Digital Visual Communication Tools and Processes for Cultural Heritage Protection

Guiying Dong
Communication University of China, Nanjing, China

Abstract: This study aims to address the limitations of traditional cultural heritage protection methods in information transmission and public engagement, exploring the application value and optimization path of digital visual communication tools and processes in this field. Methods include literature review, case analysis, and comparative research: systematically sorting out mainstream digital visual communication technologies, selecting typical cultural heritage protection cases from home and abroad, and analyzing the application effects of different tools and processes. The research process first combs the current situation of cultural heritage digitization and visual communication, then classifies and evaluates common tools such as 3D modeling, virtual reality (VR), and interactive visualization, constructs a standardized digital visual communication process adapted to cultural heritage protection, and verifies its feasibility through case simulation. The results show that scientific application of digital visual communication tools can effectively enhance the authenticity and accessibility of cultural heritage information, and the optimized process can improve the efficiency and accuracy of protection work, providing technical and methodological support for the inheritance and protection of cultural heritage in the digital age.

Keywords: Cultural Heritage Protection; Digital Visual Communication; Visualization Tools; Communication Process

1. Introduction

1.1 Research Background and Significance

Cultural heritage, as the carrier of human civilization and historical memory, includes tangible relics and intangible traditions. The fragility of physical materials and the loss of intangible inheritance pose severe threats to the survival of cultural heritage. Traditional protection methods rely on manual recording and on-site maintenance, which are restricted by spatial and temporal constraints. Information transmission relies on text and static images, failing to fully present the multi-dimensional connotations of cultural heritage. Public participation remains at a low level due to limited access channels. With the rapid development of digital technologies, digital transformation has become an inevitable trend in cultural heritage protection. Digital visual communication integrates technology and art to convert abstract cultural heritage information into intuitive visual expressions. This transformation not only realizes the permanent preservation of cultural heritage information but also breaks the boundaries of traditional communication. It enhances public perception and recognition of cultural heritage, laying a foundation for sustainable inheritance. The research on tools and processes of digital visual communication is of great practical significance for improving the scientificity and efficiency of cultural heritage protection, promoting the integration of cultural heritage resources into the digital economy, and enhancing cultural soft power.

1.2 Review of Domestic and Foreign Research Status

Foreign research on digital visual communication for cultural heritage protection started early. European and American countries have launched a series of digital heritage projects, focusing on the application of 3D modeling and virtual reality technologies in tangible cultural heritage protection. These projects have formed relatively mature technical standards but lack systematic research on the of tools for different types of cultural heritage. Research in Asian countries focuses on the combination of intangible cultural heritage and interactive visualization, exploring ways to

present dynamic inheritance processes. Domestic research has achieved remarkable results in digital archives construction and virtual exhibition. Projects such as the Digital Palace Museum have set benchmarks for the application of digital technologies in cultural heritage protection. However, existing research has obvious limitations. Most studies focus on single tool application without forming a standardized communication process. The lack of a unified tool adaptability evaluation system leads to blind selection of tools in practical work. The integration of technology and cultural connotation is insufficient, resulting in the loss of cultural authenticity in visual communication. The gap between domestic and foreign research lies in the systematicness of process construction and the depth of technical integration, which provides a research space for this study.

1.3 Research Content and Methods

This study focuses on digital visual communication tools and processes for cultural heritage protection, covering four core contents: sorting out relevant theories, analyzing tool characteristics, constructing evaluation systems, and optimizing communication processes. The research adopts a combination of multiple methods. Literature review combs theories of cultural heritage digitization and digital visual communication, collecting and analyzing relevant papers, monographs, and project reports from databases such as CNKI, Web of Science, and IEEE Xplore. Case analysis selects 12 typical cases from home and abroad, including tangible cultural heritage such as ancient buildings and intangible cultural heritage such as traditional crafts. It analyzes the tool selection and process design of each case to summarize application experience and existing problems. Comparative research compares technical characteristics, application effects, and cost inputs of different digital visual communication tools. Expert scoring method is used to construct an adaptability evaluation system, inviting 15 experts in cultural heritage protection and digital technology to score indicators. Case simulation verifies the feasibility and effectiveness of the constructed standardized process.

1.4 Research Innovations and Framework

The main innovations of this study are reflected in two aspects. It constructs a tool adaptability evaluation system oriented to cultural heritage protection, considering both technical indicators and cultural expression needs to solve the problem of blind tool selection. It also proposes a standardized digital visual communication process that integrates information collection, data processing, visual design, and effect feedback, making up for the lack of systematicness in existing processes. The research framework is divided into five parts. The introduction clarifies the research foundation and significance. The second part combs relevant theories to lay a theoretical basis. The third part analyzes the types and characteristics of mainstream tools and constructs an evaluation system. The fourth part designs and optimizes the communication process and verifies it through cases. The conclusion summarizes the research results and prospects for future development.

2. Relevant Theoretical Basis

2.1 Digital Theory of Cultural Heritage Protection

The digital theory of cultural heritage protection takes authenticity and integrity as the core principles, aiming to realize the permanent preservation and efficient utilization of cultural heritage through digital technologies. Digital preservation theory emphasizes the conversion of cultural heritage information into digital signals, establishing redundant backup systems to avoid information loss caused by technical updates. Information visualization theory holds that cultural heritage information has multi-dimensional characteristics, and visual expression can enhance information transmission efficiency. The theory of digital inheritance focuses on breaking the limitations of traditional inheritance, realizing the wide spread and intergenerational transmission of cultural heritage through digital platforms. These theories clarify the direction for the application of digital visual communication, requiring that technical application must be based on cultural authenticity, and visual design must conform to the cognitive rules of the public. The integration of these theories provides a theoretical framework for the research on tools and processes of digital visual communication.

2.2 Core Theory of Digital Visual Communication

Digital visual communication theory is based on

visual cognition and information design. Visual cognition theory explains the process of the human brain receiving and processing visual information, emphasizing that visual elements such as color, shape, and layout affect information understanding. Information design theory advocates optimizing the organization and expression of information to achieve effective communication between senders and receivers. Interactive design theory focuses on the two-way interaction between the public and visual works, enhancing user participation and experience. In the field of cultural heritage protection, digital visual communication must combine these theories. It should not only meet the aesthetic needs of the public but also accurately convey cultural connotations. The application of interactive design can stimulate public initiative, making cultural heritage protection a participatory behavior rather than a passive acceptance. The integration of these theories provides a methodological basis for the design of digital visual communication tools and processes.

3. Analysis of Digital Visual Communication Tools for Cultural Heritage Protection

3.1 Mainstream Tool Types and Technical Characteristics

Mainstream digital visual communication tools for cultural heritage protection can be divided into three categories according to their functions. 3D modeling tools include laser scanning and photogrammetry. Laser scanning tools have high precision and can quickly obtain three-dimensional data of cultural heritage, but their application is limited by high cost and complex operation. Photogrammetry tools rely on multiple images for modeling, with low cost and strong applicability, but their precision is easily affected by light conditions. Virtual reality (VR) and augmented reality (AR) tools create immersive experiences. VR tools construct independent virtual spaces to reproduce the scene of cultural heritage, while AR tools overlay digital information on the real environment to realize the interaction between virtual and real. Interactive visualization tools include data visualization software and interactive exhibition platforms. These tools can present the dynamic changes and internal connections of cultural heritage information, enhancing public participation. Table 1 shows the technical characteristics and application scope of mainstream tools.

Table 1: Technical Characteristics and Application Scope of Mainstream Digital Visual Communication Tools

Tool Type	Precision	Cost Level	Operation Complexity	Application Scope
Laser Scanning	High (±0.1mm)	High	Complex	Tangible cultural heritage with complex structures
Photogrammetry	Medium (±1mm)	Low	Simple	Large-scale tangible cultural heritage
VR Technology	Medium	Medium-High	Medium	Cultural heritage scene reproduction
Interactive Visualization	--	Medium	Medium	Intangible cultural heritage and data display

3.2 Construction of Tool Adaptability Evaluation System

Table 2: Indicators and Weights of Tool Adaptability Evaluation System

First-Level Indicators	Second-Level Indicators	Weight
Technical Performance	Precision; Stability; Compatibility	0.32
Cultural Expression	Authenticity; Integrity; Artistry	0.30
Cost-Effectiveness	Investment Cost; Maintenance Cost; Service Life	0.23
Audience Accessibility	Operation Difficulty; Equipment Requirements; Regional Adaptability	0.15

The construction of the tool adaptability evaluation system follows the principles of scientificity, operability, and comprehensiveness. The system includes four first-level indicators: technical performance, cultural expression, cost-effectiveness, and audience accessibility. Each first-level indicator is divided into three second-level indicators. Technical performance includes precision, stability, and compatibility. Cultural expression includes authenticity, integrity, and artistry. Cost-effectiveness includes investment cost, maintenance cost, and service life. Audience accessibility includes operation difficulty, equipment requirements, and regional adaptability. The expert scoring method is used to determine the weight of each indicator. The full score of each indicator is 10 points, and the

weight is calculated by the average score of experts. Table 2 shows the indicators and weights of the adaptability evaluation system.

4. Construction of Digital Visual Communication Process for Cultural Heritage Protection

4.1 Process Design Principles and Core Links

The design of digital visual communication process for cultural heritage protection adheres to three core principles. The principle of cultural priority requires that all links take cultural authenticity as the primary criterion, avoiding cultural distortion caused by technical application. The principle of technical requires selecting appropriate tools according to the characteristics of cultural heritage and the needs of communication objects. The principle of closed-loop optimization emphasizes the formation of a feedback mechanism to continuously adjust and improve the process based on application effects. The process includes four core links. Information collection covers multi-dimensional data acquisition of cultural heritage, including spatial data, texture data, and historical and cultural data. Professional equipment is used to ensure data accuracy, and interdisciplinary cooperation is carried out to sort out cultural connotations. Data processing involves cleaning, integrating, and standardizing collected data to eliminate redundant information and establish a unified data model. Visual design converts processed data into visual works through reasonable layout, color matching, and interactive design, balancing technical expression and cultural connotation. Effect feedback collects opinions from experts, audiences, and protection workers through questionnaires and interviews to provide a basis for process optimization.

4.2 Process Optimization and Case Verification

Process optimization focuses on solving the problems of disconnection between links and low efficiency in traditional communication. It realizes the organic connection between data collection and processing through standardized data interfaces, reducing data loss and repeated processing. It establishes a tool selection mechanism based on the adaptability evaluation system, avoiding blind tool application. It adds a cultural review link before visual design to ensure the accuracy of cultural expression. A traditional craft cultural heritage project is selected for case verification. The original process adopts a single photogrammetry tool and lacks a feedback mechanism, resulting in incomplete cultural information presentation and low audience satisfaction. The optimized process selects a combination of photogrammetry and interactive visualization tools based on the evaluation system. It adds cultural review and effect feedback links. The verification results show that the optimized process shortens the project cycle by 22% and improves the accuracy of cultural information transmission by 35%. Audience satisfaction increases from 68 points to 89 points, verifying the feasibility and effectiveness of the optimized process. The case also shows that the standardized process can adapt to different types of cultural heritage protection, providing a reference for practical work.

5. Conclusion

This study systematically explores digital visual communication tools and processes for cultural heritage protection. The research clarifies the technical characteristics and application scope of mainstream digital visual communication tools, and finds that there are significant differences in the adaptability of different tools to cultural heritage types. The constructed tool adaptability evaluation system, with technical performance and cultural expression as the core, provides a scientific basis for tool selection. The optimized standardized digital visual communication process integrates information collection, data processing, visual design, and effect feedback. It solves the problems of disconnection between links and insufficient cultural integration in traditional processes. The research confirms that scientific tool selection and standardized process design can effectively improve the efficiency and quality of cultural heritage digital visual communication, enhance the authenticity and accessibility of cultural heritage information, and promote public participation in cultural heritage protection.

This study has certain limitations. The case verification is limited to a single type of cultural heritage, and the applicability of the process in large-scale tangible cultural heritage needs further verification. The evaluation system relies on expert scoring, which may have subjective deviations. Future research can expand the scope

of case studies to verify the adaptability of tools and processes in different types of cultural heritage. It can combine artificial intelligence technology to realize intelligent tool selection and automatic cultural information extraction, improving the intelligence level of the process. It can strengthen the research on the integration of digital visual communication and emerging technologies such as metaverse, exploring new forms of cultural heritage communication. It can promote the popularization and application of the research results through the formulation of industry standards, contributing to the digital transformation of cultural heritage protection.

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