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RESEARCH ARTICLE

MAPPING THE KNOWLEDGE DOMAIN OF METAVERSE RESEARCH IN CHINA: AN APPLICATION OF COOC13.4 AND VOS VIEWER

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ABSTRACT

The Metaverse concept has been applied in many domains and attracted widespread attention from the Chinese academic community. In order to explore the research status, hotspots, and topics of the Metaverse in China, this study employed bibliometric and scientific knowledge mapping methods using tools such as COOC13.4 and VOSviewer. Cluster analysis was performed on 1117 Chinese metaverse-related research papers collected from the China National Knowledge Infrastructure (CNKI) since 2021. The findings suggest that the Metaverse and virtual reality, digital collections and blockchain technology, application scenarios and virtual spaces, digital technology and media convergence, digital twins and smart libraries, publishing convergence, and the digital economy, and artificial intelligence and digital transformation were the most studied metaverse-related topics in China. The research status of the Metaverse in China was analyzed to provide references for future studies.

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INTRODUCTION

Bibliometrics refers to using mathematical and statistical methods and quantitative analysis of a subject under the knowledge of the carrier of interdisciplinary subjects. It can find the authors, institutions, documents, or journals that play an important role in the research process of a subject, capture the research hotspots, analyze the research trend, and make a reasonable judgment (1) on the research trend of the subject. Scientific knowledge mapping is a visual analysis method(2) for a research field through data mining, scientific measurement, information analysis, and graphics with the rapid development of technologies such as virtual reality, digital twins, and blockchain, the Metaverse is becoming a future digital landscape (3) that affects the relationship between people, the relationship between people and virtual space, individual life forms, and social structures. At present, the Metaverse has become a research hotspot of global concern, which has attracted wide attention from academia, science and technology, Education, media, and many other research fields. Yu Guoming (4) believes that the Metaverse is the future integration form of the Internet, virtual reality, immersive experience, blockchain, industrial Internet, cloud computing, and digital twin, also known as "shared virtual reality Internet" and "full reality Internet." Fang Lingzhi et(5) al. believe that the metaverse stage is the general trend of the rapid development of the Internet and is the "end game" of the Internet.

The Metaverse is essentially a digital virtual world, which is interconnected and intertwined with the real world, and presents all aspects of human society, economy, culture, and so on in the real world in digital form. In addition, the far-reaching value of the Metaverse as the ultimate form of the Internet has also attracted many academicians, attracting more and more scholars to devote themselves to this field of research.

In this context, this paper refers to the analysis method of bibliometrics and scientific knowledge graph, conducts quantitative analysis on the papers related to the metauniverse collected by CNKI since 2021, visualizes the relevant information, comprehensively analyzes and elaborates the research hotspots and research status of the metauniverse, and explores the key research topics of domestic scholars in recent years to promote the research and development of the metaverse field.

DATA SOURCES AND RESEARCH METHOD DESIGN

Data sources: China National Knowledge Infrastructure (CNKI) was the core data source, and "Metaverse" was the subject word for retrieval. Through the advanced retrieval function of CNKI, four categories of "Peking University Core,""CSSCI,""CSCD," and "AMI" were selected in the "source category," and a total of 1172 works of literature were retrieved.

After eliminating the literature with missing keywords and authors (most of them were the paper's preface, the submission information, the meeting, and so on), 1117 valid works of literature were finally obtained. The bibliographies obtained after manual screening were exported to a format recognizable by VOSviewer and CiteSpace.

Research methods: This paper uses Co-Occurrence13.4 (COOC13.4)[35] and VOSviewer to conduct bibliometric analysis and visualizea scientific knowledge map of 1117 literature on metaverse research. COOC software has the functions of data mining and knowledge discovery, as well as the functions of Chinese and English data cleaning, multi-dimensional relationship construction, and hot spot tracking [6]. VOSviewer software is based on the principle of co-citation and co-citation of literature, which constructs and displays the bibliometric map according to the distance, size, and density between nodes. It can be used for clustering, superposition, and density views of literature to evaluate the research direction and hotspots [7] of literature. Based on COOC13.4 and VOSviewer, this paper analyzes the domestic metaverse research field and explores the frontier hotspots, research status, and research topics of metaverse research.

ANALYSIS OF THE PUBLICATION TREND OF METAVERSE TOPICS

The number of publications is an important indicator to measure academic attention to a certain research field. By analyzing the annual number of publications in the field of metaverse research, we can grasp the research status and development trend of this field in recent years from a macro perspective. It is shown in Figure 1. On the whole, the total number of publications on metaverse research is increasing year by year. It can be divided into two stages: (1) Starting from 2021, the number of articles published each year increased significantly and rapidly, reachinga peak (779 articles) in 2022. The cumulative number of articles published from 2021 to 2022 was 822, accounting for 74% of the sample works of literature. It indicates that the research on the metauniverse heats up rapidly at this stage, with strong explosive power. (2) From 2022, although the number of published papers decreased slightly, it still maintained a high annual number (more than 295 papers per year). This phenomenon indicates that scholars' attention in the field of metaverse research has stabilized in the past two years. At this time, it is necessary to summarize the previous research hotspots to explore new research breakthroughs and prepare for further in-depth research.

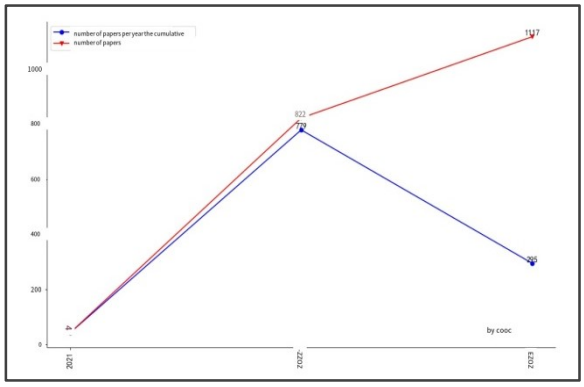
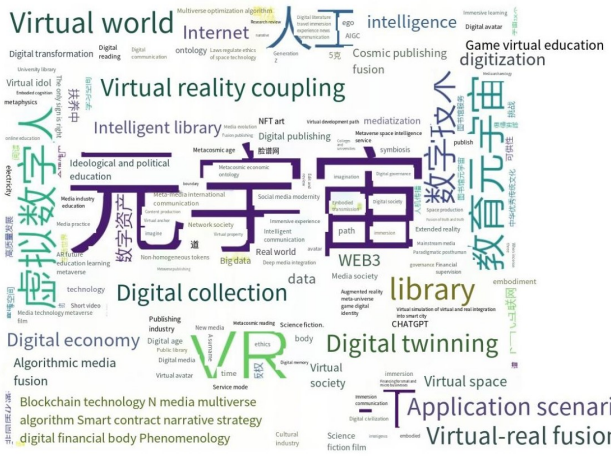


Figure 1. The annual trend chart of the number of Metaverse-related achievements published by CNKI

KNOWLEDGE MAP ANALYSIS BASED ON KEYWORDS

Research hotspots are the topics that attract the common attention of scholars in a certain academic field. They refer to the academic problems or topics[9]discussed by a group of literatures that contain many literatures and have internal connections in a certain period. Word frequency analysis is a bibliometric method [10]that uses the frequency of keywords or subject words that can explain or express the core content of the literature in a research field to determine the research hotspots and development trends.

Keywords are the author's high summary and refinement of the core content of the paper, and keywords can often be seen as the hot spots in the whole research field. A keyword appearing more frequently is a hot issue[11]. Keyword co-occurrence analysis can be used to explore the development trend and research hotspots in a research field. In this paper, the COOC13.4 software was used to conduct keyword co-occurrence analysis on 1117 sample works of literature, and the occurrence frequency of keywords determined the research hotspots in the Metaverse-related fields.



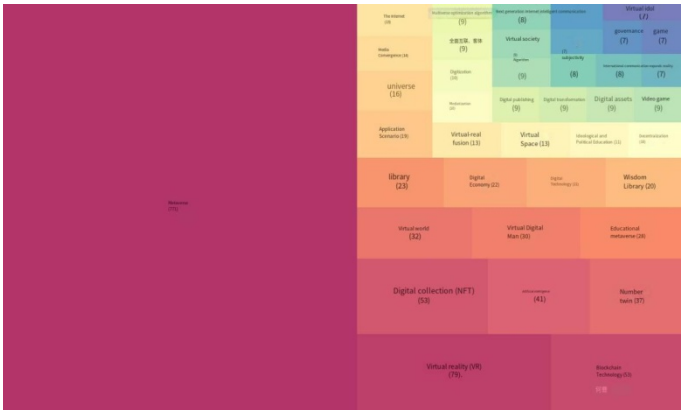


Figure 2. Keyword cloud map and Top30 high-frequency keywords

Analysis of high-frequency keywords: After data cleaning, such as deduplication, synonym merging, and invalid word deletion of relevant literature, the author drew a word cloud map based on the frequency of all keywords and sorted out the high-frequency keywords of Top30, as shown in Figure 2. From the perspective of the occurrence frequency of keywords in the sample literature, Metaverse, virtual reality (VR), blockchain technology, digital collections (NFT), artificial intelligence, and digital twins are the fields that scholars have paid more attention to in recent years.

Keyword co-occurrence cluster map: By analyzing the co-occurrence relationship between keywords, the internal structure and relationship of this research field can be described, which can be used to reveal the main trends of current research. To a certain extent, the future development direction of this field can be speculated, and more accurate research directions [12] can be provided for scholars. Cluster analysis refers to a special statistical analysis technique [13] that divides a group of research objects into several small Clusters with relatively homogeneous characteristics.

In this paper, based on the keyword co-occurrence function of COOC13.4 software, the co-occurrence matrix of high-frequency words is generated, and the VOSviewer is used to draw the clustering map of the high-frequency co-occurrence network as shown in Figure 2.

The VOS viewer clustering algorithm divides the 79 high-frequency keywords into 7 clusters (each node color represents a cluster), and each cluster contains the high-frequency keywords shown in Table 1. In the graph, nodes represent keywords, and the larger the node, the higher the frequency of keywords. The thicker the line between nodes, the higher the co-occurrence frequency of keywords. Nodes with the same color belong to the same cluster.

According to the clustering map of the keyword co-occurrence network, the research results of researchers on the Metaverse in the past three years can be summarized as the following seven research topics.

Research direction 1: Metaverse and Virtual Reality: This research direction mainly includes Metaverse, virtual reality (VR), virtual world, ideological and political Education, educational Metaverse, digital avatar, immersive experience, governance, games, realworld, and other high-frequency keywords.

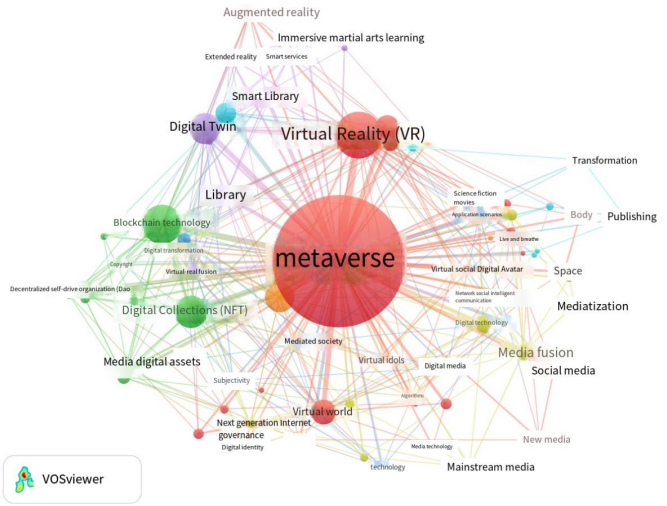


Figure 3. Cluster map of high-frequency keyword co-occurrence network

The research in this direction mainly focuses on integrating the virtual and real worlds constructed by the Metaverse. Most research and analysis are conducted from metaverse characteristics, core technologies, and application scenarios. Taking "Metaverse + education" as an example, Education is one of the main application scenarios of the Metaverse. "Metaverse + education" provides a new direction for future educational development. Metaverse uses virtual reality interaction and other technologies to enable students to penetrate the virtual fusion education scene, contact the virtual reality world as a virtual avatar, and carry out online teaching with sensory synchronization. Zhai Xuesong et[14] al. believe that Education is the main industry scene and innovation channel of the Metaverse, and conducting educational metaverse research is an important way to seek the path of high-quality education development, reshape the relationship between education subjects, and solve social problems such as education equity. The education reform under the empowerment of the metauniverse provides new possibilities for constructing future education forms in which virtual and reality are integrated and also provides a broader space for future education innovation.

However, "Metaverse + education" still faces many challenges in technological innovation, content generation, application scenarios, user addiction, data and privacy, and cyberspace security. Li Haifeng et[15] al. believe that the future development of the educational Metaverse requires the formulation of common technical standards, the construction of a research and development community, and the exploration of educational metaverse education models. In the related research of "metaverse + education," most scholars are optimistic about the future education prospect under the empowerment of the Metaverse, but some scholars have raised concerns. How the metaverse + education will develop in the future, how to deal with the challenges brought by the Metaverse, and how to break through the boundaries to promote the scientific development of metaverse education still need to be deeply discussed and studied by scholars.

Research direction 2: Digital Collections and Blockchain Technology: This research direction contains 11 high-frequency keywords: Web3.0, metaverse economy, blockchain technology, decentralized self-drive organization (DAO), digital publishing, digital collection (NFT), digital assets, smart contracts, copyright, non-homogeneous tokens, non-homogeneous tokens. This research direction mainly focuses on the characteristics and value of digital collections (NFTS) based on blockchain technology in the field of metaverse economy. With the continuous development of the metaverse economy, blockchain technology will also provide richer support for the construction and development of digital collections (NFTS). Non-Fungible Token (NFT) is a kind of encrypted digital proof of rights based on blockchain technology, which maps physical assets such as physical collections and virtual assets[16] such as images, music, and game props. NFTS, based on blockchain technology, are essentially a certificate of interest pointing to a digital collection with trading value. Digital collections can be viewed as an exploration of Chinese characteristics that complies with NFT standards. Unlike NFTs, digital collections deemphasize transactional attributes and focus more on the digital and collection attributes. Digital collections utilize hash algorithms, smart contracts, digital signatures, and timestamping technologies to guarantee information security.

Digital collections rapidly grow across various industries, including the high-profile publishing sector. On July 6, 2011, the Block Chain Application Center of the Key Laboratory of Science and Technology and Standards of the National Press and Publication Administration issued the Reference for the Application of Digital Collections, which clarified that the current digital collection is "a new form of digital publications" [17]. The digital collection provides a path for integrating the publishing industry and the Metaverse. The publishing industry also complies with the trend of the current digital development of the cultural industry. It has launched some positive exploration in the field of the digital collection, trying to explore a new development path for the transformation and upgrading of the traditional edition industry. Shi Qiming et [18]al. believe that under the background of cultural digitization, digital collections have opened up a new development path for the integration and development of the publishing industry, which is conducive to the publishing industry revitalizing existing resources, making full use of emerging technologies, increase innovation efforts, expand profit channels, and improve the construction of digital ecology. The publishing industry uses the existing digital publishing experience to explore and practice digital collections continuously, proving that integrating publishing and digital collections is feasible. With the continuous development of blockchain technology and the continuous expansion of application scenarios, digital collections will bring more opportunities and development to the publishing field.

Research direction 3: Application Scenarios and Virtual Space: This research direction contains nine high-frequency keywords: subjectivity, Internet, decentralization, mediatized society, application scenarios, technology, digital media, science fiction, and virtual space. From the high-frequency keywords involved, application scenarios and virtual space are the research directions to which scholars in the metaverse research pay more attention. Yuanyu uses AR/VR, blockchain, artificial intelligence, interaction design, and other technologies to build a virtual space that integrates entertainment, social interaction, learning, production, and life and makes it closely integrated with the real world. Scholars mainly analyze and imagine the scenario of the metaverse construction from social interaction, entertainment, culture and tourism, Education, industry, media, Library, and medical treatment.

For example, Cao Guosheng et[36] al. believe that the Metaverse is highly consistent with the direction of tourism project development

below, with core elements such as virtual space, identity heterogeneity, and immersive experience, which is of great significance to the development of the culture and tourism industry. Scholars' research on virtual space is still exploratory, mainly from the digital technology-driven interpersonal communication picture of virtual space. Hu Yu et [37] al. believe that the virtual space constructed by the Metaverse is the real space's supplement, extension, and expansion. As the future form of the development of the Internet, the virtual space constructs a new social space and enables interpersonal communication to move towards a deep media future through the media logic of connection, reconstruction, and presentation. In the future, scholars can continue to conduct in-depth research, explore more application scenarios and solve more technical problems to realize the maximum potential of the Metaverse and virtual space.

Research direction 4: Digital Technology and Media Integration: This research direction contains a total of 9 high-frequency keywords. Next generation Internet, mainstream media, embodied, international communication, mediatization, media convergence, digitalization, digital technology, immersive. This research direction mainly focuses on issues related to the integration of digital technology and media, and most studies and analyzes the Metaverse's future form from the media perspective.

Table 1. Details of the seven clustering keywords

Cluster topics	Size of cluster	Cluster keywords
Metaverse and Virtual Reality	28	Metaverse, Post-human, Augmented reality, Media, Media technology, ideological and political Education, Educational Metaverse, Digital avatar, New media, intelligent communication, Ontology, immersive experience, Governance, games, real world, electronic games, Social media, Science fiction film, Space, Space production, network society, Virtual fusion, virtual world, virtual avatar, virtual digital person, virtual Reality (VR), virtual society, body
Digital Collections and Blockchain Technology	11	Web3.0, Metaverse economy, blockchain technology, Decentralized self-drive organization (DAO), digital publishing, Digital collections (NFT), digital assets, smart contracts, copyright, non-homogeneous tokens, non-homogeneous tokens
Application Scenarios and Virtual Space	9	9. Subjectivity, Internet, decentralization, mediatized society, application scenarios, technology, digital media, science fiction, virtual space
Integration of Digital Technology and Media	9	Next-generation Internet, mainstream media, embodiment, international communication, mediatization, media convergence, digitalization, digital technology, immersion
Digital Twin and Smart Library	9	Library, Learning Metaverse, Expanding reality, Digital twin, Digital civilization, Smart library, Smart service, immersive learning, virtual and real integration
Publishing Convergence and the Digital Economy	7	Embodied cognition, the publishing industry, publishing convergence, big data, digital economy, short video, transformation
Artificial Intelligence and Digital Transformation	6	Artificial intelligence, digital transformation, digital age, digital identity, algorithms, virtual idols

The essence of Media Convergence is technology convergence, and the essence of technology convergence is digital convergence, that is, the evolution[19] of human digital technology. The development of digital technology provides a new opportunity and space for the development of media convergence, and digital technology enabling media convergence has become a new trend. Tang Jiay[20] believes that the innovation and development of digital technology are important driving forces to promote the deep integration and innovative integration of media. In the future, driven by advanced technologies such as blockchain, the Internet of things, 5G/6G, algorithms, AI, and cloud computing, media integration from the perspective of the Metaverse will be further promoted and deepened. Huang Chuxin et [21]al. believe that the deep integration of media has distinct characteristics of technological development in the digital era, and the reason for the emergence of the topic of deep integration of media is largely due to the rapid development of digital technology. Dong Tiance et [22]al. believe that media convergence originates from the social communication mechanism paradigm shift triggered by digital technology reform, which has a traction effect on media convergence. Feng Wenbo et [23]al. believe that the high-end intelligent technology cluster of the Metaverse will create a new business landscape for deep media integration. In addition, the challenges and risks existing in digital technology enabling media integration are also worthy of in-depth exploration by scholars.

Research Direction 5: Digital Twin and Smart Library: A total of 9 high-frequency keywords were included in this research direction. Library, Learning Metaverse, Expanding reality, Digital twin, Digital civilization, Smart library, Smart service, immersive learning, virtual and real integration. Scholars mainly discuss the development form of virtual and real coexistence of physical and digital twin libraries by elaborating on the application of digital twin technology in smart libraries. Digital Twin technology refers to the process[24] of constructing an identical entity in the virtual space through digital means and using physical models to reflect its full life cycle. Kong believes [25]that users live in a library space where virtual space and physical space coexist, and the virtual and real symbiotic space constructed by digital twin technology will allow libraries to truly realize real-time interaction, precise service, and meet users' personalized needs. The smart Library can use digital twin technology to build a dynamic reading data display platform for collection resources to recommend real-time resources for readers who are borrowing and build the reader's twin portrait according to the reader's reading habits and to read interests to accurately recommend [24]the reader's next borrowing experience. There are still some problems in the research of intelligent library construction. Wang Dongbo[26] believes that the application or transformation of digital twin technology in the library scene has just begun, and many studies are still at the theoretical level. Many construction modes, architecture systems, business processes, and implementation paths in newspapers successful cases. Although many domestic scholars have paid attention to and studied the smart Library to different degrees, the research on the smart Library is still in the exploratory stage and lacks a systematic summary. Therefore, the research of smart libraries based on digital twin technology must be further explored by academia and industry.

Research direction 6: Publishing Convergence and Digital Economy: A total of 7 high-frequency keywords were included in this research direction. Embodied cognition, the publishing industry, publishing convergence, big data, digital economy, short video, transformation. Some domestic scholars have conducted relevant research on integrating digital economy and publishing in recent years. The digital economy is a new economic form based on the deep integration of big data, the Internet, and artificial intelligence. Qiao[27] believes that the Metaverse is the carrier for the growth of the digital economy, and the digital economy is the main body to realize the value of the Metaverse. The Metaverse provides a new scene, driving force, and economical form for developing the digital economy. The Metaverse empowering the development and innovation of the digital economy is an important breakthrough in national strategic innovation [28]. As a booming new economic form, the digital economy provides a new development logic and opportunity for publishing convergence [29]. Wang Yang [30] believes that the publishing industry is an important application scenario of the Metaverse, and the Metaverse is also an important basis for the development of the digital economy of the publishing industry.

The Metaverse needs the publishing industry to provide rich content resources, and the publishing industry also needs the content of the new space of the Metaverse. The publishing industry should seize the new opportunities of the digital economy, apply Metaverse-related technologies to activate the creativity of the publishing industry, innovate industrial service forms, and promote the integration and innovative development of publishing. In the era of the digital economy, how to deal with the challenges of publishing industry transformation and big data and achieve the deep integration of publishing will be an important topic for scholars to think deeply about in the future.

Research direction 7: Artificial Intelligence and Digital Transformation: A total of 6 high-frequency keywords were included in this research direction. Artificial intelligence, digital transformation, digital era, digital identity, algorithm, virtual idol. This research direction focuses on the issues of artificial intelligence and digital transformation. Industrial digital transformation generally refers to the process[31] of using big data, artificial intelligence, blockchain, data center, new generation digital technology, and communication technology to carry out all-round, all-round, and whole-chain transformation and digital upgrading and reengineering of traditional industries. In the digital era, artificial intelligence, as an important part of the Metaverse, has found landing scenes in many industries and has become an important tool to help traditional industries carry out digital transformation. In the current stage, scholars mainly focus on the digital transformation of enterprises, medical care, Education, and the smart city under the framework of the three digital transformation fields of economy, life, and governance. Meng Wenting[32] et al. believe that artificial intelligence is the digital base of digital educational transformation and an important element in the transformation of teaching paradigms, which plays a unique role in connecting the fragmented decision-making process and optimizing the supply process of public educational services. Yang Wang [33]believes artificial intelligence is accelerating its integration with the real economy, promoting digital transformation, intelligent upgrading, and integrated innovation in various industries. The deep integration of artificial intelligence and finance has continuously derived new business forms and scenarios and has played an important role in small and microfinance, green finance, risk monitoring, and other aspects. Qian Xuesheng [34]believes that artificial intelligence's new generation of digital technology has become the core driving force of urban digital transformation.

CONCLUSION

In recent years, the Metaverse has developed rapidly and become a field of concern and expectation. Through the analysis of Metaverse-related literature, it is found that the establishment and application of Metaverse will lead the development direction of future industries. With the continual advancement of technology and deepening scholarly exploration, the Metaverse is anticipated to be applied in various domains. The continuous development of the Metaverse will bring unprecedented development opportunities for Education, culture, commerce, medical care, and other fields. At present, academic and practical departments have carried out a series of explorations on the development of various fields of metaverse empowerment. Although a complete theoretical and application framework has not been formed, it can also provide a reference for future metaverse research and practice.

In addition, in the development process of the Metaverse, we cannot ignore the unpredictable risks and uncertainties brought by the Metaverse as an emerging thing. We must also be aware of the risks and challenges involved, especially regarding technological innovation, content generation, application scenarios, user addiction, data and privacy, and cyberspace security. To ensure the sustainable development of the Metaverse, we need to strengthen research on digital technologies, increase investment in Metaverse-related fields, and create a more secure and reliable metaverse environment.

In conclusion, the Metaverse is a field full of opportunities and challenges. Scholars must keep an open mind and continue to deeply study and explore the application scenarios, methods, and strategies of the Metaverse to provide useful inspiration and reference for future metaverse research and promote integration, innovation, and healthy development of the Metaverse and other fields.

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