Applied studies on digital restoration display of antique buildings

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Abstract: *In order to inherit history and satisfy modern people's aesthetic pursuit of historical-style buildings, antique buildings are gradually being built. The application of digital technology in the restoration of antique buildings to improve the visitors' experience is of great practical significance. This paper takes the site of De Shou Palace as an example to carry out research on the design and application of digital restoration display of antique buildings with the audience as the center, so as to realize the purpose of making tourists feel the charm of ancient architecture through digital technology, and to provide experience for the further application of digital technology in the restoration display of antique buildings.*

Keywords: antique architecture; digital technology; visitor experience; De Shou Palace ruins

1. Introduction

China's ancient architecture is unique in the world's architectural history because of its unique artistic style [1]. With the social changes and the rapid development of science and technology, ancient architecture is facing the crisis of being submerged by the wave of modernization, in order to protect the historical heritage, pass on the culture, and meet the modern people's aesthetic pursuit of the historical style of architecture, the gradual rise of ancient architecture.

In the era of digital technology, the public has a higher pursuit of cultural life, and the expectations of tourists have changed, the display of ancient architecture museums can no longer be limited to the construction of the building itself, but also need to continue to innovate the design and means of display [2]. The use of digital technology for the digital restoration of ancient architectural culture and the processing of culture is of great practical significance, and the use of new technologies and the digital empowerment of museums play an important role in attracting the younger generation and new audiences, and promote the exchange of historical culture and education [3-5]. With the development of computer technology, three-dimensional (3D) modeling, virtual reality, augmented reality, and other digital technologies have been more widely used in the digital restoration and display of ancient architecture [4]. More accurate design and creation of ancient building models can be achieved by techniques such as 3D modeling software and laser scanning [6, 7]. Using virtual reality and augmented reality technology, antique building models or virtual scenes can be projected into reality, so that people can better experience the ancient buildings and understand their historical cultural values, Nanchang Shengmi Old Street, Chengde Summer Resort, Bohai Kingdom on the capital of Longquan and other antique buildings in the use of these technologies [4, 8, 9]. However, most researchers have focused more on the practicality and aesthetics of technology use, and aspects such as user experience and interaction have not been adequately considered [10].

Therefore, based on the project of De Shou Palace Site in Hangzhou, Zhejiang Province, China, this paper explores the application practice of digital restoration display in antique architecture, focusing on the creation of emotional value in the interaction between virtual and real, enhancing the user experience, enabling the audience to feel the beauty of ancient architecture through digital technology, and at the same time providing experience for the further application of digital technology in antique architecture.

2. Description of the project

The site of De Shou Palace is located in the northeast of the intersection of Wangjiang Road and Zhonghe Road in Xiaoying Street, Shangcheng District, Hangzhou City, Zhejiang Province, with a total area of about 10.69 hectares. De Shou Palace, originally built in the thirty-second year of Shaoxing during

the Southern Song Dynasty, served as the palace where Song Dynasty Emperor Gaozong (Zhao Gou) resided after his abdication. Located in resonance with the contemporaneous Southern Song Dynasty Imperial Citadel, the palace was colloquially referred to as the "Northern Great Inner Palace". Despite its original function as a retirement residence, this quasi-formal imperial district has gained a reputation for its resplendent grandeur, epitomizing an era of opulence and artistic exuberance. Particularly noteworthy is the meticulous artistry that adorns the rear gardens, where the synthesis of botanical elements and architectural finesse converge to create an enchanting and intricate landscape. At the same time, it offers insights into the historical and cultural milieu of the Southern Song Dynasty, serving as a specialized thematic museum. The museum as shown in Figure 1. The De Shou Palace Museum seamlessly integrates the quintessence of four successive archaeological excavations. In keeping with the dual imperatives of protecting the archaeological site and facilitating reversible exhibition methods, the museum has erected protective pavilions over the architectural remains of the palace within its central precinct. The archaeological site of De Shou Palace is the leading example in the country of a systematic and comprehensive display of the entirety of the historical and cultural characteristics of the Southern Song Dynasty. It reaches the pinnacle of significance in terms of revealing the original site in its utmost clarity, boasting the most extensive extent of archaeological excavation, and presenting the most thorough investigation of restoration processes within the field of Southern Song archaeological relics.

Figure 1: De Shou Palace ruins museum

3. Design Concept

Southern Song culture encompasses a kaleidoscope of facets, characterized by its refined elegance. The architectural landscape of the Southern Song Dynasty is notably marked by its distinctive grandeur and graceful austerity. The digital restoration exhibition initiative undertaken at the De Shou Palace archaeological site demonstrates an innovative approach by directly applying digital restoration methodologies to the physical remains. Employing techniques of digital superimposition and merging the virtual and tangible realms, this endeavor engenders the creation of a "twin virtual space," symmetrically aligned with the substantial archaeological site.

The cultural significance encapsulated within the De Shou Palace Site Museum is remarkably extensive. In order to provide visitors with a clear and logically structured exhibition experience, the current effort revolves around the central axis of interpreting the archaeological remains, gradually unfolding in layers of depth, and striving to authentically recreate the refined aesthetics of the Song Dynasty. The thematic components of the exhibition experience follow a sequential pattern that includes the interpretation of archaeological remains, the elucidation of construction knowledge, the reconstruction and presentation of urban and architectural scenarios, and the depiction of courtly and garden life. This sequence is strategically designed to facilitate a rational cognitive process, from the understanding of the archaeological core to the expansion of knowledge and the enrichment of cultural understanding. This conceptual framework revolves prominently around the tenet of "audience-centricity," with robust use of digital techniques for restoration-based exhibitions. There is a deliberate emphasis on blending the virtual with the tangible environment, supported by the careful selection of appropriate hardware to enhance environmental authenticity and increase interactive seamlessness. Adhering to the principle of preserving the integrity of the archaeological site, this design emphasizes the paramount importance of diversification, relevance, immersion, and utility within the exhibition space, while ensuring that these considerations do not compromise the integrity of the site itself.

4. Digital technology applications

The practice of restoration and presentation at the De Shou Palace archaeological site makes extensive use of a variety of digital technologies, characterized by strategic blending rather than unilateral application. This approach effectively leverages the unique strengths of each technological facet, resulting in a synergistic enhancement of results. The integration of the current state of the archaeological site with its digitally reconstructed counterpart is realized through immersive projection techniques, creating a historical milieu that allows visitors to step back in time and immerse themselves in the narratives and lifestyles that unfolded within the De Shou Palace. Similarly, dynamic digital scrolls, harmoniously synchronized with the physical layout of the site, serve as visual narratives that guide visitors through the historical scenarios, providing comprehensive insights into the leisurely life of Emperor Gaozong. The incorporation of interactive installations throughout the exhibition contributes to the edifying entertainment that enhances the enjoyment of the visit. Using techniques such as lighting design and background music, the ambiance of the exhibition is meticulously crafted to enhance the immersive atmosphere for visitors, fostering a heightened sense of engagement and resonance.

4.1 Site Projection

Within the central zone of the archaeological site, the experiential pavilion is distinguished by the deployment of a vertically adjustable tri-fold screen, employing silk material with a hue consistent with the site's ground color. This arrangement integrates the archaeological site onto the projection surface, encasing it with projections from all sides, as shown in Figure 2. Through this configuration, the projectors directly cast the original appearance of the De Shou Palace onto the refilled ground of the site, and when harmonized with the tri-fold screen, a multisensory immersive stereoscopic environment is established. Concurrently, within the exhibition hall, a "回" (character for "return" or "revolve")-shaped presentation space and an elevated glass walkway are incorporated. Positioned primarily from the southern perspective of the site, these components allow visitors to both overlook the site and engage in a deeply immersive encounter. The western zone of the site's Experience Pavilion is dedicated to showcasing the garden aesthetics of the Southern Song Dynasty. Within the span of five compartments, this pavilion uses projection technology to three-dimensionally display basic elements such as columns, paved surfaces, and tamped earth, based on the results of restoration research. A suspended square pavilion canopy is centrally located, and the surrounding perimeter of the pavilion is adorned with nanopolyester fabric screens. These screens, with textures resembling antique gauze windows, are ingeniously integrated into the structure of the pavilion to evoke a semblance of texture and charm similar to the archaeological site, as shown in Figure 3. Beneath the semi-translucent nature of this fabric, images are projected from four angles, culminating in a 3D visual experience for the naked eye. This setup allows viewers to closely observe the fabric screens, immersing them in the artistic ambience of Southern Song garden life during the seasons of spring and winter.

The tri-fold wall curtain elevation mechanism employed in this project features components sourced from the Grampian brand, characterized by a casing and lateral covers constructed from ultra-high-strength alloys, ensuring an extended operational lifespan. The electric motors selected for this application derive from the Schindler Group's Schindler Port brand, boasting an extensive warranty period of up to 10 years. For the site projection, the implementation leverages the well-established NEC NP-PA1004UL laser projectors renowned for their proficiency. With a brightness output reaching 8300 lumens and 10,000 lumens for the end projection onto the screen, these laser projectors ensure durability and stability with an operational lifespan exceeding 10,000 hours. Concerning the domain of projection image fusion technology, optimization of the projector configuration has been executed while upholding the foundational imperative of ensuring a robust integration of projection images from distinct projectors. For the site projection, the implementation utilizes the well-established NEC NP-PA1004UL laser projectors known for their efficiency. These laser projectors have a brightness output of up to 8300 lumens and produce 10,000 lumens for the final projection onto the screen. Moreover, they provide durability and stability with an operational lifespan that surpasses 10,000 hours. In the realm of projection image fusion technology, we have optimized the projector configuration with the primary objective of ensuring a strong integration of projection images from various projectors.
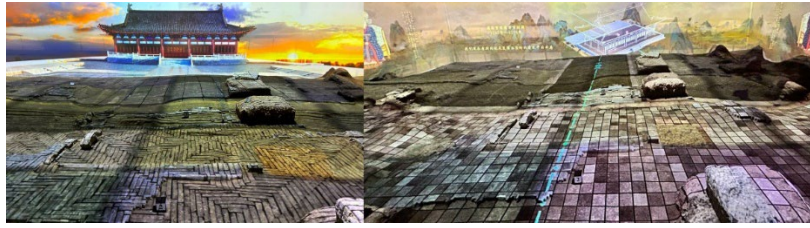
Figure 2: Tri-fold screen projection scene

Figure 3: Square Pavilion Soft Curtain Projection

4.2 3D Printing and Transparent Interactive Display Cabinets

At the entrance of the western zone exhibition hall, a prominent interactive display cabinet with a substantial transparent screen has been established. In alignment with the ethos of Southern Song culture, the tabletop of the display cabinet has been meticulously fashioned in a Chinese architectural style. To ensure the visibility of the archaeological site, the cabinet structure has been fashioned from organic transparent glass material, thereby averting any obfuscation of the underlying archaeological context. Within the display cabinet, a meticulously crafted 3D-printed model sandbox of the western zone's archaeological site has been positioned. This model is enhanced by a 65-inch high-definition transparent screen, which combines their abilities to collaboratively display the reconstructed layout of the western region's archaeological site, as depicted in Figure 4. By showcasing the three-dimensional aerial reconstructions of the western zone on an interactive transparent screen and overlaying them with the three-dimensional model inside the display cabinet, we have achieved a harmonious fusion between the virtual and tangible dimensions. This integration facilitates an enhanced perceptual apprehension of De Shou Palace's historical demeanor, affording viewers a heightened intuitive encounter with its bygone essence. Notably, the interactive touchscreen interface allows the viewer to initiate a 360° rotational view of the reconstructed three-dimensional model of the corresponding region's archaeological remnants, thus facilitating a comprehensive understanding of the entire site.
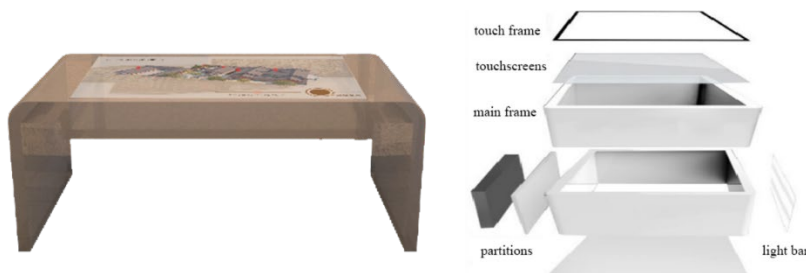

Figure 4: Transparent display case

4.3 Dynamic Digital Panorama Scroll and AR Interactive Screen

The western precinct of the archaeological site employs dynamic digital panoramas and augmented reality (AR) interactive screens, among other digital technologies, to reenact the garden scenes and leisurely anecdotes from the later years of Emperor Gaozong's reign. This approach engenders a contextualized and immersive encounter, enabling visitors to intimately experience the aesthetic allure and distinctive craftsmanship of Southern Song garden landscapes.

Within the exhibition area, a colossal dynamic digital panorama measuring 30 meters in length has been installed. This panoramic canvas chronicles a series of four-season garden narratives interwoven with the progression of ten solar terms. Augmented by projection technology, this panoramic depiction fosters a veritable sense of presence, enabling observers to undergo an immersive experience replete with multifaceted perspectives, diverse scenes, and the entirety of seasonal transitions. Through this immersive panorama, spectators are afforded the opportunity to deeply engage with the multifarious facets of Southern Song garden life, characterized by its artful ingenuity, delicate elegance, refined aesthetics, and kaleidoscopic transformations, as shown in Figure 5.
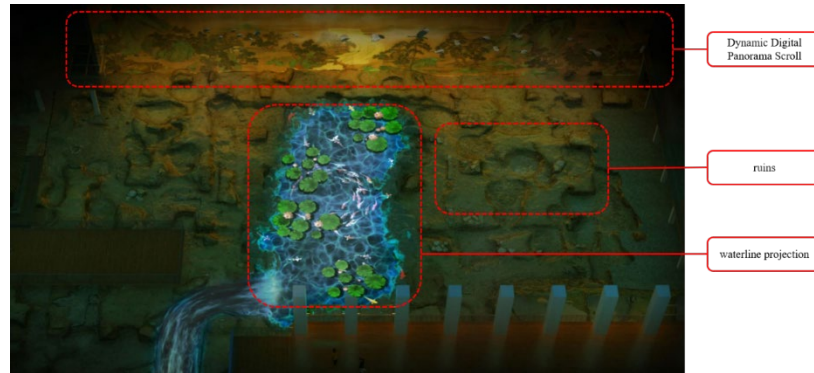

Figure 5: Dynamic scroll with projection

Furthermore, in the western sector, several interactive transparent screens with augmented reality have been strategically placed. These screens use an OLED spliced screen as a substrate and rear-facing cameras to capture real-time environmental imagery. With three-dimensional animations and sound components, these screens virtually reconstruct archaeological sites, as presented in Figure 6. Furthermore, users are able to manipulate AR devices to rotate and scale, allowing them to explore intricate details within the reconstructed scenes. During interactive engagement, participants engage their visual, auditory, and tactile senses, transitioning from passive information reception to active exploration and inspiration, thus achieving an entertainment-education effect. The applications of augmented reality interactive screens are extensive and varied. For example, techniques such as three-dimensional scene reconstruction and live-action enactment are utilized to present segments of the royal garden life during the summer and autumn seasons of the Southern Song Dynasty in a storytelling manner. Furthermore, the combination of AR interaction, image capture, and on-site spatial imaging technology facilitates the integration of three-dimensional modeling and digital animation techniques to recreate the rectangular pond landscape from the Southern Song era, AR technology is employed to fuse virtual and real elements, thereby providing viewers on the archaeological site with an immediate and intuitive presentation encompassing detailed explanations in three facets: "site information," "construction methods," and "restoration effects," pertaining to the rectangular pond. Similarly, through the orchestration of three-dimensional animations complemented by visual annotations, the construction process of De Shou Palace's architecture is dynamically simulated. This approach serves to amplify the visual impact and interactive experiential quality, offering an immersive understanding of the building construction process.

Figure 6: Transparent AR interactive screen

4.4 System design

The systematic design of this project places the audience as the primary perspective, taking into thorough consideration their visiting experience. For instance, the duration of each individual visual encounter within the exhibition is constrained to within 5 minutes, mitigating the risk of visual fatigue that might arise from extended exposure, thereby safeguarding the subsequent browsing experience for the visitors. Furthermore, the adoption of hourly play modes not only conserves energy and reduces emissions but also prevents excessive wear and tear on equipment due to prolonged continuous playback. Additionally, the implementation of a looped playback of interpretive visuals on the ground-level archaeological site ensures that during the gaps between hourly play modes, visitors are not confronted with a visual void. Moreover, the incorporation of a VIP reception mode through PAD control facilitates flexible visitor interactions, allowing for the modulation of the pace of exploration while touring the site.

5. Conclusion

This project integrates a variety of digital technologies into the restoration and presentation of historic architecture. The application of technology is considered from practical and aesthetic perspectives, with emphasis placed on user experience. Employing a range of methods to promote immersion, the project includes multiple interactive experiences, transforming the visitor's role from passive information absorption to a mix of passive reception and active exploration. This method improves the visitor's experience by promoting participatory and exploratory engagement, rather than just providing one-sided information. This results in a more engaging and enriched visit.

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