Vol.6 Iss.1 2025
https://doi.org/10.37420/j.adr.2025.009

Research on the Construction of Virtual Display Space for Intangible Cultural Heritage in Zhong Xiang City Based on Digital Technology

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Abstract:
Amid the rapid development of the digital economy and digital technology, cultural display modes are undergoing profound transformations. Virtual cultural space provides a new avenue for the inheritance and innovation of intangible cultural heritage (ICH). This paper takes the Zhong Xiang Intangible Cultural Heritage Museum in Hubei Province as the research object, addressing issues such as the insufficient appeal and limited experience of traditional ICH display methods. By integrating the immersive, interactive, and dynamic characteristics of virtual cultural display spaces, the paper proposes a strategy for constructing a heterogeneous and mixed virtual display space. Using digital technologies such as holographic projection, naked-eye 3D, augmented reality (AR), virtual reality (VR), and others, heterogeneous and mixed space scenes are created to address the physical limitations of traditional exhibition halls. This approach constructs an immersive, interactive, and diversified exhibition experience, enhancing visitors' understanding of Zhong Xiang's ICH. This study provides a reference for the digital transformation of local ICH museums and has practical significance for promoting the innovative development of traditional culture in the digital age.

Keywords:
digital technology, virtual cultural display space, intangible cultural heritage, heterogeneous hybrid.

Introduction

With the development of the economy and digital technology, new methods of cultural display are emerging. Digital technology enhances the interaction between users and cultural content, providing technical support for the construction of virtual urban cultural display spaces. In the digital age, the shift in cultural demand has made contemporary young people more inclined to experience culture through digital virtual environments, leading to a decline in the appeal of traditional display methods. ICH represents valuable wealth in the history and culture of a nation. Zhong Xiang City, rich in ICH resources, faces limitations in the traditional methods of displaying this heritage, making it difficult to meet the cultural experience needs of modern audiences. The immersive and interactive features of digital virtual cultural display spaces offer a new path for showcasing ICH. Through the multifaceted integration and innovative application of digital virtual technologies, these spaces create a richer, more vivid, and unique ICH experience, effectively promoting the preservation and inheritance of Zhong Xiang's ICH.

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1.Characteristics of Virtual Cultural Display Space Construction

1.1 Immersive Experience

"Immersive experience, as a core feature of virtual cultural display spaces, seeks to create an environment that immerses the audience in cultural perception through the integration and application of various digital technologies. This allows them to fully engage with the display of ICH and deeply experience the unique charm of this cultural legacy."

Digital imaging technology is one of the key methods for creating an immersive experience, including technologies such as electronic screens, ground and wall projections, dome screen projections, ring screen projections, and others. Digital images are primarily generated through multimedia technology, which displays information to form a digital image. The purpose of this technology is to disseminate display information, which includes diverse forms of digital content such as images, videos, and audio. It can also be integrated with sound and lighting technologies to create an immersive display environment. Ground and wall projections can transform the floor and walls of a space into dynamic display interfaces, blending display content with the surrounding spatial environment. Dome screen projections, with their large screens and surround visual effects, provide a strong sense of immersion for the audience. In a dome projection, the audience appears to be enclosed within a massive sphere, allowing for an omnidirectional view of ICH content, such as the natural landscapes and historical relics of Zhong Xiang. This creates an experience where the audience can appreciate the unique cultural charm in a virtual environment. In contrast, ring screen projections form a continuous visual space by surrounding the audience with multiple screens, offering a fully immersive 360-degree visual experience of the display content[1].

Holographic imaging technologies, such as holographic projection and phantom imaging, play a crucial role in the display of ICH. Holographic projection technology is characterized by its capacity to transcend the constraints of physical space, enabling the recreation of historical events or the visualization of future imagery. This technology enables viewers to engage with exhibits in an unprecedented way, allowing for dynamic rotations and transformations to explore the internal structure of an object or trace its evolution[2]. Compared to traditional exhibition methods, holograms provide a comprehensive view, addressing the limitations of conventional displays that fail to present exhibits in their entirety, while conveying information in a more vivid and engaging manner. Phantom imaging, a specific form of holographic projection, offers relative simplicity in its implementation, making it an effective tool for designers to create immersive exhibition experiences. Through carefully crafted plots and scenes, this technology can evoke emotional resonance among visitors, enabling them to feel the pulse of history and the rhythm of art at a profound level. For instance, the "Van Gogh Immersive Experience Fantasy of The Inner World" held at the National Museum of China serves as an exemplary application of this technology. By utilizing 360-degree holographic panoramic ultra-high-definition laser projection, the exhibition transformed nearly 200 of Van Gogh's works into holographic video images, allowing the audience to immerse themselves in Van Gogh's artistic world.

Naked-eye 3D technology utilizes the principle of binocular parallax to achieve a three-dimensional stereoscopic effect without the need for special glasses. By projecting different images to each eye, it creates a strong sense of depth and a three-dimensional visual experience, significantly enhancing the visual impact

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of the exhibition[3]. The historical background and other relevant cultural information can be projected onto building surfaces in the form of dynamic light and shadow, with variations tailored to the specific cultural atmosphere. This transforms the static building surface into a dynamic medium for information, allowing the audience to experience the evolution of ICH as they move through the space. Simultaneously, the use of surround sound technology, with precisely positioned sound design, creates an ambient audio experience that complements the content of the display, further deepening the audience's sense of immersion.

1.2 Interactivity

Interactivity is a key feature of virtual cultural display spaces, as it breaks away from the passive mode of information reception characteristic of traditional display methods, emphasizing the active participation and interactive experience of visitors. These spaces prioritize the audience's sense of involvement and engagement, enabling interaction through various sensory channels, including visual, auditory, and tactile experiences[4].

By utilizing a variety of innovative and integrated interactive technologies, virtual cultural display spaces facilitate multi-sensory interactions for visitors, providing them with a novel participatory experience. These interactions can be categorized into the following aspects: somatosensory interaction, achieved through technologies such as gesture recognition, AI dialogue, digital twins, and wearable devices, enabling information exchange; wall interactive projection technology, which utilizes infrared sensing and image system analysis to generate real-time feedback actions, allowing for interaction with relevant devices; voice-controlled interaction, where operating instructions are issued via voice recognition processing devices, providing instant feedback; and action interaction, where interactive devices or digital images are used in a game-like manner to enhance the interactive experience. Integrating these interactive methods in virtual cultural display spaces enhances their appeal, as the audience is no longer a passive recipient of content but becomes a co-creator of the experience. For instance, in the "Tianqi Painting Realm—Qi BaiShi Immersive Digital Light and Shadow Art Exhibition," visitors can not only appreciate reproductions of Qi BaiShi's paintings but also engage in interactive AI-driven art-making within the digitally reconstructed study, leaving behind their unique artworks[5].

Virtual simulation technologies, with their distinct advantages, facilitate a deep integration of the virtual and real worlds, thereby expanding the boundaries of interactive experiences for audiences. VR technology, through devices like head-mounted displays, creates fully immersive virtual environments that allow visitors to engage with intangible cultural heritage (ICH) in a vivid and lifelike manner. Within these virtual spaces, users can participate in interactive activities, deepening their understanding and appreciation of the content. Additionally, AR recognition systems seamlessly merge virtual and real-world elements by overlaying digital information onto the physical environment[6]. By using mobile devices such as smartphones or tablets, visitors can scan specific objects or scenes through the AR system, which then triggers the display of culturally significant content related to the exhibits directly on their screens. This interactive approach heightens engagement and piques visitor interest. For example, mobile apps powered by AR can animate characters from traditional paintings, making them appear to step out of the canvas and interact with the audience-offering a fresh visual and sensory experience. Moreover, puzzle-based interactive installations, like the British Museum's “Egyptian Mummies” AR decryption experience, further enhance cultural education and entertainment

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through gamified interaction. These approaches significantly enrich cultural learning by making it more engaging and enjoyable.

1.3 Dynamism

Dynamism is a key characteristic of virtual cultural display spaces, distinguishing them from traditional display environments and infusing new vitality and appeal into the presentation of ICH. With the support of virtual technologies, the display environment can undergo a continuous transformation, allowing content to be updated in real time and adapted based on audience preferences or emerging trends[7]. This dynamic flexibility enriches the display of ICH, catering to the diverse needs of modern audiences, enhancing their sense of participation and engagement, and effectively promoting the dissemination and preservation of cultural heritage. In traditional display environments, changing themes often requires altering the background or spatial setting, which increases design costs and limits the visual versatility of the exhibit, restricting the development of the narrative. However, with digital technology, display environments can be freely transformed, enabling a single space to evolve into multiple distinct scenes within a short time frame, providing a consistent and immersive setting for storytelling. For instance, at The Palace Museum Digital Exhibition in Beijing, the dynamic display of Along the River During the Qingming Festival allows the exhibition space to seamlessly transition between scenes as the narrative progresses. This creates an immersive experience where visitors feel as though they are transported into different cultural contexts, enhancing both the narrative coherence and the sense of immersion.

The dynamism of virtual cultural display spaces is also manifested in the real-time updating of display content. These spaces can quickly adjust their exhibits based on the latest research findings, audience feedback, or current social trends, ensuring that the display remains fresh and relevant. Real-time updates and personalized tours allow virtual cultural display spaces to better accommodate the diverse needs of the audience, enhancing their overall experience. Visitors can access the most up-to-date information tailored to their interests, thereby strengthening their connection with ICH and promoting its preservation and dissemination.

2.Construction Strategy for the Virtual Display Space of Zhong Xiang Intangible Cultural Heritage Museum

2.1. Heterogeneous Spatial Integration

Spatial heterogeneity fusion construction is a critical strategy in developing the virtual exhibition space for the Zhong Xiang Intangible Cultural Heritage Museum. This approach utilizes digital technologies to integrate physical and virtual environments, enhancing the presentation and preservation of ICH. By creating a hybrid spatial system that combines virtual and real elements with complementary functionalities and a coherent narrative structure, it provides visitors with a multi-dimensional spatial experience and fosters deeper cognitive and emotional engagement. This framework enables a more comprehensive understanding of Zhong Xiang's ICH.

Within the physical space of the Zhong Xiang City Intangible Cultural Heritage Museum, traditional exhibition areas dedicated to ICH will be preserved, while a specialized digital virtual experience zone will

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also be established. Leveraging digital technologies such as holographic projection, this zone will feature ICH elements that are difficult to present in physical form—such as Dong Qiao Town shadow puppetry, the Lengshuipu Earth Board Wall Bugle, Moxian female legends, and others. This innovative approach creates a dynamic fusion of physical and virtual content, significantly enriching the museum's presentation of Zhong Xiang City's intangible cultural heritage.

When constructing virtual scenes, it is essential to fully consider the architectural spatial form as a key prerequisite to ensure the effectiveness of the display. The basic layout of exhibition spaces is diverse and is typically categorized and designed based on the distribution of individual exhibition units or booths and the visitor movement flow[8]. In the process of constructing virtual scenes, both the architectural form and layout must be carefully considered to ensure that the selected scenes align with the theme and that the display content is coherent and logical. Additionally, the dimensions and proportions of ICH scenes should closely resemble real-world settings. This ensures that visitors experience a strong sense of realism while engaging with the exhibition, allowing them to become fully immersed in the restored historical or cultural environments. For example, in the virtual exhibition space of the Zhong Xiang City Intangible Cultural Heritage Museum, the virtual scene of the Dong Qiao Town shadow puppet show should simulate the traditional stage layout of shadow puppetry, incorporating distinct performance and audience areas to evoke the authentic atmosphere of a shadow puppet performance. The scale and proportions of the space should be designed to match the specific characteristics of shadow puppetry, ensuring that visitors can clearly observe the movements and intricate details of the performance. In terms of color, tones that complement the shadow play's style, such as warm hues, should be chosen to create a vibrant and immersive atmosphere.

Reasonable planning of spatial flow is crucial for ensuring a seamless transition between the physical exhibition area and the digital experience zone, thereby facilitating the smooth integration of heterogeneous hybrid spaces and enhancing the immersive experience, as well as reconstructing spatial perception. In the virtual display space of the Zhong Xiang Intangible Cultural Heritage Museum, clear signage and directional indicators can be installed to guide the audience through the physical exhibition area and the digital experience area in a logical sequence. The design of circular or linear flow paths can be employed to ensure a smooth and ordered progression, minimizing confusion and congestion. Additionally, incorporating interactive elements and designated rest areas along the flow path can enhance the visitors' sense of engagement and comfort.

2.2. The Integration of Multiple Virtual Technologies

"The integration of multiple virtual technologies is a key strategy in the construction of the virtual display space at the Zhong Xiang Intangible Cultural Heritage Museum. By conducting comprehensive digital collection of ICH projects and integrating various digital technologies for display, this approach overcomes the limitations of traditional exhibition methods. It presents the ICH of Zhong Xiang in a richer, more vivid, and immersive manner, enhancing the audience's experience and promoting the inheritance and dissemination of ICH."

All-round digitalization of various ICH projects in Zhong Xiang City, including audio, video, images, and 3D models. Taking Zhong Xiang's "Liangshan Tune" as an example, in addition to recording the audio per-

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formance of the opera, videos of the folk song's singing scene can also be filmed, and 3D virtual images of the actors' performances can be created. These can be displayed through digital devices, allowing the audience to not only listen to the beautiful melody but also watch the vivid singing scenes. The audience can even control the virtual actors to engage in communication and interaction, gaining a deep understanding of the charm of local opera.

The integration and application of various digital technologies brings a fresh perspective and experience to the display of ICH in Zhong Xiang City, allowing ICH to be presented to the audience in a more vivid, engaging, and interactive manner. When utilizing relevant digital technologies to showcase ICH projects, modern design concepts are incorporated by combining ICH elements with contemporary life scenes. Through holographic projection, designed patterns of Zhong Xiang's ICH are used as elements of modern household items, allowing the audience to witness the innovative application of ICH in modern life, thus bridging the gap between ICH and everyday life.

VR technology is employed to simulate the production process of traditional handicrafts in Zhong Xiang City, such as the making of Zhong Xiang's distinctive "Pan Long Cai." The audience can virtually operate the process by wearing VR equipment, gaining an understanding of the entire production process from material selection, cutting, seasoning, wrapping to steaming, and experiencing the charm of traditional handicrafts. At the same time, AR technology is used to combine Zhong Xiang's ICH with audience interaction. For example, by scanning a specific QR code on the audience's smartphone or tablet, a 3D model or animation related to the ICH will appear, allowing the audience to gain a more intuitive understanding and deeper learning experience. Interactive Q&A sessions are also incorporated into the display process, enabling the audience to ask questions about Zhong Xiang's ICH and receive detailed responses from a virtual assistant. Additionally, a virtual tour option is provided, allowing the audience to choose the ICH projects they wish to explore based on their interests, offering an in-depth tour to enhance both the fun and the sense of participation in the exhibition.

In the interactive experience display area, holographic projection technology can be employed to dynamically showcase the representative works of Zhong Xiang City's ICH, such as "Five Fortunes," "Longevity Lovers," "Fukwa Offering Shou," and others. Along the visitors' tour route, a VR experience zone can be set up where visitors can engage in virtual paper-cutting. The audience will be able to use various paper-cutting tools in a virtual environment and create their paper-cutting designs based on personal creativity. The system will offer real-time guidance and feedback, enabling the audience to gain a deeper understanding of the papercutting production techniques. Finally, by integrating VR and AR, the paper-cutting models created by the audience can be saved, and AR files can be exported. Visitors can use their smartphones or tablets to view the paper-cutting designs they have created, enhancing their interest in the exhibition and giving them a sense of accomplishment.

Through these diversified and integrated display methods, the ICH of Zhong Xiang City can be presented in an all-round and multi-angle manner. These methods also stimulate the audience's interest and enhance their awareness of cultural heritage and its preservation. The integration and application of various digital technologies inject new vitality into the virtual display space of Zhong Xiang Intangible Cultural Heritage Museum, enabling the ICH to shine in the digital age.

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2.3 Promoting Interactive Participation

Interactive Participation is a key approach to enhancing audience experience and improving the effectiveness of ICH dissemination. By incorporating a variety of interactive activities and innovative games into the virtual display space of the Zhong Xiang Intangible Cultural Heritage Museum, the enthusiasm and initiative of the audience can be stimulated. This allows the audience to gain a deeper understanding of Zhong Xiang's ICH through active participation, thereby increasing their cultural awareness and fostering a stronger sense of protection for such heritage.

In the digital experience area, a range of interactive activities can be set up, enabling visitors to choose projects that align with their personal interests. For example, in the VR-based traditional handicraft production experience, different levels of difficulty can be offered for the production tasks. Visitors can select the complexity of the task, and upon completion, they can receive personalized electronic certificates or tangible souvenirs, enhancing both their sense of accomplishment and the uniqueness of the experience.

The design of interactive games incorporating elements of ICH is an effective strategy for attracting audience participation and promoting the dissemination of heritage culture. This approach enables the audience to learn about intangible heritage in an engaging and entertaining way, enhancing their enjoyment of the experience. For instance, a treasure hunt game themed around Zhong Xiang's intangible heritage can be designed, where participants scan AR markers on exhibits with their smartphones to unlock detailed stories and production techniques related to the heritage. Upon completing the tasks, they can receive virtual rewards, further stimulating their interest in and desire to explore ICH[9].

2.4. Creation of Immersive Experience Space

The creation of immersive experiential spaces is a pivotal strategy for enhancing audience engagement with Zhong Xiang City's ICH. By designing multi-sensory environments and integrating narrative-driven and interactive elements, this approach fosters an emotionally resonant and immersive ICH experience. It enables visitors to deeply appreciate the unique cultural charm within a captivating atmosphere.

Through the physical revitalization of traditional ICH spaces, audiences can establish a psychological connection with the culture. Utilizing new media technologies—such as projection, interactive radar, and motion capture—ICH is deconstructed and digitally reinterpreted, further enriching the immersive experience.

In the digital experience area of the physical culture hall, an immersive environmental atmosphere is created through the comprehensive use of lighting, sound effects, scents, and other sensory elements. For instance, when showcasing scenes of traditional farming ICH in Zhong Xiang, the lighting is adjusted to simulate the angle and intensity of sunlight when displaying farmland scenes. This enhances the realism of the light and shadow effects on the crops, contributing to a more three-dimensional and layered visual experience. Adjustable spotlights are employed to highlight traditional farming tools, such as hoes and plows, allowing the audience to clearly observe the details and textures of these tools and experience the simplicity and weight of traditional farming culture. The sound effects are meticulously designed to provide the audience with a more realistic auditory experience. Sounds of birdsong, insects, and laboring are harmoniously blended to form a vivid symphony of the fields. The crisp bird songs seem to ring in the ears, evoking the vitality and energy of

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nature; subtle insect chirping enhances the tranquility of the scene, helping the audience focus more on the experience of the ICH; and the sounds of labor, such as farmers shouting or hoeing, immerse the audience in the scene of farmers working hard, intensifying the realism and sense of immersion in the environment. Using surround sound technology, the sound envelops the audience from all directions, allowing them to experience the charm of the sound in a truly immersive way, as if they were actually present in the traditional farming scene.

Through the use of digital media technology, the story of ICH is projected through both standard and ring-screen projections extending along the building's walls, creating a streamlined action-oriented visitor route and a complete narrative experience[10].For example, an experience process themed “A Day in the Life of an Intangible Cultural Heritage Inheritor in Zhong Xiang” can be designed, where the audience follows the perspective of the AR virtual inheritor via smartphones or tablets. The visitors can then walk through various non-heritage production areas, using VR equipment to participate in the crafting of non-heritage arts. Along their journey, the audience will also visit performance and activity zones, which are dynamically displayed through digital media projections, creating an interactive and immersive experience. As the audience progresses along the route, combining sound, light, and holographic projections, cultural performances such as opera and stilt walking are brought to life in the space. This storytelling method not only immerses the audience in the performances but also allows them to deeply understand the challenges and appeal of non-heritage inheritance. The overall experience is designed to be more coherent, facilitating emotional resonance with the audience. In the narrative experience, interactive elements such as virtual assistants and AI technologies are integrated into the interactive Q&A sessions. The audience is prompted to make choices at critical junctures, with these choices affecting the course and outcome of the story. This enhances both interactivity and engagement. To further heighten immersion, AI can be used to dynamically adjust the displayed content and interaction methods based on audience behavior and feedback. For instance, if a visitor lingers in front of a particular ICH project, the system may trigger a more in-depth introduction or interactive experience, catering to the visitor's exploratory desires. Meanwhile, through the dialogue and narration of AR virtual characters, the historical origins and cultural connotations behind ICH are presented, allowing the audience to experience the depth and warmth of ICH culture within the narrative, thereby further deepening their understanding and appreciation of ICH culture.

In conclusion, by employing a diverse array of technological methods and innovative design principles, a highly immersive and emotionally engaging experiential environment can be established within the digital virtual display space. This environment not only facilitates a comprehensive and multi-faceted presentation of the ICH of Zhong Xiang City but also actively engages the audience, fostering their interest and participation while enhancing their cognitive understanding and awareness of the importance of safeguarding ICH.

3.Conclusion

The integration of digital virtual cultural spaces with the Zhong Xiang Intangible Cultural Heritage Museum—through innovative experience design and heterogeneous construction—presents an effective strategy that aligns with contemporary trends while promoting the preservation and evolution of intangible cultural heritage (ICH). By introducing creative approaches to spatial planning, exhibition content, technological

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applications, and user experience design, this model addresses the limitations of traditional ICH museums, offering visitors a novel, immersive, and personalized cultural journey. This strategy not only enhances the dissemination and public engagement of Zhong Xiang City's ICH, drawing a wider audience into its preservation efforts but also establishes a forward-looking model for the digital transformation and innovative development of ICH museums in other regions. Furthermore, it plays a key role in revitalizing ICH, enabling it to flourish in the digital era. As digital technologies continue to evolve, deeper exploration into the synergy between virtual and physical cultural domains will be essential. Ongoing refinement in design and implementation will ensure that ICH retains its relevance and vitality in contemporary society.

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