Received 25 September 2022
Revised 9 October 2022
Accepted 31 October 2022

Exploring the metaverse in the digital economy: an overview and research framework

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Abstract

Purpose – Metaverse is a virtual application spawned by digital technology that is becoming increasingly relevant to our lives. However, for the opportunities created and challenges posed by the metaverse, its important elements and future evolution trend remain largely unknown. Thus, this paper aims to understand the current status of metaverse research and its future research directions.

Design/methodology/approach – Based on the analysis of the literature data on the metaverse both in English and Chinese using Latent Dirichlet allocation (LDA) topic modeling and bibliometrics, this study discussed the related research and development trend of the metaverse. The authors first defined the concept of the metaverse and analyzed 1,378 English articles from seven publishers and 590 Chinese articles from the CNKI database. Following that, the authors summarized three important themes from the current studies: virtual world, metaverse technologies and metaverse applications. Finally, a framework of future directions on metaverse research was proposed.

Findings – The review found that during the rapid development of the metaverse, opportunities and challenges coexisted. In the virtual world, metaverse technologies drive the implementation of application scenarios, and in turn, applications promote the improvement of technologies. The interrelationship between technology and application lays the foundation for the development of the metaverse. Future metaverse research will generate different research directions.

Originality/value – This review provides a valuable, systematic perspective for individuals who want to understand the metaverse. The conceptual framework on metaverse research proposed in this paper offers a

Funding: The study is funded by the Metaverse Research Center in Renmin University of China and the School of Interdisciplinary Studies in Renmin University of China.

Journal of Electronic Business & Digital Economics
Vol. 1 No. 1/2, 2022
pp. 206-224
Emerald Publishing Limited
e-ISSN: 2754-4222
p-ISSN: 2754-4214
DOI 10.1108/JEBDE-09-2022-0036

comparison of literature analysis from domestic and international perspectives and brings new insights into the development of the metaverse.

Keywords Metaverse, Digital economy, Virtual world, Review

Paper type Literature Review

1. Introduction

The development of advanced technologies has changed people's lives and created a new vitality for the digital ecology. Social bonds between individuals are no longer limited to face-to-face communication. A new round of computer revolution is developing around artificial intelligence, blockchain, immersive technology, etc. The applications of these technologies have contributed to increasing digitization of the real world, breaking the boundaries between the physical and the virtual worlds. Interactivity, multi-perception, immersion and autonomy have also become the focus of people's attention (Luo, 2019). The development of the digital economy era can be promoted by the digital transformation of industry and consumer demand.

The concept of the metaverse was first proposed in the novel "Snow Crush" three decades ago (Stephenson, 1992). This book describes a parallel virtual world where the users can live and work. Virtual interactions that break through the limitations of time and space are also known as the "ultimate form" of the Internet. Persistence, synchronization, real-time, interoperability and infinity are important attributes of the metaverse. The term "metaverse" consists of "Meta" and "Verse", which, when combined, stand for "transcendence of the universe" (Pamucar, Deveci, Gokasar, Tavana, & Köppen, 2022; Cheng, 2022). Following Cheng (2022), this paper defines the metaverse as "*a virtual world parallel and fused with the current real world, with a high degree of interaction with the real world*", with the indication that people can switch freely between real and virtual spaces.

The core technologies of the metaverse include extended reality, blockchain, brain–computer interfaces, digital twins, etc. The identity authentication system uniquely labels the individual in the digital living space. The convergence of different technologies enhances the individual's immersive experience in the virtual space. Since Mark Zuckerberg announced in 2021 that Facebook would change its name to Meta, the metaverse has received considerable attention and has been widely discussed, leading to breakthrough innovations in various industries, including social networking, entertainment, e-commerce among many others (Zuckerberg, 2021).

The metaverse is empowered by new technologies, with opportunities and challenges coexisting. The global COVID-19 pandemic has spawned new opportunities and accelerated digitization. Based on the front-end and back-end technologies, the integration of the metaverse with many fields is bringing various new developments. The metaverse has fruitful prospects for development and has been applied to various fields (Bailey, Leonardi, & Barley, 2012; Cheng, Fu, & Druckenmiller, 2017). Domestic and foreign enterprises have also begun to introduce metaverse into production and operation business. The metaverse continues to generate new momentum for digital economic growth.

However, the promising future of the metaverse also brings various unexpected problems which raise doubts on the healthy development of the metaverse and the digital economy. For instance, uncertainty in virtual world collaboration has a negative effect on the establishment of trust relationships (Srivastava & Chandra, 2018). The design principles of the virtual co-creation systems are still not adequate, and helpful frameworks need to be established for co-creation in the virtual world (Kohler, Fueller, Matzler, Stieger, & Füller, 2011). The development of sustainable transportation in the metaverse is inseparable from well-performing models and decision-making schemes (Pamucar *et al.*, 2022). Information technology (IT) can induce pressures such as invasion of privacy and work overload

(Ayyagari, Grover, & Purvis, 2011; Zhang, Wang, Karahanna, & Xu, 2022a). These issues call for further exploration of the metaverse.

The metaverse yields different perspectives to research, and many unresolved research questions need to be further explored. This study aims to understand the research status and future trends of the metaverse. And this paper differs from other metaverse literature reviews in that (1) we collected data from several databases and provided a more comprehensive review of the metaverse research; (2) we analyzed the English and Chinese literature, which is a more specific study of the development of the metaverse. In the next section, Latent Dirichlet allocation (LDA) topic modeling and bibliometric analysis are provided. Section 3 introduces the related research on virtual world, metaverse technologies and metaverse applications. Our framework of future directions on metaverse research is shown in Section 4. Section 5 summarizes the findings of this literature review.

2. LDA topic modeling and bibliometric analysis

LDA topic modeling and bibliometric analysis have been employed for the analysis of metaverse studies. This section covers most of the academic research databases, including ScienceDirect, Springer, Wiley, CNKI, etc., and is divided into two sub-sections: analysis of the literature on the metaverse in English and analysis of the literature in Chinese. Specifically, LDA topic modeling was conducted using the abstracts of both English and Chinese articles. In addition, a keyword co-occurrence network was built based on the Chinese literature.

2.1 Analysis of the literature in English

Seven popular publishers—ScienceDirect, Springer, Wiley, Taylor, Emerald, Institute of Electrical and Electronics Engineers (IEEE) and Association for Computing Machinery (ACM)—were selected for the analysis. Using "Metaverse" as the keyword, we searched in the above databases and obtained a total of 1,810 pieces of data with the fields of "Title," "Abstract" and "Keywords" through crawlers. Values that were missing or duplicate were eliminated in the process of data cleaning. Articles that were irrelevant to metaverse were also removed. Finally, 1,378 pieces of valid data were retained.

Research related to the metaverse involves various fields. In order to better understand the metaverse literature review, we analyzed the high-frequency words. As the title usually reflects the main research topic of an article, we mainly used the titles of English articles for high-frequency words analysis. We first split the titles into separate words and counted the frequency of each word. The keywords with a frequency of over 200 (see Figure 1) were selected for visualization. The words "World," "Reality," "Information," "Online," etc. are elements of the virtual world. "3D," "VR," etc. are technologies that power the metaverse, and "Digital," "Social," "Immersive," etc. are perceptions that metaverse technologies bring to individuals. "Learning," "Experience," etc. are reflections of metaverse application scenarios. Therefore, high-frequency keywords can be divided into three categories: virtual world, metaverse technologies and metaverse applications.

In this paper, we obtained the optimal number of topics according to an indicator called perplexity. The perplexity can measure the fit of the LDA model, and the lower the perplexity is, the better the models are (Hannigan *et al.*, 2019). Figure 2 provides the perplexity of the LDA model for English articles. Based on this, five topics were derived from the English literature on the metaverse (see Table 1).

As shown in Table 1, Topic 1, Technology, includes terms such as "VR," "AR" and "Blockchain." Topic 2 is Application, including terms like "Market," "Service", "Business"

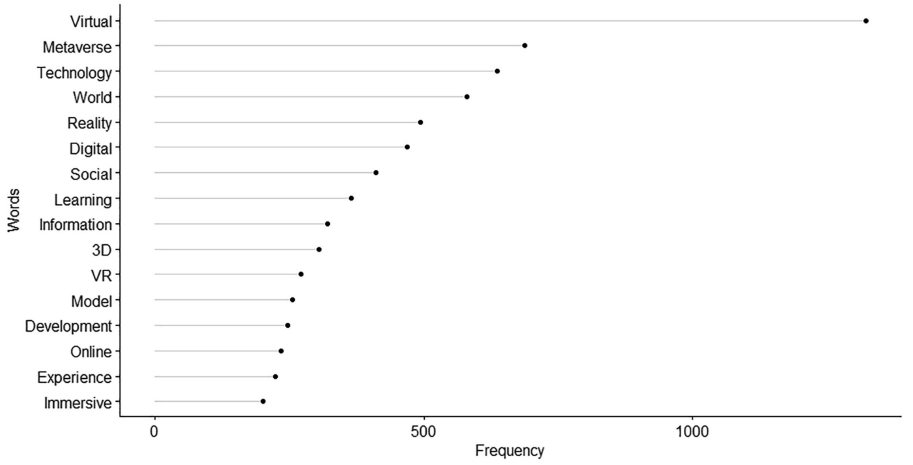

Figure 1.
High-frequency words in metaverse studies

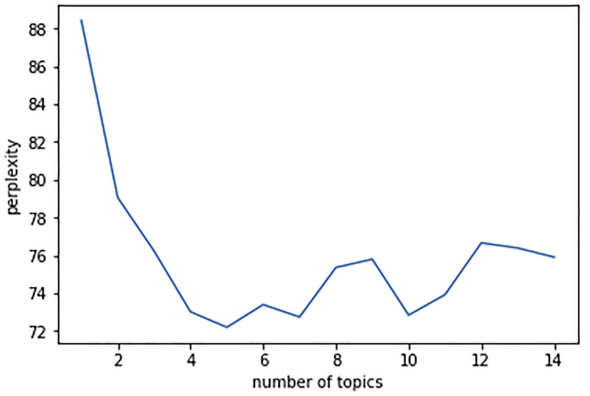

Figure 2.
Perplexity of the LDA model for the literature in English

Topic	Top 5 words
#1 Technology	VR, AI, Blockchain, Digital, Technology
#2 Application	Students, Social, Market, Service, Business
#3 Virtual world	Web, Environment, Media, Users, Worlds
#4 Framework	Design, System, Model, Content, Performance
#5 Development	Applications, Internet, Knowledge, Project, Process

Table 1.
LDA theme analysis results of the literature in English

and so on. The third topic covers "Web," "Environment," "Media," etc. which are the characteristics and elements of the virtual world. The fourth topic, Framework, is the combination of technology and application. The topic of development consisted of terms like "Application" and "Internet." The wide coverage of the above topics shows that the English literature on the metaverse is relatively comprehensive.

2.2 Analysis of the literature in Chinese

The metaverse has become a worldwide craze, and many countries have incorporated it into their development strategies. For example, the Seoul Metropolitan Government released the

Seoul Metaverse Seoul Five-Year Plan in 2021 (CoinYuppie, 2021); Japan has laid out a plan for a "Society 5.0" super-intelligent society (CGTN, 2019). China has strong potential and unique advantages in the development and construction of metaverse in terms of technological capability, economic volume and comprehensive strength. Many regions of the country have introduced policies on the metaverse to promote the development of the digital economy (Influence Matters, 2022). A number of Internet companies have already applied the metaverse to business scenarios (Stephen, 2022). China's metaverse industry plays a crucial role in the global metaverse landscape, which warrants analysis of the metaverse research conducted there.

For the analysis of the literature data in Chinese, the CNKI database (a mainstream academic database in China) was used as the data source for the search of the keyword "Metaverse." A total of 590 articles were collected after deduplication and screening. The bibliometric analysis of the 590 articles was performed by using CiteSpace to construct a keywords co-occurrence network. The keywords were used as the network nodes, and the frequency of keyword occurrences was used as the size of the nodes; the more frequent the occurrences, the larger the nodes. The connected edges indicate the co-occurrence between keywords, and the more frequent the co-occurrence, the thicker and darker the color of the edges.

It is found that the research with the theme of "metaverse" in Chinese is lagging behind its English counterpart, but the research and application scenarios on the underlying technology of the metaverse are very mature and abundant. As shown in Figure 3, the current research on metaverse in China is more focused on the conceptual technology and application scenarios. The research hotspots in the underlying technologies are as follows: virtual reality (VR), augmented reality (AR), non-fungible token (NFT), digital twins, artificial intelligence, blockchain, etc. And the research hotpots on application scenarios include smart libraries, online education, virtual digital human and digital assets, etc.

The LDA model was applied to process the topic classification of 590 abstracts of metaverse-related literature to study the topic distribution of Chinese metaverse research.

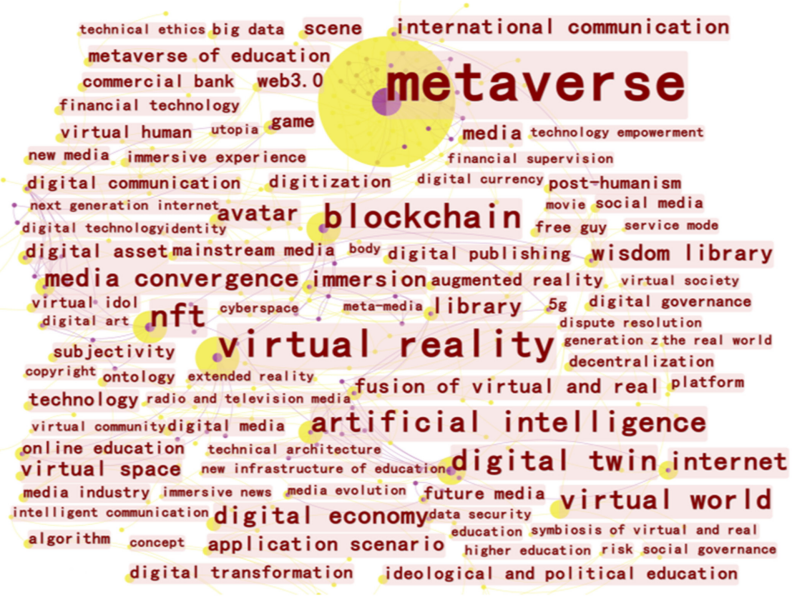

Figure 3.
Keywords co-occurrence network of metaverse research in Chinese (translated into English)

And the perplexity here reaches its lowest point at scale 2, indicating that the number of topics is most appropriate when divided into two categories (see Figure 4). By analyzing the lexical information contained in each theme in Table 2 and the articles that were classified, the two categories were named as concept and technical support, applications and construction.

Both the literature in English and Chinese emphasizes the technology (blockchain, VR, artificial intelligence, Internet, etc.) and application scenarios (education, service, game, etc.) of the metaverse, reflecting the core elements of the metaverse. Additionally, the virtual world is the focus of English and Chinese literature, and "immersion," "virtual characters," "environment" and "avatar" are all characteristics of the metaverse. The difference is that the English literature devotes more attention to the metaverse architecture, such as design, system, model, etc., while the Chinese literature focuses more analytical efforts on the concepts and application scenarios of the metaverse. As shown in Figure 5, the high-frequency words of the English literature were summarized into three aspects: virtual world, metaverse technologies and metaverse applications. Three of the five topics obtained by LDA modelling were related to these three aspects. In addition, the keyword co-occurrence network obtained by bibliometric analysis on the literature data in Chinese demonstrates some characteristics of virtual world, as well as metaverse technologies and applications. The LDA topic modeling results of the Chinese literature show that Topic 1 is related to metaverse concepts and technologies, and Topic 2 is related to metaverse applications. Therefore, combining the results of the analysis of the Chinese and English literature, we extracted three important elements of the metaverse: virtual world, metaverse technologies and metaverse applications.

Specifically, the relationships between the virtual world, metaverse technologies and metaverse applications were summarized in Figure 6. From a holistic perspective, the metaverse is both an immersive 3D digital space and a virtual network (Dionisio, Burns, & Gilbert, 2013). Therefore, the virtual world is an important representation of the metaverse (Shin, 2009). Technologies drive the realization of metaverse applications, and various innovative

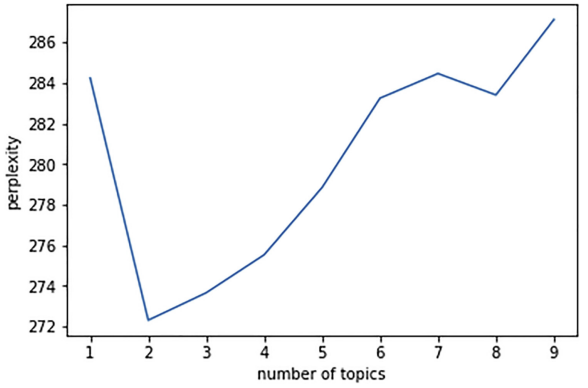

Figure 4.
Perplexity of the LDA model for the literature in Chinese

Topic	Top-10 words
#1 Concept and technical support	Social, Human, Real world, Space, Future, Communication media, Virtual world, Relationship, Culture, Life
#2 Applications and construction	Education, Concept, Library, Mode, Fusion, Scenario, Innovation, Internet, Industry, Domain

Table 2.
LDA theme analysis results of the literature in Chinese

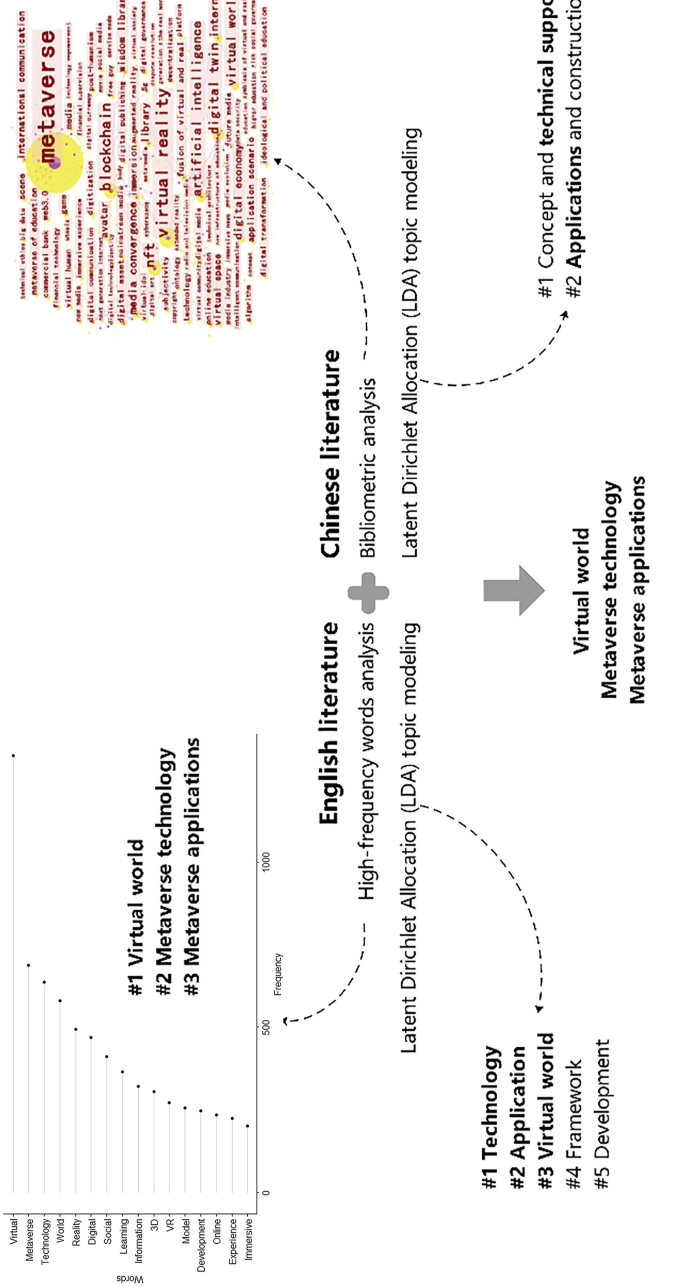

Figure 5.
Illustrative diagram of the extraction of the three metaverse elements

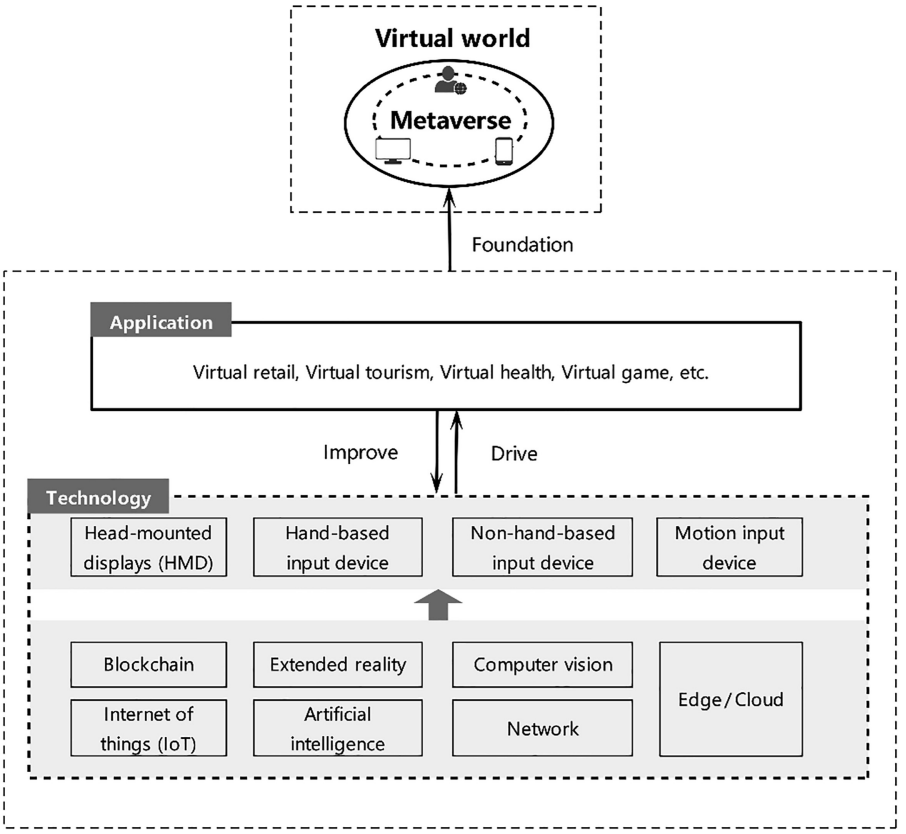

Figure 6.
Relationships between different elements of the metaverse

technologies enable users to enjoy an immersive virtual interactive experience (Huynh-The *et al.*, 2022). Software and hardware have become inseparable technical support for the development of the metaverse (Park *et al.*, 2022). Reciprocally, the applications promote technological progress (Huynh-The *et al.*, 2022). In addition, technologies and application scenarios merge to form the foundation of the metaverse in the virtual world (Ning *et al.*, 2021). The development of the metaverse is inseparable from technical support and application.

3. Related research

3.1 Virtual world

A virtual world is a virtual environment simulated by computers in which individuals can participate in various activities in an immersive 3D digital space (Nevo, Nevo, & Kim, 2012). People share knowledge and communicate through computers in virtual spaces. In effect, the virtual world belongs to the category of virtual communities, where people can work and live in digital virtual spaces (Schwarz, Schwarz, Jung, Pérez, & Wiley-Patton, 2012). Virtual communities refer to the networks of personal relationships formed in cyberspace and social aggregations that emerge (Rheingold, 2000). Similar to the virtual world, the composition of a virtual community includes computer systems, people and shared purposes (Preece, 2001). In the virtual world, individuals have avatars and identity performance (Mitchell, Murphy,

Owens, Khazanchi, & Zigurs, 2009). Virtual characters contain the basic attributes of an individual in the real world, such as gender, age, education level, etc. Virtual characters are not entirely passive, and some performance is beyond the user's control (Schultze, 2014). As users interact with virtual characters, they also help these characters learn dynamically to better simulate user behavior in the real world.

The construction and application of virtual worlds involve many scenarios. The digital learning ecosystem can be improved by examining user behavior and engagement metrics in the educational virtual world (Cruz-Benito, Therón, García-Peñalvo, & Lucas, 2015). The concepts of usability and psychological ownership were used to develop a model to engage users in the virtual world (Lee & Chen, 2011). The establishment of brand relationships in the virtual world was analyzed using bibliometric approach, and the clustering of keywords was obtained (Veloutsou & Mafe, 2020). Other studies investigated factors influencing team member performance in virtual worlds, such as leader–member exchange (Goh & Wasko, 2012), trust (Cheng, Bao, Yu, & Shen, 2021), social presence (Srivastava & Chandra, 2018), pedagogical challenges (Quintana & Fernández, 2015), metacognitive self-regulation (Pellas, 2014), etc. Teamwork in the virtual world reflects the realization of human–computer interaction (HCI) (Boughzala, de Vreede, & Limayem, 2012).

3.2 Metaverse technologies

The metaverse is the fusion of the physical and virtual world, which necessitates the development and integration of multiple technologies. The realization of the metaverse requires the support of device platforms, including extended reality, intelligent hardware and HCI. Machine vision enables individuals to interact with virtual characters in the metaverse. Lee *et al.* (2021) divided the technology base of the metaverse into eight categories: user interaction technologies, expanded reality (VR/AR/MR), computer vision, artificial intelligence/blockchain, robotics/logistics networks, edge computing/cloud computing, future networks and hardware infrastructure. Park *et al.* (2022) divided the technical support for the metaverse into hardware and software, where hardware includes physical devices and sensors, such as hand-based input device, head-mounted displays, motion input device and nonhand-based input device, and software includes the identification and rendering technologies needed to build the metaverse. This paper combines the above two classifications to categorize the technologies needed to build the metaverse into hardware and software. Hardware is the physical equipment needed for humans to enter the virtual world from reality or to interact with mixed reality (MR). It is the essential physical foundation of the metaverse. Software is the technical basis for the operation of the metaverse and is a constituent element of the virtual world. It contains blockchain, extended reality (VR/AR/MR), computer vision, artificial intelligence, Internet of things (IoT), edge computing/cloud computing and network.

(1) Smart hardware

Smart hardware includes smart bracelets, smart watches, smart cars, etc. The combination of hardware and software is carried out through the intelligent transformation that enables built-in intelligent functions in traditional equipment. One of the crucial factors in the metaverse experience is the sensory interaction device. To give users a visual immersion experience, a lightweight head-mounted display (HMD) and the ability to use high-resolution images for extended periods are required (Choi & Kim, 2017). HCI refers to the interaction relationship between humans and computers (Diederich, Brendel, Morana, & Kolbe, 2022; Card, Moran, & Newell, 1980). The higher the degree of HCI, the stronger the friendliness of the machine. HCI has gradually transitioned from keyboard operation to voice, gesture and action commands. HCI devices are essential hardware facilities for conducting HCI activities in the metaverse. Zhu (2020) has developed a glove (a hand-based input device) for human–computer interface based

on VR and AR applications which support haptic feedback to users on virtual events. Nonhand-based input device refers to a hands-free assistive device that assists the user in the metaverse by tilting the user's head (Crossan, McGill, Brewster, & Murray-Smith, 2009), turning the eyeball (Djamasbi, 2014), etc. The motion input device is also an important hardware to support the user's movement in the metaverse. The metaverse will also show similar scenes and functions.

(2) Software

If hardware forms the skeleton of the metaverse, then software serves as the organ of the metaverse. In software technology, different types of technology assume different functions. Extended reality is defined as a general term for encapsulating VR, AR and MR (Huynh-The *et al.*, 2022). AR provides users with an audiovisual experience in the real world, VR enables users to immerse themselves in the digital world fully and MR can provide a transitional experience (Huynh-The *et al.*, 2022). Digital twins, a technology that maps physical equipment within real space into virtual space, is the foundation of the metaverse. It represents real objects in the digital world through data and functions (Schluse, Priggemeyer, Atorf, & Rossmann, 2018). IoT is an important technology for digital twins, which can build twin environments in the metaverse, enriching scene construction and enhancing reality (Li, Xu, & Zhao, 2015). User ownership of physical assets correspondingly reflects the ownership of digital twins (Putz, Dietz, Empl, & Pernul, 2021). The cryptographic and decentralized nature of blockchain makes it more widely used in the metaverse (Gadekallu *et al.*, 2022). Additionally, the maintenance of the metaverse requires the support of big data and computing power, involving cloud computing, artificial intelligence network and other technologies. Previous research has reviewed the technical support needed to construct the metaverse, such as network, cloud computing, edge computing, artificial intelligence, computer vision, etc. (Lee *et al.*, 2021).

3.3 Metaverse applications

E-commerce, virtual tour and virtual health are important application scenarios in the field of metaverse development, creating an impetus for the development of the digital economy.

(1) Virtual retail

VR technologies are used differently in online retail environments (Tan, Chandukala, & Reddy, 2022). The rise of new technologies has offered development opportunities for the retail industry in which analysis of customer behavior and psychology is a trending topic. Adams (2022) found that consumer journey analytics based on personalized shopping experiences of customers might do good to their behaviors of virtual asset purchasing. Jung and Pawlowski (2014) analyzed users' consumption goals for virtual goods using the interview method, extending the understanding of user behavior in the virtual world. Baker, Hubona and Srite (2019) investigated the shopping experience and consumption behavior of consumers in the virtual world and the real world and identified the factors that affected shopping attitudes. The technological and spatial environments will affect the virtual experience of consumers, further affecting their willingness to buy virtual goods (Animesh, Pinsonneault, Yang, & Oh, 2011; Pizzi, Scarpi, Pichierri, & Vannucci, 2019). VR also contributes to the development of new products by consumer durable producers (Harz, Hohenberg, & Homburg, 2022).

(2) Virtual tourism

The use of virtual technology in tourism is gaining momentum. Sandra analyzes studies on VR and AR in the context of tourism using text mining methods (Loureiro, Guerreiro, & Ali, 2020). Studies related to virtual tour are gradually combined with psychology (Merkx & Nawijn, 2021; Yang, Lai, Fan, & Mo, 2021), emotions (Zhang, Li, Ruan, & Liu, 2022b), mental imagery

(Skard, Knudsen, Sjåstad, & Thorbjørnsen, 2021) and behavior (Wei, Qi, & Zhang, 2019). Other researchers focus on the comparison between virtual tour and in-person tour in the post-COVID-19 context (Itani & Hollebeek, 2021). The reasons why individuals visit virtual destinations have also been revealed (Kim, Lee, & Jung, 2020; Zhang, Liu , & Mou, 2023). In addition, the concept of virtual tourism is not limited to tourism itself, but is endowed with certain educational significance on some occasions (Nata, Anthony, & Yudiastra, 2021; Marra, Trizio, & Fabbrocino, 2021).

(3) Virtual health

Virtual health care was promoted worldwide during the COVID-19 pandemic (Webster, 2020; Lau *et al.*, 2020). The number of in-person visits has decreased due to virtual visits (videoconferencing with physicians or performing surgery remotely), but has not been completely replaced (Shah *et al.*, 2018). The establishment of virtual access spaces between patients and their families provides emotional and psychological support for their families (Wei *et al.*, 2020). VR has also improved the quality of life for the elderly (Afifi *et al.*, 2022). Some researchers have recognized the possible issues that need to be addressed in the area of virtual health, in which lack of trust constitutes a serious challenge. To address this issue, Mpinganjira further explored the precursors of trust in virtual health communities (Piorkowski, 2014; Mpinganjira, 2018), and Lau and Knudsen (2022) discussed the problems with telemedicine and propose a way to reduce the disparities in telemedicine.

(4) Virtual game

The virtual game enables individuals a sense of presence in the game environment, the users may become co-creators of IT or participate in an immersive first-person perspective offered by VR (Garrett *et al.*, 2018; Gorisse, Christmann, Amato, & Richir, 2017; Sanchez-Vives & Slater, 2005; Tao, Garrett, Taverner, Cordingley, & Sun, 2021). Games such as Roblox, Minecraft and Animal Crossing play a leading role in the infrastructure and user bases of the metaverse (Wiederhold, 2022). The physically immersive video game is also an important form, through which people not only find pleasure in the virtual world but also strengthen their body in the real world (Li, Ratan, & Lwin, 2022; Street, Lacey, & Langdon, 2017; Lwin & Malik, 2014). In these games, gesture recognition system is crucial for linking the physical and virtual worlds. Based on the system, an interactive interface with a better immersive interaction experience can be designed (Rautaray & Agrawal, 2011).

4. Directions for future research

The framework of future directions on metaverse research is shown in Figure 7.

4.1 Metaverse concept and framework

Concept and framework of the metaverse should be clearly defined. Despite the swift progress achieved in the study of the metaverse, its conceptualization is still uncertain, and boundaries need to be drawn in the metaverse when considering the application scenarios (Dincelli *et al.*, 2022; Mystakidis, 2022; Seidel, Berente, Nickerson, & Yepes, 2022; Yung, Le, Moyle, & Arcodia, 2022). People may think about virtual games when talking about the metaverse, but that can be an incomplete and shortsighted way to discuss the issues at stake (Hollensen, Kotler, & Opresnik, 2022). Additionally, potential opportunities and challenges in the metaverse are important elements to promote the development of the digital economy and should be explored more in the future (Ning *et al.*, 2021; Wang Liu, Liu, & Wu, 2022a; Wang *et al.*, 2022b). The conceptual framework design in metaverse application scenarios forms the basis for the

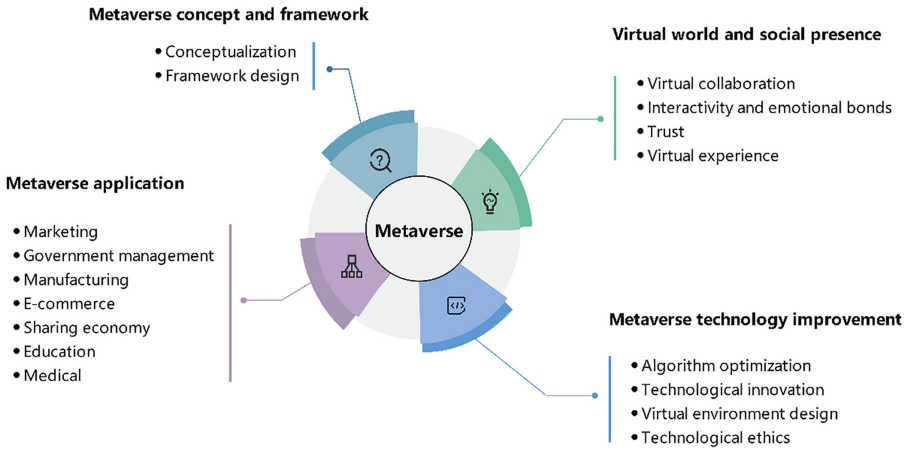

Figure 7.
Framework of future directions on metaverse research

transition from the physical world to the virtual world (Gadalla, Keeling, & Abosag, 2013). Previous research has studied the research agenda of hospitality and tourism, retail service, advertising and other fields, but the metaverse research framework for more scenarios is still absent and needs to be established (Gadalla *et al.*, 2013; Gursoy *et al.*, 2022; Taylor, 2022).

4.2 Virtual world and social presence

The development of the metaverse cannot be separated from the virtual world (Han, 2008). Social presence refers to the perception that other individuals in the virtual world are "real people" (Gunawardena, 1995). Previous research has investigated the social presence in the virtual world collaboration grounded in different theories, and collaboration has always been an important research direction in the study of the virtual world and metaverse, which is extremely important to the well-being of organizations (Cheng *et al.*, 2017; Haines, 2021; Srivastava & Chandra, 2018). Emotional interaction is an important factor in achieving a sense of immersive social presence in the virtual world, which can help understand the social and interactive properties of the metaverse (Barreda-Ángeles & Hartmann, 2022; Jin, Sun, Wang, & Zhang, 2017; Schultze & Brooks, 2019; Yung, Khoo-Lattimore, & Potter, 2021). Privacy and security issues are also gaining attention from researchers, as user trust is an individual feature in the virtual world, and the establishment of trust relationships has an impact on the interaction of individuals in the metaverse (Schiller, Mennecke, Nah, & Luse, 2014; Wang *et al.*, 2022a, b; Ye, Ying, Zhou, & Wang, 2019). Virtual activities and user participation of individuals in the metaverse also point to important research directions in the future (Girvan & Savage, 2019; Wei *et al.*, 2019).

4.3 Metaverse technology improvement

Technologies can be very important to the metaverse application development (Owens, Mitchell, Khazanchi, & Zigurs, 2011). Research related to metaverse technologies focuses on algorithm optimization and technological innovation. Technologies such as 3D virtual faces (Liang, Liu, & Lu, 2022), VR rendering optimization (Matthews, Uribe-Quevedo, & Theodorou, 2020), automatic virtual portal placement (Wang *et al.*, 2022a, b), etc. are being improved. And for others like AR, research in the field is still fragmented and focuses more on its impacts on certain application areas; thus, a systematic study can be essential (Rauschnabel, Babin, tom Dieck, Krey, & Jung, 2022). Besides, with the development of metaverse technologies, the design of virtual environments can be advanced with the inclusion of more emotional elements and more

complicated scenarios (Dozio *et al.*, 2022). At the same time, topics related to these technologies such as human rights and ethical issues are yet to be further discussed (Dwivedi *et al.*, 2022). Based on these, individuals' psychological status in reality can also be revealed through the data on their metaverse action; thus, the advancement of related research will forge a closer connection between the virtual and real world (Mystakidis, 2022).

4.4 Metaverse applications

Issues on metaverse application merit extensive discussion (Njoku, Nwakanma, Amaizu, & Kim, 2022). Previous studies have investigated the application of metaverse in marketing, government management, manufacturing, e-commerce, sharing economy and other fields (Cheng *et al.*, 2021; He, Qiu, & Cheng, 2022; Huynh-The *et al.*, 2022), delivering a fruitful direction for future information system (IS) research on the metaverse. Educational functions of the metaverse have been given enough attention; a consensus is that a customized, standardized process can better enhance student learning and collaboration (Kye, Han, Kim, Park, & Jo, 2021; Park & Kim, 2022). Medical treatment, customized hardware and software using the metaverse technologies are also promising directions for future research, which can be beneficial to both the doctors and the patients (Mozumder, Sheeraz, Athar, Aich, & Kim, 2022).

Additionally, HCI behavior and decision support management are also important directions in metaverse research (Huerta-Torruco, Hernández-Uribe, Cárdenas-Robledo, & Rodríguez-Olivares, 2022; Liu, 2021). During HCI, research concerning concepts such as values, attitudes, and decisions based on new scenarios still needs to be expanded from the perspective of psychology (Park & Kim, 2022). In the context of metaverse promotion and application, perceived workload related to different technologies in various complicated contexts is also a noteworthy issue, which may influence individuals' experiences and feelings (Xi, Chen, Gama, Riar, & Hamari, 2022).

5. Conclusions

Most of the research has explored the technology and application of the metaverse in various scenarios, giving us diverse perspectives on the problems associated with the metaverse. Although the metaverse provides many industries a wide range of digital transformation opportunities, very little is known about the evolution of the metaverse and the unresolved issues of the future. This paper investigates the concept and development of the metaverse. We find that the COVID-19 pandemic has promoted the development of the metaverse and at the same time, raised concerns about virtual technologies. Based on all of these, we condense our research into the conceptual framework to offer new insights into the development trend of the metaverse. While we are certain that these scenarios will change our lives, dramatically even, we should also be aware that new problems related to the metaverse need to be solved through further discussion.

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