

Research on Data Collection, Management, and Application in Cultural Heritage Museums

Zili Cai

Wuhan Meseum, Wuhan, Hubei, China

hydchj@126.com

Abstract. This paper focuses on the data collection, management, and application in cultural heritage museums. By analyzing successful cases of typical museums, it explores their advanced technologies and management concepts. Combining the actual situation in China, it puts forward targeted suggestions to promote the digital transformation of cultural heritage museums in China and enhance their capabilities in protection, research, and dissemination.

Keywords: Museums; Data Management; Data Application; Digitalization.

1. Introduction

1.1 Research Background and Significance

In the current digital wave, museums, as important custodians of cultural heritage, are in urgent need of digital transformation. Many museums around the world have achieved remarkable results in data collection, management, and application of cultural relics with the help of cutting-edge technologies such as big data, cloud computing, and artificial intelligence, setting an example for the global museum development. China has a rich cultural heritage, but there is still a gap in digital construction compared with advanced museums abroad. In-depth study of the data management and application experience of typical international museums will help Chinese museums learn advanced technologies and management models, comprehensively protect and inherit cultural relics, break the limitations of time and space, enhance national pride and cultural confidence, improve international influence, and promote cultural exchanges.

1.2 Research Status in Different Countries

Some Western countries started early and have achieved many results in the research of museum data management and application. In data collection, technologies such as 3D scanning and sensors are widely used for the comprehensive digital collection of cultural relics. In data management, efficient database management systems are constructed to ensure the safe and stable storage and convenient access to data. In the field of data application, the potential value of cultural relics data is explored through the analysis of audience data to optimize exhibitions[1]. In recent years, China has also made progress, but there are still shortcomings in data collection accuracy, data sharing, and precise services. The application research of emerging technologies such as blockchain also needs to be further explored.

2. Analysis of Data Collection Methods

2.1 Application of 3D Scanning Technology in Cultural Relics Data Collection

3D scanning technology, with its advantages of high precision, non-contact, and rapid acquisition of three-dimensional information, is highly favored in the data collection of cultural relics. It can convert the shape, texture, and size of cultural relics into digital models, which helps with the research, protection, and display of cultural relics.

2.1.1 Case of Yorkshire Museum

The Yorkshire Museum used the Artec Space Spider scanner and its supporting software to create a 3D digital copy of the Roman Liddel Treasure. It took less than 5 minutes to complete the fine scanning of a single cultural relic and generated 3D digital copies of four cultural relics within 1 hour. Compared with traditional photogrammetry, it greatly saved time and labor and avoided the damage that might be caused by multiple positioning of cultural relics. These digital copies not only allow researchers to observe the details of cultural relics from multiple angles for in-depth research but also enable global audiences to appreciate them through digital exhibitions and online displays, enhancing the audience experience.

2.1.2 Case of Neanderthal Museum

The Neanderthal Museum chose the EinScan Pro 2X Plus multifunctional handheld 3D scanner to digitize about 300 to 500 different types of artifacts. The scanner's fixed mode can scan small-sized stone tools, and its handheld mode can obtain data of large-sized stone tools. For stone tools with thin edges and flat placement that are not easy to splice data, the museum team fixed them in foam plastic for scanning and successfully spliced and obtained accurate 3D data models. They established an online 3D digital database of the Paleolithic era, providing rich research materials for researchers, reducing the risk of cultural relics damage, and improving teaching effects.

2.2 Traditional Photogrammetry and Other Data Collection Technologies

2.2.1 Application and Limitations of Traditional Photogrammetry

Traditional photogrammetry, which obtains three-dimensional information by taking photos of cultural relics and using photogrammetric principles, has certain applications in cultural relics protection, restoration, and exhibition. However, it has limitations such as cumbersome data collection, high positioning requirements for cultural relics, potential damage, and large errors and incomplete data when dealing with complex-shaped cultural relics.

2.2.2 Exploration of Other Emerging Collection Technologies

Laser scanning technology, with its advantages of high precision and no limitations on the shape and material of cultural relics, can quickly and accurately obtain three-dimensional data and is suitable for cultural relics with complex shapes and special materials. Close-range photogrammetry, an upgrade from the traditional method, has flexible data collection, high precision, and reduces damage to cultural relics. Hyperspectral imaging technology can obtain the spectral information of cultural relics, assisting in material and composition analysis. Thermal imaging technology can detect the internal structure and damage of cultural relics, providing a basis for protection and restoration.

3. Exploration of Data Management Models

3.1 Database Construction and Management System

The database construction and management system is the core of efficient data management in cultural heritage museums. A complete database covering multidimensional information of cultural relics helps with comprehensive understanding and in-depth research.

3.1.1 Case of Louvre Museum Collection Digital Library

The Louvre Museum invested a large amount of resources, organized a professional team, and used advanced equipment and technology to establish a collection digital library covering nearly 500,000 collections. Facing challenges such as image acquisition quality, data storage management, and classification retrieval, it adopted high-resolution cameras, distributed storage technology, scientific classification systems, and efficient retrieval systems to ensure the accuracy,

completeness, and convenience of the digital library. The digital library was opened to the public in 2021, breaking the limitations of time and space, increasing the accessibility of cultural relics, and promoting cultural dissemination and exchange. The official website's visit volume has greatly increased.

3.1.2 Case of Versailles Palace Cultural Heritage Digital Library

The Versailles Palace used 3D panoramic and virtual reality technologies to establish a cultural heritage digital library, with 22,000 collections available for online browsing. Visitors can observe the internal structure of rooms, artworks, furniture, etc., through virtual reality technology and even virtually attend balls, enhancing the fun and interactivity of the visit. The Versailles Palace also launched a multilingual mobile application, providing real-time location updates and interpretation services to improve the visitor experience.

3.2 Characteristics and Advantages of Digital Management Model

3.2.1 Comprehensive Management of Cultural Relics

The digital management system of the British Museum records detailed information about the entry, storage, and exit of cultural relics, achieving full life cycle management. The system improves management efficiency, reduces human errors, facilitates inquiries, and provides support for protection, research, and display. It can also provide data analysis for decision-making, such as adjusting the temperature and humidity control equipment of cultural relics storage areas.

3.2.2 Integration with Other Systems to Form a Control System

The digital management system of the Metropolitan Museum of Art in the United States is closely connected with anti-theft and fire prevention systems to achieve comprehensive monitoring and management. In terms of anti-theft, sensors detect abnormalities, the system quickly locates, retrieves surveillance, and notifies security personnel. In terms of fire prevention, sensors monitor the environment, trigger alarms, activate fire-fighting equipment, and notify relevant departments[2]. The coordinated operation of multiple systems enhances the ability to deal with security threats, reduces losses, and can also prevent hidden dangers through data analysis.

4. Analysis of Data Application Cases

4.1 Digital Display and Improvement of Visitor Experience

4.1.1 Case of Cooperation between French National Museums and Tencent

In 2019, Tencent signed a strategic cooperation memorandum with the French National Museums Association and launched the "Global Digital Museum of National Treasures" project. The first batch of 25 Chinese cultural relics were digitally displayed through Tencent's "Museum Official" mini-program and QQ Browser platforms. Users can browse cultural relics in high definition, view introductions, and learn about historical and cultural stories. The project breaks the limitations of time and space, clearly presents the details of cultural relics, sets up interactive games and social sharing functions, enhances the participation and experience of visitors, and expands the dissemination of cultural relics.

4.1.2 Google's "Virtual Museum Visit" Program

Google's "Virtual Museum Visit" program digitizes museums around the world using street view technology. In 2016, it cooperated with the National Museum of Brazil to retain digital image data[3]. After the museum fire in 2018, it provided a basis for recalling memories. Users can visit exhibits and exhibition halls in 360 degrees through the Google Arts and Culture platform. The high-pixel image quality allows users to zoom in and view details without being limited by time and space, providing convenience for people with mobility difficulties and having educational significance. It is a valuable learning resource for students and educators.

4.2 Data Application in Cultural Relics Protection and Restoration

4.2.1 Case of Chinon Castle Wall Restoration in France

In 2010, the Chinon Castle wall restoration project in France used 3D laser scanning and close-range photogrammetry technologies to comprehensively collect data. Laser scanning quickly and accurately obtained three-dimensional coordinate information and constructed a high-precision model. Close-range photogrammetry obtained texture and color information, making the restored wall truly restore its historical appearance. The restoration team used computer software to simulate the appearance of the wall in different times, formulated a scientific restoration plan, monitored the progress and quality of the restoration process with digital technology, and monitored the state of the wall in the long term after restoration.

4.2.2 Reconstruction of Cultural Relics in the National Museum of Brazil

After the fire in the National Museum of Brazil in 2018, the digital image data retained by Google and the reconstruction work participated by Tencent and other parties made some cultural relics "reborn." Tencent used QQ Browser's "See What You See" and "Museum Official" mini-programs to use 3D technology to accurately restore cultural relics based on existing digital content and collected materials[5]. Artificial intelligence technology assisted restorers in judging the original shape and structure of cultural relics and provided suggestions and guidance. Digital technology allows cultural relics information to be permanently preserved and promotes cultural dissemination and exchange.

5. Implications and References for Chinese Cultural Heritage Museums

5.1 Implications in Technology Application and Innovation

5.1.1 Increase the Introduction of Advanced Technologies

Chinese cultural heritage museums should introduce 3D scanning, VR/AR, and other technologies to improve the level of data collection and display. 3D scanning accurately obtains the three-dimensional information of cultural relics, providing data support for research and protection. VR/AR technology brings immersive experiences and enhances audience participation. Museums need to strengthen cooperation with technology companies, universities, and research institutions to jointly carry out technology research and application projects, customize equipment and software, cultivate technical talents, and promote the application and promotion of technology.

5.1.2 Encourage Technology Innovation and Integration

Promote the integration and innovation of cultural relics protection technology with information technology and artificial intelligence. Information technology can monitor the environment of cultural relics in real-time to ensure storage conditions[5]. Artificial intelligence can be used for cultural relics identification, restoration, and exhibition planning, improving identification efficiency, assisting restoration, and optimizing exhibitions. Museums should establish innovation incentive mechanisms, set up awards, provide funding and resource support, strengthen technology exchanges and cooperation, and promote technology innovation and integration.

5.2 References in Management Models and Operational Strategies

5.2.1 Improve the Digital Management System

Chinese cultural heritage museums should establish a complete digital management system. In the data collection stage, unified standards and specifications should be formulated to ensure data quality. The database construction should use advanced management systems and cloud computing technology to ensure safe and reliable operation, regular updates and maintenance, and strengthened security management. Professional digital management talents should be cultivated to improve management levels.

5.2.2 Expand Data Application Scenarios and Operational Ideas

Museums can use cultural relics data to carry out online exhibitions and develop digital cultural products, innovate operational models, strengthen cooperation with enterprises and social organizations, develop cultural and creative products, and conduct IP authorization business to expand profit channels and achieve sustainable development.

6. Conclusions

This paper analyzes the practical experience of data collection, management, and application in typical international cultural heritage museums and provides insights for the development of Chinese museums. Some famous museums in Western countries widely apply advanced technologies to collect data, build complete database management systems, and use digital display to enhance visitor experience and assist cultural relics protection and restoration. Chinese museums should increase the introduction of technology, encourage innovation and integration, improve management systems, expand application scenarios, promote digital development, protect and inherit cultural relics, and promote cultural dissemination.

References

- [1] Maria Cristina, Rosario Faraci. Next-Generation Museum: A Metaverse Journey into the Culture, Vol. 41 No. 1 (2023), Sinergie italian management, DOI: <https://doi.org/10.7433/s120.2023.08>.
- [2] Zingone, M. Instagram as Digital Communication tool for the Museums: A reflection on Prospectives and Opportunities through the Analysis of the Profiles of Louvre Museum and Metropolitan Museum of New York. (2019). European Journal of Social Science Education and Research, 6(3), 53-63.
- [3] Othman, M. K. Improving Children's Cultural Heritage Experience Using Game-based Learning at a Living Museum. (2021), Journal on Computing and Cultural Heritage (JOCCH), 14(3), 1-24.
- [4] Sansonetti, G., Gasparetti, F. Enhancing Cultural Recommendations through Social and Linked Open Data. User Model. User-Adapt. Interact. 2019, 29, 121–159.
- [5] Chen Zenglu, Wu Chunsheng. The Digital Development Status of Foreign Museums and Its Enlightenment to China [J]. Chinese Cultural Relics Research, 2019 (03): 58-63.