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Technological Modernizations in the Industry 5.0 Era: A Descriptive Analysis and Future Research Directions

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Abstract: Unexpected instances have posed challenges to production lines over the last few years. The latest COVID-19 global epidemic is one notable example. In addition to its social impact, the virus has destroyed the traditional industrial production system. Industry 4.0 requires adapting to changing prerequisites with adaptability. However, the next movement, Industry 5.0, has emerged in recent years. Industry 5.0 takes a more coordinated approach than Industry 4.0, with increased collaboration among humans and machines. With a human-centered strategy, Industry 5.0 improves Industry 4.0 for greater sustainability and resilience. The concept of Industry 4.0 is the interconnection via cyber-physical systems. Industry 5.0, also associated with systems enabled by Industry 4.0, discusses the relationship between "man and machine," called robots or cobots. This paper discusses the industry 5.0 possibilities, the restrictions, and future analysis potentials. Industry 5.0 is a new paradigm change that tends to bring negotiated settlement because it places less prominence on technology and assumes that the possibilities for advancement are predicated on collaboration between humans and machines. This paper aims to examine the potential implementations of Industry 5.0. Once the current progress and problem were discovered, the previous research on the investigated topic was reviewed, research limitations were found, and the systematic analysis procedure was developed. The classifications of industry 5.0 and the sophisticated technology required for this industry revolution are the first subjects of discussion. There is additional discussion of the application domains enabled by Industry 5.0, such as healthcare, supply chain, production growth, cloud industrial production, and so on. The research also included challenges and problems investigated in this paper to understand better the issues caused by organizations among some robotic systems and individuals on the production lines.

Keywords: Industry 5.0; cognitive systems; human–computer interaction; supply chain; smart education

Citation: Alojaiman, B. Technological Modernizations in the Industry 5.0 Era: A Descriptive Analysis and Future Research Directions. *Processes* **2023**, *11*, 1318. https://doi.org/10.3390/pr11051318

Academic Editors: Luis Puigjaner and Jiaqiang E

Received: 12 February 2023
Revised: 14 March 2023
Accepted: 31 March 2023
Published: 24 April 2023

1. Introduction

Innovative technology has become an important driver of social transformation. Because modernization attempts to deal with the progressive transformation from agriculture to industrialized societies, it is critical to examine technological advancements across practice settings. Emerging innovations do not transform societies on their own. Rather, it is our reaction to technology that drives change. Innovation is frequently recognized but not placed to use for an extended period. Later, it may be adopted on a massive scale, revolutionizing an entire populace [1–3]. Technological modernization is the procedure of overseeing or transitioning away from outdated approaches and system architectures, integrating systems, as well as workflows, and replacing them with more computer-controlled, creative technologies. Researchers have indeed been forced to examine IT architecture for cyber-security throughout the work-from-home era and also for electronic transformation in a time when computer-controlled intelligence, as well as robotization, are more essential than ever. Technological modernization efforts seem to be critical for leveraging artificial intelligence, enhancing communication links, trying to encourage the adoption of cloud computing, and driving organizational change administration [4–7]. In response to quickly evolving business requirements, businesses are reconsidering IT infrastructure preferences. Streamlining complicated systems and increasing acceleration throughout the integrated business software platform, which includes data centers, is becoming increasingly important. Stakeholders, IT representatives, and end users all want instantaneous cost savings, implementation flexibility, expandability, adaptability, and security, which drives change management and the requirement for new technology solutions [7–10].

Digital advancements that continuously guarantee major development routes and stable institutional arrangements that can be controlled over time are required for advanced technologies and innovation. Such conditions must be affirmed by the cultural construct, particularly by their socioeconomic dimensions. For hundreds of years, cultural incorporation has digested innovation and process advancements including technology transfer rather than modernization. This may vary from location to location, but it generally follows the same pattern. Heteronomous transactions face ethnically motivated opposition or are overlooked, whereas technological breakthroughs face slightly different situations. It is not synonymous with culture transfer and it does not automatically lead to broad modernization, but instead in a type of progress with a pace of cross-cultural adaptation, which is certainly slower than what is considered necessary by modernization. However, with the assistance of the embedding paradigm, this advancement can be primarily absorbed. It is our responsibility to start generating aspects of modernization that take social embedding and traditions into account [9–11].

The worldwide digitalization industry is anticipated to be worth USD 588.05 billion in 2021, increasing at a CAGR (compound annual growth rate) of 23.6% even during the forecast timeframe. The widespread adoption of technological platforms in industry segments such as banking, financial services, and insurance (BFSI), automotive, medical services, industrial production, and many others drive global market expansion. Furthermore, the implementation of numerous transformation technologies, such as the IoT for speeding up transformation efficiency and proficiency, as well as the beginnings of Industry 4.0, boost the market for the digitalization economy. Furthermore, rising money invested in the IT industry and the advancement of the communication network may accelerate the digitalization market growth over the next few years. The prevalence of COVID-19 has had a substantial effect on a wide range of industry sectors. The important concern for economic systems is guaranteeing continuity of operations in the face of regional shutdowns, work-from-home regulations, social disassociating guidelines, and other difficult factors. Due to the increasing demand for conversion in a variety of industries, we had a positive influence on the transition market's expansion [12].

The accessibility of digital transformation may allow numerous business operations to continue, including in remote locations. It provides employees with adaptability, comfort, collaborative effort, and the capability to carry out organizational functions. As a result, even during the pandemic, such implementations boost expertise and productivity, generating lucrative growth possibilities in the digitalization industry [12]. Figure 1 shows the findings of a study conducted by Polaris Market Research regarding the worldwide digital transformation market size.

Humans have recognized the significance of using technology as a tool of progress since the beginning of industrialization. Some of the progressions that have occurred over the past few centuries include vapor machines and equipment, assembly plants, and computer technology, which all intended to produce enormously assertive technology and improve efficiency and efficacy. Industry 5.0 shifts this conception and introduces a revolution by reducing the prominence on technology and assuming that the full potential for advancement lies in human–machine collaboration [13,14]. Industry 5.0 is thought to be the solution to the issue of a revived human-centric innovation perspective, beginning with the reorganization of the industry's manufacturing processes (systemic, organizational, managerial, knowledge-based, intellectual, and social). The emphasis of this fresh perspective originates from the fact that Industry 4.0 is still in its beginning stages of development, with its primary mission happening, approximately as anticipated, in the 2020–2025 timeframe. Moreover, the prescriptive proportions, as well as guidelines that identify international cooperation of Industry 4.0, lack a comprehensive vision that considers the true impact of such problems. Industry 5.0 intends to deliver that vision, as well as the fusion of power which would benefit massively from harmonizing and optimizing interpersonal contact. From a societal, technical, and ethical standpoint, there are various obstacles, possibilities, and problems in the transition to human-centric manufacturing and production. Ethical challenges had already started to surface in Industry 4.0. However, just as Industry 5.0 develops from and coexists with Industry 4.0, ethical issues also cross over. The human being is put in a situation where ethical concerns are increasingly important, which makes people even more relevant because of human centralization. Ethical, medical, and safety problems are crucial in industrialized and computerized workplaces using digital technology, and as a result, this is a popular area of research for the future.

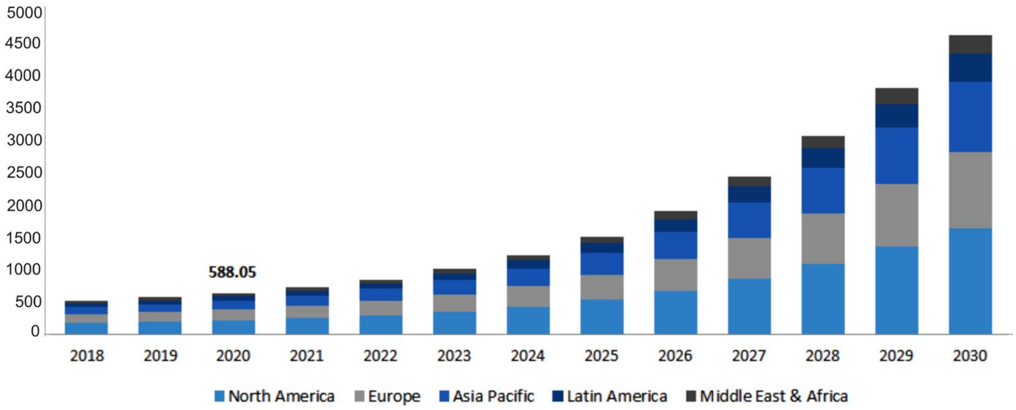

Figure 1. Digital transformation market size (USD billion) by region, 2018–2030 (Source: Polaris Market Research).

The present state of perception of Industry 5.0 is that it is a movement to restore the human connection to the manufacturing sector. The customer's need for mass personalization is driving this. This idea implies that Industry 5.0 offerings empower clients with a method to exhibit themselves, for which they would spend more money. To summarize, Industry 5.0 is a notion aimed at making the industry more environmentally sustainable, human-centered, and resilient. Others see Industry 5.0 as complement to Industry 4.0, while others see it as a progressive, gradual improvement that expands on the theories and strategies of Industry 4.0. Table 1 compares Industry 4.0 versus 5.0's definitions, objectives, systemic methodologies, human factors, supporting strategies and ideas, and climate considerations. Because Industry 5.0 is a novel concept, there is little consensus on how it should be represented. Moreover, the fundamental tendency of Industry 5.0 is the deployment of human–robot co-working environments and the development of smart societies.

Industry 5.0 is the new standard and it has already led to a generational shift regarding the interaction and collaborative effort of human beings and machines. This cyber-physical system design revolution, summed up in Industry 4.0, has progressed into Industry 5.0, fundamentally altering the way we live, work, and interact with one another. This upcoming movement of industrialization must characterize how we work collaboratively and identify the guidelines for human–machine interactions. Because most automation, intelligent machines, and even robotic systems are functioning in the surroundings, supporting the working population, or taking on significant sections of production and manufacturing procedures and functions, the stages of collaborative efforts between individuals and machines would then start changing. Industry leaders need to comprehend potential modifications and interruptions in the worldwide providers, customer base, and global markets, rather than just trends and changes in their major industries. The rapidly changing environment is putting an unexpected strain on the entire staff, governments, legislative bodies, and policymakers. Industry 5.0 unveils the features that are distinctively human creations, as well as the collaborative effort of machines. This would boost production efficiency and keep machinery monitoring under human supervision to improve production performance. As creative and intellectual intellects collaborate with machines to boost customer satisfaction, the 5th Industrial Revolution tends to promote more productive employment [10]. Industry 5.0 also provides protection for the environment by rendering more accurate decisions with predictive modeling and operating intellectual capacity. As a result, the authors recognized the significance of conducting an exploratory and descriptive evaluation of industrial automation in the Industry 5.0 era.

Table 1. A comparative analysis between Industry 4.0 and Industry 5.0.

Factors	**Industry 4.0**	**Industry 5.0**
Definition	Industry 4.0 is transforming how businesses make, innovate, and offer their goods. Producers are incorporating new innovations such as the Internet of things (IoT), cloud services and analytics, and AI and ML algorithms into their manufacturing facilities and procedures [13]	Industry 5.0 refers to a fresh and developing era of industrialization in which humans collaborate with modern technology and AI-powered machines to improve workplace procedures. This is accompanied by an increased human-centric orientation, better adaptability, and a stronger emphasis on achieving sustainable development [15–17]
Objective	Smart factory	Sustainability, human-centric, and resilient
Motivation	Mass production	Smart society and sustainable development
Human Factors	Human–computer interaction, monotonous movements	Employee protection and control, workforce learning and development
Methodology	Real-time data surveillance, an interconnected network that accompanies all phases of the life cycle	The appropriate use of technology to improve human concerns and priorities, socio-centric technical decisions, the 6R methodology, and transportation efficiency design guidelines
Enabling Technologies	Cloud technology, Internet of things, big data and analytics, information security, and cyber-physical systems (CPS)	Big data and analytics, cloud technology, the Internet of things, collaborative robots, digital securitysafety, support systems inspired by nature, decision-making systems, intelligent grids, servicing that is predicted, additive manufacturing, mixed reality
Climate Inferences	Systems are cost-effective, waste is reduced through business intelligence, additive manufacturing, optimized systems, material consumption increased, power consumption increased, and the product's life cycle has been expanded	Waste avoidance and regeneration, sources of sustainable power, data storage, transport, and analysis that use less energy, sensors that are smart and energy-efficient

The remainder of the study is presented as follows. Section 2 depicts the observations of various similar research papers. Section 3 presents the adopted methodology for the proposed investigation. Section 4 provides findings and evidence of Industry 5.0 enabling technologies in a range of industries. Section 5 discussed the various application domains for Industry 5.0. Section 6 explored the various opportunities and challenges of enabling technologies pertaining to platform transition. Section 7 finishes the paper with a thorough analysis and summary.

2. Related Works

All areas of human influence have undergone tremendous transformation in the last several decades. Customer preferences are changing; there are activities of globalization, including management model modernization. In the fourth wave of industrialization, data, communication, and learning have taken the lead as the primary managerial objects. The automation of business operations alters the nature of labor and introduces new difficulties, which also modifies the jobs that employees must perform. On the one hand, this alters professions, helps to develop fresh ones, and leads retired occupations to disappear; on the other hand, it results in unemployment. Individuals would need specific abilities, constantly known as 21st-century talents, in this new approach. These would make it possible for professionals to work more productively, transition between businesses, and remain in demand all at once. Finding the essential talents that will be most in need in the coming years can be performed in a number of different ways. In order to pinpoint gaps in the literature and establish the case for the present investigation, we have evaluated similar publications in this segment. In this respect, we looked for terms such as "industry 5.0," "the fifth industrial revolution," "paradigm shift," "COBOT", and "Human-Robot Coordination" in reputed international journals. Then, among them, we picked out and examined relevant publications between 2015 and 2023.

Chander et al. [15] investigated Industry 5.0, IoT architectural style, and AI-powered IoT. They also examined the technical aspects of the IoT network, as well as communication-enabling technologies. They talked about how AI-based technologies are being incorporated into the IoT, as well as AI-based toolkits, Edge computing, and trust modeling techniques for IoT equipment.

Shloma and Volotka [16] discussed industrialization and its societal consequences. They believed every period of industrialization has left an imprint on human history. The finest method for forecasting the future is by having a look back at history and investigating the past.

Carayannis et al. [17] offered a comprehensive review of nuclear fusion energy's geostrategic established order and underlined a perspective for the future against the background of Industry 5.0 and Society 5.0. They proposed major "soft power" co-chairs from the Global West and North, as well as from the Global South, to provide a geostrategic transition that can unleash tens of billions of dollars in financial support for various technology routes, established a global regime to protect intellectual assets, speed up the transformation from fossil energy to a "Future Fusion Economy," and inhibit fusion energy from becoming geopolitically polarized.

Kasinathan et al. [18] suggested a research project on developing technologies for achieving Sustainable Development Goals (SDGs) using emerging technologies. This research investigates the impact of disruptive innovations on product innovation, healthcare progression, a global epidemic case analysis, nature-inclusive marketing strategies, and smart cities and towns. Such consequences were also modeled as having a direct impact on SDGs 3, 8, 9, and 11.

Adel [19] planned to investigate the possible implementations of Industry 5.0. The explanations of Industry 5.0 and the sophisticated equipment required for this industrial revolution were first discussed. They also discussed the implementations enabled by Industry 5.0, such as healthcare, production lines, industrial output, cloud manufacturing, and so on. Their study outlined big data analytics, the IoT, robotic systems, blockchain, digital twins, and future 6G systems. Their research also included challenges and problems that were investigated in order to better understand the challenges posed by organizations among the robotic systems and individuals on the production line.

Orlova [20] suggested a novel methodological strategy for evaluating and managing corporate human capital (CHCM) in the context of the digital transition. CHCM employed a system assessment and synthesis techniques, expert evaluations, descriptive data analysis, and a survey. The novelty of CHCM is that, first, it conveys all of the important components and characteristics of human capital as new occupations arise; second, it integrates and exhaustively uses both qualitative and quantitative strategies for human capital evaluation, representing the subjective and objective components of human capital quantification; and third, it enables management to make merited decisions regarding individual trajectories of expert advancement of employees.

Fatima et al. [21] provided a comprehensive overview of the role of the IoT in leveraging digital transformation initiatives and Industry 4.0. The authors have addressed the use of the IoT in various industrial sectors, as well as how the notion of the IoT has progressed. Furthermore, the study summarized several scientific papers that allow the researchers to elicit the significant challenges, integration analysis, and future perspectives of the IoT.

Mourtzis et al. [22] proposed an essential literature examination to provide sufficient justification for contemplating Industry 5.0 as a structure for facilitating the peace and cooperation of industry, as well as evolving sociological phenomena and needs. Their investigation contributed to the development of a framework to aid in the transformation from Industry 4.0 to Society 5.0.

An explanatory case study approach was used by Sukmono and Junaedi [23]. The findings of the study demonstrated that the technological advancements that have decided to bring civilization to Industry 4.0 have made a substantial contribution to managing disasters. Researchers discovered that the government, emergency planning and recovery organizations, journalists, and the general public used World Wide Web chat-based electronic technology to effectively coordinate during the West Nusa Tenggara disaster. Moreover, concerning disaster mitigation, Industry 4.0 technology has constraints. Researchers proposed addressing the problems with Industry 5.0, an advanced technology built on the Internet of things.

Saniuk et al. [24] recognized the societal and economic anticipations of the fourth industrial revolution's advancement in the setting of the advancement of Industry 4.0's sustainable development, transformation, and resilience. The article presents the findings of research predicated on a critical review of the literature, as well as surveys of members of Polish society. As an outcome of the research, important social expectations regarding the future directions of Industry 4.0's notion were recognized. Suggestions for industrial growth were formed with a concentration on three areas of improvement: human-centric, viable, and adaptable. Their research findings would then enable the creation of an investing strategy and governmental policies to endorse industrial growth based on human-centric computerization of the economic system.

Carayannis et al. [25] analyzed the aviation industry as a case study for a smart environment as an instance of Industry 5.0 and Society 5.0. A systemic vision of the components that act and are acted upon within a given territory ought to be the foundation of joint economic growth in smart complex settings. Indeed, system-enabled synergies can be viewed as the result of the implementation of a specific knowledge-based accessible entrepreneurial orientation and as an alignment that can translate theoretical assumptions into formal operational stage innovation trails.

The representation above makes it clear that a lot of centric research is being conducted to create improved views within the context of Industry 5.0. Since the publication of the initial paper on Industry 5.0, numerous research publications have been presented. Therefore, it provides a platform for cutting-edge networking and advanced technologies. The goal of this research, which was to automate industrial and manufacturing operations, has undergone a significant shift in viewpoint. The researcher has discovered that this subject is a progressive issue for investigation and solution proposal.

3. Materials and Methods

Finding and collecting information from previously published research publications from academic databases was a step in the data collection procedure. The IEEE, Science

Direct, and MDPI databases were used to gather information for this research. Although articles concentrating on Industry 5.0 may not be found in the "top" publications in the area, these resources have a greater diversity of coverage in regard to sources than some other sources, which is significant. An additional aspect in selecting the recognized sources and limiting the study to the abstracts is the constraints on the databases' writers. The relevant and required "Industry 5.0" keyword was employed to explore the metadata and locate published publications that dealt with the subject of Industry 5.0. This applied to every article that had the phrase "Industry 5.0" in the titles, summaries, or search terms. This is due to the fact that Industry 5.0 continues to be a relatively new concept, and it is not yet obvious what other important phrases and analogs are employed. A total of 211 articles was found using a keyword search, including 32 from IEEE, 81 from MDPI, and 98 from Science Direct. Many publications were published between 2016 and 2023, with the earliest reference to Industry 5.0 appearing in 2016. The information gathered for each recovered publication comprised the publication, title, year of publication, and abstract. The information was then organized according to the source it was taken from and transformed into an an.xlsx document for extensive analysis. After being sorted, the dataset was labeled to indicate the publishing company, title, and abstract of every retrieved published paper. R, a quantitative language popular among researchers and data analysts, was employed to convert, visualize, and analyze the collected data. This comprised topic modeling, analysis methods, key term selection, and the transformation of data. The findings were organized by each separate database from which the abstracts were collected.

Data analysis, also described as smart text processing, text data mining, and text information retrieval, is the process of extracting information from a variety of written sources in order to find new or previously undiscovered information. By seeing patterns in articles from many sources, text mining helps to unearth fresh knowledge and information. Other techniques, including natural language progression (NLP), pattern recognition, segmentation, text categorization, information extraction, knowledge discovery, and concept retrieval, may be used in addition to text mining. Researchers have come to understand how useful text mining has become for examining published material and identifying topics and patterns within a certain field. In order to explore and analyze the published papers on Industry 5.0, the information retrieval framework shown in Figure 2 is utilized. This analysis identifies important terms that are frequently used, as well as the categories within which Industry 5.0 investigation may be categorized with the help of the text data retrieved.

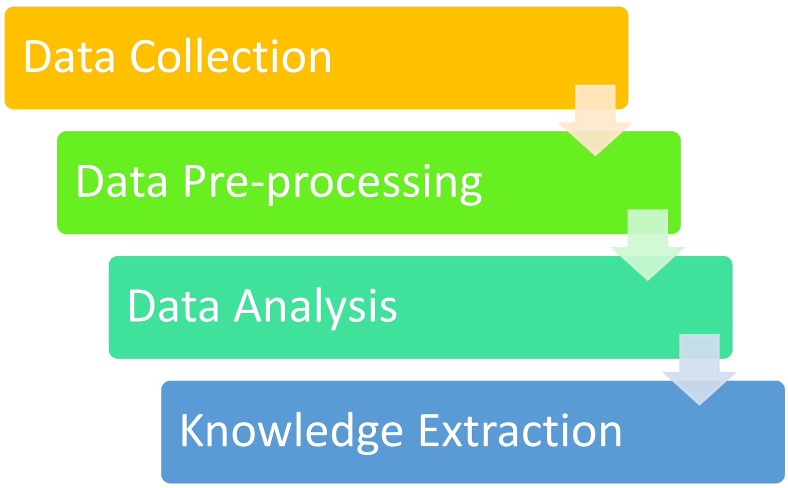

Figure 2. An analytical framework for Industry 5.0 abstractions.

4. Technological Modernizations in Industry 5.0

Industry 5.0 has already begun to implement permanent changes. This operation provides businesses with the ability to use immensely influential machines in conjunction with better-trained professionals to foster efficient, viable, and safe manufacturing. Industry 5.0 is not a passing trend, but instead a fresh way of thinking about industrial production that has fruitful, financial, and commercial implications. As a result, businesses that do not customize their manufacturing to the factory 5.0 prototype would then quickly become outdated, unable to capitalize on the comparative advantages that it provides. Not only that, but the pace of technological velocity is increasing, indicating that the rise of fresh concepts is never-ending. As a result, adapting every company's processes and converting them into the notion of the digital sector would be critical to ensuring that an organization remains viable.

4.1. Blockchain Technology

Manufacturers are currently collaborating on blockchain deployments that could assist them to streamline operational activities, gain total transparency into supply chain operations, and manage investments with technology appropriately. Blockchain technology has the possibility to transform how manufacturing companies design, produce, and scale their product lines. Furthermore, it is rewriting how companies interact due to its ability to fully accept within and between competing companies who should collaborate within common environments. There is still a lot of opportunity for manufacturers to be blockchain innovators. The sector is second only to finance in terms of perceived technological leadership. For future product finance companies, blockchain could indeed make business more efficient and quicker. Distributor outcomes and payments can be directly derived from verified blockchain transactions, eliminating the requirement for human intervention and testing. The integration of blockchain with cloud computing applications and sensors allows for extraordinary access, availability, and improved productivity across the total value cycle. Transportation and logistics in the company make the best use of the combined areas of the strength of blockchain and the IoT. Pick-ups, declines, or business agreements over physical goods, features, or transactions that can be made instantly by these technologies are all possible with intelligent contracts [26,27].

4.2. Unmanned Aerial Vehicle

Industry 5.0 is an intelligent concept that can end up making the industry smarter and much more linked by utilizing a unified platform, such as the IoT and UAV (unmanned aerial vehicle) innovation. Underneath the Industry 5.0 guideline, UAVs are continuously being developed. Even though UAVs are primarily used for both civilian and military purposes, possibilities for advanced manufacturing incorporation, such as real-time monitoring systems, wireless visibility, and environmental monitoring, must be investigated. As they are IoT devices used for efficient cost-effective data gathering and surveillance, UAVs can be taken into account as proactive problem solvers while also contributing to improved decision-making. By linking multiple production lines with a long-distance communication channel, UAV technology can accelerate industry growth. UAV technology becomes increasingly significant because it can be combined with other applications such as intelligent cities, the IoT, and so on [28]. UAV technology has the potential to increase the output of production plants, propelling Industry 5.0 forward. An UAV is fully autonomous and serves as a gateway for logging sensory data onto the cloud server via network technology with the help of a Wi-Fi component, which would also lead to this technology being used for diverse applications in pervasive computing such as pollution management, public transit, and Industry 5.0, among others.

4.3. 5G and beyond Wireless Technology

6G, also recognized as "Beyond 5G," represents the forthcoming generation of communication systems. When it comes to attempting to negotiate, the prospect of content is far more significant than technical surroundings. 6G is more of a step forward toward workplace relationships than a technical advancement. In regard to application, extra software-intensive utilities and the dispersal of data-based educational environments are emerging; they may be crucial in the advancement of autonomous transportation or the dispersal of telehealth. While 1G–4G permitted communication among people, 5G provides advice for man and objects, and the transmission of 6G would then allow communication between devices, things, and virtually anything [29,30]. The advancement of a cutting-edge testing process, the advancement of wireless Internet connectivity, investigations into IoE (5) ("all Internet"/"all-inclusive Internet") systems, high-resolution and real-time digital communications technology, and applications are all major considerations for B5G/6G. Other priorities include the development and research of industrial technology systems, smart urban planning, and the progress of Industry 5.0. Furthermore, personal data safeguarding would then, of course, persist as an ongoing concern, resulting in an important responsibility in the advancement of this technology.

4.4. Exoskeleton Technology

Exoskeletons in the place of work have grown in popularity in the manufacturing base, assisting workers and enhancing the quality of their business hours. Exoskeletons are a kind of augmented technology that accommodates body parts such as the hands, back and shoulders, lower body, and upper body to improve human effectiveness in physically demanding activities. These decrease workers' power requirements when safely pulling, transferring, and carrying tools, packets, and other advanced manufacturing assets. Musculoskeletal disorders are considerably lowered with these implementations [31].

In the near future, investment opportunities in advanced manufacturing exoskeletons will be intense. According to the latest current market update from ABI Research, advanced manufacturing shipments would then reach 274 million units in 2030, with revenue reaching USD 3.4 billion by the end of the decade. As a result, the manufacturing part of the market is the most enthusiastic about wearable robotic systems, closely accompanied by the advertising segment of the market and, to a lesser extent, the combat segment of the market. Industrial production is responsible for more than half of all exoskeleton consignments, as well as earnings in the industrial section, accompanied by energy/utilities and oil/gas. On the other hand, commercial implementations are not too far behind the manufacturing industry, with 198 million units sold and USD 2.9 billion in anticipated revenue in 2030 [32]. Figure 3 shows the findings of a study by ABI Research in this regard.

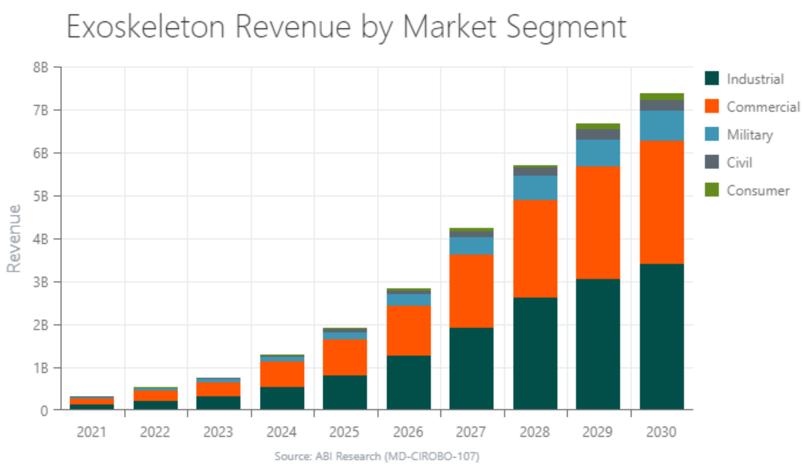

Figure 3. Exoskeleton revenue by market segment (Source: ABI Research).

4.5. Mixed Reality

Whereas augmented reality is conveyed via a portable mobile device, such as a tablet or smartphone, mixed reality is conveyed via head-mounted see-through spectacles. The merging of reality and virtual reality to create new surroundings and visualizations in which digital and physical objects coexist and communicate in real-time is known as mixed reality. Microsoft invented the term "mixed reality" when it released the Microsoft HoloLens in 2016 [33]. Aside from being head-elevated, mixed reality differs from augmented reality because it has a more sophisticated comprehension of the physical area and the capability to put holographic images in that area.

Mixed reality is also known as hybrid reality or extended reality (XR). Following the person's gaze, a headset form factor lays out the user's physical environments, as well as applications, and then employs deep learning techniques to associate digital information with particular places of the plot. Through MR program development, digital objects can communicate with physical items, and people can communicate with digital materials as if they were physical. As a result, a standard desktop computer can be transformed into an interactive online touch screen, or an MR-generated movie character could indeed sit on the homeowner's living room sofa.

So, even though mixed reality remains in its beginning phases, it is already being employed for educational content in a diverse range of industries. For instance, airline companies are using MR to prepare repair professionals at a low cost. Rather than removing an engine from an aircraft to undertake training, specialists with special headphones can perceive a holographic projection of an engine and interact with it using gestures, looking directly, and voice user interface (VUI) instructions, evolving perspectives, and extract important information layer by layer [34].

Even though three-dimensional projections, as well as online digital displays, are anticipated to play a significant part in MR, the latest mixed reality information is commonly provided through headsets. Establishing consumer items that enjoy the benefits of the MR spectrum was previously prohibitively expensive due to the technology's high processing requirements, as well as powerful computer vision and image recognition abilities. Big data, cloud computing, and significant advancements in artificial intelligence (AI) are attempting to make MR functionalities more inexpensive, and as prices fall, it is anticipated that MR would then fundamentally alter human–computer interaction (HCI) [35,36].

4.6. Additive Manufacturing

Additive manufacturing has the ability to be a key Industry 5.0 aspect in the future because it drastically reduces waste, particularly when compared to subtractive. Although Industry 5.0 has a long way to go, an increasing number of individuals believe that more could be performed to assist saving the world while also saving money for organizations' bottom lines. The method of fabricating an object one level at a time is known as additive production. It is the inverse of subtractive manufacturing, which involves cutting ahead at a solid material block until the finished product has been completed. Technologically, additive manufacturing could indeed refer to any technique that produces goods by picking up the pace, such as molding. Individuals must first develop a concept before using additive manufacturing to develop an item [37]. This is usually implemented through the use of computer-aided layout, or CAD, applications, or by scanning the object to be printed. The design is then translated into a layer-by-layer structure for the additive manufacturing equipment to pursue. This is transmitted to a 3D printer that immediately starts constructing the object. The procedures of additive manufacturing could be carried out in a variety of ways, each of which can take a few hours to many days, according to the size of the item. A nozzle is used in one common method to lay consecutive material layers on the upper edge of each other until the final result is achieved. Another method employs powders, which are usually produced from metal.

4.7. AI-Based IoT

The Internet's operational functions are shifting from the "Internet of Computers (IoC)" to the "Internet of Things (IoT)". It is necessary to consider the significance of AI methods to enable intelligent online communications. Wireless sensing networks are currently becoming increasingly hot areas of research due to their reality application areas and amazing remote surveillance of occurrences in fields such as healthcare, weather warnings, seawater stages, event forecasts, and so on. Furthermore, intelligent detectors were widely used in electronic-based household appliances, green infrastructure, and mobile gadgets.

The IoT concept is defined as "the pervasiveness all over us of a wide range of devices or objects—including such Radio-Frequency Identification (RFID) identifiers, detectors, actuators, cellular phones, and so on". They can communicate with one another and work cooperatively with their neighbors by using unique addressing strategies [36]. As a result, the overall shape for IoT adjustments will continue to alter the lives of individuals all over the world. AI strategies can also assist the IoT in the development of robotic systems whose situatedness keeps evolving roles that avert constant human instruction [38–40].

4.8. Motion Capture Technology (Mo-Cap or Mocap)

Industry 5.0's fast pace of technological breakthroughs has created new opportunities for innovative industrial processes, which must be realized using cutting-edge sensing technologies. Optical cameras and inertial measurement units (IMUs), both of which are motion capture (MoCap) sensor systems, are extensively used in industrial applications to enable teleworking, robots, additive manufacturing, and consumer safety technologies [41–43]. Digital motion capture is the procedure of recording the actions of individuals or other things. Motion capture methods are frequently applied in the entertainment business, particularly in the entertainment and filmmaking sectors. If it involves creating more intricate patterns, including facial movements or fingertip motions, it is often referred to as behavioral capturing. People's movements are captured, and a 3D computer model is made using these data. The actions are communicated to the electronic medium after being scanned several times per second. As a consequence, the avatar accurately mimics the human's gestures.

4.9. Digital Twin Technology

Digital twins continue to be essential in Industry 5.0 for enhancing the performance and effectiveness of the production cycle. An enormous amount of information gathered from digital twins, for instance, can be used to enhance the development and production of product methods. A digital twin is an imitation of an actual thing that functions and seems the same as its physical counterpart in the actual world. A digital twin may represent a digital clone of a real object, for example, a fighter jet or wind turbine, or it may represent a larger entity, such as a tower or even an entire city. Conversely, digital twin technology may be employed to simulate procedures in order to gather data to forecast how they will function [44,45]. In short, a digital twin is a software application that simulates how a method or item would work using data from the real world. To improve the results, such systems can incorporate software analytics, machine intelligence, and the Internet of things. The manner in which people may advertise products and solutions has been completely transformed by technologies, such as augmented and virtual reality, cognitive computing, machine learning, digital twins, networked supply chains, and others. However, this new method of industrial production has been subject to an artificial restriction that has existed since the start of the industrial revolution.

5. Application Domains for Industry 5.0

To create and provide the best-personalized assistance to the customer base, Industry 5.0 will indeed eliminate the disparity between robots and technically talented workers. As previously stated, Industry 5.0 will necessitate highly trained individuals and staff in order to effectively accomplish the objectives and goals of Society 5.0. Education 5.0 would then enable a person to master skills such as training, unlearning, and relearning in order to conform to and accommodate the ever-changing surrounding of the technological world. Education 5.0 would indeed be personalized, which would enhance the learning experience and prepare students to face and survive future uncertainty and risk with their supplemented skill sets, allowing them to sustainably develop new principles and assistance to advantage and compromise society in general. Industry 5.0 is a modern manufacturing model that emphasizes interaction between individuals and machines. Industry 5.0 is concerned with leveraging collaborative efforts between increasing precision machinery and human ingenuity. To render manufacturing more financially viable, it creates processes that reconfigure, collect, and recycle infrastructure [46,47].

Human consciousness is energized by cognitive computing and intelligent technology capabilities to facilitate hyper-personalization. Reinforcement learning, robotic robotization, and other innovations are performing well and being productive in increasing business proficiency and delivering high value to their customers more quickly. The Enterprise resource planning application manages the supply chain for the company or organization, from fresh material delivery to transactions and public transit. The innovation to encourage the supply chain network is being developed and deployed by the forthcoming era of supply chain solutions. Aiding and abetting individuals with manual and monotonous work is an essential part of industrial automation due to two significant factors: globally ageing professionals and the tiredness associated with manual and repetitive production assignments. To assist businesses in responding to this challenging task, exoskeletons are the symbol of worker's central importance within the future factory. Exoskeletons, also known as exo-suits, are devices worn by soldiers over their regular uniforms to increase their strength. The device includes fueled special devices and AI to improve a soldier's functionality. They could be made of durable materials, such as metal and carbon fiber, or soft and stretchy materials, such as rubber. Figure 4 depicts the various application domains of Industry 5.0 [47–50].

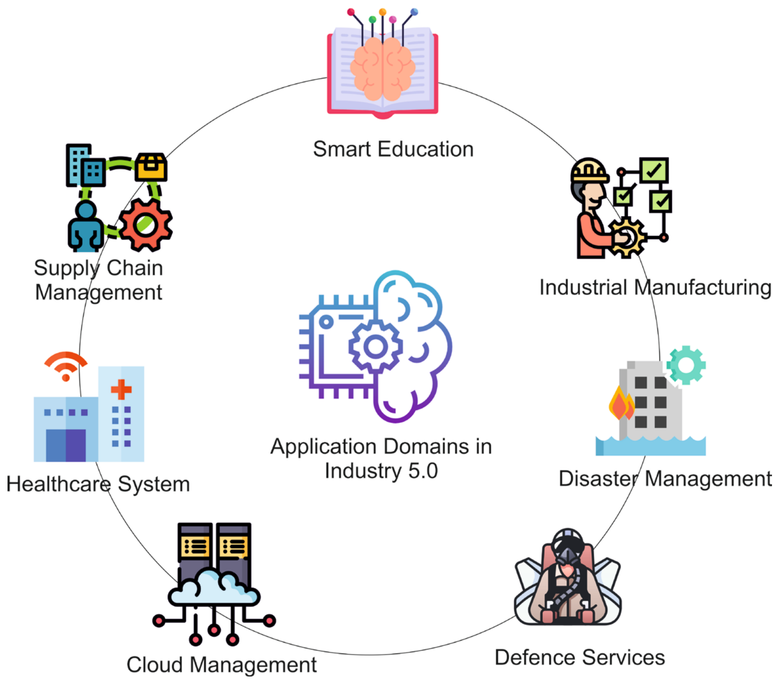

Figure 4. Different application domains of Industry 5.0.

6. Discussion

In order to fulfill the paper's objective, the most frequently occurring appearing keywords in the summary text data collected from the literature relevant to Industry 5.0 were determined using a keyword extraction method. The most often used terms were found to be big data, distribution network, digital innovation, and machine learning. This is consistent with the perception of Industry 5.0, which uses machine learning and artificial intelligence to simplify repetitive tasks while also supporting human cognition. Big data and digital innovation are also expected to create a data-rich information landscape that may be utilized for authentic resources management and planning. The thematic components of publications presented targeting Industry 5.0 were found using the data analysis approach. More precisely, it is seen that the scientific community is becoming increasingly interested in the idea of Industry 5.0 as a bridge toward human–machine interaction and coexistence.

Industry 5.0 is a popular uprising in which humans and machines find methods for working together in order to improve production efficacy. If personal interaction was lacking in Industry 4.0, it is going to be central to the fifth industrialization. Individual employees and widespread robots would then enhance production efficiency in tandem. The executive unit of each manufacturing business must describe the production line, then adhere to the key performance indicators (KPIs), as well as guarantee that the procedures operate properly. The key part would be human–robot interaction and collaborative effort. Machine intelligence and creative expression will coexist. The automated process or the robot producer will represent the new standard. Individuals and robotic systems are expected to bring the industrial production world to a higher level of efficiency and speed with highly developed technologies, such as artificial intelligence (AI) and cognitive technologies. Aside from the direct benefits to the manufacturing sector, the 5th industrialization would then play a significant role in sustainable development because the goal is to develop renewable energy sources.

6.1. Challenges to Industry 5.0

With so much excitement surrounding Industry 5.0, it is easy to overlook its possible challenges. We identified three significant issues, but only time will demonstrate which ones are genuine:

- Individuals may be required to learn entirely new abilities. Collaborating with robotic systems sounds exciting, but individual employees will need to learn how to work collaboratively with a smart machine, according to a robot manufacturing company. Technical abilities will be required in addition to soft skills. Programming or controlling an automated machine leads to new positions, such as Chief Robotics Officer.
- The introduction of new technologies has almost always taken time and dedication. How would the manufacturing sector put it all into action? What exactly are Industry 5.0 techniques? Personalized applications connecting production plants, real-time information, cooperative robotics, 3D printing, AI, the IoT, and the cloud are just a few examples.
- Additionally, such technologies necessitate investment. A cobot is not inexpensive. Training people for available employment is also expensive. Some businesses may struggle to enhance their manufacturing lines for Industry 5.0. Although, if money is not an issue, the pace of change might be. Individuals who cannot adapt to it or are slow to implement Industry 5.0 risk falling behind.

6.2. Future Research Directions

The excellent thing is that, despite the difficulties, there are more possibilities to encourage businesses to enforce Industry 5.0.

- The planned maintenance now has a better overview. It makes reference to predictive preservation, as compared to the previously used preventive preservation. Smart detectors, IoT gadgets, and customized software assist in monitoring and predicting potential failures in real-time. Only machines that are likely to fail will be halted for maintenance.
- Industrial production in Industry 5.0 guarantees to use of resources effectively, adapting to current demand. Human–machine collaborative efforts result in adaptable marketing strategies. As a result, waste and overproduction could be reduced or eliminated entirely. Domestic manufacturing and creating new jobs would also assist in maintaining the regional economy.
- In an ironic twist, sophisticated technology returns individuals to the center of manufacturing. Individuals can now focus on creativity and solutions while a cooperative robot performs repetitive, even hazardous things. Such abilities result in higher productivity, particularly when people are inspired by their task and the final outcome.

- Smart motion detectors and customized software provide real-time and prescriptive climate, moisture content, heating rate, and power consumption walkthroughs. This is incredibly beneficial for farms that rely heavily on seasonal changes. Recognizing what to anticipate and where to respond can save money and increase output.
- Using current action, intelligent and connected machinery, customized software, machine learning, and automation systems can predict efficiency. This is what gives processes adaptability; they can be adapted based on specific parameters to prevent losses.

7. Conclusions

This wave of industrialization is concerned with human–machine communication in order to make tasks simpler and more efficient. Customizability is taken to the next level in Industry 5.0. Industry 5.0 is being used more effectively to meet highly personalized requirement and to construct a virtual experience, sophisticated computer systems, and computing infrastructure. Industry 5.0 is the optimum solution for the incorporation of big data, AI, the IoT, cloud services, collaborative robots (COBOT), innovative thinking, and imagination. Industry 5.0 is anticipated to generate higher-value jobs that allow for more freedom in design thinking and creativity. It contributes to higher productivity growth and more opportunities for customer personalization. On the other hand, because of the highly industrial automation processes, developing a talented working population is a massive task. Because of interconnectivity and the utilization of standard network architectures, there is an enhanced cyber security risk in crucial industrial systems and production lines at Industry 5.0. Although Industry 5.0 gives robots more autonomy, essential and moral decisions are still made by humans. Ultimately, Industry 5.0 is predicted to change manufacturing systems and processes by allowing cooperation and collaboration between humans and machines to provide personalized products to consumers. Industry 5.0 seems to have the possibility of working in tandem with many government initiatives and programs to position Saudi Arabia as a leader in smart and mutually supportive manufacturing techniques. This paper provided a concise summary of how Industry 5.0's technological innovations might be used. Advanced technologies are highlighted for their advantages. It is necessary to assess the difficulties and detriments of implementing such technologies, particularly Internet access, device and network communication security, memory space needs, governmental laws, customer satisfaction, and most important expenses.

It is possible to determine future research orientations and forecast how Industry 5.0 would affect the industrial setting in the coming decades by looking at the information that has been offered. The development of initiatives to promote the humanization of the digital industry should constitute the focus of further study. It should be emphasized that the findings of this research could change if the number of abstracts utilized for research increases, as well as if the data and services utilized for data extraction are expanded. In a subsequent study, it is anticipated that a thorough analysis, as well as the incorporation of information crawling methods, would offer a clearer understanding of what Industry 5.0 is and the way it is viewed by the scientific community.

Funding: This research received no external funding.

Data Availability Statement: The authors confirm that the data supporting the findings of this study are available within the article.

Conflicts of Interest: The author declares no conflict of interest.

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