e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:09/September-2023 Impact Factor- 7.868 www.irjmets.com

GENERATIVE ARTIFICIAL INTELLIGENCE IN METAVERSE ERA

Raj Paliwal*1

*1Computer science department, MIT ADT School of Engineering, Maharashtra, India.

ABSTRACT

Generative artificial intelligence (AI) is a form of AI that can autonomously generate new content, such as text, images, audio, and video. Generative AI provides innovative approaches for content production in the metaverse, filling gaps in the development of the metaverse. Products such as ChatGPT have the potential to enhance the search experience, reshape information generation and presentation methods, and become new entry points for online traffic. This is expected to significantly impact traditional search engine products, accelerating industry innovation and upgrading. This paper presents an overview of the technologies and prospective applications of generative AI in the breakthrough of metaverse technology and offers insights for increasing the effectiveness of generative AI in creating creative content.

Keywords: Generative AI, Metaverse, Industry innovation, Information generation, Virtual reality, Augmented reality,

I. INTRODUCTION

Artificial intelligence (AI) has the potential to vastly improve the metaverse by automating intelligent decision-making and creating highly customized user experiences. Web3, with its distributed network architecture, provides consumers with enhanced privacy and security when conducting financial transactions online [1–3]. In addition, the immutable data storage and transfer mechanisms made possible by blockchain technology guarantee data security and integrity. In the age of Web3, generative AI technologies like Chat Generative Pre-trained Transformer (ChatGPT) have the capacity to become productivity tools by addressing problems with digital assets and content productin and filling in essential gaps in Web3's evolution [4]. Generative AI technologies are expected to accelerate the advent of the Web3 era by offering more reliable and convenient productivity tools for Web3 creators and contributors. With the advent of generative AI technologies, such as ChatGPT, there has been widespread attention in the industry towards its creativity and flexibility. The efficiency and quality of content production and dissemination may be greatly improved with the help of ChatGPT based on deep learning models, which can generate content in a wide variety of contexts and fulfill a wide range of needs. In addition to these benefits, ChatGPT can facilitate eliminating obstacles, enhancing human understanding and creativity, and generating priceless insights and innovations. ChatGPT can also use multi-modal AI technologies to analyze, interpret, and generate information in greater detail by leveraging different perceptual modes [5–7]. This will allow for real-time perception and response to content and provide flexible feedback, ultimately leading to the creation of more rich and diverse forms of content. Technologies such as virtual characters, speech synthesis, and image generation will be integrated into the reconstructed content production process. Technology advancements in AI for Generative Content (AIGC) have led to the emergence of critical technologies like ChatGPT as components of the metaverse engine layer, considerably easing the process of creating high-quality material in the metaverse [8]. Currently, the metaverse's content scale has not yet met user demands, and the cost of building metaverse spaces remains high, affordable only for a few companies. Moreover, virtual spaces created with substantial investments often lack excitement, openness, and refinement. Yet, the price of constructing metaverse environments can be drastically decreased if AI can assist creators in lowering the barriers, such as providing consistent scenes with basic descriptions [9–11]. Generative AI will elevate the quantity of content in the metaverse to a new level and drive the resurgence of industries such as virtual reality (VR) and augmented reality (AR). This is especially true in the age of AIGC, when it will be crucial for all platforms producing or planning to construct metaverse spaces to determine whether or not the metaverse can use the power of AI to first achieve richness of material, and so attract users even in the absence of users. In this paper, the technical key of generative AI and its application and potential in the metaverse are reviewed around the issue of technological breakthroughs in the metaverse. Moreover, the emerging technology ChatGPT based on generative AI is explored to lower the technical threshold for realizing creativity in the metaverse era.

II. MODELING AND ANALYSIS

With the advancement of AI technology, generative AI has become a significant area of research. According to Lim et al. (2023) [12], generative AI is a novel AI technology that can produce new content automatically by utilizing input data. The theoretical framework of generative AI comprises machine learning, natural language processing (NLP), image processing, and computer vision [13–15]. In the opinion of Andriulli et al. (2022) [16], machine learning serves as an essential foundation for generative AI. Machine learning is a field of study that emphasizes how to build effective algorithms using data, enabling computers to gain new knowledge from data. It can facilitate generative AI to learn new content from vast amounts of data and create diverse content based on different datasets. Machine learning constitutes a crucial foundation for AI and encompasses discriminative and generative models. Discrim inative models determine a conditional probability to accomplish classification and decision-making given data, while generative models directly predict a distribution and generate new data [17,18]. Consequently, AI systems are classified into discriminative AI and generative AI. Discriminative AI has played a vital role in the preceding decade of the AI era, and its technology is comparatively mature. According to their research, Samant et al. (2022) [19] emphasized the crucial role of NLP as a theoretical basis for generative AI. NLP is a field that focuses on human language and facilitates the comprehension of human language by generative AI, allowing for the creation of diverse content based on varying language data. Additionally, image processing is another vital foundation for generative AI, as it involves the analysis of image information to acquire new knowledge and generate diverse content from different image collections. Ai et al. (2023) [20] also contend that computer vision is an important theoretical basis for generative AI, as it pertains to the processing of image information to acquire new knowledge and generate diverse content from different image collections. Fig. 1 compares the workflows between traditional computer vision techniques and deep learning methods. Furthermore, some fundamental computer vision techniques may enhance the experience of users in virtual environments, enabling seamless interaction between the physical reality and digital worlds [21–23]. In summary, machine learning, NLP, image processing, and computer vision are all critical theoretical foundations of generative AI. These theories can help generative AI learn new content from vast amounts of data and generate different content based on various datasets [24,25]. Moreover, these theories can aid in the continual development of generative AI and enable its application in various fields. Construction of metaverse buildings based on generative AI In their study, Castelli & Manzoni (2022) [26] highlighted that generative AI is a form of machine learning technology that can generate new output data automatically based on input data provided. This technology's application in constructing metaverse buildings can aid architects in the rapid creation of complex building structures, improving the efficiency of building design. According to Ghannad & Lee (2022) [27], generative AI can help architects create intricate building structures quickly. With generative AI, architects can create elaborate building structures according to their ideas, such as complex exterior shapes like arches, circles, triangles, quadrilaterals, and more. Additionally, generative AI can assist architects in quickly creating intricate interior spaces, including interior decorations, layouts, and finishes. Haleem & Javaid (2022) [28] mentioned that generative AI can also assist architects in quickly creating complex materials. Architects can use generative AI to create intricate materials such as wood, metal, cement, ceramics, steel, rubber, oak, bamboo, aluminum alloy, copper alloy, titanium alloy, and more. Generative AI has the capability to assist architects in creating intricate decorations for walls, such as murals, carvings, tapestries, and other embellishments, in a swift and efficient manner. Additionally, generative AI can aid architects in designing complex func tional features [29–31], such as sound insulation, durability, wind resistance, water resistance, cold resistance, moisture resistance, and corrosion resistance. Furthermore, generative AI can also be used to water, dust, and moisture. Lastly, generative AI can be used to quickly create intricate energy-efficient features, such as surface water efficiency, wind energy efficiency, geothermal efficiency, photovoltaic energy pool efficiency, groundwater efficiency, among others. In essence, the integration of generative AI in metaverse building construction can significantly enhance the effectiveness of building design. Lu et al.'s (2022) study [32] highlights that generative AI can not only aid in creating intricate shapes and interior decorations, but also in designing complex materials and functional features, as well as implementing energy control methods and energy pool efficiency.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:09/September-2023 Impact Factor- 7.868 www.irjmets.com

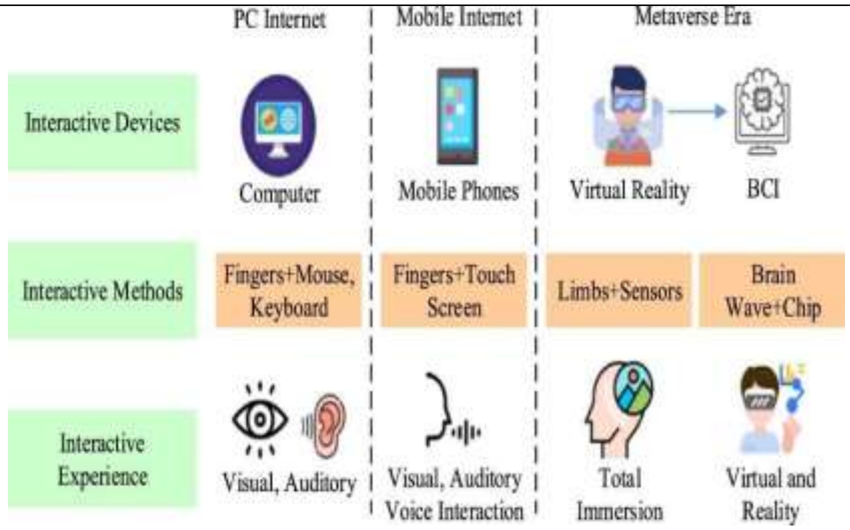

Figure 1. The evolution of interaction methods based on generative AI.

Player avatar and dialog with non-player characters based on generative AI

According to a study by Machado et al. (2021) [33], the use of generative AI in metaverse players is compelling as it enables developers to generate a wider range of game content. With generative AI, developers can create novel maps, monsters, and equipment. Moreover, it can be employed to develop distinct metaverse gameplay with unique rules, rewards, and punishment systems [34,35]. As a result, the gameplay experience can be enhanced, leading to increased player engagement. In their study, Huang et al. (2021) [36] found that generative AI has the potential to enhance players' understanding of game characters and environments, resulting in a more immersive gaming experience. Generative AI can act as an intelligent agent within the game, allowing players to create personalized strategies and seamlessly integrate different elements. By utilizing generative AI, players can exert greater control over game scripts and characters, customize the game's appearance, understand the emotional states of characters, analyze the game more efficiently, and optimize both game difficulty and the overall player experience. Additionally, developers can leverage generative AI to simulate player behavior and add new content, resulting in an improved gaming experience. According to Ramirez Gomez and Lankes (2021) [37], the use of generative AI in player avatars provides game developers with exciting opportunities to create more immersive game worlds and offer players a more thrilling gaming experience. Dobre et al. (2022) [38] highlighted in their study that generative AI has the potential to enhance the development of more realistic non-player characters (NPCs) for video games. Through the implementation of machine learning techniques, game developers can imbue NPCs with a greater range of behavioral characteristics, enabling them to respond differently to varied in-game situations. This stands in contrast to NPCs with limited, scripted responses. Generative AI can also facilitate the creation of more diverse NPCs by enabling the inclusion of a wider range of personality traits and behaviors [39–41]. With such advancements in NPC design, player interactions with NPCs can become more organic and tailored, as NPCs respond dynamically to what players say or do. The application of generative AI in NPCs and dialog is gaining traction and, as developers use machine learning to create increasingly diverse and realistic NPCs, players can expect more lifelike and varied interactions with their in-game counterparts. Beyond this, advancements in brain-computer interfaces could further revolutionize the way in which users interact with virtual worlds, allowing individuals to transmit their thoughts directly to in-game agents through brainwaves [42–44]. This would effectively free users from the constraints of time and space, as virtual worlds present themselves directly in the user's mind. Fig. 2 illustrates the evolution of interactive methods that are based on generative AI. Eysenbach (2023) [45] highlighted that generative AI in dialog is a technology that utilizes artificial intelligence to create natural language conversations. By processing the input provided by players, it can produce corresponding responses and interpret their intentions by considering the context. This technology allows NPCs to express genuine emotions during conversations and respond differently to players' actions. Both generative AI in dialog and NPCs are advantageous technologies that can enhance the immersive experience of games by enabling players to interact with virtual characters. These technologies have potential applications in other fields, such as robotics and virtual assistants, to facilitate daily communication.

Multilingual translation based on generative AI in the metaverse

The metaverse is a virtual world that is gaining popularity as a platform for communication, collaboration, and entertainment. With its evolution, there is an increasing need for multilingual translation technology. Generative AI technology offers a diverse and inclusive experience by enabling users to communicate in different languages [46–48]. In their study, Razumovskaia et al. (2022) [49] explained that multilingual translation technology works by using NLP algorithms to detect the language of the user's input and translate it into the language of other users. This technology can be used in different ways, such as enabling users to communicate in various languages or providing automatic translation for text-based conversations. Moreover, it can facilitate automatic translation for audio conversations, allowing users to communicate even if they do not speak the same language. Fig. 3 illustrates an example of a one-stop content creation application based on generative AI. According to a study by Natarajan et al. (2022) [50], multilingual translation technology has many benefits. It can significantly reduce the time and cost of manual translation, which allows businesses to introduce their products and services to international markets quickly. Additionally, it can accurately translate one language into another, which helps individuals understand those from different cultural backgrounds. This technology can also assist businesses in understanding international markets better and de veloping appropriate marketing strategies. Multilingual translation technology has been widely utilized in various fields, including international travel, education, business, medicine, law, news, and media [51–53]. Furthermore, it can be used for content sharing on social media platforms, making it possible for users to access content in multiple languages. Liu et al. (2020) [54] discussed how generative AI-based multilingual translation technology is an emerging AI technology that enables automatic translation between different languages. It works by using neural networks to learn the mapping relationships between different languages, achieving automatic translation between them. Compared to traditional machine translation methods, generative AI-based multilingual translation technology has several advantages [55–57]: (1) high accuracy. Because it uses neural networks to learn the mapping relationships between different languages, it can achieve more accurate translation results; (2) fast speed. Because it uses neural networks to learn the mapping relationships between different languages, it can achieve faster translation results; (3) better scalability. Since it uses neural networks to learn the mapping relationships between different languages, it can achieve better scalability in terms of translation results. According to Chakravarthi et al. (2021) [58], generative AI, a multilingual machine translation technology based on deep learn ing, can automatically translate text from one language to another without human intervention. This is unlike traditional machine translation methods, as generative AI's multilingual translation process is achieved through deep learning. The process consists of two main parts: text generation, which transforms the original text into the target language, and text comprehension, which understands the information in the original text [59,60]. The neural network analyzes the original text and produces the target text accordingly, and then it comprehends the target text to accurately interpret the information in the original text. Despite its advantages, generative AI's multilingual translation technology still has some challenges. Its reliance on vast amounts of data and computational power may result in performance issues during practical use. Moreover, its accuracy can be compromised by data noise and bias [61]. Generative AI's multilingual translation technology has the potential to improve communication efficiency between people from different countries by enabling quick, accurate, and fluent communication. Additionally, it can aid businesses in expanding their operations in the global market by facilitating the introduction of their products and services to other countries with speed and precision.

Implementation of generative AI

Generative AI, as described by Barn es (2022) [62], works on the basis of learning a probability distribution p(x) and producing fresh samples from it, in the form of F(•). For facial generation, for instance, machine algorithms incorporate limitations of facial models, facial traits, and the physical laws of biomechanics, as well as learn from vast amounts of data like photographs, language, and text. This allows the machine to sample and render from a subspace linked to human faces that it has learned. According to Ye & Wang (2022) [63], deep neural networks, which are trained on massive datasets to learn their fundamental patterns and probability distributions, are the backbone of generative AI. These networks then employ generative models to generate new data. Generative AI can be achieved through the following two approaches [64–66]. (1) Autoregressive models are conditional probability-based generative models that can generate subsequent content related to the previously generated content. Common au toregressive models include recurrent neural networks and transformers. (2) Generative

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:09/September-2023 Impact Factor- 7.868 www.irjmets.com

Adversarial Networks (GANs) are generative models based on adversarial learning that can generate realistic data such as images and audio. Training a GAN entails pitting its generator against its discriminator in a friendly competition to boost the former's capacity to provide realistic data. Yet, GAN training is difficult because it must maintain a delicate equilibrium between the generator and discriminator's performance while avoiding local generator optima. Talan & Kalinkara (2023) [67] indicated that one of the main algorithms used in generative AI is the transformer, which is based on a self-attention mechanism, as illustrated in Fig. 4. Compared to recurrent neural networks, transformers can simultaneously consider global information, avoiding the issue of local incoherence [68–70]. The transformer consists of two main components: an encoder and a decoder. The encoder transforms the input sequence data into a set of feature vectors, while the decoder generates the output sequence based on these feature vectors. In addition to conventional methods, deep learning neural networks are often used in contemporary generative AI models. Deep learning uses massive neural networks to learn from data and make predictions, as described by Kshetri & Dwivedi (2023) [71]. Connected neurons in a neural network relay messages to one another when stimulated by external stimuli. These methods are used to develop generative AI models with capabilities such as NLP and image recognition. Generative AI models are also widely used in generating art, music, and other creative applications. Chow et al. (2022) [72] noted that GPT-3 is an advanced language model that can generate human-like text from provided prompts. It relies on the Transformer architecture, which efficiently handles large-scale language data. Due to its ability to generate coherent and contextually relevant text in diverse applications, GPT-3 has garnered significant attention [73,74]. According to Park & Kim (2022) [75], OpenAI's DALL-E is a generative model that can produce novel visuals from textual de scriptions. DALL-E can produce aesthetically creative graphics that fit the input text by merging the language production capacity of GPT-3 with image generation techniques. Reinforcement learning is a method by which artificial agents can learn to make deci sions by interacting with their surroundings and being rewarded or punished for their actions. This method can be used to fine-tune generative models so that they can produce high-quality output.

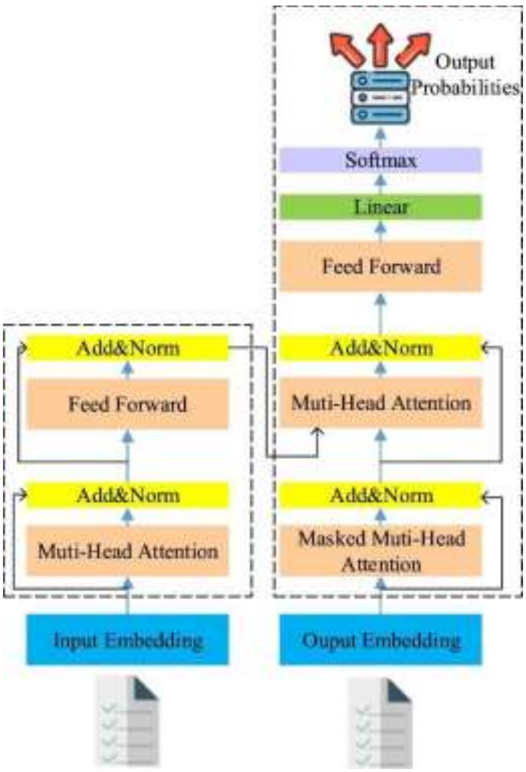

Figure 2. Architecture of the transformer algorithm.

Weking et al. (2023) [76] argued that content and interactivity, as two essential elements of the metaverse, are the driving forces behind the growth of the metaverse. Recent advances in application scenarios and the maturation of underlying interactive technology have given the metaverse a new lease on life. Multi-modal content with immersiveness, low latency, diversity, ubiquity, and clear identity attributes serves as both the

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:09/September-2023 Impact Factor- 7.868 www.irjmets.com

fundamental unit and the key pathway to the metaverse. AI will penetrate the entire metaverse ecosystem, playing a role in accelerating content development, increasing content presentation, improving distribution, and maximizing the efficiency of terminal applications [77,78]. Generational AI, as noted by Zhang et al. (2022) [79], is based on deep learning methods and artificial neural networks that mimic the brain's structure and function. These systems store, process, and transfer data via interconnected nodes or neurons operating at various levels of a hierarchical structure. NLP activities, including text summarization, machine translation, and dialog systems, have all benefited greatly from the application of generative AI. The Transformer model built on the attention mechanism is one of the most typical and has shown great success in machine translation jobs. According to Dimcea et al. (2023) [80], generative AI can also be used for image production and image restoration in computer vision. The Deep Convolution Generative Adversarial Network model based on generative adversarial networks is one of the most representative models because of its ability to generate realistic images. In the audio domain, generative AI can be used for tasks such as speech synthesis and music generation. The Wavenet model, one of the most prominent examples, can produce convincing synthetic voice and music. There are two main varieties of generative AI models, single-modal and multi-modal, as shown in Fig. 5. Single-modal models receive instructions from input types that are the same as their output, while multimodal models can obtain input from different sources and generate various output forms [81–83]. Notaro (2022) [84] noted that the emergence of the metaverse is being driven in part by the rapid development of many technolo gies, one of which is generative artificial intelligence. This technique, based on deep learning neural networks, may generate original conceptual art and other content in response to very straightforward textual instructions. Increased accessibility to AI-generated content interactivity made possible by advances in algorithms and processing power can be achieved through the integration of gen erative AI with extended reality (XR) and digital twins, among other interactive technologies [85–87]. Production of multi-modal material has become efficient and varied as a result of advancements in algorithms, computer power, and AI modeling methodologies

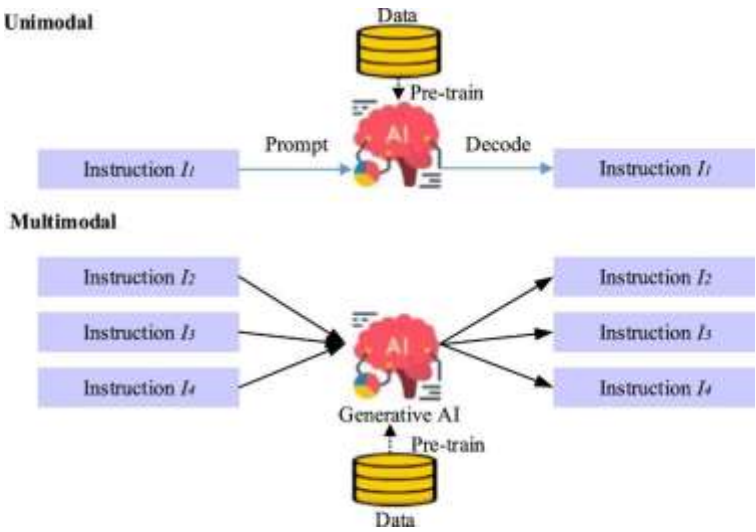

Figure 3. Two types of generative AI models.

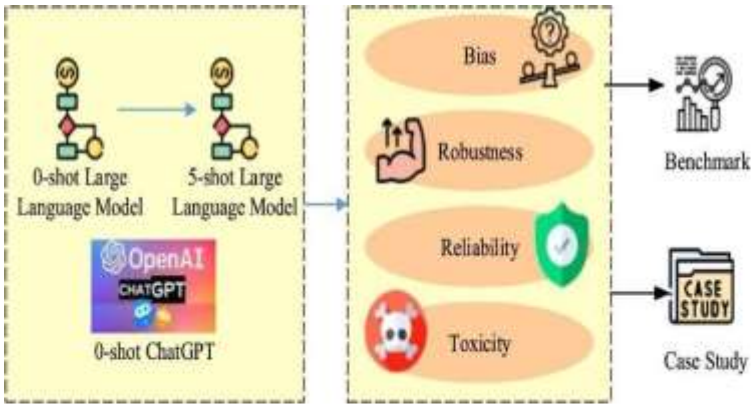

Figure 4. ChatGPT's AI ethical diagnosis framework

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:09/September-2023 Impact Factor- 7.868 www.irjmets.com

III. CONCLUSION

The metaverse will be a complex giant system carrying ultra-high concurrent data volume. This digital world will also show an exponential increase in information complexity due to the escalation of information dimensionality, far exceeding the computational limits of the human brain. This paper offers a comprehensive review of key technologies in the metaverse and the utilization of generative AI, delving into the significant role of the metaverse in various domains such as industry, governance, and scientific research. The metaverse empowers the intelligent economy's high-quality development by integrating core technologies like artificial intelligence, AR/VR, the Internet of Things, and blockchain. These technologies are poised to become the driving force behind future computational power advancements, generating a substantial demand for computing resources and leading to a transformation in computational deployment methods. AI, as a central component of future technological progress, exemplified by applications like ChatGPT, combined with the metaverse's specialized platform, holds the potential to create a new social and economic space where socioeconomic activities can flourish within a closed-loop environment. However, the development and application of the metaverse necessitate profound reflection and consideration. Key issues to address encompass striking a balance between technological progress and privacy protection, ensuring the metaverse's openness and diversity, and addressing potential security risks and ethical concerns that may emerge.

IV. REFERENCES

[1] S. Mondal, S. Das, V.G Vrana, How to bell the cat? A theoretical review of generative artificial intelligence towards digital disruption in all walks of life, Technologies 11 (2) (2023) 44 .

[2] S. Pal, T. Rabehaja, M. Hitchens, A. Hill, On the design of a flexible delegation model for the Internet of Things using blockchain, IEEE Trans. Ind. Inf. 16 (5) (2019) 3521–3530 .

[3] M. Jovanovic, M. Campbell, Generative artificial intelligence: trends and prospects, Computer (Long Beach Calif) 55 (10) (2022) 107–112.

[4] J. Perkins, Immersive metaverse experiences in decentralized 3d virtual clinical spaces: artificial intelligence-driven diagnostic algorithms, wearable internet of medical things sensor devices, and healthcare modeling and simulation tools, Am. J. Med. Res. 9 (2) (2022) 89–104.

[5] Gill S.S., Kaur R. ChatGPT: vision and challenges. Internet of Things and Cyber-Physical Systems, 2023.

[6] Q. Cai, H. Wang, Z. Li, X. Liu, A survey on multi-modal data-driven smart healthcare systems: approaches and applications, IEEE Access 7 (2019) 133583–133599.

[7] Y. Guo, T. Yu, J. Wu, Y. Wang, S. Wan, J. Zheng, Q. Dai, Artificial Intelligence for Metaverse: a Framework, CAAI Artif. Intell. Res. 1 (1) (2022) 54–67.

[8] [8] P.P Ray, ChatGPT: a comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope, Internet Things Cyber-Phys. Syst. (2023) .

[9] A. Baía Reis, M Ashmore, From video streaming to virtual reality worlds: an academic, reflective, and creative study on live theatre and performance in the metaverse, Int. J. Performance Arts Digital Media 18 (1) (2022) 7–28 .

[10] A.A Gaafar, Metaverse in architectural heritage documentation & education, Adv. Ecol. and Environ. Res. 6 (10) (2021) 66–86.

[11] R Godwin-Jones, Emerging spaces for language learning: AI bots, ambient intelligence, and the metaverse, Lang. Learn. Technol. 27 (2) (2023) 6–27.

[12] W.M. Lim, A. Gunasekara, J.L. Pallant, J.I. Pallant, E. Pechenkina, Generative AI and the future of education: ragnarök or reformation? A paradoxical perspective from management educators, Int. J. Manage. Edu. 21 (2) (2023) 100790 .

[13] M. Poggi, F. Tosi, K. Batsos, P. Mordohai, S. Mattoccia, On the synergies between machine learning and binocular stereo for depth estimation from images: a survey, IEEE Trans. Pattern Anal. Mach. Intell. 44 (9) (2021) 5314–5334.

[14] W.K. Sleaman, A.A. Hameed, A. Jamil, Monocular vision with deep neural networks for autonomous mobile robots navigation, Optik (Stuttg) 272 (2023) 170162 .

[15] X. Guo, Z. Wang, W. Zhu, G. He, H.B. Deng, C.X. Lv, Z.H Zhang, Research on DSO vision positioning technology based on binocular stereo panoramic vision system, Defence Technol. 18 (4) (2022) 593–603.
[16] F. Andriulli, P.Y. Chen, D. Erricolo, J.M Jin, Guest editorial machine learning in antenna design, modeling, and measurements, IEEE Trans. Antennas Propag. 70 (7) (2022) 4948–4952 .
[17] X. Wu, F. Guan, A. Xu, Passive ranging based on planar homography in a monocular vision system, J. Info. Process. Syst. 16 (1) (2020) 155–170.
[18] F. Gao, C. Wang, L. Li, Altitude information acquisition of uav based on monocular vision and mems, J. Intell. Robotic Syst. 98 (2020) 807–818.
[19] R.M. Samant, M.R. Bachute, S. Gite, K. Kotecha, Framework for deep learning-based language models using multi-task learning in natural language understand- ing: a systematic literature review and future directions, IEEE Access 10 (2022) 17078–17097.
[20] D. Ai, G. Jiang, S.K. Lam, C. Li, Computer vision framework for crack detection of civil infrastructure —A review, Eng. Appl. Artif. Intell. 117 (2023) 105478.
[21] M. Hawkins, Metaverse live shopping analytics: retail data measurement tools, computer vision and deep learning algorithms, and decision intelligence and modeling, J. Self-Governance Manage. Econ. 10 (2) (2022) 22–36 .
[22] R. Watson, The virtual economy of the metaverse: computer vision and deep learning algorithms, customer engagement tools, and behavioral predictive analytics, Linguistic Philos. Investig. (21) (2022) 41–56 .
[23] M. Hawkins, Virtual employee training and skill development, workplace technologies, and deep learning computer vision algorithms in the immersive metaverse environment, Psychosociological Issues Human Resour. Manage. 10 (1) (2022) 106–120 .
[24] S. Gordon, Virtual navigation and geospatial mapping tools, customer data analytics, and computer vision and simulation optimization algorithms in the blockchain-based metaverse, Rev. Contemp. Philos. (21) (2022) 89–104 .
[25] G.H. Popescu, K. Valaskova, J. Horak, Augmented reality shopping experiences, retail business analytics, and machine vision algorithms in the virtual economy of the metaverse, J. Self-Governance Manage. Econ. 10 (2) (2022) 67–81 .
[26] M. Castelli, L. Manzoni, Generative models in artificial intelligence and their applications, Appl. Sci. 12 (9) (2022) 4127.
[27] P. Ghannad, Y.C Lee, Automated modular housing design using a module configuration algorithm and a coupled generative adversarial network (CoGAN), Autom. Constr. 139 (2022) 104234 .
[28] Haleem A., Javaid M., Singh R.P. An era of ChatGPT as a significant futuristic support tool: a study on features, abilities, and challenges. BenchCouncil Transactions on Benchmarks, Standards and evaluations, 2022, 2(4): 100089.
[29] H. Yoon, Y. Lee, C. Shin, Avatar-based metaverse interactions: a taxonomy, scenarios and enabling technologies, J. Multimedia Info. Syst. 9 (4) (2022) 293–298.
[30] R.E. Weber, C. Mueller, C. Reinhart, Automated floorplan generation in architectural design: a review of methods and applications, Autom. Constr. 140 (2022) 104385 .
[31] W. Liao, Y. Huang, Z. Zheng, et al., Intelligent generative structural design method for shear wall building based on "fused-text-image-to-image " generative adversarial networks, Expert Syst. Appl. 210 (2022) 118530 .
[32] X. Lu, W. Liao, Y. Zhang, Y. Huang, Intelligent structural design of shear wall residence using physics-enhanced generative adversarial networks, Earthq Eng. Struct. Dyn. 51 (7) (2022) 1657–1676 .
[33] P. Machado, J. Romero, G. Greenfield, Artificial Intelligence for Designing Games, in: Artificial Intelligence and the Arts: Computational Creativity, Artistic Behavior, and Tools for Creatives, 2021, pp. 277–310 .
[34] S. Giddings, The achievement of animals: an ethology of AI in video games, Einspielungen (2020) 115–140.
[35] J. Ding, Autopoiesis crosses the human-machine boundary ——a brief analysis of the NPC image in the film-game integration movie, J. Edu., Humanities Soc. Sci. 3 (2022) 40–45 .

[36] X. Huang, D. Zou, G. Cheng, X. Chen, H Xie, Trends, research issues and applications of artificial intelligence in language education, Edu. Technol. Soc. 24 (3) (2021) 238–255 .

[37] A. Ramirez Gomez, M Lankes, Eyesthetics: making sense of the aesthetics of playing with gaze, Proc. ACM Human-Computer Interact. 5 (2021) 1–24 (CHI PLAY) .

[38] G.C. Dobre, M. Gillies, X. Pan, Immersive machine learning for social attitude detection in virtual reality narrative games, Virtual Real 26 (4) (2022) 1519–1538.

[39] S. Conway, M. Ouellette, Playing it cool: considering McLuhan's hot and cool taxonomy for Game Studies, Convergence 26 (5–6) (2020) 1211–1225.

[40] F.R Kawitzky, Magic Circles: tabletop role-playing games as queer utopian method, Performance Res. 25 (8) (2020) 129–136.

[41] G. Trichopoulos, G. Alexandridis, G Caridakis, A survey on computational and emergent digital storytelling, Heritage 6 (2) (2023) 1227–1263.

[42] G.A Sivasankar, Study of blockchain technology, ai and digital networking in metaverse, IRE J. 5 (8) (2022) 110–115.

[43] S. Kaddoura, F Al Husseiny, The rising trend of Metaverse in education: challenges, opportunities, and ethical considerations, PeerJ Comput. Sci. 9 (2023) e1252 .

[44] J.H. Choi, T. Chiang, Living with soft dragons: between science fiction and human-computer interaction, Interactions 29 (6) (2022) 18–20.

[45] G. Eysenbach, The role of chatgpt, generative language models, and artificial intelligence in medical education: a conversation with chatgpt and a call for papers, JMIR Med. Edu. 9 (1) (2023) e46885 .

[46] D. Bajaj, A. Goel, S.C. Gupta, H. Batra, MUCE: a multilingual use case model extractor using GPT-3, Int. J. Info. Technol. 14 (3) (2022) 1543–1554.

[47] F. Khalil, G. Pipa, Transforming the generative pretrained transformer into augmented business text writer, J. Big Data 9 (1) (2022) 112.

[48] X.P. Nguyen, S. Joty, K. Wu, A.T Aw, Refining low-resource unsupervised translation by language disentanglement of multilingual translation model, Adv. Neural Inf. Process. Syst. 35 (2022) 36230–36242 .

[49] E. Razumovskaia, G. Glavas, O. Majewska, E.M. Ponti, A. Korhonen, I. Vulic, Crossing the conversational chasm: a primer on natural language processing for multilingual task-oriented dialogue systems, J. Artificial Intelligence Res. 74 (2022) 1351–1402.

[50] B. Natarajan, E. Rajalakshmi, R. Elakkiya, K. Kotecha, A. Abraham, L.A. Gabralla, V. Subramaniyaswamy, Development of an end-to-end deep learning frame- work for sign language recognition, translation, and video generation, IEEE Access 10 (2022) 104358–104374.

[51] U. Reber, Overcoming language barriers: assessing the potential of machine translation and topic modeling for the comparative analysis of multilingual text corpora, Commun. Methods Meas. 13 (2) (2019) 102–125 .

[52] G. Alipour, J. Bagherzadeh Mohasefi, M.R Feizi-Derakhshi, Learning bilingual word embedding mappings with similar words in related languages using GAN, Appl. Artif. Intell. 36 (1) (2022) 2019885 .

[53] D. Maier, C. Baden, D. Stoltenberg, et al., Machine translation vs. multilingual dictionaries assessing two strategies for the topic modeling of multilingual text collections, Commun. Methods Meas. 16 (1) (2022) 19–38 .

[54] Liu Y., Gu J., Goyal N., & Zettlemoyer, L. Multilingual denoising pre-training for neural machine translation. Transactions of the Association for Computational Linguistics, 2020, 8: 726–742.

[55] J. Long, Application of Artificial Intelligence (AI) technology in Chinese English translation system corpus, J. Artif. Intell. Practice 5 (3) (2022) 8–13.

[56] W. Hariri, Unlocking the potential of ChatGPT: a comprehensive exploration of its applications, Technology 15 (2) (2023) 16.

[57] L. Xiang, Y. Zhao, Jl Zhu, Zero-shot language extension for dialogue state tracking via pre-trained models and multi-auxiliary-tasks fine-tuning, Knowl. Based Syst. 259 (2023) 110015 .

[58] B.R. Chakravarthi, P. Rani, M. Arcan, J.P McCrae, A survey of orthographic information in machine translation, SN Comput. Sci. 2 (4) (2021) 330.

[59] A.L. Zorrilla, M.I Torres, A multilingual neural coaching model with enhanced long-term dialogue structure, ACM Transactions on Interactive Intelligent Systems (TiiS) 12 (2) (2022) 1–47 .

[60] C. Malaterre, F. Lareau, The early days of contemporary philosophy of science: novel insights from machine translation and topic-modeling of non-parallel multilingual corpora, Synthese 200 (3) (2022) 242 .

[61] J. Oh, Y.S Choi, Reusing monolingual pre-trained models by cross-connecting seq2seq models for machine translation, Appl. Sci. 11 (18) (2021) 8737.

[62] R. Barnes, Healthcare diagnosis and treatment in the metaverse: remote sensing algorithms, networked wearable devices, and virtual patient data, Am. J. Med. Res. 9 (2) (2022) 41–56 .

[63] P. Ye, F.Y Wang, Parallel population and parallel human —A cyber-physical social approach, IEEE Intell. Syst. 37 (5) (2022) 19–27.

[64] E.V.P. Beyan, A.G.C Rossy, A review of AI image generator: influences, challenges, and future prospects for architectural field, J. Artif. Intell. Architect. 2 (1) (2023) 53–65 .

[65] M. Newell, Wearable healthcare monitoring devices, 3D medical imaging data, and virtualized care systems in the decentralized and interconnected metaverse, Am. J. Med. Res. 9 (2) (2022) 137–152 .

[66] A. Thurzo, M. Strunga, R. Urban, J. Surovková, K.I Afrashtehfar, Impact of artificial intelligence on dental education: a review and guide for curriculum update, Educ. Sci. 13 (150) (2023) 2023 .

[67] Talan T., Kalinkara Y. The role of artificial intelligence in higher education: ChatGPT assessment for anatomy course. Uluslararas ı Yönetim Bili ş im Sistemleri ve Bilgisayar Bilimleri Dergisi, 2023, 7(1): 33–40.

[68] Cui L.B., Zhu C.Z., Hare R., & Tang Y. MetaEdu: a new framework for future education. Discover Artificial Intelligence, 2023, 3(1): 10.

[69] O. Wlasinsky, Literature review on the most popular of NFTs types, Int. J. Educ. Technol. Artif. Intell. 2 (1) (2023) 8–12.

[70] N. Kshetri, Y.K Dwivedi, Pollution-reducing and pollution-generating effects of the metaverse, Int. J. Inf. Manage. 69 (2023) 102620.

[71] P. Bhattacharya, D. Saraswat, D. Savaliya, S. Sanghavi, A. Verma, V. Sakariya, D.L Manea, Towards future internet: the metaverse perspective for diverse industrial applications, Mathematics 11 (4) (2023) 941 .

[72] Y.W. Chow, W. Susilo, Y. Li, N. Li, C. Nguyen, Visualization and cybersecurity in the metaverse: a survey, J. Imaging 9 (1) (2022) 11.

[73] N.C. Tran, J.H. Wang, T.H. Vu, T.C. Tai, J.C Wang, Anti-aliasing convolution neural network of finger vein recognition for virtual reality (VR) human–robot equipment of metaverse, J. Supercomput. 79 (3) (2023) 2767–2782 .

[74] H. Hassani, E.S Silva, The role of ChatGPT in data science: how AI-assisted conversational interfaces are revolutionizing the field, Big Data Cognit. Comput. 7 (2) (2023) 62 .

[75] S.M. Park, Y.G Kim, A metaverse: taxonomy, components, applications, and open challenges, IEEE access 10 (2022) 4209–4251.

[76] J. Weking, K.C. Desouza, E. Fielt, M Kowalkiewicz, Metaverse-enabled entrepreneurship, J. Bus. Venturing Insights 19 (2023) e00375.

[77] Y. Zhong, P. Renner, W. Dou, G. Ye, J. Zhu, Q.H Liu, A machine learning generative method for automating antenna design and optimization, IEEE J. Multiscale Multiphys. Comput. Techn. 7 (2022) 285–295 .

[78] H.J. Lee, H.H Gu, Empirical research on the metaverse user experience of digital natives, Sustainability 14 (22) (2022) 14747.

[79] Z. Zhang, F. Wen, Z. Sun, X. Guo, T. He, C. Lee, Artificial intelligence-enabled sensing technologies in the 5G/internet of things era: from virtual real- ity/augmented reality to the digital twin, Adv. Intell. Syst. 4 (7) (2022) 2100228 .

[80] I. Dimcea, D.C. Cozmiuc, D. Botez, D. Darvasi, M. Untaru, R. Wagner, A.M Titu, Digital solutions for bespoke apparel achieving mass customization in as service business models, Industria Textila 74 (1) (2023) 107–120 .

[81] Q. Sun, Y. Xu, Y. Sun, C. Yao, J.S.A. Lee, K Chen, GN-CNN: a point cloud analysis method for metaverse applications, Electronics (Basel) 12 (2) (2023) 273.

[82] H. Zhang, S. Lee, Y. Lu, X. Yu, H.A. Lu, Survey on big data technologies and their applications to the metaverse: past, current and future, Mathematics 11 (1) (2023) 96 .

[83] S.E. Bibri, Z. Allam, J. Krogstie, The Metaverse as a virtual form of data-driven smart urbanism: platformization and its underlying processes, institutional dimensions, and disruptive impacts, Computat. Urban Sci. 2 (1) (2022) 24 .

[84] A. Notaro, All that is solid melts in the Ethereum: the brave new (art) world of NFTs, J. Visual Art Practice 21 (4) (2022) 359–382.

[85] X. Zheng, D. Bassir, Y. Yang, Z. Zhou, Intelligent art: the fusion growth of artificial intelligence in art and design, Int. J. Simul. Multi. Design Optim. 13 (2022) 24 .

[86] P. Rospigliosi, Artificial intelligence in teaching and learning: what questions should we ask of ChatGPT?, in: Interactive Learn. Environ., 31, 2023, pp. 1–3.

[87] S.C Chen, Multimedia research toward the Metaverse, IEEE. Multimedia 29 (1) (2022) 125–127.

[88] Y.K. Dwivedi, N. Kshetri, L. Hughes, E. Slade, A. Jeyaraj, A.K. Kar, R. Wright, So what if ChatGPT wrote it? " Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy, Int. J. Inf. Manage. 71 (2023) 102642.

[89] B. Rathore, Future of AI & Generation Alpha: chatGPT beyond Boundaries, Eduzone 12 (1) (2023) 63–68.

[90] W. Castillo-Gonzalez, ChatGPT y el futuro de la comunicación científica, Metaverse Basic Appl. Res. 1 (2022) 8-8.

[91] C. Guo, Y. Lu, Y. Dou, F.Y. Wang, Can ChatGPT boost artistic creation: the need of imaginative intelligence for parallel art, IEEE/CAA J. Automatica Sinica 10 (4) (2023) 835–838 .

[92] A.S. George, A.S.H George, A review of ChatGPT AI's impact on several business sectors, Partners Universal Int. Innovat. J. 1 (1) (2023) 9–23.

[93] Q. Miao, W. Zheng, Y. Lv, M. Huang, W. Ding, F Wang, DAO to HANOI via DeSci: AI paradigm shifts from AlphaGo to ChatGPT, IEEE/CAA J. Automatica Sinica 10 (4) (2023) 877–897 .

[94] P.P Ray, Web3: a comprehensive review on background, technologies, applications, zero-trust architectures, challenges and future directions, Internet Things Cyber-Physical Syst. (2023) .

[95] P.S Carnicelli, A welcome letter to all leisure friends, World Leis J. 65 (1) (2023) 1–2 .

[96] J.R. Rameshwar, K. Graham, Analysis of caribbean XR survey creates an XR development strategy as a path to the regional metaverse evolution, J. Metaverse 3 (1) (2023) 43–65 .

[97] L. Ramírez-Polo, C. Vargas-Sierra, Translation technology and ethical competence: an analysis and proposal for translators' training, Languages 8 (2) (2023) 93 .

[98] R. Dale, NLP startup funding in 2022, Nat. Lang. Eng. 29 (1) (2023) 162–176 .

[99] M. Liebrenz, R. Schleifer, A. Buadze, D. Bhugra, A. Smith, Generating scholarly content with ChatGPT: ethical challenges for medical publishing, Lancet Digital Health 5 (3) (2023) e105–e106 .

[100] S.B. Patel, K. Lam, ChatGPT: the future of discharge summaries?, in: Lancet Digital Health, 5, 2023, pp. e107–e108.

[101] A. Tlili, B. Shehata, M.A. Adarkwah, A. Bozkurt, D.T. Hickey, R. Huang, B. Agyemang, What if the devil is my guardian angel: chatGPT as a case study of using chatbots in education, Smart Learn. Environ. 10 (1) (2023) 15 .