

Investigation on the Application of Digital Humanities Technology and Practical Effects in Museums in the Beijing Area: A Case Study of the Palace Museum

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Abstract:

This paper takes the museums in the Beijing area as the research object and selects the Palace Museum as a typical case to explore the current application situation and actual effects of digital humanities technology in the protection of cultural heritage, exhibition display, and optimization of audience interactive experience. Through the combination of literature review and field investigation methods, this paper systematically combs through the application achievements and existing deficiencies of digital humanities technology in museums at home and abroad. The research finds that digital humanities technology has significant advantages in aspects such as digital display of cultural relics, virtual reality experience, and intelligent guided tours. It can effectively break through the physical limitations of traditional museum displays and provide audiences with a more immersive and interactive visiting experience. At the same time, there is still room for improvement in data integration, information depth, and cross-media narratives. Based on the analysis of the digital practices of the Palace Museum and other museums, this paper proposes optimization strategies such as constructing a three-dimensional communication system, reconstructing the narrative dimension of cultural relics, innovating the interactive experience mode, and building a resource sharing network, providing theoretical support and practical references for promoting the digital transformation of museums in Beijing and even across the country and the protection of cultural heritage.

Keywords: *Digital Humanities Technology; Museum Digitization; Cultural Heritage Protection; Virtual Reality; Interactive Experience; The Palace Museum*

I. Introduction

1.1 Research Topic Selection and Its Significance

Digital Humanities technology is an interdisciplinary field that combines information technology with the humanities disciplines. Its purpose is to assist in the preservation, research, and dissemination of cultural heritage through digital means. In museums, this technology can help digitize the display of cultural relics, enabling audiences to understand and experience cultural heritage through interactive methods. It also makes the management and protection of cultural relics more efficient and promotes the popularization of cultural dissemination. The rich cultural heritage and diverse museum resources in the Beijing area provide an ideal scenario for applied research in digital humanities technology.

This research project selected the Palace Museum, a world cultural heritage site, as its research object. The Palace Museum is not only a symbol of Chinese history and culture but also an important part of global cultural heritage. In 1987, the Palace Museum was inscribed on the World Heritage List by UNESCO due to its outstanding protection value in aspects such as cultural history and architectural technology. The Palace Museum is not only a treasure of ancient Chinese architectural art but also an important witness to the integration of diverse cultures. In 2024, the Palace Museum was included in the World Heritage List of "The Beijing Central Axis — The Order of China's Ideal Capital City," further emphasizing its significance in global cultural heritage.

Through field investigations combined with literature research, this study focuses on analyzing the practical application and innovative practices of digital humanities technology in aspects such as the storage and display of cultural relics and the interactive experience for audiences. The investigation of digital humanities technology will further play the leading role of Beijing as the national cultural center, providing references and inspiration for the digital development of museums across the country.

1.2 Literature Review

In recent years, digital humanities technology, as an innovative tool for the protection and dissemination of cultural heritage, has gradually become a core topic in the field of museum research. The Beijing area, with its rich cultural heritage resources and diverse museum groups, provides a unique and advantageous practical background for related research.

According to the literature search results on CNKI, the

total number of research papers on digital humanities technology has reached 3,375. However, there are only 165 papers specifically discussing its application and effects in museums, and the research on digital humanities museums in the Beijing area is even scarcer, with only 10 papers. To fill this research gap, this study has integrated 13 relevant papers through CNKI and Google Scholar, focusing on the application of digital humanities technology in the protection of cultural heritage and the related topics of cross - media narrative and the optimization of audience interactive experience. Among these papers, 7 focus on the specific application of digital humanities technology in the protection of cultural heritage, and 6 discuss the strategies for cross - media narrative and the optimization of audience interactive experience.

(1) Application of Digital Humanities Technology in the Protection of Cultural Heritage

Digital humanities technology has demonstrated remarkable potential in the storage of cultural relics and their digital display. For instance, Lu Lin from the School of Urban Art at Tianjin Chengjian University, in the research titled "Research on Interactive Design in Museums from the Perspective of Digital Humanities" ^[1], delved into the application of technologies like suspended imaging and dynamic imaging within museums, thereby offering innovative solutions for the dynamic display of cultural heritage and interactive experiences.

In the work "Panorama and a Long-term Perspective: Digital Humanities and the National Cultural Digitization Strategy" ^[2], Yang Zekun, Li Shaojian, and Kailimai carried out an in-depth analysis and exploration of chime bells by leveraging technologies such as the RDF (Resource Description Framework) and knowledge graph. They successfully established a database centered around chime bells, presenting a novel approach to the digital protection and display of this cultural heritage.

In his study "The Historical Changes of Old Beijing Hawking Calls from the Perspective of Media Evolution" ^[3], Liang Xuan from the School of Television at Communication University of China made use of digital technology to preserve the old Beijing hawking calls in Shijia Hutong as contemporary audio historical materials. Moreover, he provided materials for future new media technologies, enabling the protection and display of cultural heritage to adapt to technological advancements and ensuring the inheritance of its historical value.

Zhao Yuxiang and Lian Jingwen from the School of Economics and Management at Nanjing University of Science and Technology, in their review article "A Review of Crowdsourcing Research on Cultural Heritage from the Perspective of Digital Humanities" ^[4], discuss the construction and operation management of crowdsourcing

platforms for cultural heritage. Relying on digital technology, they created an online environment for volunteers to participate, collaborate, and interact, ensuring the efficiency and sustainability of data collection and management. Additionally, they employed digital technology for volunteer management, task matching, and data quality control, safeguarding the smooth progress of the project and the reliability of the data.

In the research “Open-source Curating: A Study on the Design and Curating Mechanism from the Perspective of Digital Social Innovation”^[5], Lu Tao, a doctoral candidate at the Central Academy of Fine Arts, elaborated in detail on the pivotal role of digital technology in the transformation of the curatorial paradigm. This has made it feasible for digital preservation, display, and utilization of cultural heritage. Through digital technology, the data related to cultural heritage has been enriched and diversified, and the public can jointly engage in the protection and innovation of cultural heritage through participation-based and citizen curatorial models.

Professor Tang Chen from the School of Chinese Language and Literature at Anhui University, along with his student Zhang Ping, in their experimental research “Experiments and Reflections on the Path of Compiling Lost Works of Classical Literary Documents in the Digital Humanities Era”^[6], took the case of compiling the lost literary works of Tang Gao, a Zhuangyuan (the top scorer in the imperial examinations) during the Ming Dynasty. They explored the application of digital technologies such as Optical Character Recognition (OCR) for ancient books and digital humanities methods. By structuring the preservation and utilization of ancient book data, they established numerous databases and intelligent ancient book platforms, enhancing the efficiency and accuracy of the work of compiling lost works, optimizing the traditional process, expanding the scope of compilation, and improving the reliability of the results.

In her research “Research on the Visualization Presentation Model of Archival Resources at Cultural Heritage Sites”^[7], Bai Xiaoqing chose cases including the “Open Platform for Historical and Geographical Information of the Silk Road”, “Digital Yuanmingyuan”, and “London Street View Museum”. She analyzed in detail the project characteristics of GIS maps, spatial immersion models, and scene superposition models, illustrating the application of digital technology to practical projects.

(2) Optimization of Cross-media Narrative and Audience Interactive Experience

Cross-media narrative has become one of the crucial means for museums to attract audiences. For instance, the paper “Research and Practice on Cross-media Narrative in Digital Humanities Services”^[8] proposes that by adopting

a multi-media narrative approach, a digital narrative space can be constructed to achieve the activation and dynamic dissemination of cultural heritage. Bernadette Berndtman, Deputy Director and Senior Researcher of the Museum at the University of Graz in Germany, pointed out in the paper “Virtual Museums: The Interdisciplinary Research Object of Digital Humanities and Museology”^[9] that a virtual museum is not merely a digital replica of a traditional museum. Instead, through digital technology, the physical museum space is extended into the virtual world. Museums can offer customized exhibition content and guided tour routes according to the interests and needs of visitors. Users can select the cultural relics or themes they are interested in and obtain a personalized museum experience.

Zhang Hongliang from the Institute of Culture of the Beijing Academy of Social Sciences, in the paper “Integration and Dissemination of Historical Culture from the Perspective of Digital Humanities: Taking Beijing as an Example”^[10], has conducted an in-depth study of the specific measures taken by museums in the Beijing area to enhance the audience experience with the help of digital humanities technology. Through technologies such as Virtual Reality (VR) and Augmented Reality (AR), museums in Beijing have shifted from traditional displays to immersive interactive exhibitions. Audiences can have “zero-distance” contact with cultural relics, breaking through the limitations of physical space and optimizing their experience. Meanwhile, the introduction of 5G communication technology has presented new opportunities for cultural dissemination. It supports the production of ultra-high-definition immersive dramas and provides a brand-new way to narrate historical stories.

In “The Characteristics and Approaches of Narrative in the Digital Age—Taking the Virtual Reality Works of the Palace Museum as an Example”^[11], Deng Jingxin, through the “Panoramic Palace Museum” project of the Palace Museum, demonstrates how digital technology combines traditional display forms with virtual interactions. This enables the audience, through natural physical participation, to obtain a deeper emotional experience and memory awakening in the virtual environment, enhancing sensory interaction and promoting the understanding and identification of cultural heritage.

In “Knowledge Organization of Museum Collections Oriented to Artificial Intelligence—Taking the ‘Conceptual Reference Model of Movable Cultural Relics in Ancient China’ of the Palace Museum as an Example”^[12], Zhuang Ying introduces that the Palace Museum, by constructing and applying the “Conceptual Reference Model of Movable Cultural Relics in Ancient China” (CRM-ACA), enables the “Digital Cultural Relics Database” to provide

intelligent retrieval and a visual knowledge graph exploration mode. Users can intuitively understand the relationships among the collections, thus enhancing the interactive experience.

Zhang Zhixue, Li Han, and Wang Cong from Peking University mentioned in the paper “The Path of Interdisciplinary Construction of Digital Humanities”^[13] that through digital means, the display of cultural heritage is no longer confined to physical space. For example, the School of Archaeology and Museology at Peking University utilized digital technology to virtually reconstruct the murals in Kaihua Temple, providing new ways of viewing and interaction. This not only achieves visual innovation but also expands the interactivity and immersive experience, enhancing the audience’s sense of participation.

1.3 Shortcomings of Current Literature and Innovations of This Study

Although the existing literature has achieved certain results in the application of digital humanities technology to the protection and dissemination of cultural heritage, there are still obvious deficiencies. Regarding the Beijing area, many case studies focus on the technology itself, lacking systematic analysis, and thus unable to comprehensively demonstrate the effects and approaches of digital humanities technology in practical operations. Research on the optimization of audience experience is also relatively fragmented. In particular, discussions about local applications and specific practical approaches are not in-depth enough. Especially against the backdrop of highly developed artificial intelligence, these deficiencies become even more prominent, because AI technology provides more possibilities for digital humanities, yet the existing research has not fully utilized this advantage.

Aiming at these deficiencies, this study selects the Palace Museum in Beijing as the research object. Through field investigations, it obtains first-hand observation experiences and primary data, and conducts an in-depth exploration of the practical application and effects of digital humanities technology in the storage and display of cultural relics and the optimization of the audience interactive experience, filling the gaps in terms of regionality and case depth. Based on these first-hand materials, when considering strategies for optimizing the audience experience, it is necessary to take into account both the feasibility of technological application and the historical value of cultural heritage.

Ultimately, based on the results of empirical research, this thesis summarizes and proposes specific practical guidelines, promotes the combination of cultural inheritance and technological innovation in Beijing’s museums, fa-

cilitates the sustainable development of Beijing’s cultural heritage, and provides theoretical support and practical basis for the digital practices of museums across the country, thus promoting the organic integration of the inheritance of Chinese culture and technological innovation.

II. Current Usage Status of Digital Humanities Technology in Museums in the Beijing Area

2.1 Basic Situation

As the capital of China, Beijing is endowed with rich historical and cultural heritages and numerous high-level museums. According to a report from The Paper, as of 2025, Beijing has 240 museums, covering various fields such as history, art, science and technology, and nature. These museums not only display a rich collection of resources but also play important roles in cultural dissemination, educational popularization, and scientific research innovation. Among them, national-level museums such as the National Museum of China and the Capital Museum, as well as various professional museums like the China Science and Technology Museum and the Beijing Natural History Museum, all enjoy high reputations both at home and abroad.

With the rapid development of information technology, the application of digital humanities technology in the museum field of Beijing has become increasingly widespread, bringing about profound changes to the display methods and management models of traditional museums. Major museums in Beijing are actively exploring digital transformation, adopting various digital display methods including digital exhibition halls and Virtual Reality (VR) exhibitions to achieve an online-offline integrated display model. At the same time, the application of intelligent guided tour systems and interactive display devices enables audiences to interact with exhibits through touch screens, Augmented Reality (AR), and other means, enhancing the visiting experience. For example, the intelligent guided tour robot introduced by the Capital Museum provides personalized interpretation services.

In addition, through digital means, comprehensive management and protection of the cultural relics in the collection have been carried out, improving the visualization and retrievability of the collections. The National Museum of China has adopted an advanced digital management system to achieve comprehensive digital storage and sharing of collection information. By using big data technology to analyze the behaviors and preferences of audiences, it provides a scientific basis for exhibition design and ser-

vice optimization, and optimizes the layout of exhibition content.

Although major museums in Beijing have made remarkable progress in the application of digital humanities technology, there are still certain deficiencies in aspects such as the improvement of collection information and the interactivity of digital displays. This provides a broad research space for further enhancing the application and effect of digital humanities technology in museums.

2.2 Basic Situation of the Application of Digital Humanities in the Palace Museum

As one of the most influential and representative museums in China and even in the world, the Palace Museum takes the lead in the application of digital humanities technology among museums in Beijing. The Palace Museum not only boasts abundant historical and cultural resources. Located on the central axis of Beijing, it was the imperial palace of twenty-four emperors during the Ming and Qing dynasties. Its exploration and practice in digital protection and dissemination, as well as in the interactive experience for visitors, have provided valuable reference experiences for other museums.

The Palace Museum has successfully achieved the digital display and protection of cultural relics by introducing advanced technologies such as virtual reality technology, augmented reality, and intelligent guided tours. For instance, through high-precision scanning technology, the Digital Cultural Relics Database and the Treasure Gallery of Cultural Relics projects of the Digital Palace Museum present precious cultural relics digitally, enabling audiences to browse the exhibits in a 360-degree panoramic view through an online platform. In addition, the Palace Museum has developed several interactive applications, such as “Panoramic Palace Museum” and “VR Palace Museum”, which have greatly enhanced the sense of participation and the experience of the audience.

III. The Application of Digital Humanities in Museums in the Beijing Area Represented by the Palace Museum

3.1 Online Field Investigation

The official website of the Palace Museum, as a model of the integration of digital technology and cultural dissemination, has achieved interactivity in user experience, rich information about cultural relics and collections, and a high degree of integration of digital humanities technology through multiple functional sections.

The Library section showcases published books and provides an online purchasing function. At the same time, it integrates a large number of professional papers and knowledge related to cultural relics, demonstrating pro-

found academic value and information depth. However, in terms of interactivity, it is relatively monotonous and fails to fully stimulate users’ senses of participation.

The Audio-Visual Hall presents rich topics such as the analysis of Along the River During the Qingming Festival, the archaeology of the Palace Museum, and lectures by renowned experts through carefully curated high-quality video content. By using multimedia means, it effectively enhances users’ intuitive perception of history and culture. This section not only provides free video resources but also brings users a profound cultural experience with its rich academic content.

The “Famous Paintings of the Palace Museum” section, as a highlight of the website, greatly improved users’ interactive experience and their ability to actively explore. Among the nearly 50,000 paintings in the collection of the Palace Museum, nearly 1,000 are national first-class cultural relics. The “Famous Paintings of the Palace Museum” section online displays 1,212 works by famous artists from various dynasties. Each collection provides ultra-high-definition digital images and supports the function of infinite zooming, which can be adapted to various terminals and browsers, allowing users to appreciate every detail of the paintings meticulously. In addition to high-definition images, the “Famous Paintings of the Palace Museum” section also further enriches the multimedia appreciation content by providing introductions to the paintings and annotations of historical backgrounds, meeting the needs of cultural and museum enthusiasts in aspects such as the appreciation of traditional calligraphy and painting art and academic research. In terms of the retrieval function, users can conduct classified searches according to dynasties, artists, schools, and themes, which greatly improves the convenience and accuracy of retrieval.

Based on a large number of collections, the Digital Cultural Relics Database covers 1,863,404 exhibits and displays them with simple pictures and basic information, having wide coverage. However, its information depth is relatively limited, only including a small amount of background information about the exhibits. Technologically, it mainly relies on the “Knowledge Graph of Movable Cultural Relics in Ancient China” project, demonstrating high technical capabilities in data integration and retrieval efficiency. It can conduct classified searches according to various characteristics of the collections. However, the richness of the information is still in need of further improvement in terms of content depth and interactivity.

The “Panoramic Palace Museum” uses 3D modeling technology and a 360-degree perspective to provide users with an immersive architectural exploration experience. The panoramic view of the Palace Museum covers most

of the ancient buildings on the exhibition routes along the central axis, providing online users with as complete a tour experience as possible. Combined with virtual guided tours and classical background music, users can comprehensively understand the architectural details and cultural values of the Palace Museum from multiple perspectives. Moreover, users can view enlarged high-definition pictures of specific cultural relics, which enhance visitors'

appreciation and learning of the details of the Palace Museum. The query module provides historical backgrounds and rich text and picture resources, including paragraphs introducing historical backgrounds and dynamic pictures supporting panoramic browsing, enabling users to have a more comprehensive understanding of the history and artistic connotations of the Palace Museum buildings.



Fig 1. The three-dimensional digital technology of the Hall of Supreme Harmony in Panoramic The Palace Museum

https://pano.dpm.org.cn/#/panorama?panorama_id=20&scene_id=2&scene_name=scene_2_summer
The VR The Palace Museum section takes the Hall of Mental Cultivation, the Lingzhao Xuan (Spiritual Marsh Pavilion), and the Juanqin Zhai (Studio of Exhaustion from Diligent Service) as its core. With the help of

three-dimensional visualization technology, it simulates the various characteristics of these three historical sites. Moreover, it is compatible with professional head-mounted VR devices, enabling a highly immersive exploration of the interior of the buildings.



Fig 2. The three-dimensional data collection work is carried out in the Hall of Mental Cultivation

https://www.dpm.org.cn/classify_detail/258879.html

In particular, through digital restoration technology, the Lingzhao Xuan achieves a seamless switch between the virtual and real states. It can simulate the splendor of the Lingzhao Xuan during its imagined completion, which in history fell into disrepair due to budget constraints. This enhances the expressive power of cultural transmission. Nevertheless, the number of VR The Palace Museum buildings is relatively small. In the future, its application scope should be further expanded to provide a more extensive immersive experience.

The Digital Treasure Pavilion showcases 360-degree details of cultural relics through 3D modeling technology, enabling visitors to have a high level of subjective interactivity. They can change the viewing angle and zoom in or out by dragging the mouse. However, the information content is relatively scarce, only providing the names of the cultural relics, the dynasties they belong to, as well as simple size information. It is recommended to combine it with the Digital Cultural Relics Database. This can not only enrich the amount of information but also provide users with a cultural relic viewing experience from more perspectives.



Fig 3. The “Painted Enamel Teapot with a Lifting Beam and Openwork Panels” in the Digital Treasure Pavilion

<https://www.dpm.org.cn/shuziwenwu/246655.html>

The game section combines cultural communication with forms of entertainment through interactive games, such as trivia and cultural relic restoration and coloring, and is especially popular among young users. This function not only improves the interest in learning, but also enhances the attraction and communication effect of historical culture. The Palace Museum website has also achieved remarkable results in the promotion of cultural and creative products, selling publications directly through the library section, and establishing a linkage between digital platforms and game design, strengthening the brand effect.

In general, the Palace Museum website has outstanding performance in the use of media symbols, technical realization, interactive experience and information dissemination, but there is still room for improvement in the depth of content and resource integration of individual sections.

In addition to the official website, the Palace Museum has also launched several official apps, which apply digital humanities technology from different perspectives. For example, the “Palace Museum Daily” app recommends exhibits to users every day in the form of a calendar, based on rich thematic content. Users not only can view new exhibits daily but also learn about the historical and cultural backgrounds related to the themes of the Palace Museum through these topics. Themes such as “Auspicious Beasts”, “Pines and Cypressess”, and “Literati” enable users to have an in-depth understanding of the cultural connotations of the Palace Museum from various angles and to experience the profoundness of Chinese culture. However, the exhibits only provide simple names and information, and there is a lack of background knowledge.

The “Palace Museum Audio Guide” app requires a payment of 11 Yuan to unlock. After unlocking, this app can automatically play detailed introductions of corresponding scenic spots according to the user’s relative position in the Palace Museum, and users can choose to turn on synchronous explanations. This allows users to more conveniently understand the background and stories of each scenic spot, enhancing the sense of interaction during the guided tour process.

The “Palace Museum Ceramics Gallery” app, based on the digital cultural relics database on the official website of the Palace Museum, mainly showcases the rich ceramic collections of the Palace Museum. Compared with the brief descriptions of cultural relics on the website, the innovation of “Palace Museum Ceramics Gallery” lies in its more comprehensive descriptions of ceramics and the addition of a timeline function. Users can understand the development process of ceramics in chronological order, from the Neolithic Age to the Qing Dynasty. This enables users who want to learn about the ceramic collections of the Palace Museum to obtain rich content and acquire

knowledge in a more systematic way.

The “Palace Museum Online Courses” app provides a rich variety of online course services. It has special zones for calligraphy, painting, court life, etc., and offers many courses of different difficulty levels, including both paid and free zones. This helps users with different knowledge bases to have an in-depth understanding of the history and origins behind cultural relics to varying degrees, and enables them to find courses suitable for their own difficulty levels. It also contributes to promoting the charm of traditional Chinese culture embodied in the Palace Museum.

The “Forbidden City 365” app offers three main sections. In the quiz section, users can answer questions during the learning process in a game-like way to win badges, adding entertainment to the knowledge quiz session. The beautiful pictures section provides users with the convenience of searching for official high-definition photography works of the Palace Museum through regional and seasonal classifications, and supports easy sharing on social media, which enhances the influence of the culture of the Palace Museum on society.

In addition, the mini-program of the Palace Museum mainly serves as a comprehensive service platform, integrating the functions of the official website of the Palace Museum and the “Palace Museum Daily” app. However, it places more emphasis on ticket booking and reservation as well as map navigation. With all the functions of the “Panoramic Palace Museum”, tourists can customize their own tour routes, conduct simple navigation, accurately estimate the order of their visits, and arrange their time reasonably.

Its personalized recommendation function allows users to collect cultural relics, famous paintings, buildings, and exhibitions after logging in, and content will be pushed based on users’ interests. Moreover, the mini-program is very convenient for streaming media sharing. Users can easily share the content they are interested in on social platforms such as Moments, Douyin, or Xiaohongshu.

Although it supports the AR exhibition function, this function can only be used when tourists are on-site, which limits its application scope. Overall, the design of the mini-program is more service-oriented, providing tourists with an efficient user experience. However, there is still room for further optimization in terms of in-depth cultural interaction and the local adaptation of the AR experience.

3.2 On - site Field Investigation

Before conducting an on - site field investigation at the Palace Museum, tourists usually need to make ticket reservations seven days in advance through the official mini - program of the Palace Museum. The author successful-

ly booked tickets for the Palace Museum, as well as the Treasure Gallery and the Clock Gallery on January 24, 2025.

After arriving at the Meridian Gate, the entrance of the Palace Museum, tourists can rent an ear - worn electronic guided tour device for 20 yuan. This device is lightly designed and comfortable to wear, and it can automatically switch the explanation content according to tourists' positions. The narrator's tone is solemn and infectious, which complements the historical atmosphere of the Palace Museum. It is worth mentioning that by spending only 11 yuan, tourists can download the "Palace Museum Audio Guide" APP officially launched by the Palace Museum and unlock voice navigation permanently. Moreover, the content of the APP and the electronic device can learn from each other, achieving cross - media interoperability. In addition, the guided tour system arranges the explanation duration reasonably according to the tourists' visiting progress, preventing tourists from staying at a certain scenic spot for too long and greatly enhancing the visiting experience of all tourists.

The regular visiting route starts from the Meridian Gate, passes through the Gate of Supreme Harmony, the Square in front of the Hall of Supreme Harmony, and then to the Hall of Supreme Harmony. However, the interior of the Hall of Supreme Harmony is usually not open to the public. The cultural relics are protected by thick glass and railings, preventing tourists from observing them up close. To make up for this shortcoming, tourists can utilize the "Panoramic Palace Museum" function in the mini - program to experience the virtual guided tour based on 3D modeling technology. This combination of online and offline methods makes it possible for digital humanities technology to break through the limitations of on - site visits due to cultural relic protection.

In areas such as the Hall of Central Harmony and the Hall of Preserving Harmony, where the interiors are not open to the public, the virtual tour of the "Panoramic Palace Museum" also enhances the offline experience. As tourists walk through the Palace Museum in person and follow the guidance of the online map in the "Panoramic Palace Museum," a unique experience emerges. Although tourists are physically following the path of the virtual tour, there is a sharp contrast between the crowded offline environment and the clear high - definition model in the online version.

In particular, the high - definition modeling technology presented in the "Panoramic Palace Museum" is extremely realistic in terms of detail. Moreover, the modeled environment is in an ideal state, free from the interference of tourists, time constraints, changes in lighting, or weather conditions. Its presentation effect is even more impactful

than the real offline experience. Despite being a virtual scene, its sense of realism surpasses the real - world experience, creating a delicate experience of overlapping yet misaligned time and space.

This strong contrast between the virtual and the real profoundly demonstrates the great potential of digital humanities technology in reshaping reality and enhancing the real - world experience. Through high - definition modeling and virtual tours, digital technology not only provides online tourists with an almost real - life touring experience but also offers a powerful tool for the dissemination and display of cultural heritage. This technological approach not only compensates for the limitations of offline visits but also creates a new way of perception for tourists, enabling them to more deeply understand the value and significance of cultural heritage in the interweaving of the virtual and the real.

Due to limitations of time and physical strength, tourists can choose the route to the Clock Gallery and the Treasure Gallery, while taking a virtual tour via the "Panoramic Palace Museum" for another route, which mainly covers the Gate of Heavenly Purity, the Palace of Compassion and Tranquility, and its garden. This choice fully demonstrates the advantages of digital technology: it can not only help tourists select the most important scenic spots within a limited time but also save a great deal of time through virtual guided tours.

During visits to the two open galleries, we can observe similar display methods and the deficiencies of digital technology. The Treasure Gallery exhibits precious cultural relics from the imperial court of the Qing Dynasty, including calligraphy and paintings, ceramics, bronze wares, and handicrafts, showcasing the rich cultural relic system of the Palace Museum. However, with the traditional display method, all cultural relics are placed in transparent glass cases and are only introduced through written descriptions. Although this method effectively protects the cultural relics, it appears rather conservative in terms of digital means, failing to utilize modern technological means such as augmented reality or 3D visualization to enhance interactivity and immersion.

The Clock Gallery displays a large number of clocks and watches collected by the imperial court of the Qing Dynasty, including many exquisite tribute items, fully demonstrating the superb craftsmanship of Chinese and foreign artisans. However, the exhibition form is still similar to that of the Treasure Gallery, remaining in the traditional display mode and lacking the incorporation of digital technology. Despite the extremely high historical and artistic value of the exhibits themselves, the lack of more interactive display methods prevents the audience from vividly perceiving these precious cultural relics through

modern technology.



Fig 4. The author photographed the exhibit “Bird Sound Rock and Stone Clock” in the Clock and Watch Museum

In the Hall of Mental Cultivation, the building currently implements a limited opening policy. Tourists can only view a part of the interior displays and are not allowed to enter for a visit. Unfortunately, the area where the Studio of Exhaustion from Diligent Service is located has also been closed to the public all year round. This limitation highlights the application value of VR technology in this scenario. Through the “VR Palace Museum” project, visitors can conduct an in-depth inspection of the interior space of the Hall of Mental Cultivation. In particular, they can carefully examine key cultural elements such as the plaque inscribed with “Zhong Zheng Ren He” (Uprightness, Justice, Benevolence and Harmony). Additionally, they can use the game characters in the “VR Palace Museum” to enter the Studio of Exhaustion from Diligent Service and deeply experience various mini-games related to traditional cultural relics, thus gaining a profound understanding of the uniqueness of the study of ancient emperors. This method of combining virtual and real investigations not only makes up for the limitations of on-site inspections but also provides a new research perspective for the digital protection of cultural heritage.

During the inspection of the Lingzhao Xuan, the author focused on the impact of tourist flow on the observation effect. During the on-site inspection, due to the dense crowd of tourists, it was difficult to conduct a comprehensive and multi-angle detailed observation of the building. This limitation was effectively solved by the VR experi-

ence and QR code provided on-site. Through the virtual environment, visitors can break through the limitations of physical space and conduct an in-depth inspection of the architectural details. It is particularly noteworthy that VR technology has successfully reproduced the architectural features recorded in the Qing Dynasty documents, enabling visitors to intuitively feel the differences between the descriptions in the historical documents and the existing remains, with the QR code on-site. This display method that combines the virtual and the real not only solves the problem of limited observation during on-site inspections but also provides a new methodological perspective for the study of cultural heritage. It conveys a more shocking cultural impression to the audience, reflecting the experience that goes beyond reality brought to you by digital technology.

During the visit to the Palace Museum, tourists can use the convenient map function in the mini-program to navigate and go to the Imperial Garden. The map configured in the mini-program of the Palace Museum not only provides the optimal route for the specific map inside the Palace Museum but also comes with an estimated walking time function, which greatly facilitates the tour. After the tour, tourists can conveniently return the electronic guided tour device at the Shenwu Gate, the exit of the Palace Museum.



Fig 5. The author took a photo of the signboard for the VR restoration experience of the Lingzhao Xuan

During this visit to the Palace Museum, the combination of offline on-site experience and online digital technology has made the tour full of depth and a sense of layering. Through digital technology, especially the application of

“VR Palace Museum”, visitors can not only gain an in-depth understanding of those scenic spots that they cannot enter in person through virtual guided tours within a limited time but also shuttle between the virtual and the real, experiencing the wonderful contrast between ancient palaces and cultural heritage. This collision between reality and virtuality has allowed the author to more intuitively feel the power of cultural transmission brought about by digital technology.

Through this visit, the author realized that although the Palace Museum has made some progress in the application of digital humanities technology, there are still significant technological gaps in offline exhibitions. Especially in venues such as the Treasure Gallery and the Clock Gallery, traditional display methods rely solely on glass cases and text cards, failing to fully utilize the advantages of digital technology to enhance the interactivity and immersion of the exhibits. Such a single display method undoubtedly restricts the interaction between the audience and the cultural relics. The lack of diverse presentation methods that modern technology can provide, such as Augmented Reality (AR) or 3D visualization displays, makes the experience of cultural heritage, which could have been further enriched through technological means, seem somewhat behind the times.

In contrast, although the innovative methods demonstrated on the digital platforms and mini-programs show rich content during virtual visits, the lack of technical support in offline exhibitions makes the traditional visiting experience more monotonous and limited. As an important symbol of cultural heritage, the Palace Museum should be more proactive in integrating digital technology, combining traditional exhibitions with modern technology to better present and inherit these precious historical cultures.

3.3 Expansion on the Characteristic Applications of Other Museums

The exploration and practice of the Palace Museum in the application of digital humanities technology have provided a valuable experience for the modern display of cultural heritage. However, the uniqueness of the Palace Museum lies in the fact that it is not only a museum but also a large-scale ancient architectural complex, which in itself is an immovable cultural heritage. When visiting the Palace Museum, the audience is not only admiring cultural relics but also walking through palaces, courtyards, and corridors, experiencing its architectural space and historical atmosphere. This unique visiting experience poses more challenges to the application of digital humanities technology in the Palace Museum: how to combine digital technology with the vast architectural space while protect-

ing the ancient buildings has become the core issue of the digital exploration of the Palace Museum.

In contrast, as a modern museum, the Capital Museum (CMM) demonstrates greater flexibility and diversity in the integration and innovation of digital technology. The CMM places more emphasis on interactivity and immersion, especially in the application of Augmented Reality (AR), Virtual Reality (VR), and multimedia interactive devices, forming a unique display mode.

The exhibition “The Glorious Central Axis” at the Capital Museum was planned to commemorate the 870th anniversary of Beijing becoming the capital city. It has been open to the public since March 28, 2023, and aims to contribute to the successful application of the Beijing Central Axis for World Heritage status. This exhibition has been preserved for a long time and its display content is continuously updated to highlight the historical status and cultural confidence of the ancient capital Beijing.

Through innovative digital technology, the exhibition constructs a historical dialogue space that transcends time and space. The 16-meter digital sand table in the center of the exhibition hall replicates the entire appearance of the central axis with millimeter-level precision. Relying on satellite surveying and mapping as well as historical data verification, it completely restores the texture of the bricks and tiles in more than 80 palaces and 13,000 ancient buildings. The LED long screen surrounding the sand table and the 3D projection system cooperate precisely. By using particle animation and digital ink painting technology, they dynamically interpret urban changes from the construction of Dadu in the Yuan Dynasty to modern Beijing. During the flow of light and shadow, it strictly follows the proportion of ancient buildings, reappearing the time and space track of seven hundred years.

The technical team has built an intelligent response system that automatically matches the commentary content through real-time positioning, ensuring that each audience member can obtain a customized exhibition viewing experience. The touch screens surrounding the sand table are equipped with a dynamic data visualization system. With a simple gesture operation, visitors can retrieve the evolution map of the urban pattern, transforming historical research into an interactive digital narrative. The daily exhibition viewing flow can reach up to ten thousand people. This new exhibition display mode, which transforms cultural heritage into a perceivable and participatory digital language, not only reproduces the architectural epic of the central axis but also gives new life to traditional culture in the digital dimension, opening up a time and space roaming for the audience that connects the ancient and the modern.

Another example is that the Capital Museum, in collab-

oration with the Central Academy of Fine Arts, launched the immersive theater “Images in Time and Space.” This project utilizes the Nanite virtual geometry system in Unreal Engine 5 to transform 700 years of astronomical

observation data into dynamic star maps. By wearing the Varjo XR - 3 headset, visitors can experience the stargazing practices of the ancient Imperial Observatory and feel the history and charm of astronomical observations.

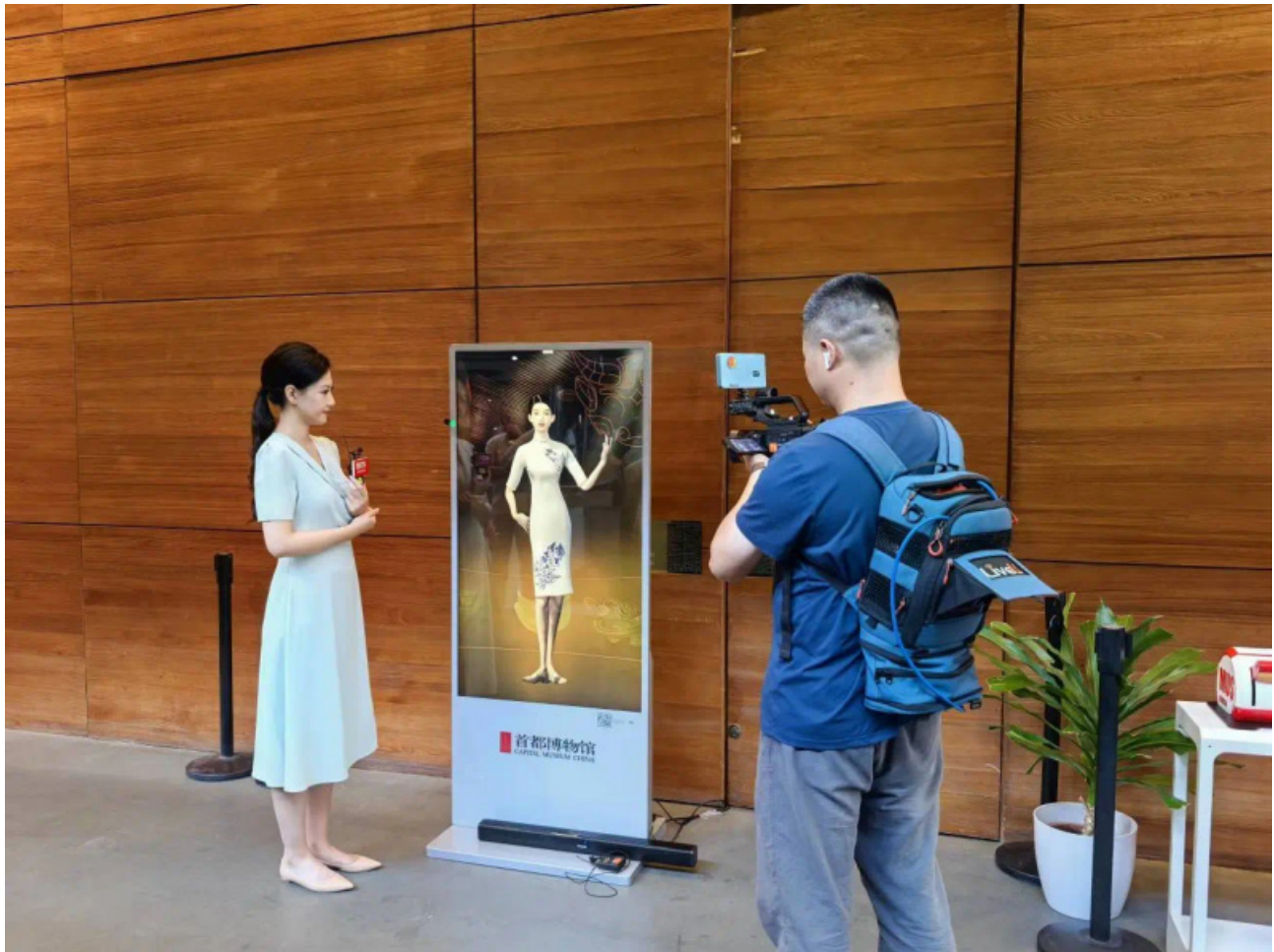


Fig 6. On the official WeChat account of the Capital Museum: “Jinghui, breaks the circle and cross-border host, ushers in a new future of digital-intelligent interaction”

In addition, during the process of digital transformation, the Capital Museum has deeply applied AI technology and created the digital human “Jinghui.” This digital human is a meta - universe avatar built on the NVIDIA Omniverse platform. It integrates the voice recognition engine of iFlytek and the BERT natural language processing model. Through 30 millimeter - wave radar sensing nodes deployed within the museum, it can perceive the positions of visitors in real - time and provide personalized guided tour services. These millimeter - wave radar sensing nodes can accurately detect the specific positions and movements of visitors, enabling interaction with “Jinghui” and enhancing the immersive experience of visitors.

It is worth noting that in order to enable the elderly to better enjoy the convenience brought by digital humanities technology, the technical team of the Capital Museum has

developed a simplified touch interface and an offline voice guided tour system. These are designed to be user-friendly for elderly visitors, marking the museum’s efforts in making digital services more accessible and suitable for the elderly.

IV. Application Strategies of Digital Humanities Technology in Museums

Digital humanities technology is injecting new vitality into the museum industry and bringing about multi-dimensional changes. When entering contemporary museums, visitors can intuitively feel the changes brought about by technology: by scanning a QR code with their mobile phones, they can listen to the historical stories behind cultural relics; VR devices can make bronze wares that have been “sleeping” for thousands of years come “alive” in front of their eyes; and interactive touch screens allow

visitors to become participants in exhibition curation.

These changes are not limited to exhibition halls. With the help of digital platforms, high-definition images of cultural relics from the Palace Museum can be simultaneously presented in a classroom in New York, and the details of the murals in Dunhuang can be carefully examined by restorers in Berlin. In the field of cultural relic protection, 3D modeling technology is creating digital archives for each cultural relic, and artificial intelligence is assisting in monitoring subtle environmental changes inside display cases. Technologies and humanistic wisdom from different fields converge here, not only safeguarding the memories of civilizations but also creating new possibilities for cultural dissemination.

(1) Establish a Three-dimensional Communication System
The deep integration of digital platforms and virtual exhibitions is reconstructing the communication pattern of museums. Through Internet and mobile application technologies, institutions such as the Palace Museum have achieved global synchronous access to exhibit information. Intelligent guided tour systems represented by the AI digital human “Jinghui” can not only provide personalized explanation services for on-site visitors but also attract overseas audiences through cloud platforms. This dual-track parallel mode effectively breaks through the physical boundaries of traditional exhibitions. With the help of the Internet, mobile applications, and social media platforms, museums can instantly transmit exhibit information to audiences around the world, truly enabling cross-regional inclusive sharing of cultural resources.

When constructing the digital humanities content of museums, it is necessary to consider various ways of digital humanities information dissemination, build a cloud service platform that is adaptable to multiple terminals, and form a three-dimensional communication pattern. This allows audiences to accurately receive the information they want through different terminals.

(2) Reconstruct the Narrative Dimensions of Cultural Relics

Utilize digital technology to comprehensively expand the communication methods of museums, enabling them to break through the limitations of traditional physical spaces. Contemporary digital technology endows static cultural relics with new possibilities of expression. The combination of high-precision 3D modeling and 3D mapping projection technology enables the dynamic reproduction of casting techniques of bronze ware patterns. The coordinated application of digital sand tables and hand-drawn animations allows for the visual presentation of the historical evolution process of ancient architectural complexes. This multi-modal narrative not only completely preserves the physical forms of cultural relics but also, through the

reconstruction of virtual scenes, provides a three-dimensional interpretation of the humanistic spirit and historical context behind the artifacts, forming a “hypertext” system for knowledge transmission.

During the digitalization process of cultural relics and their spaces, an interdisciplinary collaboration mechanism can be established. Historians and digital artists can be jointly involved in developing narrative scripts to ensure that the academic depth of the stories of cultural relics is combined with the vividness of visual presentations.

(3) Innovate the Interactive Experience Mode

The application of intelligent touch control and VR technology is rewriting the traditional logic of visiting exhibitions. The “Digital Central Axis” project of the Capital Museum, through the gesture recognition system, enables visitors to independently disassemble the mortise and tenon structure of ancient buildings. The Nanjing Museum, on the other hand, uses AR glasses to achieve an instant augmented display of cultural relic patterns.

This transformation from “one-way transmission” to “two-way dialogue” not only activates the cognitive engagement of visitors but also constructs a “discovery-based learning” path for knowledge acquisition. To further optimize the interactive experience, it is recommended to follow the “user-friendly” principle and develop an adaptive interface and a multi-level interactive mode to meet the needs of visitors of different age groups and professional backgrounds.

(4) Build a Resource Sharing Network

The construction of digital platforms has given rise to new types of collaborative relationships among cultural and museum institutions. Shared resources can not only enhance the depth and breadth of research but also enable more cultural institutions and experts to conveniently access cultural relic data, promoting the continuous progress of cultural heritage protection technologies and theories. The “Digital Dunhuang” resource database led by the Dunhuang Academy has already achieved the interconnection of cultural relic data among more than 30 institutions around the world.

This cross-regional digital alliance not only improves the collaborative efficiency of academic research, but its standardized data interfaces have also formed a “digital gene bank” for cultural heritage, laying a solid foundation for subsequent activation and utilization. It is recommended to solve two major technical problems to improve the stability and compatibility of cultural relic data sharing.

Firstly, high-precision modeling can use 3D scanning technology to completely record the details of cultural relics as digital models, which is convenient for display and research. Secondly, develop open APIs so that various institutions can directly access and share the content of the

database without the need for additional data conversion, thus improving the efficiency of cooperation.

(5) Explore the Possibilities of Cross-border Integration

The extensibility of digital technology has opened up new dimensions for cultural expression. The practice of integrating serious academic content with immersive experiences not only maintains the professional depth of cultural interpretation but also enhances communication effectiveness through multi-sensory stimulation, forming a new type of cultural field that appeals to both refined and popular tastes.

For example, the game “Black Myth: Wukong” incorporates modern gaming technology based on traditional cultural elements, and “Black Myth: Wukong” has drawn attention to the protection of ancient buildings in Shanxi. This cross-border cooperation between cultural and museum institutions and the gaming industry not only attracts the attention of young audiences but also provides new possibilities for the activation and utilization of cultural heritage.

In the future, museums can establish cross-industry cooperation mechanisms through digital humanities technology, promote the integration of cross-industry cultural creativity and technology, and ensure the long-term preservation and intergenerational inheritance of cultural relics.

(6) Establish a Digital Inheritance Mechanism for the Future

In the future, museums can cooperate with other industries through digital technology to enhance the protection and restoration of cultural relics. By using 3D scanning technology, museums can create digital archives for each cultural relic. Precise digital models can assist in the restoration work, reducing damage to cultural relics. At the same time, digital archiving can also ensure that cultural relics are permanently preserved in the virtual world, unaffected by time and the environment. Digital technology can provide more guarantees for the protection of cultural relics. For example, museums can use blockchain technology to ensure that the digital archives of cultural relics have a legal effect and prevent information tampering. This dual preservation method of physical cultural relics and digital archives ensures that cultural relics can be preserved and passed on for a long time.

Museums should establish a long-term mechanism for maintaining and updating digital archives to ensure the continuous usability of cultural relic data, and improve the efficiency of cultural relic restoration and protection through artificial intelligence technology.

The research in this article shows that digital humanities technology is reshaping the functions and communication models of museums in all aspects. Digital platforms and

virtual exhibitions have broken through physical boundaries, achieving multi-dimensional dissemination of cultural relic information on a global scale. Technologies such as high-precision 3D modeling, VR/AR, etc., have given dynamic life to static cultural relics, reconstructing the narrative dimensions of cultural relics, enabling visitors to achieve “discovery-based learning” in interactive experiences.

At the same time, cross-institutional resource sharing and cross-border cooperation not only improve the efficiency of cultural heritage protection and restoration but also provide a solid guarantee for the long-term inheritance of cultural relics through digital archives and blockchain technology. Overall, these findings demonstrate the huge potential of digital humanities technology in promoting the cultural dissemination of museums, innovating experiences, and protecting cultural relics, opening up a brand-new path for traditional museums to achieve modern transformation.

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