
Research on Digital Preservation and Innovative Dissemination of Ezhou Bronze Mirror Culture from the Perspective of AI-Enhanced Interactive Virtual Reality

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Abstract

As a gem of ancient Chinese bronze art, Ezhou bronze mirrors face challenges in preservation and dissemination such as the fragility of the physical objects, monotonous display methods, and difficulties in interpreting and perceiving their deep cultural connotations. The integration of Artificial Intelligence (AI) and Interactive Virtual Reality (IVR) technology opens new pathways for the deep revitalization and innovative transmission of cultural heritage. Based on an analysis of the cultural value of Ezhou bronze mirrors, this paper elaborates on the transformative advantages of the AI-VR fusion in constructing immersive, intelligent, and personalized cultural experiences. Through feasibility analysis, the paper constructs a digital preservation and dissemination strategy system with AI as its core engine, proposing three key modules: "AI-Powered Ornament Decoding and Immersive Narration", "Intelligent Simulation of Craftsmanship and Interactive Learning", and "AIGC-Driven Dynamic Dissemination and Cultural Creative Derivative Development". The proposed system aims to establish a digital ecosystem that integrates intelligent preservation, in-depth education, and cross-border dissemination, providing an innovative solution for the "living" transmission and value regeneration of Ezhou bronze mirror culture in the digital age.

Keywords Ezhou Bronze Mirrors; Artificial Intelligence; Interactive Virtual Reality; Digitalization of Cultural Heritage; User Experience

1 Introduction

Ezhou, renowned as the "Hometown of Ancient Bronze Mirrors", boasts excavated mirrors distinguished by their exquisite casting techniques, rich ornamental themes, and profound cultural significance. They serve as crucial physical materials for studying ancient Chinese society, art, and technology. However, traditional methods of preservation and dissemination, such as static museum displays and catalog publications, struggle to fully reveal their intrinsic craftsmanship mysteries and spiritual value, particularly failing to engage the younger generation. With advances in AI and VR technologies, it is now possible to transcend physical boundaries and create a perceptible, interactive, and explorable digital cultural space. This paper aims to explore how to deeply integrate interactive virtual reality technology into the preservation and dissemination of Ezhou bronze mirror culture, designing practical application strategies to revitalize this precious cultural heritage in the digital era.

2 Artistic Characteristics and Current State of Dissemination of Ezhou Bronze Mirror Culture

2.1 Artistic Features of Ezhou Bronze Mirror Culture

Ezhou is one of Hubei Province's first provincially designated historical and cultural cities. Its location, "where Chu ends and Wu begins", has fostered a regional culture characterized by multiplicity, multifacetedness, and diversity. Elements such as E-Chu culture, Three Kingdoms culture, bronze culture, religious culture, ceramic culture, and revolutionary culture interweave here, forging a uniquely Ezhou regional identity [1]. The artistic achievements of Ezhou bronze mirrors are primarily manifested in three aspects: First, the diversity and mythological nature of ornamental themes. From panchi (coiled

dragon) patterns and grass-leaf patterns to divine beast mirrors and pictorial mirrors, their ornamental system is complete. Particularly famous are the divine beast mirrors and historical figure story mirrors from the Wu and Jin periods. Within the confined space of the mirror back, they incorporate celestial beliefs, historical allusions, and secular life, constituting an "epic engraved in bronze". Second, the exquisiteness of casting techniques. Utilizing high-relief methods, the ornaments are prominently raised with distinct layers and smooth lines, showcasing the exceptional lost-wax or pottery mold casting skills of ancient artisans. Third, the richness of inscription content. Mirror inscriptions are not only tools for periodization but also bearers of contemporary auspicious phrases, social ideologies, and commercial information, holding significant documentary value.

2.2 Research Value of Ezhou Bronze Mirror Culture

Bronze mirrors served as daily-use objects in antiquity. Beyond practicality, their ornamentation needed to align with contemporary aesthetics and ideological demands. During the Wei-Jin period, amidst widespread societal suffering from warfare, the populace yearned for a state of peace and well-being [2]. Ezhou bronze mirrors are "living fossils" for studying ancient China, especially the politics, economy, religious beliefs, artistic trends, and technological levels of the middle and lower Yangtze River region from the late Han to the Six Dynasties period. Their evolutionary sequence is a crucial benchmark for archaeological periodization; their ornaments and inscriptions are a window into the ancient spiritual world; and their casting technology represents the pinnacle of metalworking craftsmanship of that era.

3 New Opportunities for Traditional Culture Dissemination in the AI Era

3.1 Digital Preservation and Dissemination of Cultural Heritage

Digital technology has revolutionized the paradigm of cultural heritage from "physical preservation" to "information preservation". Through technologies like high-precision 3D scanning and multispectral imaging, millimeter-accurate "digital archives" can be created for Ezhou bronze mirrors. This not only provides a permanent, non-destructive data foundation for restoration and research but also liberates the artifacts from their physical constraints, enabling limitless and multifaceted dissemination.

3.2 AI-Powered Ornament Decoding and Immersive Narration

Utilizing deep learning (Convolutional Neural Networks-CNN), vast quantities of bronze mirror ornaments (beast knobs, deities/humans/horse-drawn carriages, pictorial motifs, etc.) can be automatically identified, classified, and annotated to build a structured, interconnected "Ezhou Bronze Mirror Ornament Gene Bank". Based on Natural Language Processing (NLP) and knowledge graph technology, ornaments can be linked to historical texts, myths, legends, and institutional systems. In a VR environment, when a user gazes at a specific ornament, AI can generate and voice its cultural symbolism (e.g., the immortality beliefs behind the "Queen Mother of the West" image) in real-time or trigger a related micro-narrative animation. By analyzing user behavior (dwelling time, interaction choices) via AI, recommendation algorithms can generate personalized VR tour and narrative pathways for users with different interests (e.g., history enthusiasts, art students).

4 Feasibility Analysis of VR Application for Ezhou Bronze Mirror Culture

4.1 Feasibility of VR Technology Application

In museum virtual exhibitions, VR technology enriches narrative methods, enhances immersion and interactivity, and provides new paths for cultural preservation and dissemination. Research indicates that immersive exhibitions, by increasing viewers' freedom to explore and enabling their active participation in cultural reconstruction, lead to richer perceptual experiences [3]. Narratively, some projects break linear display paths to form more three-dimensional narrative structures, such as the "Changchun Memories: Water Purification Virtual Tour Exhibition" employing dual narrative threads. Compared to traditional exhibitions, this exhibition demonstrates greater layering and depth in content delivery.

Furthermore, VR technology holds immense value in the virtual restoration and cultural preservation of artifacts. It can virtually reconstruct historical sites and architectural spaces, showcase the living characteristics of regional culture, and serve the dual functions of cultural dissemination and preservation [4].

4.2 Advantages of VR Technology Application

VR technology is capable of creating virtual environments within the human perceptual system, providing users with a sense of presence. Through specialized devices like Head-Mounted Displays (HMDs) and controllers, users can interact with the virtual environment. VR simulates senses such as vision, hearing, and touch to create realistic virtual experiences [5]. VR technology can effectively achieve "preventive conservation" of cultural relics, performing virtual restoration and assembly via digital twins to avoid secondary damage to precious originals. It breaks spatial and temporal constraints, allowing a global audience to "be" in a dedicated Ezhou Bronze Mirror Virtual Museum anytime, anywhere. Through gamified and storified interactive design, it transforms dry knowledge into engaging exploration, effectively enhancing dissemination efficacy. It provides scholars with a virtual research platform for disassembling, measuring, and simulating artifacts at will, aiding in solving difficult problems in archaeology and craft history.

5 Strategies for Preservation and Dissemination of Ezhou Bronze Mirror Culture Based on Interactive VR

5.1 Intelligent Ornament Interpretation and Immersive Perception

Construct an "Intelligent Ornament Interpretation System". When users use a VR controller to "click" on mirror back ornaments like the Azure Dragon, White Tiger, or Queen Mother of the West, the system instantly delivers the cultural origin, symbolic meaning, and evolutionary history of that ornament via text, images, audio, or even 3D animation. Further, an "Ornament Reconstruction" interactive game can be designed, where complete patterns are broken into fragments for users to reassemble via a puzzle-like activity in the virtual space, deepening their understanding of the compositional logic and aesthetic principles of the ornamentation.

5.2 Virtual Simulation of Bronze Mirror Craftsmanship and Immersive Experience

Create a virtual casting workshop as the core of the strategic system. Users will embody a Han Dynasty artisan, personally experiencing the complete process from mold-making, smelting, and pouring to polishing and consecration within the VR environment. For instance, users need to manually carve ornaments on a clay mold using virtual tools, cooperatively operate lifting a "molten copper ladle" for pouring, and sense the flow and solidification of the metal liquid. This embodied cognitive experience transforms the abstract notion of "exquisite craftsmanship" into perceptible muscle memory and operational challenge, fostering genuine admiration for ancient technological wisdom—an effect unattainable by any text, image, or video explanation.

5.3 AIGC-Driven Dynamic Dissemination and Cultural Creative Derivatives

Lightweight and modularize the aforementioned VR experiences to develop applications suitable for online platforms, mobile VR devices, and even web browsers. Promote these through social media and cultural heritage apps, hosting online VR bronze mirror art exhibitions. AI analyzes user preference data for mirror ornaments and colors from social media, providing trend reports for designers. Simultaneously, user-customized mirror models (e.g., with their own surname inscribed) or elegant ornament patterns generated during the VR experience can be directly converted into digital collectibles or used to develop offline cultural creative products (e.g., scarves, stationery, decorations), forming an "online experience-offline consumption" closed loop, achieving a win-win for cultural value and economic benefit.

6 Conclusion

Interactive virtual reality technology offers a new perspective for rediscovering and interpreting Ezhou bronze mirror culture. It serves not only as a technical tool but also as an innovative medium for cultural storytelling. The strategic system comprising "intelligent interpretation", "virtual simulation", and "online revitalization" proposed in this paper aims to liberate Ezhou bronze mirrors from static display cases, transforming them into audible, visible, playable, and tangible entities. In the future, as the concept of the metaverse througoh, Ezhou bronze mirrors can engage in dialogue with other civilizations within it, continuing to shine with their millennial-spanning wisdom and artistic brilliance. This exploration serves not only Ezhou bronze mirrors themselves but can also provide a replicable paradigm for the digital survival and revitalization of similar cultural heritage.

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Conflicts of Interest

The authors declare no conflicts of interest.

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人工智能增強型交互式虛擬現實視域下鄂州銅鏡文化的數字化保護與創新傳播研究

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摘要：鄂州銅鏡作為中國古代青銅藝術的瑰寶，其在保護與傳播方面長期面臨實體文物脆弱、展陳形式單一、深層文化內涵解讀與感知困難等現實挑戰。人工智能與交互式虛擬現實技術的融合，為文化遺產的深度活化與創新傳承開闢了新路徑。本文立足鄂州銅鏡的文化價值分析，闡述了AI與VR技術融合在構建沉浸式、智能化、個性化文化體驗方面的變革性優勢。通過可行性分析，構建了以AI為核心引擎的數字化保護與傳播策略體系，提出「AI賦能紋飾解碼與沉浸敘事」、「工藝智慧模擬與交互式研習」以及「AIGC驅動的動態傳播與文創衍生開發」三大核心模塊。該體系旨在構建一個集智慧化保存、深度化教育、跨界化傳播於一體的數字生態系統，為鄂州銅鏡文化在數字時代的「活化」傳承與價值再生提供創新性解決方案。

關鍵詞：鄂州銅鏡；人工智能；交互式虛擬現實；文化遺產數字化；用戶體驗

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