

Study on the Technical Model Design of a Tourist Attraction from the Metaverse Perspective

Shuang Tian, Qinghua Song*

School of Information Engineering, China University of Geosciences Beijing, Beijing 100083, China

Abstract. With the development of digital technology and the epidemic's impact in recent years, the public's demand for "cloud tourism" using various virtual technologies has gradually increased. The concept of building a tourist attraction in a metaverse is studied based on the metaverse perspective and the current development of metaverse technology. The rationality and feasibility of building a metaverse tourist attraction are analyzed. The application of high technology in various fields in recent years in constructing metaverse tourism scenery is studied and analyzed. A feasible technical model of metaverse tourism scenery is proposed based on this research.

Keywords: Metaverse; Tourism Industry; Technological Frame; Blockchain.

1. Introduction

As the hottest technology concept in recent years, the metaverse has received much attention in the education, gaming, and cultural tourism industries. Many people have suggested that the metaverse concept can be applied to developing innovation in various fields. In the cultural tourism industry, many companies worldwide have explored the concept of "metaverse + cultural tourism" and have set up some experimental projects to develop initial innovations. In this paper, the concept of metaverse tourism scenery is studied based on the metaverse perspective. After analysis, a technical model of metaverse cultural tourism scenery is proposed, and the establishment and operation of each layer in the model are analyzed in depth.

2. Overview of the Metaverse

There is no single definition of a metaverse in the world. The concept was first proposed in the 1992 science fiction novel *Snow Crash*, in which a metaverse is a virtual world created by mapping the real world, in which humans can interact with each other in a variety of ways using digital devices and digital bodies. In 2021, Meta, an internationally renowned Internet company, proposed a metaverse in which the definition of a metaverse is an embodied Internet that allows everyone to be immersed in it, not just the current Internet that can only be browsed [1]. In 2022, the China National Committee for Terms in Sciences and Technologies defined a metaverse as a virtual world constructed by humans using digital technology that maps or transcends the natural world and can interact with the real world [2]. In a nutshell, the metaverse aims to create a virtual space that gives humans a high degree of immersion and allows humans in the virtual space to also interact with the natural world in many forms of behaviors through various high technologies such as the Internet of Things and VR devices. The concept of the metaverse is not limited to the definition of "Internet" but is a comprehensive technological concept that incorporates a wide range of technologies[3].

3. Application of Metaverse-Related Technologies in the Cultural Tourism Industry

Metaverse-related technologies encompass blockchain, extended reality, the Internet of Things, cloud computing, and other related technologies. Currently, these technologies are being applied to a certain extent in the cultural tourism industry, laying the technical foundation for creating metaverse scenic in the future. Several of these standard technologies are selected below for a brief introduction.

3.1 The Application of Blockchain Technology in the Cultural Tourism Industry

In the cultural tourism industry, the application area of blockchain technology lies in identity authentication and financial security. Zhang Man et al. analyzed the positive impact of blockchain technology on building a high-quality tourism industry from four perspectives: transaction, merchant, platform, and user, emphasizing that blockchain technology can improve the current credit system of the tourism industry, enhance transaction security, and reduce related costs at the same time[4]. The number of projects applying blockchain technology in the cultural tourism industry is also gradually increasing, and several tourism companies are already using blockchain technology in multiple fields. For example, Evolvable and Virgin Galactic have applied blockchain technology in tourism payment, Shoulv Rujia Hotel Group in accommodation management, and Kunming Shilin and Lijiang Yulong Snow Mountain in the field of scenic area management to achieve the corresponding functions[5].

3.2 The Application of Extended Reality Technology in the Cultural Tourism Industry

Expanded reality technology provides the cultural tourism industry with a new form of the tour through virtual reality (VR), augmented reality (AR) and mixed reality (MR), and other technical means, allowing visitors to ignore time and space distances and get the experience of visiting tourist attractions thousands of miles away. Extended reality technology is now widely used in the cultural tourism industry, and related research is gradually increasing. Wang Lulu suggested that the "VR + cultural tourism" model could be used to promote the integrated development of cultural tourism in Luoyang. Using the characteristics of VR technology can unlock the temporal and spatial constraints of precious historical resources, allowing people to experience the heritage of history and culture better while creating a new level of consumer energy[6]. Alexandra Bec et al. propose that extended reality technology can create second chance tourism. Through extended reality technology, tourists can experience tourism and cultural resources that have been destroyed or severely deteriorated. On the one hand, it can bring new opportunities to tourism resources experiencing deterioration or at risk of future destruction. On the other hand, it can create new cultural and tourism consumption opportunities[7].

3.3 Application of IoT Technology in the Cultural Tourism Industry

IoT technology is a bridge connecting the natural world and the virtual world, through which the real world and the virtual world can influence each other. IoT technology in the cultural tourism industry has now been initially applied. Taking China lane lane Scenic Area as a sample, Zhang Ji et al. proposed that the Internet of Things technology, together with 5G communication, artificial intelligence, and other related technologies, could be used to establish an integrated information service platform to improve the management and service level of traditional scenic spots [8]. On the other hand, Hui Suo et al. proposed that IoT technology plays a crucial role in upgrading the tourism industry and that IoT technology is a vital link in building a new tourism online service platform[9].

3.4 Application of Digital Twin Technology in the Cultural Tourism Industry

Digital twin technology is a subset of IoT technology, defined explicitly as creating and simulating a physical entity, process, or system within an information technology platform[10]. Digital twin technology has the potential to be applied in a multitude of ways, including the establishment and preservation of ancient villages, the creation of virtual scenic locations, and more. Tang Qiyuan proposed that ancient villages can be protected based on digital twin technology, enriching the online and offline integrated interactive tourism experience [11]. Bruno S. Frey et al. propose that cultural heritage scenic areas can be replicated using high technology such as digital twins. The problem of over-tourism of the original site can be mitigated by building replicated scenic areas of highly similar cultural heritage sites in other locations[12].

4. Related Research on the Integration of Metaverse Concept and Cultural Tourism Industry

4.1 The Feasibility of Applying the Metaverse Concept from the Perspective of the Cultural Tourism Industry

With the development of digital technology, a high degree of digitalization in the cultural tourism industry is gradually moving from a vision to a reality, while at the same time, due to the epidemic in recent years, the public's demand for online cloud tourism without leaving home is gradually increasing. The use of metaverse technology to create a new form of cultural and tourism entertainment has gone from an idea of a few to a new subject that can be explored in practice. The core of cultural tourism activities is "experience", and the metaverse is a form of technology that allows humans to engage in highly immersive activities in a virtual space. Metaverse technology can effectively enhance the general public's experience when undertaking 'cloud tourism'[13].

In May 2022, the Chinese government proposed a policy for applying digital technology in the cultural sector, which states that metaverse technology has a promising application in the cultural tourism sector. The integration of China's cultural tourism industry with metaverse technology is accelerating [14]. In 2022, many enterprises and related scenic spots in China have also collaborated on many tourism metaverse projects, actively exploring the field of tourism metaverse. For example, the "Datang Spiritual Realm", an original Chinese culture-tourism metaverse created by Taiyi Group and the Datang City of Night, will be launched in October 2022. Visitors will be able to experience the Datang City of Night in Xi'an in a virtual space and do shopping in the virtual space [15]. In November of the same year, Zhangjiajie Tourism Scenic Area became the first scenic area in China to set up a meta-universe research center. The metaverse technology will be used based on the original scenic tourism projects to enhance the tourist experience of visitors [16]. However, no tourism metaverse projects worldwide are currently in large-scale operation. Most of the metaverse projects are more of an exploration of the field and are a prelude to the development of future metaverse projects.

4.2 Related Research in the Field of Culture-tourism Metaverse

The concept of the metaverse is gaining traction, and the volume of academic research in this field has shown steady growth, coinciding with the focus on the metaverse meta-year in 2021. In the field of culture-tourism metaverse, the predominant focus of current research lies in exploring metaverse scenic spots and developing operational models. Shi Peihua et al. analyze the rationality of the cultural tourism industry and metaverse technology and study in depth the application prospects, main scenarios, risks and challenges, model paths, and countermeasures of the metaverse in the cultural tourism sector [13]. Feng Xegang et al. propose a specific concept of the "culture-tourism metaverse" and further analyze the value of the culture-tourism metaverse in promoting the development of the cultural tourism industry, as well as a preliminary concept of the development model of the culture-tourism metaverse [17]. Only a few studies have presented some ideas on the technical framework level of the metaverse. Pannee Suanpang et al. propose a scalable metaverse architecture that divides the process of applying metaverse technology under the cultural tourism domain into a 3D acquisition layer, a linking layer, and a deployment layer from a technical perspective. The 3D acquisition layer collects realistic data and renders realistic elements in the virtual world. The linking layer combines characters, objects, and scenes in the virtual space and realizes the interaction between characters and virtual scenes. The deployment layer integrates the computing results of the above two layers and user-related information and uploads the configuration on the HTTP server[18]. The specific architecture design is shown in Figure 1 below. By analyzing the ecological logic of blockchain technology and meta-universe, Li Ming et al. divided the metaverse into five layers, from top to bottom: meta-network, meta-system, meta-service, meta-application, and meta-space. The meta-network provides the essential support technology for the entire meta-universe system. The metasystem provides system support using multiple technologies. Meta services provide support for

upper-level meta-application scenarios. Moreover, meta-applications and meta-spaces provide users with specific interactive functions and spatial presentations [19]. Current international research has focused on the conception of industrial models for applying metaverse-related technologies in the field of cultural tourism, with few studies on technological models for applying metaverse technologies in single metaverse scenic areas.

System architecture of Extensible Metaverse

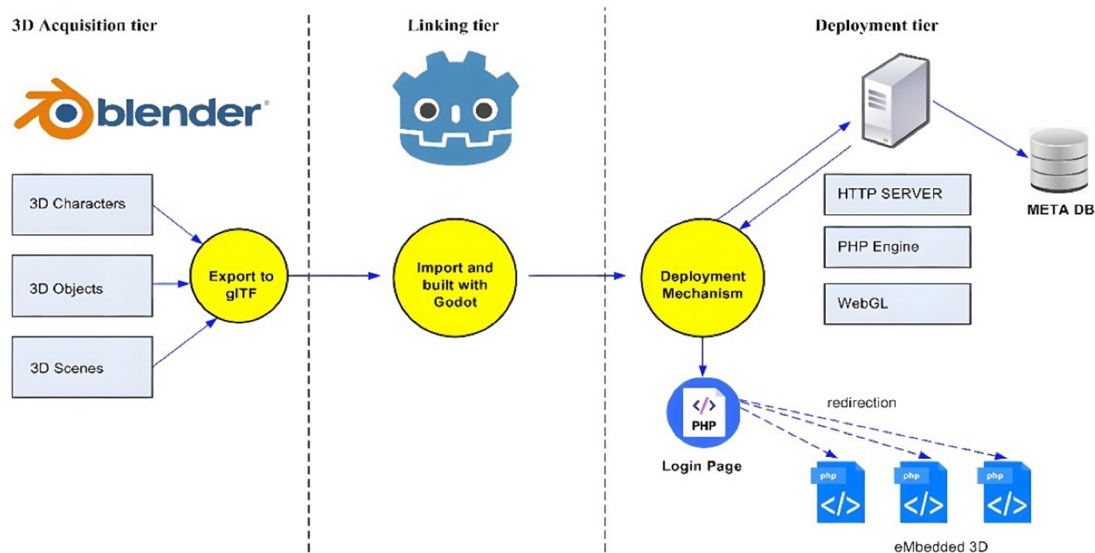


Fig 1. Three-tiered architecture of the proposed metaverse^[18]

5. Technical Framework Analysis of Metaverse Scenic Spots

Using metaverse-related technology can generate virtual scenes in virtual space that are highly similar to real ones and, through further development, can provide visitors entering the virtual space with a rich and varied touring experience. This paper proposes a technical framework for constructing a hierarchy of tourist attractions based on metaverse technology from the perspective of technical characteristics and relevant practical application scenarios. The framework is divided into five layers, from the bottom up the physical layer, the software layer, the data layer, the rules layer, and the interaction layer. The details are shown in Figure 2 below:

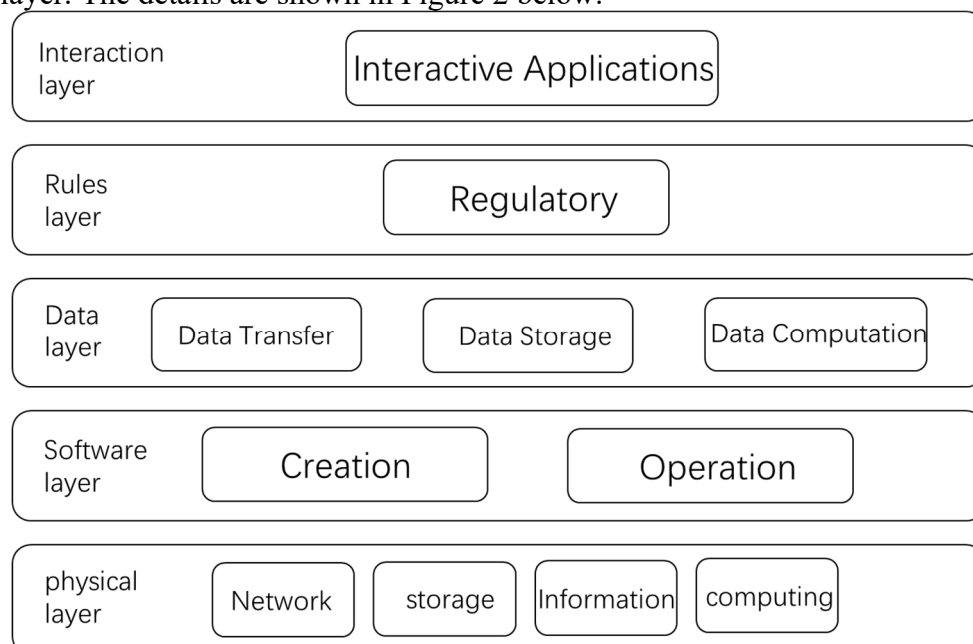


Fig 2. Metaverse Scenery Technical Framework

5.1 Physical Layer

The physical layer is the hardware foundation on which the entire metaverse is built. The role of this layer is to provide the hardware equipment base for the entire metaverse, providing it with the primary hardware facilities for high-speed network communication, storing relevant data, collecting real-time information, and performing large-scale calculations. This layer can be divided into four modules based on the functions provided: network services hardware, storage services hardware, information services hardware, and computing services hardware facilities.

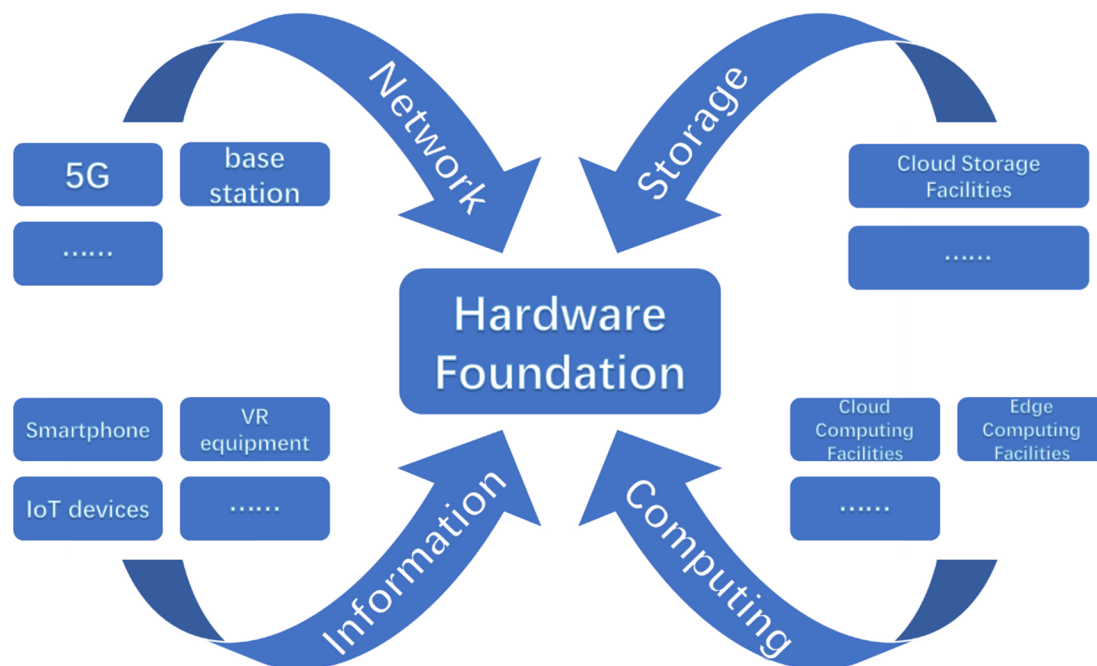


Fig 3. Metaverse Scenery Technical Framework physical layer

5.1.1 Network Services Hardware Facilities

The stable operation of the metaverse requires a network service with high bandwidth, low latency, and high reliability. This service requires a complete set of supporting network facilities for the scenic spot and an equivalent network infrastructure construction in society. 5G technology is the only technology that can meet this network requirement[20]. 5G network for individual user network service speed can reach 0.1~1GB/s experience network speed, end-to-end delay can reach millisecond level, connection density can reach one million per square kilometer level. 5G network can meet the metaverse for network demand[21]. With the gradual implementation of 5G technology in global commercialization, the coverage of 5G communication base stations is gradually increasing in countries worldwide. In the foreseeable future, countries can build a national network system that meets the requirements of the metaverse.

5.1.2 Storage Services Hardware Facilities

The metaverse will generate a large amount of data during its operation. These data include system data, such as the fine 3D model of the metaverse itself, and user data, such as a large amount of user information. It is obvious that the traditional centralized storage method cannot meet the demand for storing information in the metaverse. Distributed storage using cloud storage facilities would be the only solution to the problem of storing information in the metaverse.

5.1.3 Information Services Hardware Facilities

Whether it is a digital avatar used by visitors entering the metaverse or a model based on realistic scenery in a scenic area, different types of sensors must be used to collect information about reality. Users can collect information about themselves by using various intelligent digital devices such as cameras, VR devices, and physical gamepads to upload to the metaverse. The user's identity can be

verified in various ways on the smartphone platform, and various sensors can generate information about the user's appearance and body movements, for example, facial information can be generated by the camera, and this technology is already being used in some games. For example, in recent years, the NBA2K series has introduced a "face scan" feature, which allows the camera to scan the user's face and create in-game characters with a high degree of resemblance to the user's face. WalkOVR, the renowned VR sci-fi company, has launched a new generation product in 2021, WalkOVR MOCAP, which allows users to wear this device to perform acts such as dancing or running in a metaverse environment[22]. On the other hand, real-world scenic information can be generated and updated through IoT technology. Yue Han et al. propose a dynamic hierarchical metaverse synchronization framework using IoT devices. The paper envisages the use of portable IoT devices, such as drones, to sense the state information of real-world entities in real-time in order to synchronize and update the corresponding digital entity model information in the metaverse[23].

5.1.4 Computing Services Hardware Facilities

According to Intel's calculations, the metaverse must be supported by 10 trillion times per second of floating-point computing power [24]. This demand for computing resources far exceeds what society can provide today. In order to meet this demand for computing resources, a whole new system of computing networks will need to be built in the future. Yang Cai et al. propose that the infrastructure of the future metaverse should be a universal computing platform, which includes a cloud data processing center and edge servers. The whole system can dynamically meet the required computing tasks of the metaverse system[25]. The scenic spot itself needs to allocate a certain scale of cloud computing facilities. On the other hand, the scenic spot also needs to cooperate with relevant enterprises in the scenic service area, configure edge computing servers that support their scenic services, and build a computing network systems that can support their scenic services.

5.2 Software Layer

The central role of the software layer is to provide software support for the creation and stable operation of the metaverse.

The technologies used to build a metaverse and to create a digital body of visitors include digital twin technology, game engine technology, and artificial intelligence technology. Digital twin technology can provide technical support to generate various things in the metaverse.

The digital twin technology can be used with the IoT and other related technologies to collect information on relevant parameters in the natural scenic area and map them into a model of the scenic area in the virtual world. Throughout the process, the model may be further enhanced through the utilization of 3D modeling software and related techniques, with the ultimate goal of achieving the highest possible level of fidelity in replicating the scenic area from the physical world. Moayad Aloqaily et al. propose that the digital twin and technologies such as the Internet of Things, blockchain, and artificial intelligence can be integrated to construct the metaverse. Their team proposes a technical framework for metaverse construction based on digital twin technology, which can provide an essential reference for constructing a metaverse scene area with sustainable operation[26].

On the other hand, creating the user's digital avatar also requires digital twin technology, which allows the user to reflect his or her natural appearance on the digital body. Saeed Banaeian Far et al. propose that mapping the digital twin to the real world can be both on a large scale, such as the whole world, and on a small scale, such as each user using the meta-universe itself. Users can use digital twins to create digital bodies in the metaverse that are highly similar to themselves[27].

Suppose traditional software systems continue to be used in the metaverse. In that case, they may not be adequate for the development and stable operation of metaverse applications. In the future, the metaverse may have a proprietary software system architecture. Tristan Braud et al. argue that the current XR platform software architecture hinders the development of XR applications. Hence, the paper proposes a novel operating system architecture for the XR platform that addresses the current XR operating system's limitations. The system supports fine-grained integration of digital content and

environments, standardized interaction across applications, multiuser experiences, and hybrid working modes when using XR devices to access virtual spaces at an urban scale[28].

5.3 Data Layer

The data layer is mainly responsible for the transmission, storage and computation of various data in the operational phase of the metaverse. An array of cutting-edge technologies will be employed during this stage, encompassing but not limited to 5G technology, cloud storage technology, blockchain technology, cloud computing technology, and edge computing technology, among others.

The metaverse needs a network service with high bandwidth, low latency, and high reliability, and 5G technology, which is being developed at this stage, can meet this need. On the other hand, as an extension of 5G technology, 6G technology has the potential to achieve a high degree of automation and intelligence in communication networks in the future. 6G networks can achieve a more profound integration of applications and networks through ubiquitous, intelligent, and deeper connectivity[29].

The operation of the metaverse generates a large amount of data. Distributed cloud storage technology is an option for storing large amounts of information in the future metaverse. While cloud storage technology uses distributed storage of large amounts of data, this also poses difficulties for data retrieval and access functions and may require a whole new data management system in the future. On the other hand, the security of data stored in the metaverse should also be taken into account. Blockchain technologies are most of the technologies now available for the secure encryption of distributed stored data. Hongyin Chen et al. proposed a distributed file storage protocol based on blockchain technology, which ensures the reliability of distributed stored information through enhanced robustness and file loss compensation mechanisms[30].

In the face of the large number of computing demands generated by the metaverse in the process of operation, a new computing network system should be built using cloud computing technology, edge computing, and other high technologies. It is necessary to intelligently deploy computing resources for processing computing tasks of different scales, maximize the use of computing resources and minimize the time delay on the user side, to improve the user's tour experience. Wei Yang Bryan Lim et al. propose a cloud-edge-local computing network system that uses hierarchical computing resource calls to address computing needs while minimizing latency at the user end[31]. Cloud computing technology is the central part of computing services, taking up most of the computing work, and due to its scalability and high-performance computing services, together with Elastic Compute Services, it can provide users with low latency and high-performance computing services[32]. Due to this feature of cloud computing, it is bound to become an essential part of the construction of computing services in the metaverse scene in the future.

5.4 Ruler Layer

The role of the rules layer is to regulate the activities of the interaction between visitors and the scenic area in the metaverse, ensuring the information security and economic safety of both the scenic area and the visitors. The data of the scenic companies in the metaverse and the personal information of visitors and their digital avatars are at risk of information theft. At the same time, the economic transactions that take place within the scenic areas in the metaverse are also at risk of economic crime. Yuntao Wang et al. suggest significant threats in the metaverse regarding authentication, data management, personal privacy, and economic transactions, but they can all be prevented by taking relevant measures.

The technical means used in this layer can be diverse, and different technical means can be used to prevent different security risks. For example, for the security of authentication, Hidayet Aksu et al. propose a machine Learning-based fingerprinting tool for wearable devices to mitigate possible dangerous attacks on authentication mechanisms[34]. Jiacheng Shang et al. studied the security threat model for AR devices. They demonstrated that the attack they used could stealthily obtain the personal information of AR device users and proposed three mitigation solutions to defend against this attack from hardware deployment and software system level[35].

This layer of safety and security practices also requires the cooperation of government departments, which should introduce relevant regulations to regulate the metaverse market. They should also exercise their authority to deal with the regulation in some vital regions. Jackaran Singh Saini et al. propose that government departments have the obligation and responsibility to use laws to protect data security in the country. Public data in society should be under the direct supervision and control of the government. Private data security should also be safeguarded by enacting relevant laws to safeguard citizens' information while maintaining a democratic nature [36].

5.5 Interaction Layer

In a metaverse scenery, visitors should be able to interact with multiple scenes in the scenery in various ways. A single metaverse application in the metaverse should provide these interactions. In the face of the metaverse, a new next-generation network entity technology, traditional application development concepts, and related technologies may not be able to meet the development needs under the metaverse domain. Developing applications in the metaverse scenario may require a new metaverse development environment. The research in this field is still in the exploration stage. Research in the field is still in the exploration stage. The technologies used at the interaction layer will likely be diverse, and each application may employ different technologies depending on the application content and the development company [37].

6. Possible Problems in Construction

6.1 Technical Issues

The process of establishing metaverse scenic spots requires the use of a variety of new and emerging technologies. However, the current development of many of these technologies is insufficient to support the development of metaverse scenic spots. For example, the core technology of the metaverse - blockchain technology, which has been put into large-scale applications worldwide, has been used in many field applications [38]. However, there are still imperfections. For example, blockchain technology is still far slower than traditional transaction methods in data storage and interaction. Using blockchain technology to process economic transactions in scenic spots may result in long waiting times for payment and a poor visitor experience [39]. On the other hand, many development companies and scenic spots still need the large number of computing resources required to run the metaverse.

6.2 Security Issues

With the gradual establishment of industries related to the culture-tourism metaverse, the standardization of the metaverse market should also be gradually enhanced. The security of digital assets in the metaverse, the security of economic transactions between visitors and businesses in the scenic area, and the security of personal information uploaded by visitors to the metaverse should also keep pace with the development of the market, maximizing data security at a technical level and introducing relevant policies and regulations at a policy level to establish market order.

7. Conclusion

Based on the technical characteristics of the metaverse, this paper proposes a technological framework concept for metaverse scenery, combining current examples of the integration of the metaverse and the cultural tourism industry and related research. The framework proposed in this paper consists of a physical layer, a software layer, a data layer, a rules layer, and an interaction layer from the bottom up. This framework depicts the whole process of constructing and operating a metaverse scenery from the basic physical facilities to the generation of interactive behaviors in the metaverse. However, in realizing the current framework of the metaverse scenic vision, it will still face technical and security problems. However, it is believed that with the advancement of technology

and the implementation of relevant policies, the metaverse scenic vision under the framework proposed in this paper will eventually be built successfully, providing a new form of visit and consumption for the cultural tourism industry.

References

- [1] Meta. (2021, October 28). Founder's Letter, 2021. Retrieved January 12, 2022, from [https:// about. fb. com/ news/2021/10/founders-letter/](https://about.fb.com/news/2021/10/founders-letter/).
- [2] Gong Caichun, Du Zhenlei, Zhou Hua & Chen Guoxian. (2023). Definition and Related Thoughts of Term "Metaverse". *China Terminology* (01),27-35.
- [3] Fang Wei & Fu Yuxiang.. Metaverse: conceptions, key technologies and applications *Journal of Nanjing University of Information Science & Technology (Natural Science Edition)*.
- [4] Zhang Man, Yao Bo, Bao Fuhua & Wang Hui.(2021). Exploring the application value of blockchain in the high-quality development of tourism. *Tourism Overview*(05),11-13.
- [5] Huang Xiankai.(2020). Blockchain: Application Innovation in Tourism Industry and Future Development. *Journal of Beijing Technology and Business University(Social Sciences)*(05),1-10.
- [6] Wang Lulu.(2022). VR technology to help the development of cultural tourism path exploration. *Industrial Innovation* (16),77-79.
- [7] Alexandra Bec;Brent Moyle;Vikki Schaffer.Virtual reality and mixed reality for second chance tourism[J].*Tourism Management*,2021,Vol.83.
- [8] Zhang Ji, Yang Wenxin, Liang Xiaohui, Wang Xia, Wu Huiting, Jiang Lei & Yang Xiaoyu.(2020). Exploring the application of 5G intelligent cultural tourism in Kuanzhai Alley Scenic Area. *Communication & Information Technology* (05),50-54.
- [9] H. Suo, J. Wan, C. Zou and J. Liu, "Security in the Internet of Things: A Review," 2012 International Conference on Computer Science and Electronics Engineering, Hangzhou, China, 2012, pp. 648-651, doi: 10.1109/ICCSEE.2012.373.
- [10] Liu Datong, Guo Kai, Wang Benkuan & Peng Yu.(2018). Summary and perspective survey on digital twin technology. *Chinese Journal of Scientific Instrument* (11),1-10. doi:10.19650/j.cnki.cjsi.J1804099.
- [11] Tang, Turnip Eaves. (2021). Research on the application of digital twin technology in the conservation of ancient villages. *Informatization of China Construction* (15),65-67.
- [12] Bruno S. Frey & Andre Briviba (2021) A policy proposal to deal with excessive cultural tourism, *European Planning Studies*, 29:4, 601-618, DOI: 10.1080/09654313.2021.1903841.
- [13] Shi Peihua, Wang Yijun & Li Zhong.(2022). Research on the Application Prospects, Main Scenarios, Risks and Challenges, Model Paths and Countermeasures of Metaverse in the Field of Cultural Tourism *Journal of Guangxi Normal University(Philosophy and Social Sciences Edition)*(04),98-116. doi:10.16088/j. issn.1001-6597.2022.04.009.
- [14] Wang, Weijie. (2022-09-05). Meta-universe Opening up a new future of cultural tourism industry. *China Culture News*,003.
- [15] Guandian. (2022, October 17). JD Tech and Taiyi Group reached a cooperation agreement, "Datang Lingjing" will open "Dongshi" commercial street Retrieved January 12, 2022, from [https:// www. guandian. cn/article/20221017/316523.html](https://www.guandian.cn/article/20221017/316523.html).
- [16] Lu, X. Y. (2021, November 19). The first in the country's scenic spots! Zhangjiajie Meta Universe Research Center is listed, the local government said: "We are serious". *National Business Daily*. Retrieved January 12, 2022, from <http://www.nbd.com.cn/articles/2021-11-19/2003529.html>.
- [17] Feng Xuegang & Cheng Xin.(2022). Culture and tourism meta-universe: technology-enabled new model of integrated development of culture and tourism *Tribune* (10),8-10. doi: 10.19765/j.cnki.1002-5006. 2022. 10.005.
- [18] Pannee Suanpang; Chawalin Niamsorn; Pattanaphong Pothipassa; Thinnagorn Chunhapatragul; Titiya Netwong; Kittisak Jernsittiparsert. Extensible Metaverse Implication for a Smart Tourism City [J]. *Sustainability*,2022, Vol.14(14027): 14027.

- [19] Li Ming, Zhang Liang, Song Wenpeng & Wu Meiyu.(2022). Blockchain: Core Metaverse Infrastructure. Computer Engineering (06),24-32+41. doi:10.19678/j.issn.1000-3428.0064120.
- [20] Njoku J N, Nwakanma C I, Kim D S. The Role of 5G Wireless Communication System in the Metaverse[C]//2022 27th Asia Pacific Conference on Communications (APCC). IEEE, 2022: 290-294.
- [21] Huang Yuhong, Wang Xiaoyun & Liu Yiguang.(2017). Overview of 5G mobile communication system. Application of Electronic Technique (08),3-7. Doi: 10.16157/j.issn.0258-7998.179003.
- [22] PR Newswire.New Generation fully wireless VR motion capture device, to dance or physically run in Metaverse[J].PR Newswire US.,2021.
- [23] Han Y, Niyato D, Leung C, et al. A dynamic hierarchical framework for iot-assisted metaverse synchronization[J]. arXiv preprint arXiv:2203.03969, 2022.
- [24] Wei Min, Lei Bo & Zhao Qianying.(2023). Challenges and Suggestions of Information Infrastructure in Metaverse. Radio Communications Technology (01),31-36.
- [25] Cai Y, Llorca J, Tulino A M, et al. Compute-and data-intensive networks: The key to the Metaverse[J]. arXiv preprint arXiv:2204.02001, 2022.
- [26] Aloqaily M, Bouachir O, Karray F, et al. Integrating Digital Twin and Advanced Intelligent Technologies to Realize the Metaverse[J]. IEEE Consumer Electronics Magazine, 2022.
- [27] Far S B, Rad A I. Applying Digital Twins in Metaverse: User Interface, Security and Privacy Challenges[J]. Journal of Metaverse, 2022, 2(1): 8-16.
- [28] Braud T, Lee L H, Alhilal A, et al. DiOS--An Extended Reality Operating System for the Metaverse[J]. arXiv preprint arXiv:2201.03256, 2022.
- [29] Fu Y, Li C, Yu F R, et al. A survey of blockchain and intelligent networking for the metaverse[J]. IEEE Internet of Things Journal, 2022.
- [30] Chen H, Lu Y, Cheng Y. FileInsurer: A Scalable and Reliable Protocol for Decentralized File Storage in Blockchain[C]//2022 IEEE 42nd International Conference on Distributed Computing Systems (ICDCS). IEEE, 2022: 168-179.
- [31] Wei Yang Bryan Lim;Zehui Xiong;Dusit Niyato;Xianbin Cao;Chunyan Miao;Sumei Sun;Qiang Yang.Realizing the Metaverse with Edge Intelligence: A Match Made in Heaven[J].IEEE Wireless Communications,2022,: 1-9.
- [32] Xuan-Qui Pham;Tien-Dung Nguyen;Thien Huynh-The;Eui-Nam Huh;Dong-Seong Kim.Distributed Cloud Computing: Architecture, Enabling Technologies, and Open Challenges[J].IEEE Consumer Electronics Magazine,2022,: 1-8.
- [33] Yuntao Wang; Zhou Su; Ning Zhang; Rui Xing; Dongxiao Liu; Tom H. Luan; Xuemin Shen.A Survey on Metaverse: Fundamentals, Security, and Privacy[J].IEEE Communications Surveys and Tutorials, 2022, PP(99): 1.
- [34] Hidayet Aksu; A. Selcuk Uluagac; Elizabeth Bentley. Identification of Wearable Devices with Bluetooth [J]. IEEE Transactions on Sustainable Computing,2018,: 1.
- [35] Jiacheng Shang;Si Chen;Jie Wu;Shu Yin.ARSpy: Breaking Location-Based Multi-Player Augmented Reality Application for User Location Tracking[J].IEEE Transactions on Mobile Computing, 2022, Vol. 21(2): 433-447.
- [36] Jaskaran Singh Saini;Dinesh Kumar Saini;Punit Gupta;Chhattar Singh Lamba;G. Madhusudhana Rao.Cloud Computing: Legal Issues and Provision[J].Security and Communication Networks, 2022, Vol.2022.
- [37] Liu Wei, Zhu Rui & Shan Rongrong.(2022). Library and Metaverse: What, Why and How? Library Tribune (07),7-17.
- [38] Guo Shangtong, Wang Ruifeng & Zhang Fengli.(2021). Summary of Principle and Application of Blockchain. Computer Science (02),271-281.
- [39] Liu Shuangyin, Lei Moyixi, Wang Lu, Sun Chuanheng, Xu Longqin, Cao Liang... & Li Jingbin.(2022). Survey of Blockchain Key Technologies and Existing Problems. Computer Engineering and Applications (03), 66-82.