# The Exploration of the Two Forms of Representation of Virtual Reality Technology Applied to Museum Display

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**Abstract.** In the current era of booming emerging information technology, the application of virtual reality technology is an important trend in the future development of museums and an important means of implementing new media applications. It can enrich the dimensions of museum exhibitions, drive traditional museums to transform into new media armed museums, touch visitors' multiple senses including vision, hearing, and touch, and stimulate their enthusiasm to participate in museum exhibitions, Improve the efficiency of learning and cognitive activities within museums, and maximize the social educational potential of museums. This article focuses on exploring the two most basic situations in which virtual reality technology is applied to museum displays. It provides a detailed explanation and comparative analysis of each situation from several aspects such as target positioning, presentation characteristics, technical core, specific effectiveness, and development direction, providing reference for colleagues in carrying out work in related fields and exploring new ideas for museum displays to further diversify their forms of expression.

**Keywords:** Virtual Museum; Information technology; Virtual reality; Social Education.

## 1 Introduction

As an important base for collecting and disseminating human civilization, museums have always been committed to improving the effectiveness of dissemination and display through various technological means. Against the backdrop of the rapid development of modern information technology, how to apply new media to disseminate and showcase the excellent cultural genes of museums is an important issue that museums need to explore when facing new opportunities and challenges. As a cutting-edge means of providing users with the maximum immersive experience, virtual reality technology's unique immersion, interactivity, and conceptualization have brought a new display form to museum exhibitions. The feasibility and inevitability of combining virtual reality technology with museums have been demonstrated to a certain extent [1-3]. Scholars have conducted in-depth explorations on immersive projection technology [4], 3D modeling and texture technology [5], and the realistic experience supported by wearable


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devices [6]. It is precisely because of the assistance of virtual reality technology that museums are no longer limited to simply describing complex historical and cultural information, but are more focused on improving and enhancing the experience and feelings of visitors. At present, museum exhibitions are striving to break through themselves, keep up with the times, and transform towards a new museum exhibition model rich in new media elements, entering a new era of efficient utilization of social education and cultural dissemination functions.

## 2 Why do museums need virtual reality technology?

Due to limitations such as outdated concepts, limited venues, and underdeveloped technology, the chronic problems of traditional museum exhibitions are evident. In the dim and secluded exhibition hall, the exhibits are placed in tight and seamless display cabinets, accompanied by plain and uninteresting introduction text signs. Most visitors' first impression of the museum still lingers on the classic images of the exhibits being lackluster, outdated and rigid in content, and rigid in layout. Overall, the traditional display methods of museums are limited by time and space, centered around exhibits, static, and lack of interaction. These common problems are the main reasons why museums cannot attract visitors, but their origin is to some extent for the needs of cultural relics protection. In response to the ancient challenge between protection and display, virtual reality technology is a panacea, which not only protects the safety of cultural relics and ancient buildings as much as possible, but also satisfies the audience's willingness to fully appreciate and speculate[7].

Virtual reality technology originated in the 1960s, utilizing visualization technology in the field of computer graphics, computer simulation technology in the field of artificial intelligence, and position tracking technology to simulate and create a highly simulated virtual three-dimensional environment. Through related devices and sensors, it provides a comprehensive sensory experience of audio-visual touch, making users in virtual reality scenes feel as if they are in the real world, Gain immersive experiences that are almost real or beyond reality [8].

Virtual reality technology has three significant characteristics: immersion, interactivity, and conceptualization [9], which highly emphasizes human subjective initiative, fundamentally breaking the traditional exhibition barriers centered around exhibits, and transitioning to a new exhibition model centered around the audience, attracting visitors to actively "enter" museums and personally "approach" exhibits. Furthermore, on the basis of rich media contexts and multi-dimensional interactive experiences, audiences are more likely to interpret the cultural information and spiritual connotations hidden behind exhibits, effectively promoting deep cognitive learning. In addition, the free and convenient access of the public to museum exhibit resources is the foundation for museums to expand their potential for social education functions. Combined with network technology, virtual reality can enable traditional museum exhibitions to break through time and space limitations, greatly increase the scale of user numbers, and more widely leverage the museum's cultural dissemination capabilities for a longer period of time.

The British Museum has always been at the forefront of exploration in the field of virtual reality, not only building a digital museum that can be accessed directly online through virtual reality technology [10], but also designing and creating the famous virtual reality experience Viking VR in the physical exhibition hall[11]. This experience is jointly created by an interdisciplinary team of staff from various fields such as art, archaeology, and curation, Provide viewers with an experience of the living environment of 9th century Vikings.

The application of virtual reality technology in the Chinese Palace Museum is also a good reference example. As early as 2003, the Palace Museum established a specialized research institute for the digital application of cultural assets [12], which was a precedent in China at that time. Afterwards, the research institute spared no effort in exploring the application of virtual reality technology in the protection and external display of ancient buildings. Since 2003, the Forbidden City has released virtual reality programs such as "The Forbidden City: The Palace of the Emperor", "Three Great Halls", "Heart nourishing Hall", "Diligent Studio", "Lingnuo Pavilion", "Imperial Garden", and "Underground Search for Truth". Users can browse through viewing channels such as the Palace Museum's studio and computer terminals, enter palace buildings such as the Taihe Hall and Zhonghe Hall that are not open to tourists, or witness the style of ancient palaces that are only known in literature but no longer exist in reality. They can learn about the internal structure and specific furnishings of the palaces, and also observe the original overall appearance of ancient buildings from the perspective of designers, which is unimaginable in real-life visits. Of course, the first reason why this application is successful is that it ensures the integration of content and form, and form serves content. The original appearance of the palace is the basic content, and the 3D data modeling based on this basic content strives to be realistic, achieving the effect of entering the palace without entering it. Secondly, break through the limitations of interactivity. Users can not only roam the palace according to their own ideas, achieving large-scale switching between different scenes; You can also view various details of cultural relics at close range 360 degrees without dead corners through operations such as scaling and rotation. Thirdly, create a context that triggers the audience's imagination. The work restores scenes from specific historical periods, places cultural relics in their own historical positions, narrates relevant historical stories, and leads the audience through the historical era represented by cultural relics. Fourthly, make implicit information visible. The palaces, artifacts, and treasures of the Forbidden City are considerable, but intangible cultural heritage information such as the construction process of the palace and the use of artifacts is difficult to obtain. Based on literature records and guidance from experts in related fields, the virtual construction process of the work is presented vividly and vividly in front of the audience, satisfying their thirst for knowledge and reflecting the historical appearance and cultural spirit of the Forbidden City more comprehensively.

At present, major museums around the world not only recognize the characteristics of virtual reality technology and its good compatibility with museum exhibitions, but also actively explore practical aspects. By observing relevant cases, virtual reality technology has four main manifestations in museum exhibitions, namely virtual reality, virtual virtual reality, virtual reality combination, and virtual experience based on physical

exhibits. These four new forms of museum exhibitions have their own characteristics in terms of target positioning, presentation characteristics, implementation approaches, specific effectiveness, and development direction. In the specific practice process, detailed decisions need to be made based on relevant parameters such as the exhibition type, audience positioning, expression objectives, and funding personnel of museum exhibitions. This article explores and analyzes the two most commonly used and basic forms of expression.

## 3 Entity based virtual museum

Some historical sites and museums, although well preserved, cannot be opened to visitors for the purpose of preserving ancient architecture and cultural relics. For example, only a small part of the Terra Cotta Warriors of the First Emperor of Qin in Shanxi Province, China, is open to the audience at present, and the rest are still intact underground [13]. The Colosseum in Rome, Italy, may seem to be open to the public, but there are actually underground passages and basement parts that are not visible to the public[14]. Some have complete exhibition conditions, but considering the time and geographical limitations of most users, they are unable to visit the site in person, which cannot achieve the expected large-scale educational dissemination effect of the museum. Many famous heritage museums have truly and completely preserved the original appearance of historical relics, serving as important bases for displaying and explaining historical backgrounds, cultural heritage, and human activities. However, due to their remote location and inconvenient transportation, many visitors are unable to reach them, seriously hindering the museum's social education and cultural dissemination functions. The manifestation of ennity based virtual museum, combined with the powerful dissemination function of the network, can be used to break through relevant limitations.

Entity based virtual museum, as the name suggests, is based on the prototype of physical museum scenes, using virtual reality technology to construct digital scenes, and displaying three-dimensional digital models of physical venues through digital terminals. This can also be easily understood as a digital museum corresponding to a physical museum, with its foothold in "reality". How to present the overall scene, exhibition layout, and independent exhibition details of the physical museum as truthfully and accurately as possible is the key to constructing a virtual reality museum. This form of virtual museum was developed earliest and is the main manifestation of museum virtualization currently. Its core technology is relatively simple and mature, and its implementation approach is relatively convenient, but its limitations are also very obvious, suitable for displaying immovable cultural relics and museum collections, but its expressive ability for intangible cultural heritage is relatively limited.

The implementation process of entity based virtual museums includes two aspects: the construction of the data layer and the design and development of the display layer. There are currently three main ways to construct museum data resources. The first type is manual software modeling, which uses 3DS MAX modeling software based on the overall architectural drawing data of the museum [15]; The second type is 3D scanner

scanning modeling [16], which scans the physical model through a 3D scanner to complete digital acquisition, and then combines modeling technology and LOD technology. Early digital museums mostly utilized these two forms, with the advantages of high model accuracy, strong reliability, freedom to roam, and the ability to present detailed information of exhibits from multiple angles in a three-dimensional manner. The disadvantages were high cost, long time consumption, low modeling efficiency, and low cost-effectiveness. The third method is image based modeling [17], which utilizes VR panoramic cameras such as matterport to collect multiple internal points of the museum, and then integrates them through computer 3D reconstruction algorithms to obtain a simple 3D model. The advantages of this method are that it greatly improves modeling efficiency, has low cost, short time consumption, high efficiency, and high cost-effectiveness. Its drawbacks are low accuracy and reliability of the 3D model. Although it can achieve simple virtual roaming and user interaction, it cannot achieve complete immersion like the first method, and cannot perform three-dimensional interactive observation on individual exhibits, let alone observe the details of the exhibits. In the display phase, the most commonly used is to provide "user demand oriented" website services, such as the digital exhibition platform of the National Museum of China(http://www.chnmuseum.cn/portals/0/web/vr/), in which users can directly access the digital form of the museum through this network link, and use the mouse to select roaming and visiting functions in the scene. The second is to directly run the virtual museum scene application program through a digital playback terminal, allowing for roaming and browsing on a computer terminal without the need for networking.

There are many cases of virtual reality museums, such as the British Museum, the Louvre, the Metropolitan Museum of Art, the Hermitage Museum in St. Petersburg, Russia, the National Museum of China, the Palace Museum, and the Sanxingdui Museum. The British Museum in London has been collaborating with Google since 2015 to showcase the interior space of the museum using Google Street View map technology, allowing visitors to freely browse over 60 museum interior spaces without leaving their homes. Tourists can conduct panoramic virtual tours in the order of floors and rooms, and there are also historical timelines and selected collection images on the exploration page for learning and reference(https://www.britishmuseum.org/british-museum-home). There are currently four virtual exhibitions open to the public at the Louvre. Users can choose the exhibition they are interested in and click on "Launch virtual tour" to start a live VR tour(https://www.louvre.fr/en/online-tours).The Sanxingdui Panoramic Digital Museum in China [18] is constructed using 3D laser scanning modeling, CCD imaging technology, and panoramic virtual technology. It provides users with online virtual roaming, high-altitude observation, and other means to visit the Sanxingdui Comprehensive Museum, Bronze Museum, and surrounding scenery, and observes the details of numerous precious exhibits such as bronze, jade, gold, and ceramics from all angles. Due to breaking through the time and space constraints faced by physical museums, more viewers can learn about the artifacts and culture of Sanxingdui civilization, greatly expanding the cultural dissemination breadth of Sanxingdui and enhancing its social education potential.

Due to the significant and immediate effectiveness of this application, it can greatly enhance the social communication effectiveness of museums in a short period of time.

In the future, ennity based virtual reality museums will still be one of the main forms of expression. With the further maturity of modeling and mapping technology, as well as the continuous development of network technology, virtual reality museums will develop towards the direction of mixing and matching the coarse and fine grain size of the model, combining photos and images for texture mapping, and developing artificial natural interface interaction technology, providing users with a more realistic, immersive, and interactive experience. In terms of 3D model construction, how to conduct comprehensive 3D modeling for movable exhibits and achieve a 360 degree observation effect; In terms of historical and cultural expression, how to design and develop virtual scenes that align with historical prototype scenarios based on the construction of venues; In terms of interactive experience design, how to integrate multiple sensory experiences such as vision, hearing, and touch, and fully leverage the advantages of virtual reality technology's combination of software and hardware, are all directions that need to be researched in the future.

## 4 Virtual Museum Without Physical Entity

Some historical sites or precious cultural relics can only be seen in literature records, and their physical entities have disappeared, such as the Bamiyan Buddha located on the cliff edge of the Bamiyan Valley in Afghanistan[19]; Some cultural relics cannot be displayed due to safety protection needs or physical space limitations, such as the "Qian Li Jiang Shan Tu" currently collected in the Beijing Palace Museum [20]; Some exhibitions are entirely based on the initiator's idea of aggregating exhibits scattered within multiple museums into a virtual digital museum for users to view and browse online, such as Google Arts & Culture, whose mission is to preserve and bring the world's art and culture online for everyone to see[21]; These situations can be represented through virtual museum without physical entity.

The virtual museum without physical entity can be regarded as a pure virtual museum, which is a digital museum constructed by conceptualizing and designing prototypes, combining 3D modeling and image texture mapping technology without a physical museum. Although the virtual museum does not have physical venues as the prototype foundation, its essence is still based on historical sites or exhibits that truly exist. When restoring historical sites, it is necessary to restore as much as possible the layout, structure, and exterior features of the original buildings at that time, and the interior decoration should also strive to conform to historical reality. Although pure virtual museum venues are virtual, the items displayed within them still need to have physical prototypes or documented prototypes, and the construction of the exhibition hall itself must comply with the laws of the physical world. Museums have a social positioning of collecting and disseminating human civilization, therefore, no matter how illusory the application of virtual reality may be, they always maintain a connection with real objects that truly exist in history.

From the perspective of implementation approaches, the data layer construction of the virtual museum without physical entity includes two methods: manual software modeling and 3D scanner modeling. The construction of this museum model can only

rely on manual software modeling,The construction of the museum space models can only rely on manual software modeling, and requires the collaboration of experts from various fields such as history, architecture, and information technology, referencing the data analyzed from literature materials, to jointly build a relic model that is as close to historical reality as possible. For models of movable exhibits, in the absence of physical foundations, they can only be modeled through manual software, combined with virtual images drawn by computers for texture mapping. During the user browsing experience stage, they can access online digital museums through the internet or interactively explore by running digital museum applications.

Practice has proven that the successful cases of virtual museums without ennity have played a crucial role in inheriting historical and cultural heritage, as well as promoting cultural exchange. For example, there are many famous historical buildings in China that have been damaged or even disappeared due to various reasons, such as the Yuanmingyuan, Daming Palace, Afang Palace, and Weiyang Palace. The use of virtual reality (VR) technology for virtual reconstruction is of great significance for inheriting and promoting the excellent traditional Chinese culture. Especially for the Yuanmingyuan, known as the "Garden of Ten Thousand Gardens," the virtual restoration work has always been highly valued and has achieved excellent results. In 2009, Professor Guo Daiheng from Tsinghua University led a team of more than 80 professionals to embark on a grand project of virtual restoration of the Summer Palace. After in-depth research on over 10000 historical archives, 4000 restored design drawings, and 2000 digital building models, the team successfully and accurately restored over 60% of the scenic spots of the Summer Palace after 15 years.[22] This magnificent feat allows us to glimpse the true face of this major historical and cultural heritage. Its outstanding architectural style, unique garden layout, and rich cultural and artistic connotation are presented comprehensively under our nose. There is also a special type of museum that only exists in the virtual world. For example, the Kremer Museum[23], initiated by Dutch art collector George Kremer in 2017, does not have a physical prototype, but is a completely virtual museum. The exhibits of this virtual museum are presented through ultra high-resolution digital models constructed from 74 Dutch master paintings. This virtual museum provides an exquisite virtual environment where viewers can enjoy these paintings up close, and even magnify Van Gogh's masterpiece 'Starry Night' by a factor of 100. This experience undoubtedly provides art enthusiasts with a more detailed and direct viewing experience. It breaks various restrictions of physical museums, allowing viewers to freely appreciate art works at any time and place. Overall, this purely virtual form of museum not only enriches our viewing experience, but also provides us with a new way to access and appreciate art. This form is very suitable for applications such as virtual restoration of cultural relics and restoration of lost historical sites. With more accurate interpretation of historical literature and further deepening of related archaeological discoveries, the degree of virtual museums being closer to historical reality will become higher, and the confidence of relevant staff in virtual restoration will become stronger. The number of virtual museum development will also increase. With the continuous development of modeling and mapping techniques, higher model accuracy and more realistic mapping will make the scene more realistic, thereby giving users a stronger sense of immersion. In addition, with the further development of 5G network

technology, richer interactive experiences will be designed and developed. Finally, with the further development of artificial intelligence technology, research on intelligent virtual exhibition layout for purely conceptual museums based on physical exhibits will also take a new step.

## 5 Conclusions

The most basic and common forms of virtual reality application in museum displays are ennity based virtual museum and virtual museum without physical ennity. These two forms of expression are suitable for different application scenarios and have their own characteristics in both humanistic and technical aspects. Although the technical roadmap has similarities at the basic core level, attention still needs to be paid to their respective emphasis in specific implementation. In terms of specific practice, both types of virtual museums have achieved good results, but there are still certain problems that need to be further explored and studied in the future practice process.

Firstly, no matter which display method or technical means we choose, it must be organically integrated with the theme and content of the exhibition. Clearly defining our goal is crucial, which is to improve the social education level and information dissemination efficiency of museums while ensuring their safety and proper preservation of their collections.

Secondly, how can virtual reality hardware devices be better integrated into multi sensory experience design to attract user interest? In fact, from the perspective of virtual reality technology, these two display forms are only their basic applications, and the advantages of multi-sensory interactive experience of virtual reality technology have not yet been fully developed. With the continuous progress of virtual reality hardware devices and the reduction of costs, virtual reality museums based on interactive devices will be the future development trend. For example, 3D glasses can provide a three-dimensional immersion better, interactive handles can allow users to feel the tactile impression of handheld exhibits, and motion tracking devices allow users to roam virtual scenes through natural walking. The application of these technologies can enhance user interest, narrow the distance between users and museums and exhibits, and achieve more ideal results.

Thirdly, how to better interpret and represent historical and cultural phenomena implied? The two display methods usually reproduce historical scenes through static scenes, without deep exploration of the content, neglecting in-depth interpretation and expression of the historical context and social culture behind the physical exhibits. However, scenario creation is precisely the advantage of virtual reality technology. Therefore, in the process of further exploration, we should fully leverage the advantages of virtual reality in creating scenarios based on in-depth exploration and research of historical facts. We should carry out certain artistic creation and processing on historical figures and stories in the venue, restore virtual scenes that are in line with historical reality, achieve the effect of surpassing traditional scene restoration and display, and enable users to more intuitively feel the historical atmosphere and humanistic spirit at that time. At the same time, we should integrate visual, auditory, and tactile experience

design, fully utilize the multi-sensory experience function brought by virtual reality technology, so that users can more immerse themselves into historical situations, participate in interaction, and enhance historical knowledge and emotional identification furthermore.

## References


1. Hirose M. (2006) Virtual reality technology and museum exhibit. International journal of virtual reality, 5: 31-36.
2. Nisiotis L., Alboul L., Beer M. (2019) Virtual museums as a new type of cyber-physical-social system. In:Augmented Reality, Virtual Reality, and Computer Graphics: 6th International Conference. Santa Maria al Bagno. 256-263.
3. Yumei H. (2020) On the construction of virtual museum. In: IOP Conference Series: Earth and Environmental Science. IOP Publishing. 062034.
4. Carrozzino, Marcello, et al. (2017) A Virtual Travel in Leonardo's Codex of Flight. In: Augmented Reality, Virtual Reality, and Computer Graphics: 4th International Conference. Ugento. 310-318.
5. Carvajal, Daniel Alejandro Loaiza; Morita, María Mercedes; BILMES, Gabriel Mario. (2020) Virtual museums. Captured reality and 3D modeling. Journal of Cultural Heritage, 45: 234-239.
6. Baraldi L., Paci F., Serra G., et al. (2015) Gesture recognition using wearable vision sensors to enhance visitors' museum experiences. IEEE Sensors Journal, (5): 2705-2714.
7. Li Z., Li H., Li Y. (2006) The technology of stereo photography and virtual reality in research of virtual museum. In: Technologies for E-Learning and Digital Entertainment: First International Conference. Hangzhou. 1358-1365.
8. Feng, K.P. (2021) Virtual Reality Technology and Applications (in Chinese). Electronic Industry Press, Beijing.
9. Liu S., Jia J. (2009) Design and implementation of virtual culture museum. In:2009 4th International Conference on Computer Science & Education. Nanning. 686-689.
10. Wang Y.L., Sun Y.J., Zhou C.W. (2021) Research on the development and application of museum cultural Resources display based on virtual reality technology. E3S Web of Conferences. EDP Sciences, 236: 01048.
11. Schofield G., Beale G., Beale N., et al. (2018) Viking VR: designing a virtual reality experience for a museum. In: Proceedings of the 2018 Designing Interactive Systems Conference. Hong Kong. 805-815.
12. (2004) Viewing the Forbidden City Like a Bird - VR "The Forbidden City: The Palace of the Emperor" (in Chinese). Forbidden City, (01): 56-57
13. Guo N.H. (2020) Dreaming Back to the Tang Dynasty - Understanding an Ancient City (in Chinese). Branch Construction, (28): 42-43.
14. Guidi G., Gonizzi Barsanti S., Micoli L. L., et al. (2017) Accurate reconstruction of the Roman circus in Milan by georeferencing heterogeneous data sources with GIS. Geosciences, 7: 91.
15. Hevko I., Potapchuk O., Lutsyk I., et al. (2020) Methods building and printing 3D models historical architectural objects. In: The International Conference on History, Theory and Methodology of Learning. Kryvyi Rih. 75: 1-6.
16. Cooper, J.P., Wetherelt A., Zazzaro C., et al. (2018) From Boatyard to Museum: 3D laser scanning and digital modelling of the Qatar Museums watercraft collection, Doha, Qatar. International journal of nautical archaeology, 47: 419-442.

17. Hu. Y, Sun. W, Liu. X, et al. (2020) Tourism demonstration system for large-scale museums based on 3D virtual simulation technology. The Electronic Library, 38: 367-381.
18. Luo H., Lan X. (2015) Research on the Application and Development of Virtual Reality Technology in the Protection of Large Ruins(in Chinese). DADA2015 International Academic Conference on Digital Architecture. ShangHai. 240-247
19. Toubekis G., Mayer I., Döring-Williams M., et al. (2017) Preservation and management of the UNESCO World Heritage Site of Bamiyan: Laser scan documentation and virtual reconstruction of the destroyed Buddha figures and the archaeological remains. Universitätsbibliothek der RWTH Aachen, Aachen.
20. Yu W.Y. (2021) Analysis of the Integration and Development of Virtual Reality Technology and Cultural Industry (in Chinese). China Media Technology, (12): 71-73
21. Proctor N. (2011) The Google Art Project: A new generation of museums on the web? Curator: The Museum Journal, 54: 215-221.
22. Yang X.X. (Tsinghua Lecture on Humanities) (2020) Guo Daiqian: Devoted 20 years to rebirth the Old Summer Palace in the virtual world(in Chinese). https://m.thepaper.cn/baijiahao_9632920.
23. 2023 The Kremer Collection. (2023) The Kremer Museum. https://www.thekremercollection.com/the-kremer-museum/.