

Cultural Heritage Reconstruction and Virtual Display in Digital Cultural Heritage Conservation

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Abstract:

With the increasing attention and support from the government in cultural heritage conservation, digital cultural heritage conservation technology has been rapidly developed and applied. Policy support and funding have promoted the innovation and upgrading of digital cultural heritage conservation technology, and have pushed forward the deepening of digital cultural heritage conservation work. This article explores the technology of cultural heritage reconstruction and virtual display in digital cultural heritage conservation, analyzes the basic principles and processes of heritage reconstruction, introduces the methods of 3D data acquisition, restoration and optimization, texture information addition, model optimization, as well as virtual display and application. At the same time, this article also discusses the technological and management challenges in digital cultural heritage conservation, and proposes corresponding solutions.

Keywords:

Digital Cultural Heritage Conservation, Cultural Heritage Reconstruction, Virtual Display

1. Introduction

Cultural relics are an important component of human cultural heritage and have irreplaceable historical, cultural, and artistic value. However, due to the fragility of relics themselves and the impact of environmental factors, many relics are in varying degrees of damage and deterioration. Therefore, the preservation and inheritance of cultural relics have become important issues to be urgently addressed in today's society. With the continuous development of digital technology, digital preservation of cultural relics has gradually become an important means of relic protection and exhibition. Digital preservation of cultural relics uses digital technology to record, protect, and display relics, enabling the value of relics to be better reflected and passed on. This article mainly introduces the technology of relic reconstruction and

virtual exhibition in digital preservation of cultural relics, and discusses the technical and management challenges faced by digital preservation of cultural relics.

2. Technology of Digital Relic Reconstruction

Relic reconstruction refers to the process of reconstructing destroyed, damaged, or lost relics through digital technology. This technology uses computer technology and digital technology to reproduce the shape, structure, texture, and other features of relics in a digital manner through 3D scanning, digital modeling, virtual reality, and other methods. Digital relic reconstruction technology can enable people to understand the history and cultural value of relics more intuitively and realistically, and can also help relic protection personnel to repair, protect, and study relics.

2.1. Basic Principles and Process of Relic Reconstruction

The basic principle of digital relic reconstruction is to obtain the surface morphology information of relics through 3D scanning technology, and then use computer technology and digital technology to model and reconstruct relics. The basic process of relic reconstruction includes the following steps:

(1) Acquisition of 3D data for relics

a. Laser 3D scanning: Use a laser scanner to perform high-precision scanning of the surface of the relic, and convert the scanned point cloud data into a 3D model.

b. Optical 3D scanning: Use optical equipment such as digital cameras or scanners to photograph or scan the surface of the relic, and obtain the 3D model of the relic through software processing.

c. CT scanning: Use a medical CT machine or an industrial CT machine to scan the relic, obtain the internal structure information of the relic, and generate a 3D model.

d. Stereo photography: Use multi-angle photography to take photos of the relic and perform image matching and stereo reconstruction through computer software to obtain the 3D model of the relic.

Different types, sizes, and shapes of cultural relics require different collection methods, so it is necessary to choose the appropriate collection method based on the specific situation of the relic. During the collection process, it is important to pay attention to the accuracy and stability of the collection equipment, as well as the methods used to protect the relics to ensure the quality of the collected data and the safety of the relics.

Small cultural relics (such as coins and small sculptures) usually require high-precision scanners to capture their details and textures. This type of scanner is typically desktop or handheld and can quickly and accurately scan small cultural relics. For example, the Artec Space Spider scanner is a high-precision scanner suitable for small cultural relics.

Large cultural relics (such as buildings and tombs) usually require scanners with higher power and a larger range to capture their details and overall structure. This type of scanner is typically mobile or fixed and requires professional technicians to operate. For example, the FARO Focus 3D scanner is a mobile laser scanner suitable for large cultural relics.

Precious cultural relics (such as ancient paintings and books) require non-contact scanning methods to avoid damaging the relics. This type of scanner is typically an optical scanner or an X-ray scanner. For example, the Konica Minolta Range 7 3D scanner is an optical scanner suitable for precious cultural relics.

Natural cultural relics (such as fossils and biological specimens) require high-resolution and high-precision scanners to capture their tiny details and structures. This type of scanner is typically a microscope scanner or a CT scanner. For example, the GE Phoenix v|tome|x L 300 CT scanner is a high-resolution CT scanner suitable for natural cultural relics.

(2) Repair and optimize the 3D model of the relic

a. Model cleaning: Remove and trim unnecessary parts in the 3D model to reduce the model volume and optimize the model topology structure.

b. Hole filling and patching: Repair missing parts and gaps in the 3D model to restore the original shape and structure of the relic.

c. Optimization of polygon structure: Optimize the excessive or insufficient polygons in the 3D model to improve the detail representation and rendering effect of the model.

d. Model simplification: For large relic models or scenes that require real-time display, simplify and compress the 3D model to reduce the model volume and improve the rendering speed.

e. Texture optimization: Optimize and enhance the texture of the relic surface to improve the realism and authenticity of the model. These methods can be operated through computer software. Software such as MeshLab, 3ds Max, Blender, and others provide rich repair and optimization tools.

(3) Adding texture information

a. Taking texture photos: Use a digital camera or high-resolution scanner to take high-definition photos of the surface of cultural relics, and then use computer software to paste the photos onto the surface of the 3D model.

b. Hand-painting texture: According to the texture characteristics and historical data of cultural relics, hand-paint the texture image with painting software, and paste it onto the surface of the 3D model.

c. Obtaining resources from the internet: Search or purchase high-quality cultural relic texture images from the internet, and paste them onto the surface of the 3D model.

d. Texture generator: Use computer software to generate texture images and paste them onto the surface of the 3D model.

Before adding texture information, it is necessary to unwrap the 3D model of the cultural relic to make the surface of the 3D model unfold into a 2D plane, making it easier to paste the texture onto the correct position. Common 3D modeling software provides UV unfolding and texture mapping functions, such as Maya, 3ds Max, Blender, etc. Using these methods, the cultural relic 3D model can have a more realistic appearance and details, better displaying the charm and historical value of the cultural relic.

(4) Application of model optimization technology

a. Polygon reduction: Polygon reduction is a technique that reduces the number of triangles in a polygon mesh model. By reducing the number of triangles in the model, the file size of the model can be greatly reduced, and the computational burden during rendering can be reduced, thus improving the rendering speed of the model.

b. Elimination of duplicate vertices and edges: Eliminating duplicate vertices and edges in the model is a common technique for improving the geometric structure quality of the model and reducing the file size of the model. By eliminating duplicate vertices and edges, the complexity of the model can be reduced, and the performance and rendering effect of the model can be improved.

c. Texture compression: Texture compression is a technique that compresses high-resolution textures into smaller file sizes. By compressing textures, the file size of the texture can be reduced, thus improving the rendering speed and performance of the cultural relic 3D model.

d. Mesh optimization: Mesh optimization is a technique for optimizing the geometric structure of the model. Through mesh optimization, the topology structure of the model can be optimized, the number of triangles in the model can be reduced, and the details of the model can be increased, thus improving the realism and authenticity of the model.

e. Texture mapping optimization: Texture mapping optimization is a technique that merges multiple texture maps into one texture map. By optimizing texture mapping, the number of texture maps can be reduced, thus improving the rendering efficiency and performance of the cultural relic 3D model.

These methods can be used alone or in combination, depending on the actual situation and needs of the cultural relic 3D model. Through model optimization technology, the realism, authenticity, and performance of the cultural relic 3D model can be improved, better displaying the historical value and cultural heritage of the cultural relic.

(5) Virtual display and application

a. VR virtual exhibition: VR virtual exhibition is the application of 3D models of cultural relics in virtual reality technology, achieving virtual exhibition. By wearing VR headsets, visitors can freely move in virtual scenes, observe cultural relics up close, and learn about the historical background and cultural connotations of the cultural relics through interactive means. VR virtual exhibition can provide a more immersive exhibition experience, enhancing visitors' sense of participation and experience.

b. AR augmented reality display: AR augmented reality display is the application of 3D models of cultural relics in augmented reality technology, achieving augmented reality display. By scanning the QR code on the exhibition items or using AR applications, visitors can project 3D models of cultural relics onto the real scene for comparison and observation. AR augmented reality display can combine virtual cultural relics with real cultural relics, enhancing the fun and interactivity of cultural relic display.

c. Online virtual exhibition: Online virtual exhibition is the application of 3D models of cultural relics in network technology, achieving online virtual exhibition.

By uploading 3D models of cultural relics to virtual exhibition platforms or museum websites on the Internet, visitors can view and interact with them online through web browsers. Online virtual exhibition can promote the display of cultural relics globally, enhancing the dissemination and accessibility of cultural relic exhibition.

d. 3D printing application: 3D printing is a technology that prints physical cultural relics from 3D models of cultural relics using a 3D printer. By 3D printing 3D models of cultural relics, cultural relics can be transformed from virtual to physical states, achieving physical display and observation of cultural relics. The application of 3D printing can provide physical support for cultural relic research and protection, while also bringing new ways of display for cultural relic exhibition.

2.2. The application status and development trends of digital heritage reconstruction technology

Digital heritage reconstruction technology has been widely applied in fields such as heritage preservation, cultural heritage research, and cultural tourism. For example, this technology can help heritage conservation personnel better understand the structure and damage of heritage objects in preservation and restoration work, and assist in repairing them. Additionally, digital heritage reconstruction technology can provide more accurate data support for cultural heritage research, helping people to gain a deeper understanding of the history, cultural background, and value of heritage objects.

In the future, the development trends of digital heritage reconstruction technology will first reflect its increasing intelligence and automation. For example, through machine learning and artificial intelligence technologies, automatic reconstruction of heritage objects and model generation can be achieved. Secondly, digital heritage reconstruction technology will become more detailed and accurate, achieving more realistic reconstruction and presentation of heritage objects' details and features through high-precision scanning technology and higher-quality model generation algorithms. Finally, digital heritage reconstruction technology will become more diverse and interactive, such as combining virtual reality technology to achieve interactive display and experience of heritage objects, allowing people to gain a more immersive understanding of their history and culture.

3. Virtual Exhibition Technology for Cultural Relics

Virtual exhibition technology refers to the use of digital technology to create virtual displays of cultural relics, allowing for multi-dimensional, multi-scale, and three-dimensional exhibitions and experiences. Virtual exhibition technology mainly includes virtual reality, augmented reality, and holographic projection.

3.1. Application of Virtual Reality Technology in Cultural Relics Exhibition

Virtual reality technology can provide an immersive exhibition experience for people, allowing them to better understand the history, culture, and artistic value of cultural relics. Virtual reality technology mainly includes hardware devices such as head-mounted displays, handheld controllers, and motion sensors, as well as software tools such as virtual reality software and content creation tools.

Virtual reality technology can achieve three-dimensional display of cultural relics, allowing people to better understand the three-dimensional structure and features of cultural relics. At the same time, virtual reality technology can also achieve multi-

angle display of cultural relics, allowing people to freely choose the angle and distance to observe cultural relics. Virtual reality technology can also be combined with other digital technologies, such as speech recognition technology and intelligent recommendation algorithms, to achieve intelligent interpretation and interactive exhibition of cultural relics, allowing people to have a deeper understanding of the history and culture of cultural relics.

3.2. Application of Augmented Reality Technology in Cultural Relics Exhibition

Augmented reality technology refers to the use of computer graphics and computer vision technology to superimpose virtual 3D models or information onto real scenes, enhancing and supplementing the scene. In cultural relics exhibitions, augmented reality technology can use devices such as smartphones or tablets to superimpose virtual cultural relic models onto real scenes, achieving enhanced display and exhibition of cultural relics.

In cultural relics exhibitions, augmented reality technology can achieve three-dimensional display of cultural relics, allowing people to better understand the three-dimensional structure and features of cultural relics. Augmented reality technology can also achieve interactive exhibition of cultural relics, such as through gesture control or speech recognition technology, allowing people to operate and explore cultural relics.

3.3. Application of Holographic Projection Technology in Cultural Relics Exhibition

Holographic projection technology refers to the use of laser, optics, and computer graphics technology to project 3D models of cultural relics into the air, creating realistic holographic images. In cultural relics exhibitions, holographic projection technology can achieve holographic display of cultural relics, allowing people to better understand the three-dimensional structure and features of cultural relics.

Holographic projection technology can achieve three-dimensional display of cultural relics, allowing people to better understand the three-dimensional structure and features of cultural relics. Holographic projection technology can also achieve multi-scale display of cultural relics, allowing people to freely choose the size and shape of the cultural relics to observe.

4. Challenges and Prospects in the Digitization of Cultural Heritage Preservation

The application of digitization technology in cultural heritage preservation can effectively improve the efficiency and quality of heritage preservation and exhibition. However, digitization of cultural heritage still faces several challenges. This section will discuss the challenges in the aspects of technology, management, and talent, and present prospects for the future.

4.1. Technological Challenges

Digitization of cultural heritage involves many technological challenges, among which the most important are accuracy and precision, speed and efficiency, sustainability and reproducibility. Cultural heritage digitization requires high precision and accuracy to better restore the original appearance of the cultural relics and conduct scientific research, while also ensuring better protection and exhibition of

the relics. Furthermore, the speed and efficiency of cultural heritage digitization need to be continuously improved to better meet the increasing demand for heritage preservation and exhibition. Cultural heritage digitization also requires sustainability and reproducibility to better ensure the long-term preservation and inheritance of cultural relics, avoiding the difficulty of maintaining and using digitized data due to technological updates. Therefore, overcoming technological challenges in cultural heritage digitization is crucial for the protection and inheritance of cultural heritage.

4.2. Management Challenges

Management challenges in cultural heritage digitization mainly involve data management and security, quality management and evaluation, as well as cooperation and sharing. Data management and security issues need to be effectively addressed to ensure information security and privacy protection of digitized cultural heritage data. During the digitization process, it is necessary to establish a sound data management system and technical security system, and strengthen the backup and recovery of digitized data to avoid damage to cultural relics caused by data loss or leakage.

Quality management and evaluation of cultural heritage digitization is also an important management challenge. Effective quality management and evaluation systems need to be implemented to control the quality and effectiveness of cultural heritage digitization, evaluate and monitor digitization results, and timely identify and solve problems.

4.3. Talent Challenges

In the future, digital cultural heritage protection will pay more attention to technological innovation and talent development, while strengthening cross-disciplinary integration to bring new ideas and methods to cultural heritage protection and exhibition. For example, by applying artificial intelligence and big data technology to digital cultural heritage protection, automatic identification and classification of cultural relics can be achieved, improving the efficiency and accuracy of cultural relic digitization. In addition, virtual reality and augmented reality technology can be used to restore cultural relics to their historical appearance, providing viewers with a more realistic and immersive cultural relic exhibition experience.

5. Conclusions

Digital cultural heritage protection is a very important task that can protect and exhibit valuable cultural heritage, enabling people to better understand and recognize history and culture. This article explores the technology, management, and talent challenges of digital cultural heritage protection from the perspectives of relic reconstruction and virtual exhibition, and analyzes the future development trends of digital cultural heritage protection. Digital cultural heritage protection also faces many challenges, requiring continuous strengthening of technological innovation and talent development, and enhanced international exchanges and cooperation to bring new ideas and methods to cultural heritage protection and exhibition.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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