SpringerBriefs in Applied Sciences and Technology
Computational Intelligence

Soumi Majumder · Nilanjan Dey

Metaverse for Industry 5.0

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Metaverse for Industry 5.0

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ISSN 2191-530X ISSN 2191-5318 (electronic)
SpringerBriefs in Applied Sciences and Technology
ISSN 2625-3704 ISSN 2625-3712 (electronic)
SpringerBriefs in Computational Intelligence
ISBN 978-981-97-2454-3 ISBN 978-981-97-2455-0 (eBook)
https://doi.org/10.1007/978-981-97-2455-0

Preface

This book provides a thorough overview of the metaverse as it appears in Industry 5.0. The concept of the Metaverse is in line with Web 4.0, as shown in Industry 5.0. This is a digital ecosystem where organizations and individuals collaborate in a human-centric manner. As a result, it aids in creating personalized value for businesses. This virtual universe, which connects numerous interrelated worlds, enables real-time interactions between users and computer-generated environments. The goal of Industry 5.0's Metaverse is to promote innovation while enhancing performance, effectiveness, and general wellbeing. The main metaverse elements include artificial intelligence (AI), virtual reality (VR), augmented reality (AR), mixed reality (MR), and the Internet of Things (IoT), which provide customized and value-driven solutions. This book investigates the concept of the Metaverse in the context of Industry 5.0, highlighting its definition, evolution, benefits, drawbacks, technological advancement, challenges, opportunities, ethical issues, and integration into various sectors such as healthcare, construction, manufacturing, and others. The book reveals the following areas: HR in the metaverse—the progress needed to transform HR; the benefits of the metaverse for HR; the maximizing HR potential in the metaverse vs its limitations and challenges; people and machines in harmony; the relationship between the metaverse and industry 5.0; the technologies involved in the industrial metaverse; the motivation behind the integration of the metaverse with Industry 5.0; Web2 to Web3—the changing face of digital privacy; the challenges facing cybersecurity in the metaverse; the industrial metaverse—the transforming businesses: real-world use cases; and the potential of the metaverse in manufacturing, construction and healthcare sector. Change is inevitable, and with the changing trends of the market, companies must adopt newer versions of methodologies and make updates in every function of businesses so that they can enjoy a large share of productivity and profitability. To be competitive and sustained in market adaptation, the changing face of business is the prime particular.

The main objective of this book is to increase organizational efficiency by emphasizing the best modern methods in the functional areas of a business. The intended audience of this book includes academicians, researchers, research scholars, and

industry people who stand to benefit significantly from its contents. Business management students (undergraduate and postgraduate) and engineering students who are interested in producing new products, services, concepts, and potential solutions through metaverse technology are also target audiences. The content applies to the business leaders who bring changes and confront challenges in every sphere of action.

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Chapter 1
Introduction

Metaverse is a common topic among human resource leaders who engage in virtual conversations during breaks in the present. People are curious about its meaning and how it will affect various aspects of life and business. However, doubts have arisen about the feasibility of Metaverse since Meta, the parent company of Facebook, recently laid off employees after heavily investing in it. The term "metaverse" is vague, making it difficult to understand, similar to how people talked about the Internet in the 1970s. Metaverse technology is not a specific technology but rather a shift in how we interact with technology. It is part of the development toward Web 3.0, which creates a new version of the Worldwide Web. Essentially, Metaverse is a more interactive version of existing social networking platforms that can include virtual and augmented reality, but it is not necessary for them to participate [1]. Any space with virtual world characteristics, such as Fortnite, that can be accessed through different devices might qualify as a Metaverse. The metaverse is a digital marketplace where people are able to participate in the development, purchase, or sales of goods, but this does not depend on Fortnite. The metaverse comparison is similar to comparing Google with the Internet, Fortnite being just one aspect of this metaverse, and other companies are already investing in it, as evidenced by Facebook's recent meta-rebranding. The metaverse is a virtual space in which humans are able to interact and have contact with one another without geographical constraints. It is a way for people around the world to take part in events, work, travel, and even be married. As more people are working remotely, this form of social networking is becoming increasingly advanced, and some companies are experimenting with metaverse possibilities for remote collaboration. However, to guarantee its success, it is crucial that adequate safeguards are established. There are important opportunities for individuals and businesses in this metaverse, but they need to be able to accommodate both physical and digital experiences [2]. Digital experiences are playing a growing role in society and professional life, even though younger people are accustomed to using metaverses part time. The use of metaverses will fundamentally change how we work, which could have implications for human resources professionals.

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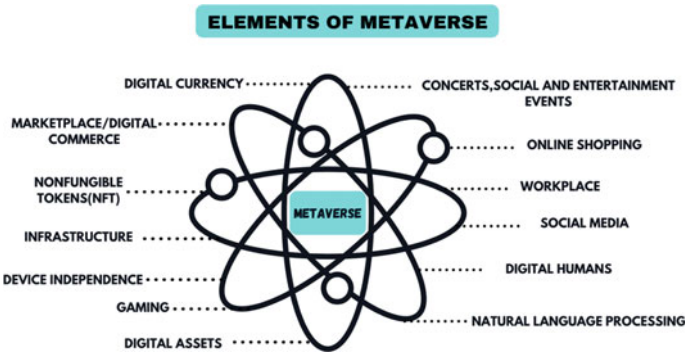

Fig. 1.1 Elements of metaverse

By being at the forefront of this transformation, these professionals need to ensure inclusiveness and a sense of well-being in an online environment. To achieve this, it would be necessary to build a metaverse that encourages cooperation, productivity and good behavior. HR will require expanding new policies and educating leaders on how to administer and direct in this new environment. The metaverse can also be advantageous for employee commitment, especially for those who work from home. As the metaverse continues to develop, it is flattering an immersive dais that can be utilized for various applications, such as entertainment, education, training, and collaboration. While the metaverse is not without its challenges—notably with respect to data defense and high expenses—it could reform our workplaces. HR will need to turn this expansion to ensure that this new prospect of work allows even more communities to contribute distantly and do so in a more reliable way. The standard of inclusivity is serious to the growth of the metaverse—the metaverse is still in its early on days, and future stakeholders desire it to be secure and proficient for everyone.

Figure 1.1 shows the elements of the metaverse. The elements are digital currency, concerts, social, and entertainment events, online shopping, digital workplaces, social media, digital humans, natural language processing (NLP), digital assets, gaming, device independence, infrastructure, nonfungible tokens (NFT), and the digital marketplace.

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Chapter 2
HR in the Metaverse—The Progress Needed for the Metaverse to Transform HR

The HR industry in the metaverse is not yet fully developed and is unstable, which makes immediate adoption expensive. Equipping each employee with a virtual reality or VR headset could cost companies anywhere from $600 to $1000 per employee. Furthermore, companies may need to upgrade their employees' broadband subscriptions to support the technology and provide training, which can add up to a significant expense, especially during this uncertain period of metaverse development [1]. As a result, companies should be cautious in adopting metaverse HR, particularly because most organizations already have between six and fifteen HR solutions in place.

Despite that caution, the potential practical use and opportunities presented by metaverses in their organizations must be taken into account by HR leaders. The metaverse, beyond the realm of video games, is a digital or virtual reality that has the potential to transform our workplaces. Metaverse technologies are being increasingly used by major software companies, including Microsoft, Meta, Google, and Apple, with a number of investments addressing the need for collaboration at work. VR technology, such as Meta's Horizon workspace or Microsoft Mesh, enables teams to cooperate in a common environment regardless of where they are located [2]. The necessary resources and expertise to implement this change are in the hands of HR professionals, who must ensure that future employment is based on people's needs. As enterprise virtual reality is projected to increase from $829 in 2018 to $4.26 by 2023, Bill Gates believes that we will make a transition away from Zoom calls and toward newer 3D versions. In business, the metaverse is also gaining ground and provides human resources with greater leadership and ownership responsibilities.

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2.1 Equity in a New, Digital Work Environment

It is possible to create a more equitable working environment through the use of a metaverse workspace, but the risk of exacerbating existing inequalities caused by globalization is also present [3]. Human resource experts will encounter a wide range of obstacles, including the possibility of dividing workers who are experienced in technology versus those who have no experience and unequal access to Internet speed at different locations as well as the need to ensure an effective work environment that can provide for safety, health, and dignity. However, it is the workplace that needs to take a closer look at diversity, inclusion and belonging, although metaverse involves communication through avatars. To avoid undesirable behavior, e.g., harassment, abuse or bullying, human resources professionals must decide how to manage the online environment. Identifying such behavior in the virtual realm, integrating these concepts into workplace policies, and instructing employees about unacceptable conduct in the metaverse are all critical measures.

2.2 Creating a Productive, Collaborative Workplace

It is believed that the design of a space can impact its usage. Round tables are capable of encouraging conversation, while a rectangular table can give power to the boss. The metaverse provides an opportunity to create a work environment in which cooperation and innovation are encouraged without physical constraints. Remote employees can, on a metaverse level, engage with each other more directly and personally by bridging the gap between physical and digital offices [4]. However, it is up to HR departments to incorporate the metaverse into organizations in a way that enhances business performance. The essential blueprint of the metaverse allows for the establishment of spaces that promote association, novelty, administrative, diversion, or a combination of these elements, going beyond the traditional office setting. HR departments will play a central role in serving companies. Departments, management, and teams use this technology effectively. They will need to set up new policies for fusion work to ensure vigorous metaverse exertion practices and coach leaders on running in these new surroundings.

2.3 With the Metaverse, Hiring Will Likely Change

The metaverse can cause significant changes in HR procedures and has a positive effect on the work of HR experts [5]. Organizations such as Samsung, Hyundai, and PwC have already tested the use of the metaverse to recruit, onboard, and interview potential employees. Moreover, the metaverse can assist in remote working by offering immersive 3D training and simulations. Although data protection and high

expenses pose challenges, the metaverse has the potential to revolutionize workplaces, and HR professionals need to direct its development to ensure genuine remote participation.

2.4 Giving Potential Candidates the Best Experience Virtually

The emergence of the metaverse is bringing about a noticeable change in the business environment, with companies investing heavily in their technological infrastructure. For instance, virtual recruitment fairs are becoming increasingly popular, allowing job seekers to interact with potential employers and gain an understanding of the company's culture. Many individuals are optimistic that businesses will offer more virtual tours, such as the one created by Deloitte in collaboration with Blend Media, which can be accessed via a desktop or immersive headsets, providing an engaging and interactive experience. Deloitte's 360 Tour is a great illustration of how businesses can create captivating and informative tours, thereby helping candidates feel more at ease and confident about their new workplace [6].

2.5 Creating an Immersive and Hands-Free Work Structure

The organization of work and teams is expected to undergo a substantial change in the metaverse workplace. Over the past two years, there has been a movement toward a hybrid work structure in which meetings and collaborations occur on technology platforms. Conversely, group conversations and collaborations will become more immersive, with interactions encouraged using hands-free devices and avatars instead of laptops and smartphones. For instance, Meta, formerly known as Facebook, has created Horizon Workrooms to transform remote work collaboration. The workplace is a virtual meeting where colleagues can work together from any location. Employees can participate in a meeting as an avatar or join a virtual room by video calling through a computer. Workrooms enable employees to collaborate on ideas using virtual keyboards and bring their computers and keyboards into VR to work together [7].

2.6 Better and Faster Learning Experience

The workforce needs to be educated, which means that human resources will need to be invested in change management training if we want to get ahead of the metaverse. New technologies will need to be introduced in the workplace for the integration of this metaverse, and human resources must adapt their virtual management strategies if they train employees on how to take advantage of that software. To do so, HR can create an interactive and immersive learning experience from virtual reality that improves employee performance by 70%. This method is facilitated by companies such as Make Real and Vodafone, which have successfully implemented it to provide training on real-life scenarios [8]. These virtual reality training experiences are not only a means for remote learning and the development of knowledge but also cut the time taken to learn by 96%.

2.7 Creating a Safe and Inclusive Work Environment

For organizations to succeed, they must have a safe and pleasant work environment; however, this can prove challenging because of the growing number of remote workers. There's a solution to this, although, in Metaverse. Collaborating, communicating and sharing ideas creates a virtual space for team members and employers. To foster a sense of community and assist employers in the creation of an open, equitable working environment, Metaverse offers different tools and features.

2.8 Creating a Productive and Collaborative Working Environment

It is essential for organizations to develop a working environment conducive to the exchange of ideas and activities to increase efficiency and productivity. Given the increasing frequency of remote work, companies are increasingly looking for new and innovative ways to connect their physical and virtual teams. The HR solution within the metaverse framework is a game changer, fostering cooperation and increasing productivity. The Metaverse is a secure platform that allows teams to work together on tasks and projects. Its wide set of tools makes it easy for users to create an immersive environment that facilitates communication and collaboration between remote teams in the form of 3D spatial audio, video chat or voice commands [9].

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Chapter 3
Benefits of the Metaverse for HR

Luckily, by applying the metaverse, human resource departments can restore corporate culture and connect with their employees. It is an advanced communication platform that will change how teams work, thereby changing the way they maintain their brand culture, promoting productivity and satisfaction among team members and managing HR processes. The metaverse is not just a digital space for sharing or consuming content; it serves the purpose of deliberately creating experiences [1]. This includes cutting-edge technologies that enable humans to see, feel, touch and eventually taste it in a 3D environment through the convergence of augmented and virtual reality, artificial intelligence, blockchains and 5G networks. HR teams need the right technology if they are to be metaverse to their organization. By changing the way employees work, interact and communicate with their employers, the metaverse will have a profound impact on human resources. There are a number of ways that virtual and augmented reality can change human resources, e.g., offering immersive training experiences enabling employees to practice new skills in simulated environments while improving collaboration among team members, which will make communicating and resolving issues with each other more comfortable. In addition, the metaverse provides a way for workers to make contacts and establish bonds at online conferences or events.

3.1 VR Recruitment

By making it easier for job candidates to understand the conditions of work and the working environment, the metaverse may contribute to a better hiring process. To make the candidate's view of a task more interesting and meaningful, it may be appropriate to use virtual and augmented reality technologies so that their suitability for this task can be easily assessed. In addition, interviews and evaluations could be carried out using virtual reality with the aim of creating an open recruitment

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https://doi.org/10.1007/978-981-97-2455-0_3

process that identifies the most suitable candidates. This approach may also produce a positive initial impression and alleviate feelings of isolation due to distance work. In the field of virtual reality recruitment, human resources can leverage Metaverse for candidates to be able to participate in an immersive job preview, virtual interviews and simulation that provide a realistic experience of company culture and work environment.

3.2 Onboarding

To familiarize new employees with the company and their tasks, regardless of their location, the Metaverse can offer a more immersive and interactive way of doing so. For instance, employees can view the entire office from a 360° perspective and participate in activities such as face-to-face meetings with important team members and departments using interactive avatars while they practice core job tasks in simulated environments through virtual onboarding programs [2]. It could also give new staff a greater sense of belonging to the company, even if they are working from remote locations.

3.3 Performance Management

By providing accurate and impartial evaluations of employee performance, the metaverse offers a way to better manage performance. Objective and data-driven assessments can be achieved through the use of sensors and data analysis. This can result in a more comprehensive and unbiased appraisal of the performance of employees, which will lead to fair and objective evaluations [3]. Moreover, to facilitate the identification of areas where improvements can be made and provide a focus on training and development opportunities, it is possible for firms to make simulations that assess employees' skills and knowledge in a real environment.

3.4 Compensation and Benefits

By providing staff with more active and interactive interactions, the metaverse can improve compensation and benefit schemes. Companies can create a simulation enabling workers to exchange benefits with other providers and simplify their understanding of available entitlements, giving them insight into the optimal use of provider packages by using virtual and augmented reality.

3.5 Succession Planning

To develop effective leaders, organizations must select the best talent of their staff and evaluate their potential as leaders. Using simulation in the Metaverse, which can serve as a practical laboratory for practice and feedback, is one way to enhance leadership skills. The use of augmented reality technology could also be useful in ensuring constant and timely assistance for staff as they develop their leadership capabilities, which would allow them to evolve continuously [4]. In addition, when experienced employees leave a company, enhanced reality could assist in the transfer of knowledge. With Metaverse, these experienced employees are able to record their knowledge and experience in a dynamic and engaging manner so that it will be possible for them to pass this information on to others.

3.6 Time and Absence

Due to the importance of monitoring employees' working time and attendance, HR departments heavily rely on this task. To speed up and increase the tracking time, metaverse technology can be useful. To record their working hours, employees may use virtual avatars that do not require a physical time card. Moreover, the management of real-time scheduling and change schedules can be facilitated by virtual reality technology. The metaverse can facilitate requests for time off and absence reports by making it possible to offer virtual portals. To ensure that this organization continues to be sufficiently staffed, managers have the option of approving or rejecting requests and making necessary changes in their schedules at any time.

3.7 Cost Analysis for Implementation

In general, the cost of creating a metaverse environment for human resource management business functions can be significantly greater when hardware and software are needed to create and run virtual workspace [5]. However, in the longer term, it is estimated that a metaverse environment can save costs by eliminating the need for physically located office space, road transport and any additional expenses to maintain an ordinary workplace. In addition, it is thought that this metaverse environment will increase productivity, communication and cooperation. It is also possible that the use of technologies, such as virtual and augmented reality, can make it easier for employees to benefit from information and resources, which will help them perform their duties in more effective ways [6]. The overall costs of implementation may differ according to the organization's specific needs and objectives. Therefore, organizations are advised to make use of a cost benefit analysis to estimate the possible return on investment for creating metaverse business functions related to human resources.

3.8 Interactive VR Employee Training Programs

VR technology is used in the Human Resources Metaverse to allow employees to interact with training programs. They will be given the opportunity to take part in simulations that closely reproduce real-life scenarios, thus enabling them to practice and improve their skills in customer service, leadership development, and hazardous environment training [7].

3.9 Virtual Team-Building

Virtual team-building activities, where employees can collaborate and interact with each other on team-specific tasks or through social interactions in interactive virtual environments, can be facilitated through the use of this metaverse. This may lead to a feeling of comradeship and teamwork between employees.

3.9.1 Remote Work and Virtual Offices

The combination of virtual reality (VR) and human resources (HR) can enhance remote work by creating virtual workspaces and offices where employees can collaborate, communicate, and conduct meetings from anywhere, resulting in a virtual work environment that boosts productivity and engagement. With the implementation of metaverse HR, organizations can improve their talent acquisition, training, team development and remote working capabilities, leading to better employee involvement, performance and overall organizational success.

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Chapter 4
Maximizing HR Potential in the Metaverse Versus Limitations and Challenges

The Metaverse is a virtual space for which users can use implicit and amplified authenticity devices, providing them with an alternative world of interaction. This is a space where businesses can radically transform the way they operate, allowing employees from all over the country to work remotely and collaborate with each other easily. To ensure that workers have access to the required virtual reality devices and training, these changes pose challenges for professional HR managers who must adjust to such a new environment. To create immersive learning programs that replicate complex situations and to provide trainees and workers with practical experience in an environment under strict supervision, human resources professionals can use the metaverse. This approach can be an effective tool for developing the skills needed for the future of human resources. The metaverse offers HR professionals an opportunity to revolutionize the recruitment process, which could be beneficial for them. Virtual recruitment enables applicants to explore businesses they are interested in without visiting their office, thereby enabling them to decide whether that company would be a good fit. Virtual recruitment is already being tested by PwC and Samsung, resulting in considerable success. Beyond the recruitment process, the metaverse's influence is felt in other areas. Virtual reality can be used by human resources professionals to create virtual orientation courses for employees in which they are introduced to the company's culture, values and working environment within individual teams or departments.

The benefits of a heterogeneous environment can be enjoyed by companies, but there are also drawbacks such as technological difficulties, accessibility barriers, security and privacy risks, restricted applicability or cultural resistance. Due to the need for modern technical infrastructure and expertise, implementing a multiverse environment may be costly and time intensive. It may not be possible for some staff members who need hardware or software to use it, and people with disabilities may face additional difficulties. In addition, it is not possible to perform all types of work effectively in a virtual environment, and certain workers prefer the familiarity or social interaction of an actual office. The impact of Industry 4.0, or the 4th Industrial

S. Majumder and N. Dey, *Metaverse for Industry 5.0*,
SpringerBriefs in Computational Intelligence,
https://doi.org/10.1007/978-981-97-2455-0_4

Revolution, which has already had a significant effect on economies around the world and on how businesses are operating in different sectors, is still to come. It enables real-time data exchanges, process optimization, cost lowering and quality improvement to be shared between companies. To ensure that communities can obtain the full benefit of their skills and improve the protection, competence and significance of work, industrial 5.0 is being developed with a focus on associations among humans and technology. In this context, new ways of supporting and complementing people will need to be developed through more sophisticated technologies such as AI and robotics. The development of Industry 5.0 has created great potential for business organizations, and it is essential to maintain a close view of its advancement [1, 2].

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Chapter 5
People and Machines in Harmony

Industry 4.0 refers to the amalgamation of mechanization and data swaps in manufacturing. Industry 5.0 is a novel idea that focuses on mutual associations between humans and machines. The objective is to generate sustainable goods and services.

It is anticipated that the shift from Industry 4.0 to Industry 5.0 will bring about various technological advancements (Table 5.1). Companies are projected to increasingly depend on self-learning systems to automate and enhance their processes. Furthermore, the collaboration between humans and machines will become more efficient, aided by the availability of advanced robotic systems and AI. This will enable robots to handle physically demanding or hazardous tasks, while humans will act as experts to make complex decisions and supervise tasks. Moreover, the use of augmented reality is likely to increase, making industrial maintenance and work instructions more interactive and user friendly. These advancements will aid companies in adapting more rapidly to changing market conditions and accelerating the development of innovative products.

5.1 Relationship Between Industry 4.0 and Industry 5.0

In essence, Industry 5.0 is not intended to replace Industry 4.0 but rather intended to supplement and leverage its strengths. The main goal is to improve the flexibility and preparedness of companies while also fostering greater connectivity and cooperation throughout the entire value chain, encompassing customers, suppliers, and partners [1]. It is imperative to prioritize data security in this new technological environment. Industry 5.0 offers a wealth of possibilities for industries to prosper in a world that is becoming more digitized and to seek new markets.

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https://doi.org/10.1007/978-981-97-2455-0_5

Table. 5.1 Relationships between industries 4.0 and 5.0

Features	Industry 4.0	Industry 5.0
Focus	The use of automation and technology in manufacturing and production to enhance efficiency	Development of manufacturing processes that are sustainable and eco-friendly
Emphasis	The act of utilizing data and analytics to enhance processes and make them more efficient	The significance of human communication and teamwork
Competencies	IoT, AI, ML for task and decision automation	The merging of sophisticated technologies with human abilities and ingenuity
Use	Robotic and automated devices designed specifically for tasks that are monotonous, dangerous, or require a high degree of accuracy	The acquisition of novel abilities and capabilities by human employees
Factories	Factories equipped with intelligent technology to optimize their own production processes	A production system that is both integrated and flexible, allowing for customization based on customer needs and adaptation to changing market trends
Technologies	Digital twins and simulation tools for production process optimization	Utilizing digital replicas and simulation technology to improve manufacturing processes
Efficiency	Utilizing digital replicas and simulation technology to improve manufacturing processes	To minimize waste and lessen the impact on the environment, the focus is on prioritizing sustainability and ethical production practices

5.1.1 Automation

Industry 4.0 and forthcoming Industry 5.0 share a common emphasis on automation as a key priority. Through the use of connected systems and robotics, many manual tasks can be automated, resulting in time savings, cost reductions, and improved output quality [2]. Automation is not restricted to direct production but also applies to the entire production process, resulting in optimization. For instance, it is possible to automatically control the stock level and predict maintenance so that production can be prevented from being interrupted.

5.1.2 Artificial Intelligence

The function of artificial intelligence (AI) will be crucial in Industry 5.0. Furthermore, its value is not only to support human labor but also to improve decision-making processes in organizations. For example, self-learning algorithms can be used to optimize manufacturing processes and improve the quality of products [3]. Predictive maintenance, where machines and facilities are continuously maintained

and handled, can also greatly utilize AI. Machine errors can be identified quickly, and necessary actions can be obtained through the analysis of data and the use of machine learning tools and techniques. In the near future, it is likely that artificial intelligence will play an increasingly crucial role in industries and companies. We should be aware of its potential applications.

5.1.3 Sensors, Networking, and Intelligent Manufacturing Technology

To prepare for Industry 5.0 and remain competitive in changing markets, companies can use digital technology and networking in their production processes. Automation, which uses robots and networked systems, plays a crucial role in this adaptation because it streamlines production and makes manual work more efficient. To prepare for Industry 5.0 and remain competitive in a changing market, companies can use digital technology and networking in their production processes [4]. Automation through robots and networked systems will play a vital role in this adaptation, as it makes production more efficient and manual work more efficient. Artificial intelligence (AI) is also increasingly important because it improves communication between humans and machines and facilitates decision-making. In addition, sensors and smart manufacturing technology facilitate collaboration between suppliers and customers and promote efficient work throughout the value chain. Companies that invest in these improvements can gain a competitive advantage.

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Chapter 6
Industry 5.0 and Employee Satisfaction

Through Industry 5.0, businesses have significant opportunities to make their operations more efficient, cut costs and improve the quality of products. The production process can be optimized to achieve greater effectiveness and productivity through the use of advanced sensors and connected systems [1]. The use of artificial intelligence and machine learning techniques enables early detection of issues and prompt corrective actions. One of the key benefits is enhanced workforce management. Companies can increase productivity without the need to hire additional staff by substituting manual processes with automation. This approach fosters an appealing work environment and promotes employee engagement. Additionally, sensors can provide real-time insights to improve working conditions and prevent hazardous situations [2]. As a result, Industry 5.0 has advantages for both companies and workers. An innovative production model that relies on digital technologies fosters resilience and sustainability in the workplace. Organizations that are already taking steps to prepare for and invest in these advancements are establishing a solid foundation for long-term success and competitive edge. Figure 6.1 depicts the three pillars of Industry 5.0: (i) the human-centric approach, (ii) sustainability and (iii) resilience. The human-centric approach establishes diversity and empowerment with talent management. The sustainable approach is concerned with leading actions of sustainability and respecting planetary boundaries, and resilience involves adaptive technologies.

6.1 Enabling Technologies

Enabling technologies are advanced technologies that aid in personalized interactions between humans and machines, leveraging their individual strengths. They comprise bioinspired technologies that use smart materials with embedded sensors that are both recyclable and provide additional features. Digital twins and simulation technologies enable the modelling of entire systems, whereas data broadcast,

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https://doi.org/10.1007/978-981-97-2455-0_6

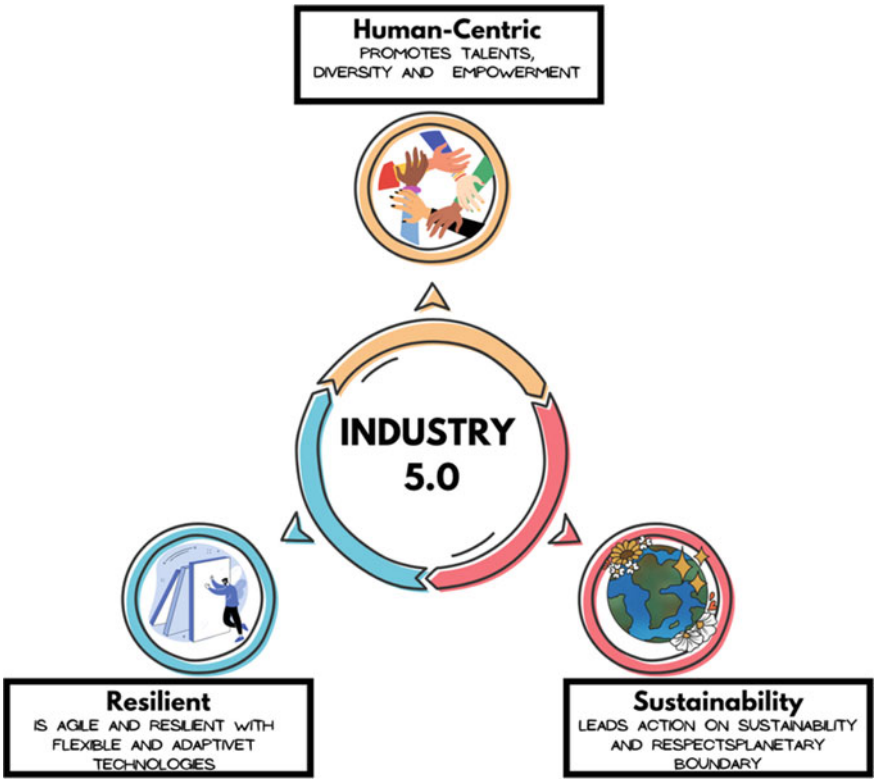

Fig. 6.1 Industry 5.0 and employee satisfaction

storage space and psychoanalysis technologies facilitate the administration of data and system interoperability. Artificial intelligence plays an essential role in detecting causalities in intricate, vibrant systems, resulting in practical insights.

Additionally, the Industry 5.0 revolution encompasses technology for power effectiveness, renewability, storage and independence. Notably, Industry 5.0 is not exclusively technology-driven but rather a value-driven initiative intended for dynamic technological conversion with an exact purpose. Figure 6.2 presents the value cohort with enabling technologies [3]. It consists of man–machine contact through a digital twin and imitation. Value generation has focused on the financial system, ecosystem and humanity that can enclose strategy [4].

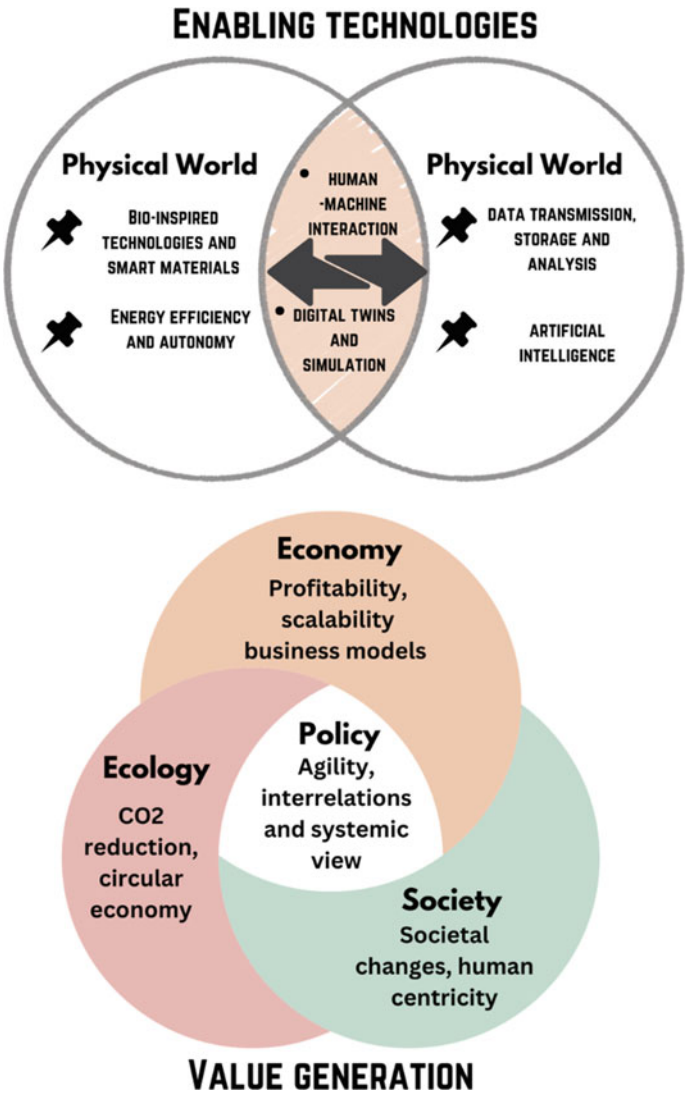

Fig. 6.2 Value generation with enabling technologies

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Chapter 7
Relationship Between Metaverse Countries and Industry 5.0

The advancement of technology and increased automation in everyday activities has led to a growing interest in the potential of living in the metaverse. During the fifth industrial revolution, machines and humans worked together to increase the efficiency and productivity of the manufacturing sector. The industrial metaverse, which is part of Industry 5.0, offers a more immersive experience and better communication through the integration of various technologies, such as virtual and augmented reality, AI, blockchain, 3D modeling, digital twins, edge computing, and 6G networks. This study provides a comprehensive overview of industrial metaverse applications, including Society 5.0, education, healthcare, transportation, supply chain management and agriculture. The report also explores research projects that showcase the conceptualization and implementation of the industrial metaverse. This study highlights challenges in creating industrial metaverse solutions, possible solutions and future research directions. Utilizing Industry 5.0 applications demands timely decision-making, and hence, a platform that enables human experts to immerse themselves in the situation prior to making any decisions is essential. This platform has the potential to minimize damage to property and life and enhance the quality of products for customers [1]. The metaverse is a perfect solution to bridge this gap by integrating video, augmented reality (AR) and virtual reality (VR) technologies to create an alternate world that appears hyperreal, where users can connect, work and play virtually. Microsoft and Facebook have recently promoted this technology, with Facebook investing heavily in it. Facebook anticipates that the metaverse will replace the internet, creating an even more immersive and embodied experience for users. The metaverse has the potential to transform Industry 5.0 by enabling professionals to monitor manufacturing progress virtually, doctors to treat patients in a digital environment and governments to plan infrastructure in smart cities. In addition, users can create digital assets, experience products and shop in the metaverse [2, 3]. Recently, several surveys have been conducted by researchers on how Industry 5.0, and the metaverse have the potential to cause significant changes in lifestyles and industries. One study delved into the enabling technologies for Industry 5.0, such as IoT, AI, AR,

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VR, big data analytics, edge computing and 5G, and their applications in healthcare, SCM, smart education and cloud manufacturing. Another study focused on human–robot collaboration in healthcare to enhance patient outcomes. A few other studies have explored the impact of Industry 5.0 on engineering education, the pharmaceutical industry and human-centric manufacturing. Similarly, studies on the metaverse investigated the hardware, connectivity, computer approaches and user participation needed to make it a viable and functional technology. However, few studies have examined the integration of these two technologies. This review aims to provide a comprehensive discussion on the applications of the metaverse for Industry 5.0.

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Chapter 8
The Technologies Involved in the Industrial Metaverse

Hailing from the Eastern Region has delved into the intricacies of the cutting-edge technologies employed in the industrial metaverse, a virtual realm utilized by businesses to provide services. These technologies, known as Meta-X according to EqualOcean Intelligence, encompass an array of tools and concepts such as mixed reality, computer engines, digital twins, AIoT, computer graphics, and blockchain. Mixed reality has been applied in complex industrial scenarios, facilitating swift operations, remote collaboration, real-time equipment diagnosis, and industrial model design [1]. The computing engine acts as a computing resource for rapid tasks. Digital twins enable the creation of digital replicas not only for individual machines but also for entire factories and production chains, encompassing the entire economic system. The AIoT combines artificial intelligence and the Internet of Things to enhance the management of nearby devices and machines. Computer graphics is employed to construct 3D models for virtual interactions within the industrial metaverse. Finally, blockchain, a decentralized technology, revolutionizes transaction management by cultivating trust among all parties involved in the production chain through its immutable and transparent attributes. Figure 8.1 is a pictorial representation of the technologies involved in the industrial metaverse. A few of them are described below.

8.1 Virtual Reality

VR refers to a digitally created three-dimensional environment that completely engulfs users in a virtual realm. Users can engage with virtual objects through various techniques by utilizing a VR headset or helmet. While VR is just one part of the metaverse, it is an integral component that offers a virtual domain where multiple users can interact at the same time. In the context of Industry 5.0, the metaverse

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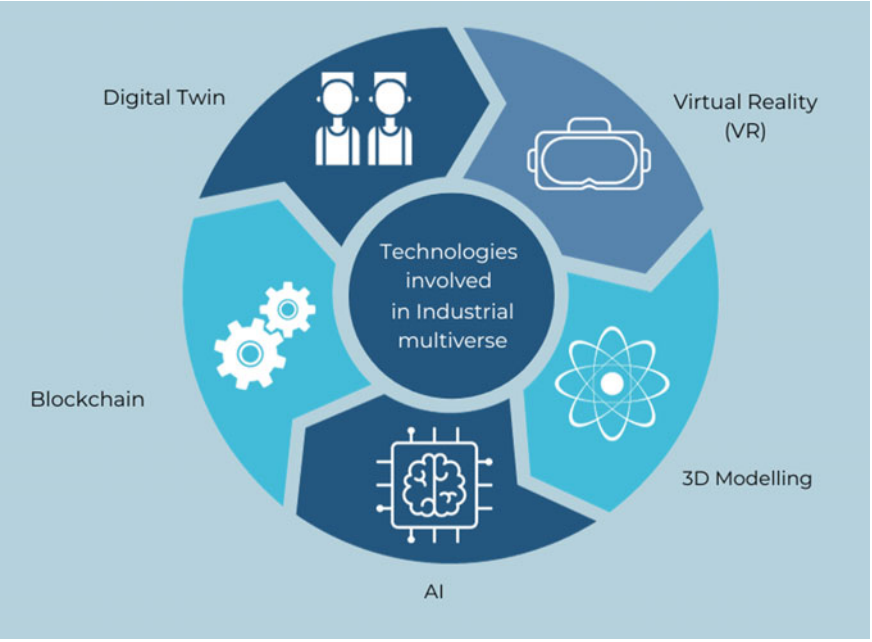

Fig. 8.1 Technologies involved in industrial metaverse

will revolutionize the way humans experience virtual reality, fostering collaboration between individuals and machines to develop tailored products [2]. By bridging the gap between reality and the virtual world, VR empowers users to personalize products using virtual tools.

8.2 3D Modeling

3D modeling is the process of creating a three-dimensional representation of an object or surface, which allows for the creation of virtual environments. The metaverse, on the other hand, is a shared, interactive, immersive and collaborative virtual 3D environment. Conversely, 3D modeling is essential for building avatars and spaces that enable users to interact and engage in activities within a virtual world. The metaverse relies heavily on 3D images and visualization. In Industry 5.0, advancements in 3D modeling will play a significant role in visualizing the entire process of transforming raw materials into finished products. Through cutting-edge technologies, the metaverse will facilitate personalized mass.

8.3 Artificial Intelligence

Artificial intelligence (AI) refers to the ability of computers or robots to perform tasks similar to those of humans [3]. AI can contribute to the metaverse in various ways, including content analysis, supervised speech processing and computer vision. For example, it can analyse user images to create more realistic avatars, generate AI-enabled nonplaying characters that respond to avatar actions in a virtual reality world, enable seamless and multilingual communication in the metaverse through natural language understanding and generation and autonomously expand the metaverse without human intervention. Additionally, AI can enhance human–computer interactions within the metaverse.

8.4 Digital Twin

A "digital twin" does not refer to an inactive replica. It is a customized, unique, constantly changing digital or virtual representation of a real system. It is dynamic in that any alterations to the physical system, including upgrades, damage, aging and repairs, also affect the digital counterpart. The Metaverse has the potential to revolutionize our digital lives in a world where everything is moving increasingly towards being digital and virtual. People can feel that the genuine and vivid sensations of the digital world retreat to this point of intersection between the actual and virtual worlds [4]. In other words, metaverse may be described as the internet's future. The Metaverse, the next development in online and social media, moves us closer to fully stimulating virtual reality through disruptive revolution. However, for the Metaverse to offer fully integrated, immersive and interesting 3D experiences, a digitalized representation of the real world is needed as a starting point. As a result, the discussion around the Metaverse becomes more heated. To provide new opportunities and experiences for digitally oriented customers, many organizations and enterprises are currently researching and expanding upon metaverse-based basics. Organizations may incorporate dimensionally accurate real-world environments into the metaverse virtual mirror world by implementing digital twins.

8.5 Blockchain

Blockchain also facilitates the metaverse to purpose as a gratis and open-source decentralized podium where users may produce apps and connect in online deals. The metaverse will present an easy-to-use border for decentralized wallets and interactions as open-source blockchain architecture. The decentralized metaverse system of implicit worlds and 3D environments was shaped using blockchain technology.

Anyone may produce their own virtual world or 3D surroundings using the trouble-free Metaverse structure. People can interrelate there in numerous parts of their lives. It incorporates a variety of platforms and websites that may be viewed using a solitary browser [5]. Users may generate avatars, interact with other metaverse users, and buy, sell and trade virtual things. The purpose of Metaverse is to offer an elastic, secure and accessible blockchain platform. It also places strong importance on the progress of digital property and elegant contracts. The Metaverse Digital Asset System (MDAS) allows users to produce and bring out their own unique digital assets, which may include anything precious, such as stocks, bonds or even incentive points. Elegant contracts are computer programs that may be used to separately adjust the transmission of digital possessions on the Metaverse blockchain.

The advancement of technology in Industry 5.0 is set to revolutionize the user experience through automation and personalization. By utilizing artificial intelligence techniques such as machine learning, deep learning and neural networks, as well as reinforcement learning and other algorithms, the collaboration between humans and machines will become more efficient, leading to increased productivity and mass customization of products. Augmented reality (AR) is a cutting-edge technology that allows users to immerse themselves in a virtual environment overlaid onto the real world. By superimposing virtual objects based on the user's perspective, AR enhances user interaction and provides realistic solutions with minimal hardware requirements. This technology paves the way for the development of the metaverse, a virtual ecosystem where users can interact with the internet and various applications such as virtual office spaces. AR object detection techniques further enhance the immersive experience within the metaverse by constructing a vibrant 3D environment.

Moreover, the metaverse integration of blockchain technology provides new opportunities for users to engage with the virtual world. Various industries, including tourism, education, entertainment, retail and engineering, can leverage the metaverse to enhance their offerings. In Industry 5.0, the focus is on mass customization and ultra-personalization, demanding the integration of technologies such as AR to facilitate collaboration between cognitive systems, robots and humans. AR bridges the gap between the virtual and physical worlds by overlaying data onto the physical environment [6, 7]. Technicians and workers can benefit from real-time guidance for machine maintenance, and digital management of workspaces can be achieved, ensuring a harmonious balance between businesses and manufacturing processes.

In 2008, Nakamoto Satoshi introduced the idea of blockchain in a white paper. A blockchain, also known as a distributed ledger, is composed of interconnected blocks. Each block is connected to the previous block through its header's hash value. In addition to the cryptographic hash, a block contains timestamp, nonce, and transaction data. To create and validate new blocks, all nodes must agree on a consensus process. The blockchain's advanced encoding system greatly facilitates data exchange within the metaverse. It ensures the security of sensitive information through authentication, access control and consensus methods [8]. Additionally, the blockchain provides a comprehensive audit trail, enabling individuals and organizations to verify all transactions. By integrating blockchain with the metaverse, the quality of data in the

metaverse will be enhanced. As users engage with various applications in Industry 5.0, sensitive information involving multiple parties will be exchanged. Therefore, users in Industry 5.0 require more control over their data to prevent unauthorized access. In this regard, the metaverse effectively supports Industry 5.0 by ensuring the integrity and transparency of information through blockchain transactions. This also ensures users' data privacy in Industry 5.0. The data stored in different applications of Industry 5.0 are very important, and attackers will try to exploit the storage [9]. A tampered with the stored data directly affects the outcomes of the applications, which may lead to unnecessary complications. "In contrast, the metaverse provides users with the opportunity to interact with organizations in a virtual environment, enabling them to personalize and customize products according to their preferences. To protect sensitive information, the blockchain utilizes a consensus mechanism that requires unanimous agreement from all participating nodes before any stored data can be altered. Moreover, the inclusion of 3D modeling enables the creation of realistic representations of objects and surfaces, contributing to the development of immersive 3D virtual worlds. Edge computing plays a crucial role in achieving seamless synchronization between the physical world and the metaverse, ensuring efficient transmission of immersive virtual experiences. Additionally, the application of AI enhances the intelligence of the virtual environment, significantly improving overall immersion. Finally, the implementation of blockchain technology strengthens data privacy and security within the metaverse through authentication, access control, and consensus methods".

The introduction of 6G technology within the Metaverse provides numerous benefits, including rapid speeds, minimal delays and energy efficiency. These characteristics enhance the connection between real-world objects and the metaverse, maximizing the potential of virtual reality [10, 11]. Augmented reality (AR) enriches the user's experience by overlaying computer-generated information onto their physical surroundings. Digital twins are particularly valuable in the maintenance sector, as they aid in the human comprehension of equipment and offer comprehensive insights into different components. The integration of blockchain technology ensures secure data storage in the context of Industry 5.0, making it impervious to attacks. In Industry 5.0, collaboration between humans and machines necessitates the secure transfer of data across various applications. For instance, in smart manufacturing, users may wish to customize a product and transmit relevant data to the manufacturer. However, there is a risk of unauthorized individuals tampering with these data during the exchange. To address this concern, Metaverse provides a virtual space where users can create their desired designs and securely share them with organizations using the advanced encoding system offered by blockchain technology. This integration guarantees data privacy, trust, and reliability in the exchange of shared information for Industry 5.0 and its users. The development of sixth-generation (6G) wireless communications technology is currently underway, serving as the successor to 5G. 6G boasts significantly faster speeds and builds upon the advancements of its predecessors. These networks will be more diverse and heterogeneous, supporting

technologies such as virtual reality (VR), augmented reality (AR), real-time communications, ubiquitous intelligence, and the Internet of Things (IoT) [12]. The characteristics of 6G networks make them indispensable for the metaverse, a collective shared space based on virtual reality. Taking advantage of its speed, low latency and low consumption, 6G enables seamless connections between the real world and the metaverse. This integration allows VR to reach its full potential and bridge the gap between the physical and virtual worlds. The integration of 6G networks into the metaverse will have a significant impact on Industry 5.0, the next phase of industrial development that emphasizes human–machine collaboration. The metaverse of technologies such as XR applications enables various applications, such as online stores, virtual meetings and virtual experiences of learning. 6G networks provide uninterrupted services, offering high-quality experiences and parallel working capabilities for Industry 5.0 users.

Edge computing plays a crucial role in enhancing communication and synchronization within the metaverse. By distributing processing tasks across the network, edge computing architecture improves the transmission of immersive virtual experiences and ensures faster data services for real-time decision-making. Its distributed structure also enhances network resilience and security [13]. Digital twins, which are digital representations of real-world entities or systems, play a vital role in bridging the physical and virtual worlds. In Industry 5.0, digital twins are used in the maintenance sector to enhance human understanding of equipment and facilitate better decision-making. By providing comprehensive information about machines, digital twins help reduce the need for repairs and support informed decision-making. Integrating digital twins with the metaverse empowers humans with valuable insights and supports decision-making in Industry 5.0.

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Chapter 9
Motivation Behind the Integration of the Metaverse with Industry 5.0

The emergence of Industry 4.0 has prompted the manufacturing sector to prioritize the utilization of AI/ML algorithms to enhance predictive maintenance, production efficiency and decision-making regarding quality. In addition, the introduction of industrial information integration engineering facilitated the integration of various related fields, such as information and communication technology (ICT), into industrial sectors, resulting in improved industrial processes. In addition, the metaversum supports virtual prototyping, which helps companies create virtual representations of objects and production facilities, leading to cost optimization without physical resources. It also facilitates virtual simulation and analysis of the design, which reduces risk. In addition, Metaverse provides a virtual user interface for real-time remote monitoring, allowing technicians to quickly diagnose equipment problems [1]. Industry 5.0 represents the next generation of the industrial revolution, aiming to integrate human creativity with efficient and precise machine technology. This integration will lead to the development of resource-efficient and user-friendly solutions. Industry 5.0 will rely on technologies such as IoT, AI, digital twins, big data and robotics to drive advancements in society, agriculture, education, healthcare and other sectors. In this new paradigm, humans and machines collaborate more efficiently and creatively to produce high-quality, high-speed products. The integration of the metaverse with Industry 5.0 will enhance customer engagement through virtual factory tours and interactive sessions facilitated by XR devices. It will also enable virtual product presentations and support mass personalization. Securing block chain technologies will facilitate payment processing between organizations and users, while AI-powered digital assistants will enhance customer service and the overall customer experience. The benefits of integrating the metaverse in Industry 5.0, as opposed to Industry 4.0, have motivated further study in this area. These benefits are illustrated in Fig. 9.1.

Advancing collaboration between humans and machines involves utilizing the impressive computational capabilities of machines, which surpass those of humans, allowing them to swiftly and accurately perform complex calculations [2]. By

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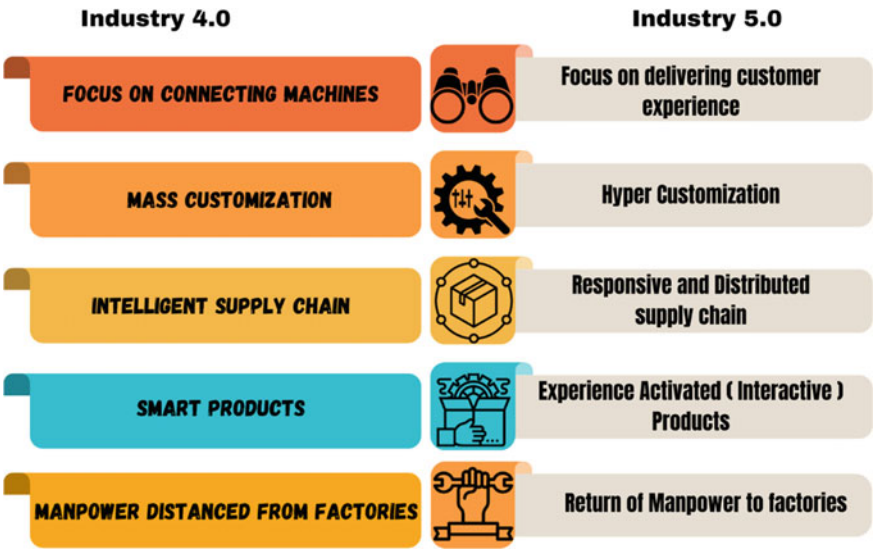

Fig. 9.1 Integration of industry 4.0 with industry 5.0

fostering cooperation between humans and machines, Industry 5.0 applications can achieve remarkable outcomes. Especially in the realm of large-scale machinery, even the smallest error can have catastrophic consequences. To solve this problem, metaversums and related technologies provide a virtual platform where people can simulate tasks using XR applications. With artificial intelligence, people can analyse success rates and identify potential threats before starting real work. This approach reduces the likelihood of errors and ensures safer and more efficient operations.

9.1 Enabling Humans in the Loop in Industry 5.0

In the context of Industry 4.0, automated equipment and AI models are used to develop products. However, these AI models and automated robots lack the same level of understanding of experience and emotions as humans. In the evolution toward Industry 5.0, the integration of various sensors will give rise to the metaverse. This metaverse will offer people the opportunity to experience and cooperate with products in customs that were previously unimaginable with existing technologies. This integration will enable humans and machines to work together, with the assistance of the metaverse, to enhance the quality of the products they create [3, 4]. For instance, in the field of education, medical students can greatly benefit from the metaverse in their Education 5.0 journey. They will have the ability to visit a virtual anatomy lab and even perform surgery on virtual patients in collaboration with trained professionals. This immersive experience will revolutionize their learning process. Additionally, to

develop a product effectively and with the highest quality, designers require accurate information from the client regarding the product's description and specifications. However, in certain situations, the client may not be able to provide such precise information. In such cases, organizations traditionally construct a prototype with the client's approval before proceeding with mass production. This conventional procedure is time-consuming, requires significant manpower, and incurs high costs even before large-scale production begins.

Here, the metaverse, along with supporting technologies such as XR (extended reality) and digital twins, can play a critical role in reducing stress on real-world systems and assisting humans in making better decisions. By leveraging these technologies, organizations can streamline the product development process and achieve maximum creativity and innovation in designing products in Industry 5.0. To enhance the shopping experience, in the past, online shoppers had to rely solely on product visuals and descriptions when making purchasing decisions. They had no way of customizing the products and could only see them after they were delivered. This often leads to customer dissatisfaction with quality, design and delivery delays, which could lead to product rejection. Such situations can cause significant damage to organizations if multiple customers are affected.

Conversely, however, customers will experience a game-changing scenario. They have the opportunity to witness the entire process of the creation, delivery and sale of products in the advanced supply chain of Industry 5.0. Customers obtain a 3D perspective that allows them to accurately estimate delivery times and associated costs. In addition, they can customize the products of their choice by interacting directly with the production machines [5]. By providing detailed production plans, customers can greatly reduce the possibility of errors or discrepancies. As a result, customer turnover is reduced, and product return costs are minimized, benefiting both organizations and customers.

9.2 Challenges and Future Directions

In this section, we explore the obstacles encountered in integrating the metaverse into Industry 5.0 and possible future paths. The automation of various aspects of life inevitably raises concerns among users, such as increased computing requirements and concerns about information security, user privacy, potential health problems and the risk of unemployment. In contrast, developers and technology seekers face the necessary challenges to facilitate more dynamic and responsive interactions between humans and machines, establish appropriate standards, address security gaps, and effectively deploy technological advances.

Metaverse uses various interactive devices to fully immerse users in a virtual world. These devices are considered to congregate the needs of users with a focus on portability, lightweight design, comfort and portability. An ideal interactive space should be fluid, allowing technology to recede into the background as users immerse themselves in the virtual surroundings. Some of the interactive technologies and

devices employed in the metaverse include virtual reality (VR), augmented reality (AR) and mixed reality (MR). VR creates an artificial virtual environment that enables users to immerse themselves in a manner similar to the real world. AR, on the other hand, merges digital objects with live video through wearable devices, allowing users to work together with the implicit world. MR is an advanced technology that integrates collected digital data to enable interactions with the physical environment.

The majority of portable and lightweight interactive devices are comfortable to use Fig. 9.2. However, their high prices hinder the widespread adoption of virtual technology. The prolonged use of virtual reality headsets can lead to psychological issues and strain on the neck and head. Additionally, concerns arise regarding the quality of metaverse models. To address these challenges, it is vital to have top-quality VR, AR, and MR devices, as well as reliable models, to enhance user interaction (Fig. 9.2). Realistic visual rendering can help mitigate these problems by enabling users to experience sensations such as bouncing balls or rippling water, although replicating tactile sensations remains difficult. Creating a sustainable interface may involve holograms and eye lenses in addition to head-mounted devices. It is also important to consider interactions between nonplayer characters and users to enrich the virtual world experience. To accurately interpret human actions, multimodal pretrained learning models can be used to analyse visual language movements and prevent avatars from misinterpreting human emotions [6]. Integrating the metaverse with Industry 5.0 poses a challenge, as it requires collaborative decision-making between humans and machines. The inability of humans to physically touch or feel machine-provided prototypes may lead to inaccurate judgments. Moreover, seamless interaction between humans and machines is crucial, as any delays in network or bandwidth can result in critical situations. The current devices and equipment used for interaction may not be suitable for all aspects of Industry 5.0 and may require customization based on specific application requirements. Consequently, creating a flawless virtual replica of real industrial machinery remains an unresolved challenge.

The main challenge in implementing the metaverse is integrating a range of technologies, such as IoT, VR, AR, AI, and gaming, which have different computational requirements. The metaverse involves handling large amounts of data and requires high-speed computing with minimal delays [7]. It is similar to a multiplayer gaming environment, where multiple users participate simultaneously, necessitating powerful graphic processing units or GPUs and head-mounted displays or HMDs to create an immersive virtual world alongside the physical world. To ensure universal access to the metaverse, edge computing and cognitive edge services are crucial. By leveraging AI, decisions such as avatar positioning can be made locally on end devices, and low-latency tasks can be performed on edge servers instead of cloud servers, reducing data latency. Aggregated data can then be communicated to cloud servers for computationally intensive tasks. This integration allows for resource allocation using AI models, improving the user experience in densely populated environments. AI-enabled edge computing solves the issue of computational overhead. To achieve an immersive metaverse experience comparable to that of the physical world, requirements such as reduced latency, real-time rendering and control, and high-quality visuals must be met. Mobile edge computing, empowered by 6G, has become

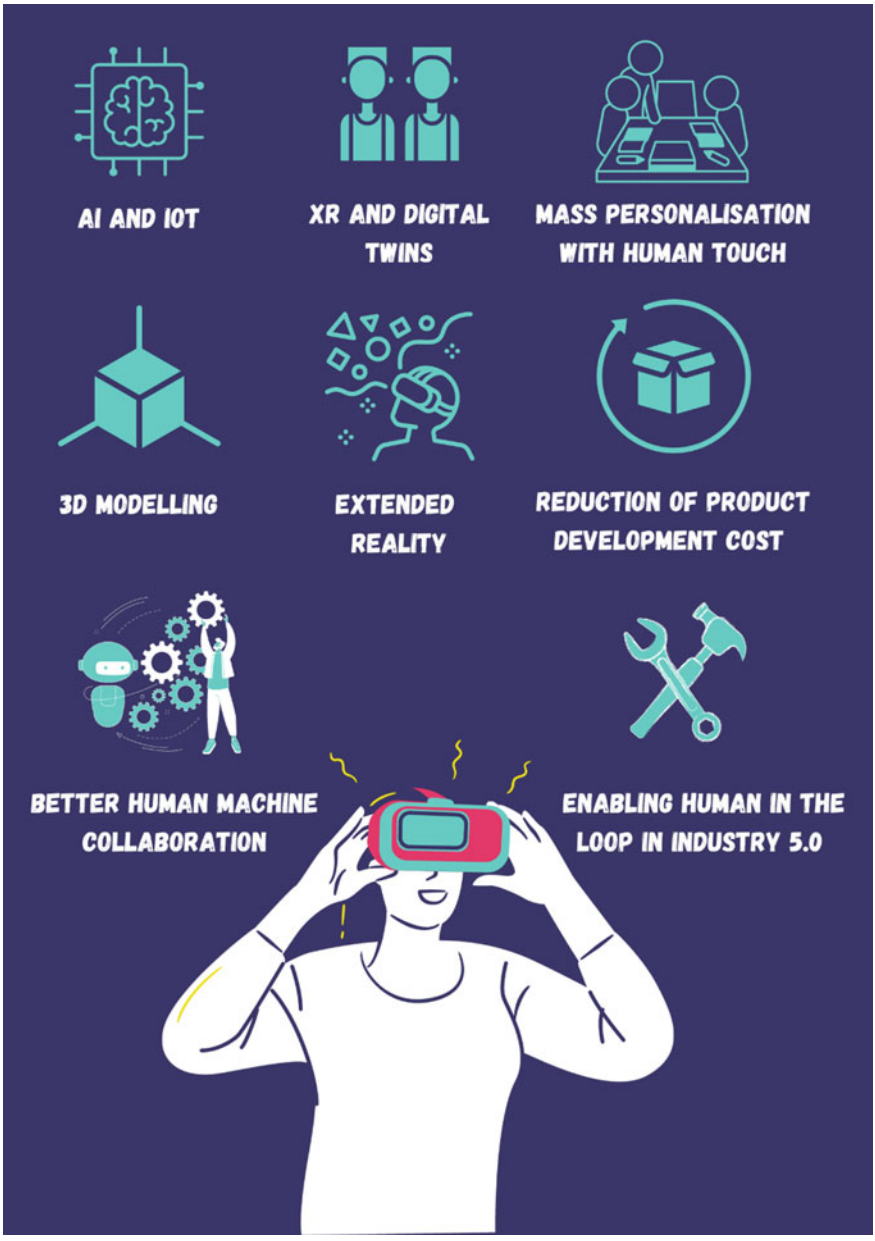

Fig. 9.2 Motivation behind the integration of the metaverse with industry 5.0

essential for meeting these requirements. By effectively managing latency, network load and computational resource allocation through the junction of the metaverse with movable edge computing, blockchain, 6G technologies, and AI, these goals can be achieved. Mobile edge computing will play a crucial role in large-scale deployment. The incorporation of the metaverse with Industry 5.0 also poses a noteworthy challenge, requiring substantial processing power, high-performance computing systems, extensive cloud infrastructures, and a robust network with efficient data transmission capabilities.

In the vast and diverse online realm of the Internet, where there is a wide range of sources, individuals actively search for online communities that align with their preferences in the pursuit of finding a perfect match for their choices. This desire for a unique online community has given rise to the metaverse, a centralized platform that brings together various technologies, services and goods. Security in the metaverse encompasses the protection of both data and software. Consequently, individuals with specific interests may feel compelled to join the metaverse, and some may display unconventional behavior as they compete with other users, potentially resorting to exploitation. The concept of AI singularity can further enhance the metaverse by enabling AI entities to continually enhance their performance, possibly reaching a point where they are unaware of their own existence.

In the future, this section proposes practical solutions to address the challenges faced by metaverse ecosystems. One possible solution is to combine a meta-blockchain with sixth-generation (6G) networks [8]. The ecosystem of the metaverse (Fig. 9.3) contains physical and virtual worlds. Industrial metaverse and consumer metaverse are the parts of this ecosystem. Industrial metaverse has parameters such as health care, education, transportation, virtual service and virtual community management. It supports the creation of new industries with real value, where consumer metaverse includes concerts, short videos, movies, games, art shows and social activities, which help to create nee virtual experiences.

A significant concern in the metaverse ecosystem is the security and privacy of user data, considering its operation as a virtual social world. Threats such as cyber bullying and cyber flashing pose significant risks in this social environment. To establish trust among metaverse users, it is crucial to implement a secure and transparent system. Blockchain technology, with its distributed, immutable and transparent ledger, can play a vital role in achieving this goal. By utilizing intelligent resource management and efficient storage of transactions, a meta blockchain can facilitate secure and privacy-preserving transactions within the metaverse. Making the Most of 6G networks, however, establishing a meta blockchain may result in more computational labor, particularly when considering virtual players and other technologies. This is where 6G networks, with their higher frequencies, greater capacity and reaction times of less than a second, are useful. The presentation of the structure may be greatly enhanced by combining 6G networks with the meta-blockchain. Multiple applications may be integrated into 6G networks because of their greater user data rates, terahertz frequency ranges and supporting technologies. Edge computing can also help with augmented reality (AR) holography and allow reaction times that are even quicker (0.1 ms RTT latency). As a result, applications such as telesurgery, digital

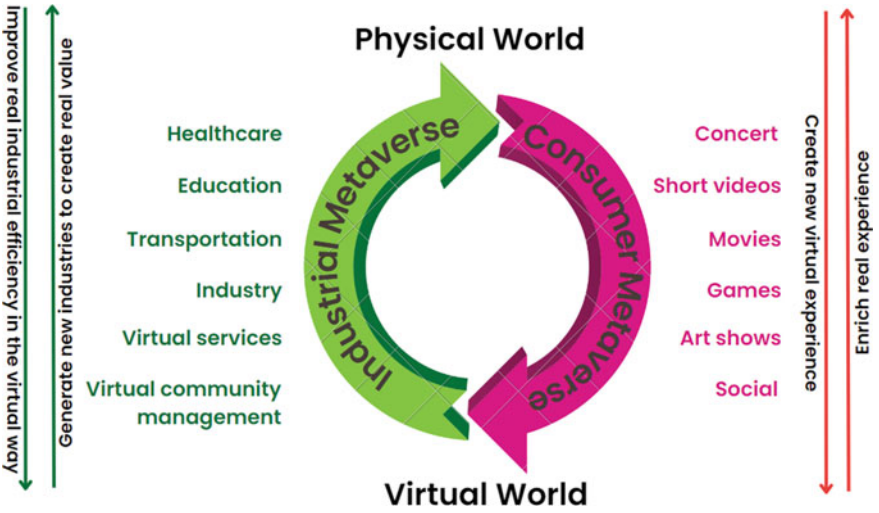

Fig. 9.3 Industrial metaverse ecosystem

twinning, multiplayer gaming, 3D printing, etc., may be secured using 6G networks and meta-blockers. The difficulties posed by both 6G networks and blockchain technology must be recognized and resolved. It is necessary to find solutions to problems with multiplexing, access control assaults, and scalability. The fusion of 6G networks and the meta-blockchain can open the door to a safe and effective metaverse environment by creating creative solutions to these problems. To improve security, privacy and general performance within the metaverse ecosystem, a meta-blockchain coupled with 6G networks provides viable options. Utilizing these technologies will enable the safe support of apps across different domains, resulting in a more immersive and dynamic experience.

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Chapter 10
Web2 to Web3: The Changing Face of Digital Privacy

Although digital privacy on websites is now typically regulated, the metaverse is still extremely young and lacks any privacy laws. Tim Bos, the creator and CEO of ShareRing, predicts that "the getaway metaverses will be ones wherever populace can have real experiences that they cannot at present perform in the actual world". Many businesses, he continued, are attempting to create something that has the allure of Fortnite or Minecraft but allows users to do more than simply play battle royal games. Through the metaverse, online commerce is likewise on the rise, but once more, no one has yet worked out how to provide more than a basic Web2 site. Owing to the fact that 20 min of virtual reality (VR) use creates almost two million exclusive data mechanisms, the risk to solitude in Web3 and the metaverse is better than that in Web2. These comprise, among many other things, how you respire, stroll, imagine, travel and seem. To obtain information, the algorithms evaluate the user's body language. Consent is almost difficult to obtain in the metaverse since data collection is ongoing and involuntary [1]. The privacy concerns of these technologies are grossly unaddressed by current data protection regulations. A machine learning algorithm could successfully identify a user with 95% accuracy, according to research, given just five minutes of VR data that had been scrubbed of any personally identifiable information. Most biometrics laws do not cover this kind of information.

Numerous privacy issues have arisen as a consequence of the metaverse's extension, and these issues must be addressed. The following are a few of the majority of urgent issues: data compilation and use—companies working in the metaverse may accumulate much in-person identifiable information from users, which increases questions about how that data will be used and who will have access to it. A lack of organization over private data-users may not have complete control over their personage information in the metaverse, which enhances concerns regarding the potential exploitation of such information. Tracking and monitoring- There may be a lack of familiarity with how user actions in the metaverse are monitored and who has contact with that information. Data security-sensitive personal data may be lost or stolen as a result of metaverse cyberattacks. Privacy vs. pseudonymity- Although

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https://doi.org/10.1007/978-981-97-2455-0_10

many users may like to use pseudonyms in the metaverse, this can potentially raise privacy issues if their real-life identities can be connected to their virtual ones.

10.1 Challenges Facing Cybersecurity in the Metaverse

There are many metaverse cybersecurity challenges, some of which are device vulnerability, decentralization, identity and authentication and modernization challenges. The following are the discussed sections of the stated challenges.

I. Device Vulnerabilities

In the case of device vulnerabilities, the metaverse field represents the weakness and security gaps that are present in the devices used for assessing the virtual world. These devices require users to input personal type information that may be used for targeted advertisements. If the security of devices is not properly safe, information can be stolen by hackers [2]. Metaverse devices such as augmented reality and virtual reality devices are vulnerable to malware, hacking, and various types of cyberattacks. Cybercriminals use these cyberattacks to steal personal information, disrupting device operations and sometimes hijacking devices. Most of the risks faced by AR and VR devices are (i) privacy, (ii) data security, (iii) social engineering, (iv) unreliable content, (v) physical damage and (vi) unreliable content [3].

II. Identity and Authentication

Metaverse identity and authentication are expository components of cybersecurity. Here, users create virtual avatars that include individual real characters, such as age and gender. The accounts of users can hack, and their avatars can take over. Another problem regarding identity and authentication is that metaverse users have multiple identities that are difficult to verify. There is also a risk of false identities, as virtual identities have been created by users twelve, who also manage them. Moreover, to consider the metaverse has no specific authority over it. Virtual identities are difficult to manage.

III. Moderation Challenges

Another metaverse issue is the challenge of moderation; it is very challenging to ensure that the behavior of users within a metaverse environment is authentically monitored and regulated. The same problem is applied to content generation. There is a lack of unified approaches for content moderation. Another issue of metaverse is to develop relevant tools and techniques for identifying and regulating harmful content efficiently. The metaverse is a relatively new concept, so existing tools for modernization are not suitable for pursuing unique challenges in the virtual world. For enabling children's safety, the metaverse is truly censorious. It has the ability to expose potential harm, e.g., cyber bullying, grooming, inappropriate content and many [4]. The users of the metaverse can misrepresent their age at this juncture, or they may use a false identity to gain access to age-inappropriate content. This

will provide a challenge for creating and developing age-appropriate moderation standards.

IV. Decentralization

The metaverse is a virtual word that is decentralized in nature. This means that no central authority is there. Therefore, no regulations or controls have been established in the virtual world. An increased level of freedom is allowed by process decentralization. This is able to raise concerns about the lack of oversight as well as accountability toward harmful behaviors and content.

10.2 Solutions for Cybersecurity in the Metaverse

There are few amicable and potential solutions for mitigating metaverse cybersecurity issues.

I. Developing robust security protocols

One of the most suitable solutions is to develop robust security protocols. The developers of the metaverse require strong security protocols. This helps to protect users' financial and personal data. The method consists of encryption technologies, two-factor authentication and securing channels of communication. This prevents unauthorized access to delicate information.

II. Educate users

In the midstories, it is essential to educate people about the risks of cybersecurity and promote safe behavior. This includes a supply of resources and guidelines related to password security, safe browsing and social engineering attacks for making users safe and secure.

III. Artificial Intelligence-powered security tools

The implementation of artificial intelligence-empowered security tools is another vital solution for metacyclic security. The AI-empowered security tools include anomaly detection algorithms and behavior-based threat analysis. These findings can help to identify potential cybersecurity threats and prevent attacks before their occurrence.

IV. Develop community-driven moderation

A community-based modernization approach provides support for moderation challenges in the field of metaverse. This approach empowers users to report and flag inappropriate content and behaviors. This enforces community standards to regulate the behavior of users.

V. Collaboration with governments and institutions

Collaboration and network building among governments, developers and institutions help to develop global standards for metaverse cybersecurity. It ensures compliance with subsist laws and regulations; thus, it promotes awareness of cybersecurity [5].

VI. Prioritize privacy

Privacy is a prime factor in the metaverse, and developers must create user privacy through the implementation of data protection laws and regulations, which limits data collection and the use of anonymization technologies. As it has been proven that metaverse establishes new vectors of attack, it becomes difficult to predict and evaluate how businesses will protect themselves against this kind of cyberattack [6]. Around the world, it is difficult to measure the density of cybersecurity and its consequences, so the globe has yet to understand the status of cybersecurity and the various types of attacks that may occur and can uplift cybersecurity behavior.

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Chapter 11
Issues in the Metaverse

The metaverse commits a swarm of vivid opportunities for businesses, finances and humanity. It has been visualized as a virtual world parallel to our own, where every individual has a digital twin. It could be a virtual territory where the relations structure and promises are prepared, and commodities are bought and sold. Associates can work together to construct a home or create digital commerce that produces real-life property. It could transform social networking sites, distant work and leisure.

11.1 Ownership Issues in the Metaverse

Ownership issues exist in the metaverse, which refers to challenges and difficulties in relation to the control system and usage rights of digital assets and property in digital environments. Few ownership issues, such as intellectual property rights, virtual property rights and jurisdiction, are discussed below.

I. Intellectual property rights

Metaverse has the ability to create and distribute a vast quantity of digital content, i.e., virtual clothing, accessories, digital art and many. This has led to questions about ownership of the rights for the content and its way of protection.

II. Virtual property rights

In the virtual world, individuals have the right to own virtual property and include buildings, land and enterprises. Moreover, virtual property rights refer to the purchase, sale and control of virtual property, which is never an end to discussions.

III. Jurisdiction

The metaverse has the capacity to spread across the globe, so it is difficult to determine which law should be applied in the field of intellectual property rights and

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https://doi.org/10.1007/978-981-97-2455-0_11

virtual rights. The jurisdiction issue is one of the striking ownership affairs of the metaverse.

11.2 Contractual Issues in the Metaverse

The enforceability of the agreement is achieved through a metaverse, which is signed between people for the sale and transmission of goods. In the area of metaverse control, affairs include questions and challenges in relation to rules and regulations, governance and administration of virtual environments and how they interact with the physical world. There are few key control-related issues, such as content control, economic control and political control.

I. Content control

People may generate, delegate and consume a variety of digital content in the virtual world, which includes user-generated content. There is an important topic of discussion regarding what quantity rules and regulations should place on this virtual world. Moreover, what type of information should permit is also a topic of concern.

II. Economic control

It is indeed a quickly changing economic system in the metaverse that includes online marketplace and digital currencies. The most concerning areas are the validity, reliability and fairness of these systems. This concern also plays a role in the regulation and management of the public and private sectors.

III. Political control

Currently, virtual environments are used for political expression, activities and organization. This has led to the question of which virtual environment should be subject to political regulation, administration and control mechanisms. Political control also implies freedom of speech and democracy.

11.3 Privacy Issues in the Metaverse

The growth and development of metaverse has given birth to numerous privacy concerns that must be addressed. Some of the striking issues at this juncture include data gathering and usage issues, a lack of control of personal type information tracking and monitoring issues, and data security and privacy issues [1].

I. Data gathering and use

A business operating in a metaverse environment can create a large amount of user-provided personal data. This raises concerns about the usage of this information and who can access it.

II. Lack of control over personal information

The users have less ability to manage and handle their personal data within the metaverse environment. There is a concern about possible abuse of personal data.

III. Tracking and monitoring

Tracking and monitoring are other kinds of privacy issues. There is not enough information regarding the activity of users in metaverse environments that can be tracked and monitored, and the accessibility of these data is also limited in terms of capacity.

IV. Privacy vs. pseudonymity

Privacy and pseudonymity are creating privacy concerns if the real-world identities of users are linked with their virtual identities. Many of the users prefer to use pseudonyms within the environment of metaverse, but there is a probability of privacy risk.

Finally, online harassment and virtual or cyber bullying are also major concerns of metaverse privacy issues. To be very proactive and protective of one's privacy and security, one can minimize the potential risk factors for metaverse and can enjoy the many benefits of a metaverse environment.

Figure 11.1 shows the various security challenges of field metaverses, namely, automation, updations, security and data integrity, encryption capabilities, privacy issues and common frameworks. Automation is the technological usage for performing various tasks, where inputs from humans are limited. Updating refers to the process or act of upgrading. Data security and integrity are phenomena that enable the accuracy, completeness, consistency, reliability and validity of organizational data. Data encryption is a path for translating data plaintext to cipher text, or it may be transformation from unencrypted to encrypted data. The users use encrypted data with an encryption key and decrypted data with a decryption key. Data privacy is a striking component of the metaverse, as there is a probability of disclosing personal data and information. Information relating to only personal if there is a possibility to uniquely identify an individual. Another issue texted in the figure is a common framework that includes debt treatment; case-based treatment is driven by requests from eligible debtor countries.

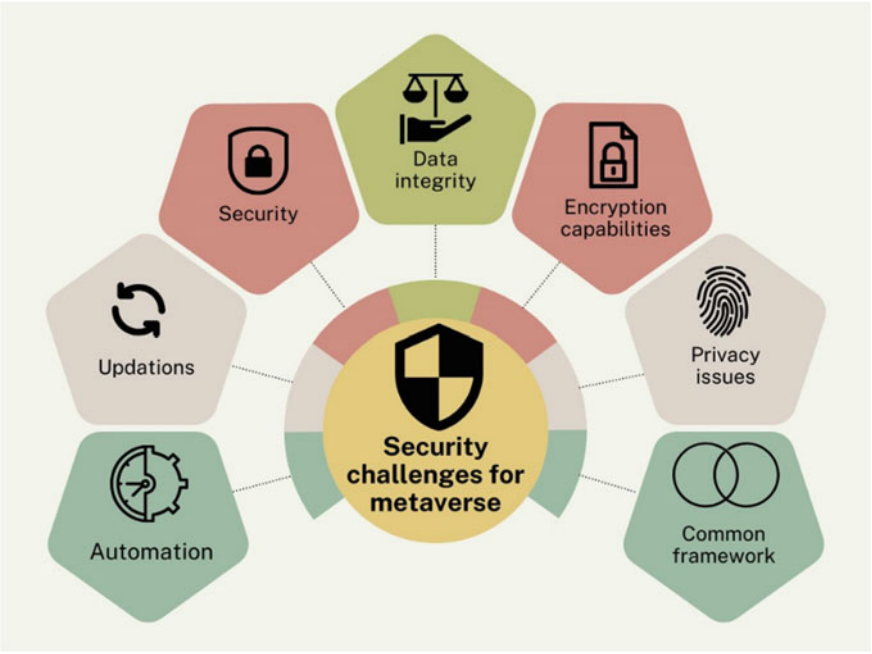

Fig. 11.1 Security challenges for metaverse individuals

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Chapter 12
The Industrial Metaverse is Transforming Businesses: Real-World Use Cases

In recent years, there have been many cases around the world where the metaverse has transformed businesses in the industrial sector. In this section, we will discuss the applications and usage of the metaverse in the manufacturing industry. Industry 5.0 has given birth to people centric, sustainable and resilient approaches. The application of industrial metaverses in various fields has been effectively maintained, and the abovementioned approaches are considered three pillars of industry 5.0 (Fig. 12.1). The discussed section on the metaverse transformation of business is related to three pillars of industry 5.0

12.1 Industrial Design and Engineering

The design of the real world can be improved by increased design in the metaverse. The large-scale production, such as the metaverse design of airplanes, can be related to the real-time nature of the model, which is based on virtually the airplane interior. In place of the money and time required to construct or print a 3D model, the airplane parts can be tested, revised, monitored and iterated in seconds. Metaverse provides flexibility to engineers to create industrial designs with clear and brief detailing [1]. Engineers use VR to see a product in a real-world setting and interact with it along with design modifications. This approach can save time and diminish physical prototyping costs; this allows for faster innovation in efficiency. In addition, these metaverses provide new ideas and perspectives for engineers and designers. Industrial metaverses are able to streamline design and various engineering processes. It brings better quality products to the market faster [2].

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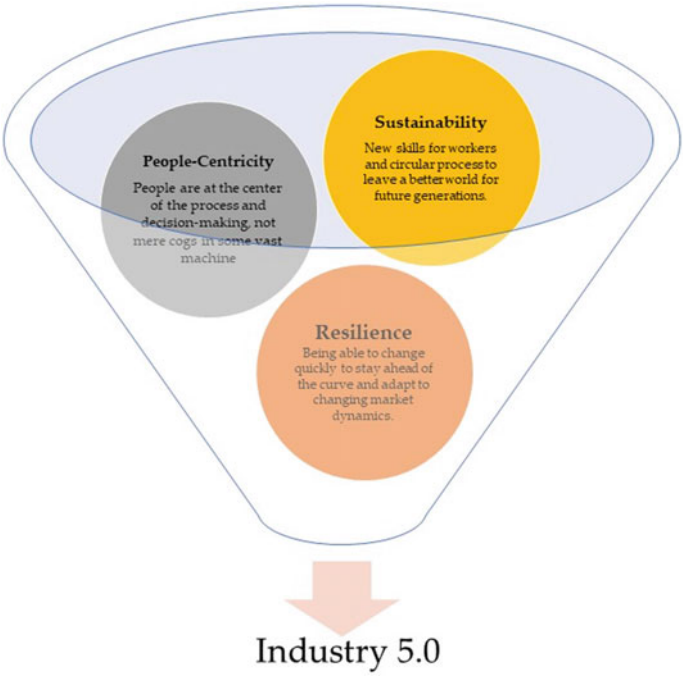

Fig. 12.1 Three pillars of industry 5.0

12.2 Supply Chain Management and Logistics

With the development of the industrial metaverse, the end-to-end supply chain network can be transformed. The metaverse has the potential to map the supply chain network. The journey from manufacturers to shoppers and distributors to retailers can be mapped out along with stakeholders involved in the entire supply chain. The components included warehouses, factories, transportation routes, centers of distribution and many more. The flow of goods, identification of potential bottlenecks and reduction of waste are optimized through virtual representation. In the industrial metaverse, TradeLens and Vechain are ideal use cases. These are the technologies where the optimization and streamline of supply chain operations are being performed. The tradeLence platform operates smart contracts and digital signatures to automate the process of the supply chain. This helps to reduce paper-based documentation and manual processes. VeChain operates block chain technology. The metaverse generates a virtual representation of each step or stage in the supply chain process. It starts from raw materials and ends with finished goods. To record every transaction and movement of goods, blockchain technology was used.

12.3 Manufacturing Operations and Maintenance

It is possible through the metaverse to see the real world virtually from anywhere and at any time. Traditional manufacturing depends on physical processes and mechanisms. Currently, it is transforming with the metaverse. The implementation of the metaverse in the manufacturing industry is revolutionizing and remarkable in terms of how products are designed, produced and maintained, which can be achieved through the application of the metaverse in industry. This will have an impact on increased efficiency, lowering the cost and quality improvement of products. The application of emerging technologies such as HoloLens 2 helps the industry to make its operations more efficient [3].

12.4 Improved Product Design

At present, product designers are using metaverse techniques for stimulating and testing production processes without taking too much time. Designers are identifying ways to enhance safety and efficiency in the process of manufacturing by easily dragging and dropping assets into digital twin simulations.

12.5 Enhance the Production and Manufacturing Process

By using metaverse simulations, many factory scenarios can be tested, and insights can be gained. By using this kind of simulation, one can recognize optimized opportunities in the production process without causing any disturbances [4]. Currently, smart companies are using Microsoft Dynamics 365 Guides or real-time instructions laminated on equipment. Internet of Things (IoT) sensors gather data on machine operation and performance, quality metrics, checklists and inventory levels. This provides the ability of operators to identify and resolve issues. Moreover, optimization of production parameters and improvement of overall manufacturing efficiency and qualitative methods of production are also performed by the IoT.

12.6 Improved Quality Control

Through the integration of IoT sensors into the manufacturing process, real-time data can be collected from different equipment, tools and machinery. The data are transmitted to the metaverse for analysis and visualization. This approach involves inspecting equipment virtually and proactively identifying potential problems, i.e., abnormal vibrations, temperature variations and other anomalies, which may provide

nonfunctioning equipment. The use of metaverse applications in the manufacturing industry and enabling technologies such as AR and VR are optimized for manufacturers; thus, they have improved productivity. With the help of Dynamics 365 Guides and Remote Assist, an expert can grip 3D drawings in a real-world environment. By wearing HoloLens, frontline workers can explain their physical space with digital ink, which would create an interactive mesmeric experience.

12.7 Better Warehouse and Logistics Management

Logistic and warehousing processes can be optimized by addressing metaverse technology. In this case, augmented reality is used. For example, the company DHL, a global logistic firm, is operating AR headsets for sending real-time information to its workers, i.e., order detailing, locations of inventory and picking up instructions [5]. This allows workers to perform hands-free operations and effectively navigate the warehouse. This helps to reduce errors and improve accuracy.

12.8 Marketing and Sales for Manufacturing Products

Metaverse entitles customers to innovate virtual product experiences that permit them to interact with products within a virtual environment. The potential of the metaverse has created numerous opportunities and possibilities for industries to market their products. To launch brand new products, virtually launching techniques are used. Currently, business organizations create virtual launch events; here, users can meet and experience the new products virtually, and they can learn about the features and preorder the products [6]. This will create buzz among their customers. The factory tour that takes place virtually can connect customers with the brand of the company. Thus, the customers experience the production process, and they can look inside the facilities without visiting the factories physically. The system of virtual booths in trade shows helps to showcase the products to the global audience. Visitors are engaged by these booths because demonstrations of the product are easy because of the use of virtual presentations, videos and other interactive demonstrations. Virtual trade offers environmentally friendly and cost-effective methods for marketing products. In this process, products can reach potential customers globally.

12.9 Research and Development

The industrial metaverse has also contributed greatly to the field of research and development. Industrial metaverse apps have emerged as game changer techniques because of their optimized and collaborative capacities to revolunise the way industries conduct research and development. This has led to innovation, creativity and efficacy. The physical prototypes used to conduct research and development on products are becoming obsolete because they are time consuming and involve more expensive processes. Currently, the use of industrial metaverses to create and test virtual prototypes is highly acceptable due to its ability to optimize operations and reduce costs.

Ford is discussed here; it is one of the largest automobile manufacturing companies in the world. The company has explored the usage and utilization of metaverse for field research and development, i.e., the design of vehicles, safety testing and monitoring and manufacturing optimization. The company has utilized virtual reality (VR) simulations to create virtual prototypes of vehicles and manage virtual tests for safety performance.

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Chapter 13
The Potential of the Metaverse in Manufacturing

The metaverse is a concept in which people can interact with each other and transform the data virtually. It provides internet and intranet facilities to companies that are surrounded by a variety of technologies, such as virtual reality headsets or VR headsets, 3D modeling tools and more alluring digital experiences for both customers and employees. We have discussed in this section that alluring interactions with these technologies can have an impact on manufacturing operations and improve customer and employee experiences.

13.1 A Better Customer Experience

The manufacturers who do business on furniture production are offering their customers an interactive experience via their websites, where customers have the opportunity to design their living spaces and can find furniture and fixtures according to their preferences. Another striking thing is that renovation projects use immersive experiences for design and blueprint-making sessions [1]. The users interact with the blueprint and layout of interiors in houses, hotels, restaurants and offices before purchasing them. Companies use an accurate 3D virtual representation of the plant or facility. The manufacturing of different products with production lines is displayed with a 3D virtual representation. Developers in the real estate sector, home buyers, site engineers and other manufacturing companies verify progress at construction sites. They try to model different scenarios for layout design before decision making on the use of immersive and collaborative technologies. 3D technology and virtualization businesses and customers can be engaged in product design sessions from any place across the globe. Hybrid working teams collaborate with new product development; they determine their right appropriate manufacturer and look at creative and innovative designs and their implementations. Contract manufacturers can provide offers to their clients to enjoy virtual experiences for looking at production lines. The creation

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SpringerBriefs in Computational Intelligence,
https://doi.org/10.1007/978-981-97-2455-0_13

of products and the review of progress on orders with managed demand and supply planning have become efficient. Realtors create realistic tours of properties to entitle remote views and make decisions. The offices are offering real-time virtual tours to customers for experiencing their spaces. Other businesses, e.g., cruise lines and tour operators, are providing their customers with a hypnotic experience for potential tour packages, which includes purchasing propensity. The areas under which industrial design collaborates with metaverse could be transformative experiences where distributed teams experience interactive and mesmerizing incidents. Suppliers and designers can meet in virtual spaces to share and discuss various ideas and explore 3D representations of the integration of their created designs or components.

13.2 Enhanced Employee Experience

Currently, the reshape of work can be made possible by applying metaverse methods. The future is focused on including new trends in team collaboration, even when AI-empowered colleagues or bots are available through these technologies. Training and development on skill acquisition are accelerated through virtualization. The most striking part of the metaverse is that it significantly changes employees' onboarding and training methods. Immersive experiences help new employees better understand the company, business, vision, mission, philosophies, values, products and services. Some industrial and manufacturing companies have started or plan to train workers in the use and maintenance of equipment, using VR headsets for training instead of dangerous or difficult physical equipment. The metaverse can quickly help new employees in the work environment, including setting up devices, setting up HR, paying and financing avatars, helping with troubleshooting and understanding policies and procedures [2].

A combination of present digital and mechanical technologies has made the process of manufacturing increasingly difficult. The outcome must be based on training and retraining the workforce. Training helps current employees better adapt and work smoothly. Experiential learning is a type of learning that is beneficial for operating machinery, building models and performing computations, using equipment, reviewing scenarios and understanding ideas and concepts. It combines virtual reality with learning theory. On-the-job training methods with heavy equipment and tools may be risky for newly hired employees. With the help of VR training programs, trainees benefit from making mistakes without facing real-world consequences. In this type of training program, newly hired employees do not need to visit real physical work places, which are risk prone areas; they can use digital twins for virtual and physical environment environments to manage any equipment break fixes, which remediates malfunctions and balances the instruments to the correct specifications. The metaverse has the ability to fix issues in the pipeline, and the process is very much concerned with outcomes. The decision-making process in the manufacturing sector has emerged through the use of digital twins. To simulate real-world plants or products, mathematical models, including analytical tools, are used. The real-time

data feed is used in the visualization process from the Internet of Things devices and sensors. It helps to create "what if" analysis and simulations to predict and monitor performances, these are all useful for the decision-making process of manufacturing personnel.

Manufacturers may also facilitate businesses and improve customer decision-making [3]. For instance, automakers put much effort into utilizing the Metaverse to let potential customers acquire a "feel" for the product and even customize automobiles according to their preferences and requirements. Manufacturers may considerably save expensive rework and do things right the first time by using these enabling "experiences" through simulation, visualization and modeling. The goal of manufacturing in the Metaverse mode is to decrease the amount of time needed to add value in the production process. This approach saves costs and eliminates the risk of making poor decisions.

An example is given in this juncture, which includes LG, involved in Metaverse. As part of its mission for future global startup competition, the LG Electronics North American Innovation Centre (LG NOVA) has revealed the "Selected 20" businesses moving on to the next round. From a pool of more than 1300 candidates, the top 20 were chosen, and they were awarded $100,000 each for a total of $2 million for 20 proof-of-concept projects. To build a framework for doing business with the rest of the LG Corporation, the entrepreneurs are now working with their LG NOVA counterparts. The Top 10 will need to demonstrate that their company idea is viable and lucrative as well as how their technology advances the larger goal of LG and LG NOVA of innovating for a better life. Strong businesses are investigating a range of applications among the group with the aim of promoting wider acceptance of novel immersive, interactive technology and generating more substantial commercial prospects. These businesses have considerable potential in the metaverse sector, where LGs are actively looking for expansion opportunities. With the assistance of LG mentorship and resources, startups that win the competition will have the chance to further develop their product offerings.

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Chapter 14
Metaverse in the Construction Sector

In the construction sector, designers and homeowners should make extensive decisions, and they should communicate during the phases of designing, manufacturing and maintaining buildings. The methods of traditional design and planning are set up on two-dimensional floor plans or may build on three-dimensional models that have prolonged limitations. These difficulties include difficulty in intuitively expressing the spatial sense and proportion of buildings and difficulty in real-time interactive design and cooperation. With the increasing use of metaverse technology, the construction sector has started to emphasize the application of metaverse technology to construct design, construction and maintenance. To improve the efficiency of building design, reducing the waste of building materials and improving the sustainability of a building's metaverse technology are highly important. The metaverse uses VR technology that combines digital information from the real world and digital information from the virtual world to create a highly interactive and visual virtual space. Along with digital modelling, VR technology and conjunct design, metaverse technologies are able to present design and planning solutions for buildings. This technology helps to improve the efficacy and visualization effect of architectural blueprinting. Digital transformation has taken place in the construction sector due to the application of metacosmic technology. Exploring the potential level of prospects and challenges in architectural design through metacosmic implementation has improved building sustainability. The Metaverse Application Scenarios in the Construction Industry are discussed below.

14.1 Architectural Design and Planning

It is indeed true that metaverse technology can provide architectural design and planning to designers with brand new design protocols. In this way, the architectural design process becomes more intuitive, collaborative and conjunctive. In the galaxy

S. Majumder and N. Dey, *Metaverse for Industry 5.0*,
SpringerBriefs in Computational Intelligence,
https://doi.org/10.1007/978-981-97-2455-0_14

of metauniverse designers, portrait architectural models can be constructed, and collaborative designs can be constructed through virtual reality head displays. Thus, architectural design has been carried out in a highly intuitive and realistic way. The technology used in the metaverse can accomplish three-dimensional simulation and city planning and clustering. Neighborhood planning is also part of this process. By constructing urban models, planners can conduct urban planning and design in a virtual environment. They are conducting interactive and multidimensional planning analysis and simulation. They are able to improve the feasibility of planning solutions and their sustainability. Metaverse technology can be combined with urban planning architectural design at the same time to accomplish integrated design and the planning of buildings and cities.

14.2 Building Construction and Supervision

Metaverse technology provides a new interactive supervision environment to the supervision team and thus makes the supervision procedure effective and precise. In the field of metaverses, the construction model provides supervision to teams and supports the stimulation of construction processes in 3D modeling. This technology involves interactive and multidimensional construction supervision with increased coordination. The safety of the construction sector is based on interactive collaborative supervision technology [1, 2]. The implementation of the industrial metaverse has reduced the occurrence of accidents in the construction sector. There are many advantages of metaverse technology, as it combines supervision with quality management to achieve real-time monitoring data and enables precise and prompt quality control and management. Through the construction of a supervision model, the accuracy and efficiency of supervision can be greatly improved, and the nature of quality problems can be identified and reduced.

14.3 Building Operation and Management

To build operations and management, metaverse technology can create and provide a collaborative and intelligent environment for the maintenance of teams, increasing the activity and security of operation procedures. An architectural model generates three-dimensional visualization in the metaverse, and the simulation of building facilities is realized with this technology. To accomplish intelligent and accurate environmental monitoring and management, metaverse technology may also merge building operation with environmental management. Building environmental models in the metaverse allows real-time environmental data monitoring and analysis, accurate environmental control and management, and an improvement in the sustainability and environmental quality of structures.

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Chapter 15
Application of Metaverse Services to the Healthcare Industry

In the healthcare sector, the application of metaverse services has become immensely popular and promising. It is necessary for the health sector to know about the value system and commitment of metaverse services. It is an important aspect of strategic planning to build long-term vision and objectives for the healthcare sector. The evaluation of relevant technology for potential business opportunity development is not as easy, as a systematic approach is required to properly balance current metaverse service necessities. If the health sector is overlooked in the evaluation of business opportunity development in metaverse services and proper strategic planning processes, then the metaverse service strategy is not able to fulfil the driving demands of the market. Unless the customers' needs are not met, it tries to satisfy the customers. If certain objectives in metaverse service are selected with a soupcon of consideration for the other objectives, the strategic decision-making process becomes costly in terms of both technology and operative planning. Metaverse technologies such as extended reality (XR) and virtual reality (VR) are very promising. Many of the products and services in the health sector are explored through metaverse methods. It is predicted that by 2025, the global augmented reality and virtual reality market will reach approximately 815 billion dollars. The collaborative and interactive technology-related health sector market will likely reach $5.1 billion by 2025. In the healthcare sector, the use of extended reality (XR) is immensely active [1]. For the training and education purposes of health sector professionals, XRs are used in a variety of ways. For surgery or patient care, it has been utilized. To support medical training and rehabilitation treatment, XR is used. The exact surgical location for patient treatment, XR, can be used to visualize the patient's condition. Remarkably, Johns Hopkins University succeeded in performing the first surgery worldwide by using X-vision, an AR-based spinal surgery support system. This approach obtained Food and Drug Administration approval and has been utilized since 2020 for patient treatment. VR is applied for mental illness, rehabilitation psychotherapy and many other purposes to motivate patients to participate in training and various therapeutic treatments. Augmented reality (AR) has developed a system for efficient operation

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SpringerBriefs in Computational Intelligence,
https://doi.org/10.1007/978-981-97-2455-0_15

by medical staff, and it helps to improve the efficacy of patient health management. This technology is also applied in inquiries of medical history and information about a particular patient. This also supports the development of an operation assistance system. In the education field of health care, tasks, i.e., diagnosis, surgery and treatment, are becoming easier to virtually train professionals through the use of virtual reality (VR) simulation, which is similar to the actual situation. In the operating room, augmented reality (AR) is used to monitor additional surgical information [1]. Thus, this approach improves surgical concentration and accuracy. In the near future, it is also predicted that XR technology will be actively used in the domains of telemedicine and surgery [2]. This will be based on the conditions under which complicated medical procedures may be implemented and voice control may be activated. XR maximizes the effects of treatments, reduces training costs, and improves surgical accuracy and safety. XRCC reproduces a special type of healthcare environment and provides a strong sense of immersion beyond the restriction of the real environment of treatment. For example, Tetra Signum has developed a medical education platform that provides non-face-to-face service, and it has improved virtual education platforms with accurate content for surgical education. The platform has worked on VR CPR Training Solution (cardiopulmonary resuscitation). At present, exchanges between foreign personnel are limited, and in this type of situation, a university hospital is using the education platform of the Tetra Signum. Remote lecture discussions and observations of isolated operating rooms, including eight different countries' doctors—Singapore, Japan, the UK and many—have been conducted. By using human body models, surgical minds produce a specific medical training service; in this case, VR technology has been used instead of real patients. With this technology, training services on aesthetic plastic surgery and cataract surgery have emerged for doctors and medical students. Aesthetic plastic surgery is an example of cosmetic surgery, and training services for this type of surgery have been developed through virtual engines. This technology is being implemented to help medical staff learn where to inject and how to provide detailed and systematic anatomical information about the face. It helps to learn where the syringe tip is in the skin precisely within the 0.5 mm error range. This is particularly important for doctors and other medical staff. Techno Village's Rehaveware is a fully immersive VR rehabilitation treatment service for recovering patients' lost movement functions. Its functions are related to known brain diseases such as stroke, Parkinson's disease, and brain surgery, among others [3]. Patients who suffer from hemiplegia disorders receive treatment via this service with an extreme level of immersive VR. The patient's willingness to exercise and the therapeutic effect are being improved and increased with the internet of things (IoT), namely smart globes and smart balls. In the future, metaverse technology will be used to extend and apply psychological treatment products for potential dementia patients, children and adolescents who suffer from family violence or serious diseases. In the galaxy of treatment in the health sector, metaverse technologies such as the XR have been developed in terms of patient surgery and training and development of medical personnel. A representative case is the augmented reality-based spinal surgery support system XVision of Augmedics. The patient's spine structure can be visualized by doctors via X-vision. The surgeon

receives help and support to further identify the exact surgical location and procedure. X-Vision has been approved by the US Food and Drug Administration (FDA). The first spine surgery through X-vision was successfully completed in 2020. To visualize patient anatomy information during cardiac surgery with the application of mixed reality (MR) SentiAR's holographic cardiac ablation guidance service, CommandEP is needed. It is used as a medical imaging service that includes reviewing, analyzing, communicating and exchanging multifaceted digital images.

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Chapter 16
Conclusions

Industry 5.0 is a game changer phase that consists of the Internet of Things (IoT), artificial intelligence, cloud computing, robotics, etc. It is immensely important to collaborate man and machine. A flexible and adaptable work environment has been created through Industry 5.0. It provides a faster response to customers and merges with modern market trends. Industrial metaverse studies have focused on virtual environments that tend to replace the physical techniques of industrial methods. An industrial metaverse is the use of advanced technology such as VR, AR, MR and others to establish a prominent connection between digital and physical principles. Real-time monitoring and optimization of industrial activities are becoming feasible through industrial metaverse. This approach provides decision-makers with insightful information. The metaverse increasingly encompasses the industrial sectors. The concept of industrial 'metaversion' has been developed by several businesses, i.e., Rockwell Automation, a leader in Industrial Automation and Digital Transformation. The Industrial Metaverse Market is expected to grow from $1.5 to $4.5 billion by the year 2026, and at a Compound Annual Growth Rate (CAGR) of 19.6%, there is a sizable amount of prospective business opportunity in this industry. The use of digital twin technology, the need for remote operations and monitoring, and the necessity for predictive maintenance are some of the striking factors that influence this expansion. In the modern era of business, companies such as simence and ABB are the two names that have invested significant resources in the development of the industrial metaverse, digital twin, IoT, AI and ML domains. Additionally, businesses that focus on industrial metaverse solutions have received venture capital investment. In the conclusion section, we note that the Industrial Metaverse has the potential to revolutionize operations in the industrial sector by simulating, testing and optimizing processes. Its development is also being spearheaded in Schneider Electric. More businesses are anticipated to use this technology as the Industrial Metaverse develops to boost productivity, lessen its impact on the environment, and encourage diversity. As a result, companies should perform a cost–benefit analysis and think about investing in a metaverse environment to adjust to the shifting nature

S. Majumder and N. Dey, *Metaverse for Industry 5.0*,
SpringerBriefs in Computational Intelligence,
https://doi.org/10.1007/978-981-97-2455-0_16

of the workplace. Changes are inevitable, and with the changing trends of the market, companies must adopt newer versions of methodologies to update the functions of businesses so that they can enjoy a large share of productivity and profitability. To be competitive and sustained in the market, these are the prime particulars.