacturers to enhance personalization, reduce waste, and maximize source-productivity.

**Efficient line production forecast:** Based on the current activity, smart and connected machines, machine learning, and industrial automation are forecasting the efficiency of production. It improves business efficiency, which means that processes can be tweaked to prevent losses based on the parameters. To protect their industrial production from disturbances and disasters like COVID-19, manufacturers need to increase their production resilience (Zaharia er al. 2020).

**Creativity:** A level of personalization that is sufficient to meet the needs of customers is not being made possible by technological advancements. Personnel is a part of Industry 5.0 that can take advantage of the technology's potential. It looks for new ideas that could lead to personalization-focused product development (Nahavandi S (2019)).

## Innovations and Modernizations

Diverse sectors, including healthcare, manufacturing, textiles, education, and food, are undergoing Industry 5.0 evolution. Bundesgartenschau, a woolen pavilion with a robot hand created by a joint venture between the businesses, is used to discuss these products. The item in question is the KR 500 FORTEC robot. It can move the parts, apply adhesives, and allow the robots to work together, all of which are typical carpentry tasks.

The majority of industries are moving toward the smart social factory by adopting Industry 5.0 methods. Repsol's intelligent management project was chosen as the project to better comprehend Industry 5.0 concepts (Javaid et al. 2020). In order to increase the company's productivity and security, Blockchain and robotic process automation technologies are utilized. The first Repsol Cobot is an automated guided vehicle that handles logistics tasks like waste disposal, raw material delivery from a warehouse, and lab visualization. Repol is carried out on the project Block lab, where the company transmits sensitive data using the Blockchain's properties. The project is properly managing 10,000 samples annually and is intended to streamline safety issues in samples (Pereira, 2020).

## Innovative Applications in Industry 5.0

### Smart Hospital

Industry 5.0's smart hospital goal is to build a real-time smart hospital. Healthcare monitoring systems can be provided by this technology. It is crucial to improving the doctors' lives. During the COVID-19 pandemic,

doctors can make use of this smart healthcare technology to concentrate on patients who are infected and provide useful data for better treatment. In addition, it assists students and medical students in obtaining the necessary medical training during the COVID-19 outbreak. Natural language processing, genetic data, and medical imaging are all examples of applications of machine learning (ML). It is primarily concerned with disease diagnosis, detection, and prediction (Fraga-Lamas et al., 2021).

According to Abdelmageed and Zayed, Industry 5.0 makes it possible to properly manufacture personalized smart implants in response to shifting customer demands. The use of artificial intelligence technology by medical professionals to measure a variety of issues, such as glucose levels, is on the rise. By producing implants in accordance with the patent match, which are the initial requirements for orthopedics, it facilitates mass personalization. Even the conventional method of manufacturing implants for patients has changed, and it is also capable of upgrading a variety of tools and medical devices.

Revolution uses these technologies because they enable precise surgical procedures. Better education, learning, and research and expansion procedures are beneficial to medical students. Industry 5.0 in orthopedics calls for customized, high-quality implants with a long lifespan. Overproduction, poor tool selection, and a lack of transparency are just a few of the issues it addresses (Lu Y (2017)).

**Manufacturing Industry**

Industry 5.0 is regarded as a novel production model that places an emphasis on human-machine interaction. Industry 5.0 involves harnessing the creative potential of humans and increasingly precise machinery through collaboration. Processes that repurpose and recycle resources are developed to make manufacturing sustainable. The manufacturing sector must also reduce its impact on the environment. In order to reduce waste and maximize resource efficiency, additive manufacturing is required to increase personalization. By removing manual labor from manufacturing processes all over the world, Industry 5.0 is revolutionizing the industry. Intelligent robots and systems are reaching unprecedented levels of penetration into manufacturing shop floors and supply chains, as Brown and Wobst demonstrated. By storing design files of manufacturing items in the cloud with strict access controls and the ability to use manufacturing resources from multiple locations, smart manufacturing enables designers

to safeguard their creations. There are a number of potential uses for Industry 5.0 (Masood 2020).

Ghobakhloo and others stated that the designers are permitted to locate manufacturing facilities close to areas with inexpensive manufacturing costs and raw materials. Cloud manufacturing will be responsible for controlling plant machines and manufacturing life cycle operations. The service-oriented model assists manufacturing in combining services with production capabilities in order to provide clients with appropriate solutions. Through business innovations, the manufacturing industry's production efficiency, value-added, and market share are all aimed at being increased by including service factors in the process. The manufacturing services are managed by the cloud-based platform, and they are utilized in a cost-effective manner. The production resources in cloud manufacturing are distributed, networked, and networked (Yadav G et al. 2020).

## Technologies for Industry 5.0

Cloud computing, blockchain, big data analytics, IoT, and 6G networks are among the Industry 5.0 enabling technologies.

### Cloud Computing

The delivery of computing services, such as databases, software, intelligence analytics, networks, and others, is known as cloud computing. This technology is enabling cost-effective innovation and scale economies. This technology stores and manages data on remote servers using the internet, and then data is accessed via the internet. It provides processing power and applications-related computing services on demand. The virtual environment known as the industrial cloud provides a supportive environment for applications used in the industry. Cloud service providers are developing applications for mobile and web use, such as IoT monitoring tools. Additionally, the use of an API that can automate data normalization from a variety of data production sources is supported by the cloud. Edge computing devices manage business analyses and handle data analytics with limited computing resources (Hopkins JL 2021).

Cloud computing provides a scalable infrastructure for supporting data edge devices, as stated by Haleem, Javaid, and Khan. The edge IoT platforms are supported by this cloud infrastructure. The edge devices, such as autonomous robots and other robots deployed on the shop floor,

are managed by these platforms. Every day, the industry has access to data from local servers in order to manage critical data. The amount of data sent to the centralized server can be reduced with Industry 5.0. By continuing with a larger workforce and allowing preventive data to detect and mitigate machine failures, cloud computing (Saurabh et al. 2021).

**Collaborative Robots**

The goal of Industry 5.0 is to bring development and production back to the hands of people. It gives the human operators robot benefits like technical precision and the ability to lift heavy loads. Humans have a high capacity for critical tasks, which enables the implementation of a high degree of control and the capacity to personalize the production phases. The need for human inputs that are able to extend the current iterations is one of the significant implications of collaborative robotics and Industry 5.0. The new era of robotics and production is represented by collaborative robots and Industry 5.0. Industry 5.0 and Cobots are the heart that can combine human craftsmanship and robot efficiency and constancy. Customized products and specialist expertise become more readily available as a result of people-centricity. Quality and data collection consistency are at the heart of Industry 4.0 (Zhang et al. 2020).

In contrast, Industry 5.0 uses robots and highly skilled individuals to create individualized goods for customers, including smart devices and automobiles. With Industry 5.0, the robots begin to cooperate. Heavy lifting and consistency are carried out by these collaborative robots, and skilled humans are provided with the cognitive abilities of craftspeople. In the context of manufacturing, robots are unavoidably altering human and machine relationships. The term “Industry 5.0” refers to people who work with smart machines and robots. Utilizing cutting-edge technologies like the Internet of Things, robots are enhancing human productivity. It brought a human touch to Industry 4.0 for business efficiency and automation. A network of physical things and things embedded with sensors, software, and other technologies is how it is described. It’s a way to connect devices and systems over the internet and exchange data (Ghobakhloo et al. 2020).

According to , the Internet of Things (IoT) is a new paradigm that will alter the conventional way of living in the high-tech lifestyle. The Internet of Things (IoT) is the focus of this research, which aims to improve cutting-edge technologies by offering cost-effective solutions to data and information security issues. As a hot topic among IoT developers, there is

the development of secure social network interaction and privacy concerns. Because it includes smart homes, the smart city is thought to be an important IoT area. It includes IoT-enabled home appliances, heating systems, security systems, and other systems that communicate with one another to improve comfort and save energy.

Sinclair and others came to the conclusion that the issues in IoT are authentication and access control; for strong security, those are necessary to have promising solutions. In order to reduce the amount of sensitive data that is lost, a solution is required to verify communication parties. It comes with an authentication scheme and checks the key security controls for various security threats like man-in-the-middle attacks. In the Internet of Things (IoT) based on the communication network, the proposed authentication and access control methods assist in providing authenticity in addition to confidentiality throughout the entire transaction. Data-centric cloud platform applications can benefit from this dynamic approach (Chowdhury et al. 2020).

**Big Data Analytics**

Industry 5.0 is a cutting-edge technology that makes it possible to use 3D symmetry in the designs of the innovation ecosystem. Matheus and co. said that big data analytics is a complicated way to look at big data to find hidden patterns, market trends, and other data. With a variety of data sets, including structured and semi-structured data, it employs an advanced analytical technique. It has enormous data sets that can be stored and processed using conventional tools. It is utilized as real-time data to enhance the business industry's competitive advantages, with an emphasis on offering possible recommendations for predictive discovery. Using a list of the issues' underlying causes, big data analytics is used to identify discrepancies. Big data analytics is used by the majority of businesses to make strategic decisions. To learn more about the preferences of its customers, the company uses a variety of factors, such as population and accessibility to the location. Monitoring customer experiences and finding solutions to problems are two ways to enhance customer experiences and cultivate long-term relationships. In the absence of comprehensive data on the manufacturing cycle, even big data presents a challenge for Industry 5.0 (Abubakr M 2020).

**Blockchain**

It is a distributed, decentralized technology in which the digital ledger stores the transaction data in blocks of records. It is a shared ledger that can make it easier to keep track of assets and record transactions in the business network. The information powers the company. Therefore, blockchain technology provides the data by providing members of the network with access to shared and complete information stored in an immutable ledger. By keeping track of things like production, payments, and orders, blockchain technology helps customers. To prevent efforts and records from being duplicated in the database system, the participants in the network keep transaction records in a distributed ledger. A smart contract that is to be executed automatically and stored on the blockchain is intended to speed up the transactions. It is defined as corporate conditions, including paid travel insurance terms. The transactions are to be blocked in chains that can't be undone, which makes it easier to verify that all Blockchain transactions have been completed.

In order for the company to verify the recorded transactions, data accuracy is required. Because members of the network share the distributed ledger, wasted time is eliminated (Bach et al. 2019).

## Challenges of the 5.0 Industry

It's easier to overlook potential difficulties in Industry 5.0. For the business's success with Industry 5.0 developments, these obstacles are being identified and resolved.

1. As a result of working with advanced robots, workers must acquire knowledge of collaboration with smart machine and robot manufacturers. People must develop competency skills. Human workers face difficulties in acquiring technical skills in addition to the soft skills required. Managing translation in the new jobs and programming the industrial robot are difficult tasks that require a high level of technical expertise.

2. The human workforce must devote more time and effort to the adoption of advanced technology. Industry 5.0 necessitates the use of customized software-connected factories, collaborative robotics, artificial intelligence, real-time information, and the internet of things (Aureli 2017).

3. Investments are required for cutting-edge technologies. The price of the UR Cobot is high. Costs are rising as a result of human workers being

trained for new positions. According to these businesses found it difficult to upgrade their production lines for Industry 5.0. Industry 5.0 adoption is costly because it necessitates highly skilled workers and intelligent machines to boost efficiency and productivity.

4. Industry 5.0 faces a security challenge due to the importance of establishing ecosystem trust. In order to protect against the use of quantum computing to deploy IoT nodes in the future, this scale of authentication is used in the industry. Industry 5.0's use of artificial intelligence and automation poses a threat to the company, necessitating reliable security. Because the ICT systems are the focus of the applications in Industry 5.0, strict security measures are required.

The retail, healthcare, finance, manufacturing, and other industries all play a role in the evolution of Industry 5.0. Various studies, applications, and enabling technologies of Industry 5.0 are used to discuss the lessons learned. The advantages, disadvantages, and directions for future research on Industry 5.0 are depicted in Figure 1 (Akundi et al. 2021).

## Applications of Industry 5.0

Benefits for society and the industry are provided by Industry 5.0. The business's competitiveness also rises, which helps it attract the best talent. Technologies that make good use of natural resources are supported by this industry's adoption. Artificial intelligence's future is represented by human robotics like Sophia. It supports human decision-making and is supported by enabling technologies that aid in sector revolution. This paper also discusses a number of challenges, including managing resources and a large amount of data (Christian 2016).

### Enabling Technologies

Smart materials, human-machine interaction, big data analytics, cloud computing, and other technologies can all be combined with the enabling technologies of Industry 5.0. Using software resources to exchange data about industrial sectors, smart manufacturing and intelligence help the business reduce network traffic, facilitate transactions, and protect privacy. Smart contracts manage security, authentication, and automated service-related actions, while blockchain technology automates agreement processes among various stakeholders (Neto et al. 2021). The intelligent information standard, which promises high energy efficiency, high reliability, and traffic capacity, is expected to be met by the 6G network.

The enabling technology for managing a large amount of data is big data analytics. Even the internet of things is a chance for Industry 5.0 to cut operating costs by fixing problems with the communication network, managing waste, streamlining the supply chain, and improving production processes, among other things (Saraswa 2021).

## The Limitations of the Industry

It is essential to have technology's trust and acceptance (Frederico 2021). Training those who are utilizing the new technologies goes hand in hand with the technology's adaptation to humans. Security, privacy, a lack of skilled workers, a lengthy procedure, and a large budget are the current obstacles. In order to comply with industrial laws and regulations that can facilitate collaboration with smart machines and cobots, adoption of Industry 5.0 is required. Cognitive computing, human-machine interaction, and quantum computing are Industry 5.0 future directions (Carayannis et al. 2021).

## Future Scope

**Computing with the mind:** This application aims to transform human thoughts into a computer-generated model. The self-learning algorithms make use of data mining, pattern recognition, natural language, and other things that the computer can read that mimic the human brain. The term "human-machine interaction" refers to communication and interaction via the user interface between humans and machines. Because they enable humans to control machines through intuitive and natural behaviors, natural user interfaces like gestures are used to attract attention. Because it helps to keep people at the center of the system and allows technologies to be built in, this is the direction that Industry 5.0 will take in the future. Even the user interface contributes to an understanding of people's motivations and behavior (Aslam et al. 2020).

A type of computation known as quantum computing can use collective properties of quantum states, such as interference entanglement, to carry out calculations.

Quantum computations are carried out by these devices, which are referred to as quantum computers. It is making calculations that focus on the likelihood that the object will be in its current state before it is measured.

## Conclusion

According to the study, the author started the work with definitions of Industry 5.0 from both the academic and industrial communities' perspectives. In addition, applications that aid in comprehending Industry 5.0's features have been discussed, followed by enabling technologies. The concept of Industry 5.0 aims to accurately combine human and machine efficiency. This paper also discusses difficulties that aid in dealing with the problems brought on by Industry 5.0. This paper discusses future directions that should be handled better for the use of this industry in the near future.

## References

1) Pathak A, Kothari R, Vinoba M, Habibi N, Tyagi VV. Fungal bioleaching of metals from refinery spent catalysts: a critical review of current research, challenges, and future directions. *J Environ Manag.* 2021;80:111789. doi: 10.1016/j.jenvman.2020.111789. [PubMed] [CrossRef] [Google Scholar]
2) HeD, Ma M, Zeadally S, Kumar N, Liang K. Certificateless public key authenticated encryption with keyword search for industrial internet of things. *IEEE Trans Ind Inf.* 2017;14(8):3618–3627. doi: 10.1109/TII.2017.2771382. [CrossRef] [Google Scholar]
3) Nahavandi, S. Industry 5.0—A human-centric solution. Sustainability 2019, 11, 4371. [CrossRef]
4) Vinitha, K.; Prabhu, R.A.; Bhaskar, R.; Hariharan, R. Review on industrial mathematics and materials at Industry 1.0 to Industry 4.0. Mater. Today Proc. 2020, 33, 3956–3960. [CrossRef]
5) Madsen, E.S.; Bilberg, A.; Hansen, D.G. Industry 4.0 and digitalization call for vocational skills, applied industrial engineering, and less for pure academics. In Proceedings of the 5th P&OM World Conference, Production and Operations Management, P&OM, Havana, Cuba, 6–10 September 2016.
6) Rada, M. Industry 5.0-from Virtual to Physical. LinkedIn. 7 March 2018. Available online: https://www.linkedin.com/pulse/industry-50-from-virtual-physical-michael-rada (accessed on 3 February 2022).
7) Skobelev, P.O.; Borovik, S.Y. On the way from Industry 4.0 to Industry 5.0: From digital manufacturing to digital society. Industry 4.0 2017, 2, 307–311. 6. Müller, J. Enabling Technologies for