Research on the Cultural Heritage and Innovation of Museums in the Context of the Integration of Art and Digital Technology

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Abstract: With the rapid development of digital technology, the cultural inheritance and innovation of museums have ushered in unprecedented opportunities and challenges. This paper deeply explores the cultural inheritance and innovation of museums in the context of the integration of art and digital technology, and analyzes the current application status of digital technology in museums, the difficulties it faces, and the future development path. The study found that although the application of technologies such as virtual reality (VR), augmented reality (AR), digital exhibitions, and artificial intelligence in museums has made significant progress, museums still face problems such as high technical costs, challenges to the authenticity of artworks, insufficient public participation, and data security and intellectual property protection in the process of digital transformation. To this end, this paper proposes innovative paths such as digital collection and protection, digital display and dissemination, digital education and public participation, new media art and exhibition innovation, and the integration of digital technology and creative industries. These paths not only help museums better protect and inherit cultural heritage, but also provide the public with a richer and more diverse cultural experience. Although this study has achieved certain results in theory and practice, there are still some limitations, such as the lack of in-depth empirical research and full consideration of the differences between different types of museums. Future research can further focus on empirical research, interdisciplinary research, and international cooperation to promote the sustainable development of museum cultural inheritance and innovation.

Keywords: Integration of Art and Digital Technology; Museum Cultural Heritage; Digital Innovation Path

1. INTRODUCTION

With the rapid development of digital technology, museums, as an important carrier of cultural heritage, are facing unprecedented opportunities and challenges (Di Leo, 2023). Traditional museums provide the public with a platform to access history and culture through physical exhibitions and cultural relics displays, but the emergence of digital technology has changed the way people obtain information and brought new possibilities for museums' cultural heritage and innovation (Cantoni et al., 2019). From the immersive experience brought by virtual reality (VR)

and augmented reality (AR) technology to personalized services driven by artificial intelligence and big data, digital technology is reshaping the museum's operating model and public participation (Feng, 2022). Therefore, it is of great practical significance to study the cultural heritage and innovation of museums in the context of the integration of art and digital technology. This study aims to explore how digital technology can help museums ' cultural heritage and innovation, analyze its current application status in practice, the difficulties it faces, and the future development path. By systematically combing through the digital transformation cases of museums at home and abroad, summarizing the successful experiences and shortcomings, it provides theoretical support and practical reference for the digital development of museums. The study not only helps to enhance the cultural communication capabilities of museums in the digital age, but also provides new ideas and methods for the protection and inheritance of cultural heritage.

2. CURRENT STATUS OF INTEGRATION OF ART AND DIGITAL TECHNOLOGY

2.1 Current status of digital technology application in museums

With the rapid development of digital technology, museums have gradually diversified their applications in display, education and communication . Virtual reality (VR) and augmented reality (AR) technologies have brought new immersive experiences to the audience. The "Digital Palace Museum" project of the Palace Museum recreates the splendor of the ancient palace through VR technology, making the audience feel as if they are in the historical scene . This technology not only enhances the audience's sense of participation, but also improves their understanding and interest in cultural heritage. The development of digital exhibitions and online display platforms has also provided new channels for museums to spread their message (Giannini & Bowen, 2022)5] . Many museums have broken the limitations of time and space by establishing virtual exhibitions, allowing more people to access precious cultural heritage . The British Museum's online exhibition platform provides a wealth of digital exhibits and interactive experiences, attracting millions of viewers around the world. These platforms not only display high-definition images of cultural relics, but also enhance audience participation and learning effects through multimedia content and interactive functions. The application of artificial intelligence and big data in museums is also

expanding. Through big data analysis, museums can better understand the needs and preferences of visitors and provide personalized services . The Shanghai Museum uses big data to analyze visitors' visiting behavior and optimize exhibition layout and guided tour services. In addition, artificial intelligence technology is also used in the identification and protection of cultural relics. Through image recognition technology, the damage of cultural relics can be quickly identified to provide support for restoration work.

2.2 Typical Cases of Digital Transformation of Global Museums

Many museums around the world are actively exploring the path of digital transformation(Poulopoulos & Wallace, 2022). Foreign museums such as the British Museum and the Louvre have improved the dissemination of cultural heritage through digital means. The British Museum 's "Digital Museum" project not only provides a wealth of online resources, but also interacts with the audience through social media and mobile applications. The Louvre uses AR technology to provide visitors with a more vivid exhibition experience, allowing visitors to obtain detailed information about exhibits through mobile applications. Domestic museums have also made significant progress in digital transformation. The "Digital Palace Museum" project of the Palace Museum is a typical example. The project provides visitors with a full range of digital experience by integrating a variety of digital technologies, such as VR, AR and big data. The Palace Museum has also launched a variety of cultural and creative products through digital platforms, further expanding the cultural communication function of the museum. The Shanghai Museum has innovated in digital education, attracting a large number of young audiences through online courses and interactive activities.

2.3 Assessment of the Current Status of the Integration of Art and Digital Technology

Although the application of digital technology in museums has made significant progress, the breadth and depth of its integration still need to be further improved. At present, the application of digital technology is mainly concentrated in the display and dissemination links, while there are still deficiencies in the protection of cultural relics and the expansion of educational functions . Although many museums have displayed high-definition images of cultural relics through digital means, their application in cultural relic restoration and protection is still relatively limited. In

addition, although digital technology has achieved certain results in improving public participation, how to further enhance the audience's interactive experience and cultural identity is still a problem that needs to be solved (Carvalho, 2022; Tham et al., 2023) . The "Digital Palace Museum" project of the Palace Museum provides visitors with a full range of digital experience by integrating multiple digital technologies. The project not only reproduces the glorious scenes of ancient palaces through VR technology, but also provides visitors with a more vivid exhibition experience through AR technology. In addition, the Palace Museum also analyzes visitors' visiting behavior through big data to optimize exhibition layout and guided tour services. These measures not only improve the audience's participation, but also enhance their understanding and identification with cultural heritage.

3. DILEMMA OF THE INTEGRATION OF ART AND DIGITAL TECHNOLOGY

Digital technology has brought many opportunities for cultural heritage and innovation in museums, but in the actual application process, museums also face a series of challenges and difficulties. These difficulties not only involve technical aspects, but also involve resource allocation, public participation, data security and intellectual property protection .

3.1 Technology Cost and Resource Allocation Issues

The application of digital technology requires a large amount of capital investment, including hardware equipment, software development, maintenance costs, and training of professional technicians. For many museums, especially small museums, the high cost of technology has become a major obstacle to digital transformation. Although virtual reality (VR) and augmented reality (AR) technologies can provide an immersive exhibition experience, the cost of purchasing equipment and developing content is high, which many museums cannot afford(Luo et al., 2024; Luther et al., 2023). When small local museums try to introduce VR technology for exhibitions, they face the dual dilemma of insufficient funds and shortage of technical talents. Although they recognize the importance of digital technology in improving exhibition effects, they are unable to purchase advanced VR equipment due to lack of sufficient financial support, and it is also difficult to hire professional technicians for system development and maintenance(Giannini & Bowen, 2022). This imbalance

in resource allocation has made it difficult for many small museums to move forward in the process of digital transformation. In addition, the rapid update of digital technology also requires museums to continuously invest in equipment upgrades and system maintenance, which further increases the financial burden on museums(Poulopoulos & Wallace, 2022).

3.2 Challenges of Digitalization to the Authenticity of Artworks

of artworks is one of the core values of museum cultural heritage. However, the application of digital technology has changed the way artworks are presented to a certain extent, triggering a discussion on the authenticity of artworks. Although digital reproduction can make artworks accessible to more people, it may also weaken their uniqueness and irreplaceability (Hess et al., 2018; Luther et al., 2023). In addition, when digital technology is used to display artworks, it may not be able to fully restore the original texture and details of the artworks due to technical limitations, thus affecting the audience's understanding and appreciation of the artworks. When the Louvre launched the digital display of "Mona Lisa", it triggered a public discussion on the authenticity of artworks. Although digital display allows viewers to observe the details of the work more closely, some viewers believe that digital reproduction cannot completely replace the shock and emotional resonance brought by the original work. This questioning of the authenticity of artworks reflects the challenges faced by digital technology in cultural heritage, namely how to preserve the core value and unique charm of artworks while displaying them digitally.

3.3 Insufficient Public Participation and Interactivity

Although digital technology provides museums with more opportunities to interact with the public, in actual applications, public participation and interactivity are still insufficient. On the one hand, the user experience of some digital platforms is poor, making it difficult for visitors to obtain a satisfactory interactive experience. When some museums launched online exhibitions, although they provided rich exhibit information and interactive functions, the platform operation was complex and the user interface was not intuitive enough, resulting in low audience participation(Kumar, 2024; Zhao & Yezhova, 2023). On the other hand, the interaction between online and offline is not closely connected, and visitors cannot obtain a complete experience of combining online and offline during their visit. This lack of public participation and interactivity not only affects the museum's communication effect, but also weakens the

audience's sense of identity with the museum culture (Dong, 2024; Gorbul & Rusakov, 2022).

(IV) Data security and intellectual property protection: As museums become more digitalized, data security and intellectual property protection have become important issues. In the process of digitization, museums have accumulated a large amount of data, including high-definition images of cultural relics, exhibition information, visitor data, etc.(Lazzeretti & Sartori, 2016). This data not only has important cultural value, but may also involve commercial interests. Therefore, the safe storage and management of data is crucial. In addition, the digital display of artworks has also raised the issue of intellectual property protection(Mantzou et al., 2023). Digital reproduction and online dissemination have made it easier to copy and disseminate artworks. How to protect the intellectual property rights of artworks and prevent unauthorized use and reproduction has become an important issue that museums need to solve.

4. PATHS OF MUSEUM CULTURAL INHERITANCE AND INNOVATION

In the face of the difficulties encountered in the process of integrating art and digital technology, museums need to actively explore innovative paths to achieve the dual goals of cultural inheritance and innovation. The following discussion will be conducted from the aspects of digital collection and protection, digital display and dissemination, digital education and public participation, new media art and exhibition innovation, and the integration of digital technology and creative industries.

（一） Innovative Paths for Digital Collection and Protection

4.1 Multi-Dimensional Digital Archive Construction

Digital technology has provided new ideas and methods for museums' collection and protection work. Through high-precision digital collection and processing, such as three-dimensional scanning and high-definition photography, museums can establish detailed digital archives for cultural relics. This not only facilitates the preservation and research of cultural relics, but also provides a basis for restoration when physical cultural relics are damaged . The Gansu Museum of Bamboo Slips has carried out three-dimensional digital scanning and collection of more than 400 bamboo slips to establish permanent, high-precision digital archives for cultural relics .

In addition, museums should also use intelligent environmental monitoring systems to accurately control temperature, humidity, light and other conditions to create the best preservation environment for cultural relics. At the same time, they should strengthen cooperation with technical personnel in materials science, biotechnology and other fields to jointly develop more environmentally friendly and efficient protection materials and methods.

4.2 Application of Intelligent Protection Technology

With the help of the Internet of Things and artificial intelligence technologies, museums can achieve real-time monitoring and intelligent control of the preservation environment of cultural relics. By installing sensors in exhibition halls and warehouses, environmental parameters such as temperature and humidity, light intensity, and harmful gas concentration can be monitored in real time, and intelligent systems can be used to automatically adjust environmental equipment to ensure that cultural relics are in the best state of preservation .The Uffizi Gallery in Italy has achieved all-weather environmental monitoring of its collection of cultural relics through an intelligent system, effectively extending the life of the cultural relics.

4.3 Interdisciplinary Collaboration and Innovative Conservation Methods

Museums should strengthen cooperation with disciplines such as materials science, chemistry, and biology to jointly develop new protective materials and technologies. Utilize the moisture-proof and mildew-proof properties of nanomaterials to develop new packaging materials suitable for the preservation of cultural relics; use biotechnology to detect and control microorganisms on the surface of cultural relics to prevent biological erosion. This interdisciplinary cooperation can not only improve the level of protection of cultural relics, but also promote the innovation and development of cultural relic protection technology.

4.4 Innovative Paths for Digital Display and Communication

Digital display and dissemination are important links in museum cultural inheritance and innovation. Museums can create immersive exhibition experiences through digital technologies such as virtual reality (VR), augmented reality (AR), digital twins, real-time cloud rendering, holographic projection, and naked-eye 3D. (Simbirtseva et al., 2020)Liangzhu Museum's "Online Theme Exhibition of Liangzhu

Civilization on the Cloud " uses interactive technology, and the Exhibition Hall of the History of the Communist Party of China uses naked-eye 3D technology to restore the Long March scene for the audience. The application of these technologies has enabled digital art exhibitions, 360° panoramic exhibition halls, smart guides , immersive interactive experiences and other projects to flourish in museums. At the same time, museums should strengthen their integration with other industries, especially the cultural and tourism industry , to promote a wider, deeper and more sustainable museum tourism boom.

4.5 Deepening application of immersive exhibition technology

Museums should further deepen the application of immersive exhibition technology and enhance the audience's sense of participation and experience through multi-sensory stimulation. Use holographic projection technology to reproduce the dynamic display of historical scenes or cultural relics, so that the audience can feel as if they are in the historical events; through VR and AR technology, provide personalized guided tour services for the audience, and the audience can scan the exhibits through mobile devices to obtain detailed information, historical background and related stories. The Louvre designed an interactive guided tour for "Mona Lisa" through AR technology , and the audience can use the mobile phone application to deeply understand the creative background and artistic value of the work.

4.6 Diversified construction of digital communication platforms

In addition to traditional official websites and social media platforms, museums should actively expand diversified digital communication channels. They should develop dedicated mobile applications that provide online exhibitions, virtual tours, interactive games and other functions; use short video platforms and live broadcast technology to carry out online lectures, cultural relics restoration live broadcasts and other activities to attract more young audiences. The "Forbidden City Cultural Relics Restoration Live Broadcast" activity launched by the Palace Museum on the Douyin platform attracted millions of viewers online, effectively enhancing the public's awareness and interest in cultural heritage protection.

4.7 Innovation in Cultural and Tourism Integration and Digital Experience

Museums should strengthen their in-depth integration with the cultural

tourism industry and create new highlights for cultural tourism through digital technology. Develop location-based augmented reality (LBS-AR) applications so that when tourists visit the historical and cultural blocks around the museum, they can use mobile phone applications to obtain virtual historical scene reproductions and cultural story explanations. In addition, museums can also cooperate with tourism agencies to launch digital cultural tourism routes, organically combining museum exhibitions with local historical and cultural attractions to enhance the experience and appeal of cultural tourism .

4.8 Innovative Paths for Digital Education and Public Participation

Digital education and public participation are important ways for museums to inherit and innovate culture. Museums can attract public participation through the development of digital educational resources, such as online courses and interactive activities. In addition, museums can also enhance the public's sense of cultural identity and participation through the design of digital platforms and interactive activities for public participation.

4.9 Development of Personalized Digital Educational Resources

Museums should develop personalized digital educational resources based on different audience groups. For young audiences, they should develop highly interactive online courses and gamified learning tools to stimulate their interest in history and culture through interesting content; for adults and professionals, they should provide in-depth academic lectures, online seminars and virtual academic exhibitions. The British Museum launched the "Ancient Civilization Exploration" series of courses through an online platform, attracting tens of thousands of learners around the world.

4.10 Construction of a Digital Platform for Public Participation

Museums should build digital platforms for public participation and encourage visitors to participate in the museum's cultural activities through interactive messages, online exhibition planning, and cultural and creative design. Through online voting and questionnaires, they can collect visitors' suggestions on exhibition themes and content; they can also hold online cultural and creative design competitions and invite visitors to design cultural and creative products related to the exhibition. This form of public participation can not only enhance the audience's sense of cultural identity,

but also provide new ideas and creativity for the museum's cultural communication.

4.11 Digital Education Model of Community and School Cooperation

Museums should strengthen cooperation with communities and schools, and extend cultural and educational resources outside of school through digital technology. They should cooperate with schools to develop school-based courses, and use virtual reality technology to allow students to "visit" museums in class; they should cooperate with community centers to hold online cultural lectures and interactive activities to enhance the cultural literacy of community residents. This cooperation model can not only expand the educational influence of museums, but also promote the fair distribution of cultural resources.

4.12 New Media Art and Museum Exhibition Innovation

New media art provides new possibilities for museum exhibition innovation. Museums can explore the application cases of new media art in museum exhibitions through the definition and characteristics of new media art, such as interactivity and immersion. This innovation not only improves the audience's participation, but also enhances their understanding and appreciation of artworks.

4.13 Exhibition Design of Interactive New Media Art

Museums should make full use of the interactive features of new media art and design exhibition projects that encourage participation. Through touch screens, somatosensory interactive devices, and intelligent projection technology, visitors can interact with exhibits in real time, such as touching the screen to view the details of cultural relics and controlling the rotation of virtual cultural relics through gestures . This interactivity not only increases the participation of visitors, but also stimulates their interest in and desire to explore cultural heritage.

4.14 Cross-Media Narrative and Exhibition Innovation

Museums can extend exhibition content to different media platforms through cross-media narratives. Through online storytelling, offline exhibition interaction, social media sharing and other methods, a full range of cultural experiences can be constructed. Visitors can learn about the exhibition background through online platforms before visiting the exhibition, gain in-depth information about the exhibits through

interactive devices during the visit, and share their feelings and experiences through social media after the visit. This cross-media narrative not only enriches the form of the exhibition, but also enhances the audience's sense of cultural experience.

4.15 Integration of New Media Art and Traditional Art

Museums should explore ways to integrate new media art with traditional art, and reinterpret traditional art works through digital technology. They should use digital projection technology to integrate modern art elements into the display of ancient murals, and use virtual reality technology to reproduce the process of ancient art creation, so that the audience can appreciate traditional art while feeling the charm of modern technology. This integration not only injects new vitality into traditional art, but also attracts more attention from young audiences.

4.16 Integration of Digital Technology and Museums' Creative Industries

The integration of digital technology and the museum's creative industry is an important direction for museum cultural inheritance and innovation. Museums can expand their cultural communication functions through the digital development of cultural and creative products , such as digital cultural and creative products and virtual cultural and creative products. In addition, museums can also achieve a deep integration of culture and creativity through cooperation with the digital creative industry. Development and innovation of digital cultural and creative products Museums should use digital technology to develop a variety of cultural and creative products, such as digital artworks, virtual exhibition tickets, interactive cultural and creative toys, etc. By developing limited edition digital artworks through blockchain technology, audiences can obtain unique cultural experiences by purchasing and collecting these digital artworks. In addition, museums can also develop interactive cultural and creative products with educational significance, such as cultural and creative puzzles developed through AR technology, in which audiences can view the cultural relics information and historical background corresponding to the puzzle through mobile phone applications during the puzzle process.

4.17 Digital Marketing and Brand Building

Museums should use digital technology to enhance their brand influence and market competitiveness. Use big data to analyze audience interests and

behaviors and develop precise marketing strategies;

5. DISCUSSION AND OUTLOOK

This study focuses on the cultural inheritance and innovation of museums in the context of the integration of art and digital technology. Through in-depth analysis of the current situation, difficulties and innovation paths, it reveals the current status and challenges of the application of digital technology in the museum field. From the current situation, the application of digital technology in museums has made significant progress, especially in the fields of virtual reality (VR), augmented reality (AR), digital exhibitions and artificial intelligence. These technologies not only improve the display effect of museums, but also expand their educational functions, enabling more people to access and understand cultural heritage. However, museums also face many difficulties in the process of digital transformation, such as high technical costs, challenges to the authenticity of artworks, insufficient public participation, and data security and intellectual property protection. These problems not only affect the digital transformation process of museums, but also pose new challenges to their cultural inheritance and innovation.

In terms of innovative paths, this study proposes several solutions. Through high-precision digital technology, the collection and protection level of cultural relics can be improved; immersive technology can be used to optimize the display and dissemination effects; rich digital educational resources can be developed to enhance public participation; new media art can be combined to innovate exhibition forms; and the cultural and creative industries can be expanded through digital means to achieve a deep integration of culture and creativity. These paths will not only help museums better protect and inherit cultural heritage, but also provide the public with a richer and more diverse cultural experience. Although this study has achieved certain results in theory and practice, there are still some limitations. First, the study mainly focuses on technology application and case analysis, and lacks in-depth empirical research on the long-term impact of digital technology on museum cultural inheritance and innovation. Second, the study failed to fully consider the differences in digital transformation of museums in different regions and types. Future research can further refine the classification and explore more targeted solutions.

In the future, museums need to pay more attention to public participation and interactive experience, and enhance the audience's

cultural identity and sense of participation through digital means. At the same time, museums need to strengthen international cooperation and exchanges, share experiences and resources of digital transformation, and jointly promote the protection and inheritance of global cultural heritage.

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