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Research on AR-Based Interactive Design for Digital Display of Ancient City Ruins: A Case Study of Youzhou Ancient City

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ABSTRACT

The wide application of digital technology in the field of art design has transformed the way people appreciate cultural heritage and plays an important role in promoting the revitalization and utilization of cultural heritage. Based on field investigations of Youzhou Ancient City ruins and historical document analyses, this study employs the design methods of narratively reconstructing cultural contents, designing scenario by combining virtual and real scenes, enhancing visual images with AR, and promoting embodied interaction experience of users to develop an AR-based interactive digital display for Youzhou Ancient City. The resulting application "Feng Hua (Cultural Essence)" demonstrates the deep integration of culture and digital technology, which positively enhances user's understanding and recognition of Youzhou Ancient City and ethnic minority cultures. This exploration provides new perspectives for the digital display and preservation of cultural heritage.

KEYWORDS

Augmented Reality; Digital Presentation; Ancient City Ruins; Interactive Design

1. INTRODUCTION

President Xi Jinping stated, "In the process of a nation's prosperity and development, cultural prosperity plays a fundamental role. Through cultural flourishing, we can accelerate the realization of the Chinese Dream of national rejuvenation." The protection and inheritance of cultural heritage are essential aspects of cultural prosperity, representing a deeper sense of cultural confidence.

The advancement of digital technology is revolutionizing the way people explore ancient cultural sites. Utilizing VR (Virtual Reality), AR (Augmented Reality), and 3D holographic projection to recreate narratives of historical sites demonstrates the deep integration and innovative fusion of technology with cultural heritage preservation and inheritance. These digital approaches open up new pathways for the protection and dissemination of cultural heritage. Therefore, making full use of digital technologies through interactive and engaging AR-based exhibition design can allows visitors to experience the warmth of cultural relics, enhance their immersive experience of Youzhou Ancient City, deepen their understanding of cultural heritage, and foster greater reflection on Chinese history and culture, ultimately strengthening national cultural confidence.

2. THE CURRENT SITUATION AND PROTECTION AND DEVELOPMENT ISSUES OF THE YOUZHOU ANCIENT CITY RUINS

With a long history, the Youzhou Ancient City Site is located in Chengchuan Town, Etuoke Qianqi, Inner Mongolia Autonomous Region, and is one of the important ancient city sites in northern China.

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As early as the Western Han Dynasty, Youzhou had become a strategic location in the northern region, not only undertaking important military defense functions but also being one of the centers of political, economic, and cultural development in Inner Mongolia at that time. As an important area for the exchange and integration of ancient nomadic and agricultural ethnic groups, it once became an important hub for "Hu-Han exchanges". During the Tang Dynasty, Youzhou was divided into two stages, "Old" Youzhou and "New" Youzhou. "Old" Youzhou was responsible for managing the Sogdians and other nomads, while "New" Youzhou was established in the later period of the Tang Dynasty and mainly managed the Tangut nomads [1].

The Youzhou Ancient City bears a long history and rich culture. However, unlike other ancient city sites, the original appearance of the Youzhou Ancient City has been severely damaged by long-term weathering and erosion due to its long history and remote location in the grassland area. People can only witness the rammed earth city walls on the spot, and the traditional visiting and viewing is monotonous and boring, resulting in a superficial understanding of the culture and history of the ancient city. Therefore, deeply integrating modern digital technology and conducting augmented reality innovative display design to achieve the cultural visual development of the Youzhou Ancient City will have positive practical significance.

3. THE APPLICATION PROSPECTS OF AR TECHNOLOGY IN THE DIGITAL DISPLAY OF ANCIENT CITY RUINS

AR technology integrates computer-generated virtual environments with the user's surrounding real environment through photoelectric display technology, interaction technology, multiple sensor technologies, and computer graphics and multimedia technology, making users believe from a sensory perspective that the virtual environment is a part of their surrounding real environment. AR is characterized by combining virtual and real, real-time interaction, and 3D registration [2]. Ronald Azuma proposed a widely accepted definition of AR, which includes three features: immersion, real-time interaction, and 3D simulation [3].

AR is a modern information technology developed on the basis of VR. In July 2023, the "China Augmented Reality (AR) Industry Research Report" released by iResearch Consulting Group pointed out that the development of China's AR industry is steadily advancing. With the rising popularity of the concept of metaverse, AR has become a choice for business and capital. China's AR technology has gradually permeated various fields such as industrial manufacturing, healthcare, education, retailing, military, games, and entertainment, and its practical value has been continuously demonstrated, transforming the way we interact with the world. AR can be regarded as the "middle ground" between VE (completely synthetic) and telepresence (completely real) [4]. By leveraging AR technology, cultural heritage can be digitally reconstructed in diverse forms such as digital animations, videos, audio, and text, and then superimposed in real-time onto real-world scenes. This technological approach not only visually presents certain cultural content to users but also offers them real-time interactive experiences through the integration of virtual and real elements.

Embodied Cognition, an important theoretical paradigm in cognitive science, emphasizes the core role of the body and its interaction with the environment in the cognitive process. As a medium technology, AR can overlay virtual information onto the real world, enhancing the user experience without completely replacing reality. This makes it an important means to achieve the embodiment of media. Immersive AR technology, which combines the features of media and embodiment, as well as reality and virtuality, is a key technological approach for achieving public participation and mixed reality, and has been successfully applied in the fields of cultural heritage preservation and tourism [5]. For instance, in 2023, the Liangzhu Ancient City Ruins in Zhejiang Province launched the "Mogan Mountain Pilgrimage Route AR Experience Project", which integrates AR, AI, and large language models and other digital technologies to superimpose real-world scenarios and recreate the grandeur of a thousand years ago, providing tourists with an immersive time-travel experience. The

French application “La Casa Batlló” uses AR to allow users to explore the Palace of Versailles in a highly immersive and interactive way, aiming to transform the grand architecture and historical stories of the Palace of Versailles into an interactive digital experience.

The deep integration of culture and digital technology has become an inevitable trend in the protection and redevelopment of cultural heritage. The innovative application of AR technology in some cultural heritage protection projects also provides new perspectives for the digital display of ancient city ruins.

4. INTERACTIVE DESIGN METHOD FOR NARRATIVE AR DIGITAL DISPLAY OF YOUZHOU ANCIENT CITY

Digital display interactive design is an interdisciplinary field that combines digital technology, user experience (UX), and spatial design. It aims to enhance information transmission efficiency and audience engagement through dynamic, immersive, and multi-sensory interactive display methods. With its interactivity, comprehensiveness, and strong sense of presence, which traditional methods cannot match, digital display interactive design is widely applied in museums, exhibitions, retailing, education, and other scenarios.

Based on the analyses of the cultural background of Youzhou Ancient City and the application of AR technology, “Feng Hua (Cultural Essence)” of Youzhou Ancient City takes the local characteristics and cultural stories of the ancient Ordos region as the prototype basis, and uses immersive AR technology as the implementation means. Following the principles of artistry, immersion, interactivity, and cultural significance, we propose a narrative digital display interactive design method for Youzhou Ancient City as follows:

4.1. Narratively Reconstructing Cultural Contents

Starting from the relevant traditional culture of the ancient city of Youzhou, historical facts are verified. By sorting out the history, stories, and character resources of the ancient city, the scene scripts are formed. The representative elements of the ancient city such as the city wall, cultural relics, and cultural stories are digitized. Combined with the remaining city relics of Youzhou and the cultural content spectrum of this period, a database of cultural symbol components is established as the basic content database for AR narrative. It can also serve as an important component for AR object recognition.

In terms of multimodal scripts, the narrative framework is determined through the different texts, interaction tasks, sound effects, and dynamic visual elements of the three intended scenes. AR is used to dynamically link the script content with the physical space, creating a cross-modal experience field where the virtual and the real coexist. In terms of spatial selection, the interactive scenes are placed at the remaining city walls based on the special geographical location and city site remains of Youzhou. Combined with the characteristics of the three different scenes, a distinctive Youzhou ancient city is shaped and displayed. In terms of cultural relics, according to the historical period, Hu nationality’s music and dance, trade, stone carvings, and musical scores are selected as the AR virtual story scenes and real object recognition props.

4.2. Designing Scenario by Combining Virtual and Real Scenes

Using AR technology, digital content is matched with the physical space of the Youzhou ancient city ruins and an interactive scene that integrates the virtual and the real is designed. Restored building models are superimposed on the ruins of the ancient city, and historical figures are set in front of the city walls to trigger dynamic contents such as dialogues and actions.

In the sketch drawing stage, the panoramic deformator is used for layout drawing, and the 2D main character “Kang Daddy” runs through the three scenes.

Scenario One combines the 3D model of the ancient city with 3D UI, introducing the name, location, founding time, and range of Youzhou respectively. There is a scaled-down model of the ancient city in the lower right corner, allowing for a detailed view of the city gate and other details, see our Figure 1 below.

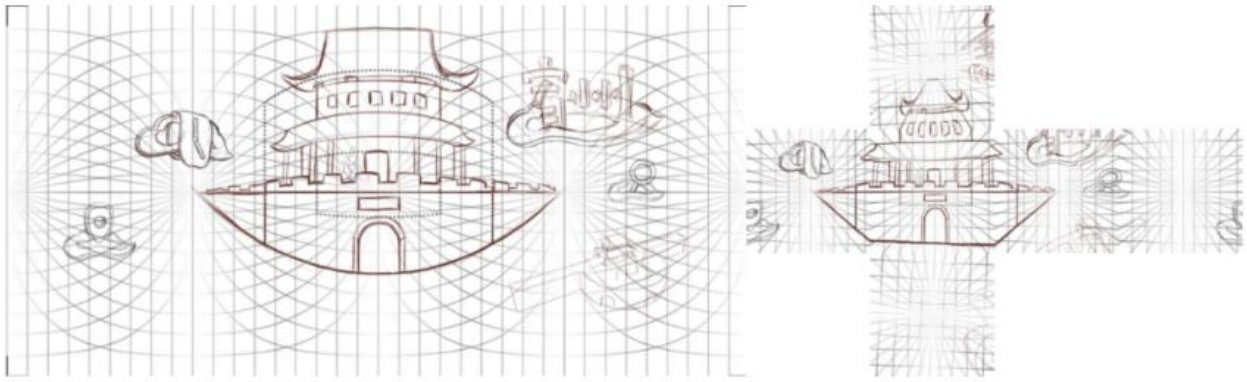

Figure 1. Scenario One 360° Space Sketch (Hand-drawn by the Author)

Scenario Two combines 2D animation with 3D models, mainly showing animations of feasting and dancing of Sogdian people in Youzhou. The table is a 3D model, with musical scores placed on it, and trees and other models beside it (Figure 2).

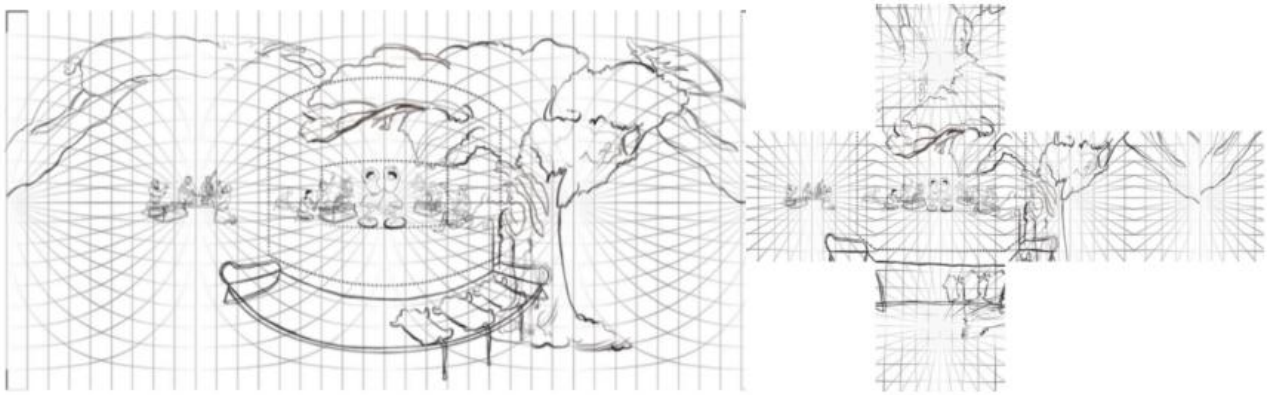

Figure 2. Scenario Two 360° Space Sketch (Hand-drawn by the Author)

Scenario Three also combines 2D animation with 3D models, mainly showing the trade scenes of Sogdian merchants on the Silk Road. The treasure box and its contents, as well as the camels, are 3D models, while the camel caravan and trading scenes are 2D animations (Figure 3).

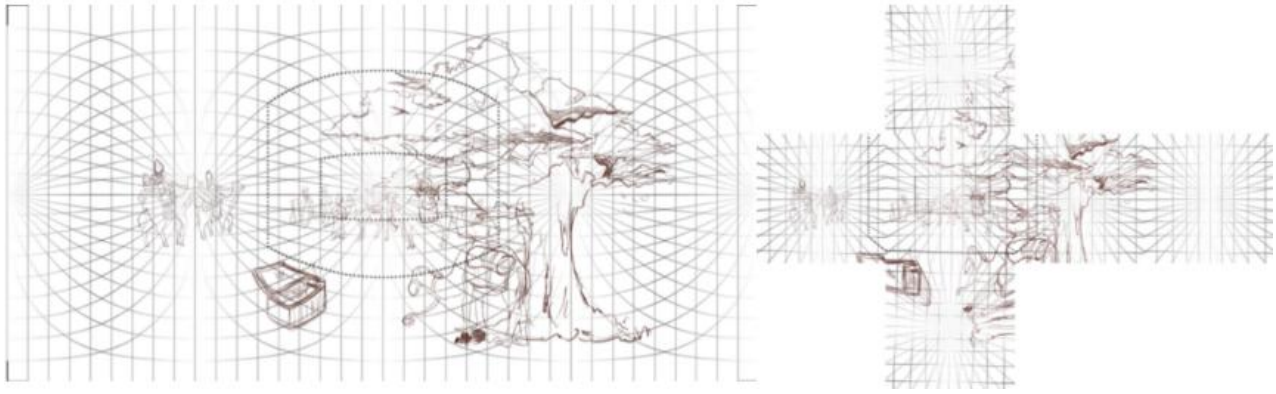

Figure 3. Scenario Three 360° Space Sketch (Hand-drawn by the Author)

The AR multimodal script serves as the key core for constructing an immersive experience. By deeply integrating visual, auditory, tactile, and other sensory interactive elements, it creates a multidimensional narrative space, as shown in Figure 4.

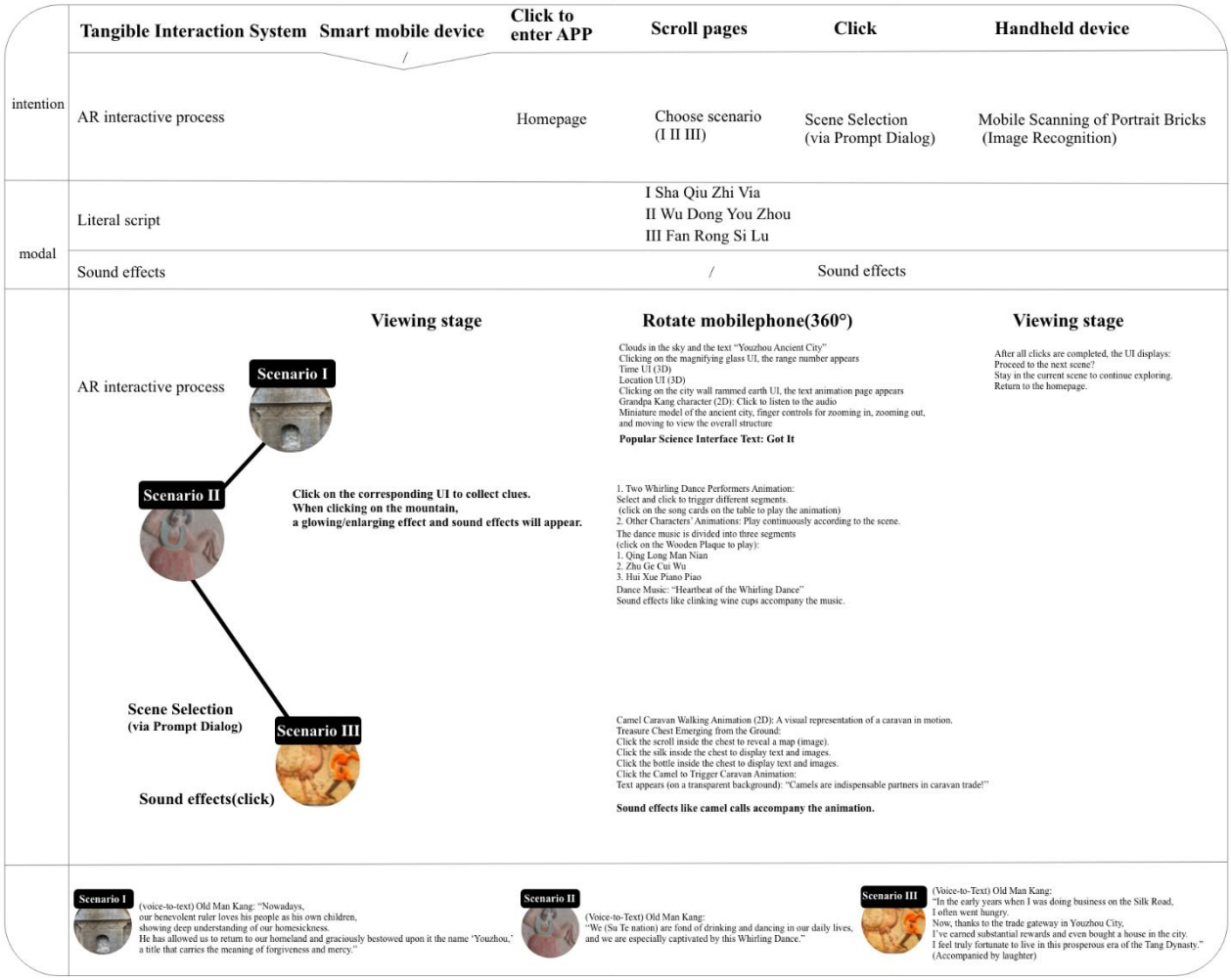

Figure 4. AR Multimodal Script

Make a scene composition analysis table, which covers the key elements and analysis dimensions of the work. Through this table, the advantages and disadvantages of AR scene composition can be systematically analyzed to provide a basis for optimal design, as shown in Table 1.

Table 1. Scene Composition Analysis

Serial Number	Composition Range	Description of Content
1	Foreground Content	Youzhou City miniature model, all UI (3D) tables and chairs, music score cards, trees (3D) treasure chests, porcelain, silk and other trade items, camels (3D)
2	Middle-ground Content	Youzhou City model
3	Background Content	Hu Xuan dance, music performance (2D) ancient Chinese banquet aesthetics (2D) trade transactions and camel caravans (2D)

4.3. Enhancing Visual Images with AR

Information is conveyed through images or dynamic pictures, and the interaction experience is enhanced by combining multiple senses by adding background music, narration, and other elements. Youzhou ancient city has natural advantages in cultural heritage and geographical location. Based on the construction of the cultural content spectrum, representative symbols and graphics are extracted from existing cultural elements such as cultural relics. The visual verification part of the picture includes multiple aspects such as characters, costumes, items, actions, and scenes. The main character "Kang Daddy" was verified based on the Sogdian merchant pottery figurines of the Tang Dynasty, as shown in Figure 5. The main clothing of Sogdian men in the Tang Dynasty included close-fitting long robes with turned-up collars, narrow-sleeved long robes with crossed collars, and close-fitting long robes with round collars, etc. Similar to men, women mainly wore close-fitting long robes with turned-up collars and close-fitting long robes with round collars [6].

Figure 5. Sogdian Merchant Figurine Head (From Shaanxi History Museum)

The movements of the Hu Xuan dance and the music fragments were verified from the segment "Heart Responds to Hu Xuan" in the "National Treasure Concert" of the "Yellow River Water Comes from the Sky" special program of the National Treasure program on CCTV in 2020. The instruments and movements in the characters' performance scene were verified from the Tang Dynasty musical figurines and the Sogdian Anja tomb murals in the museum, as shown in Figure 6.

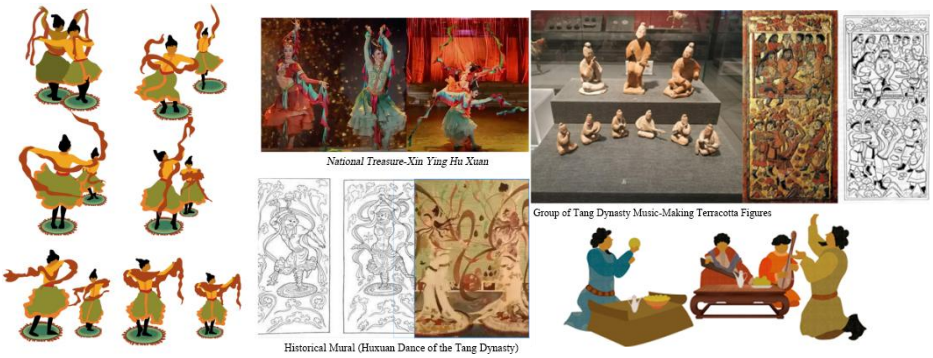

Figure 6. Music and Dance Sequence Artwork Design (Hand-drawn by the Author)

In addition, cultural and tourism promotion is carried out through popular media and platforms such as social media and short video platforms, and the influence and popularity of the Youzhou ancient city ruins are enhanced by holding cultural activities and exhibitions.

4.4. Promoting Embodied Interaction Experience of Users

Embodied cognition holds that cognition does not merely occur in the brain but is formed through bodily perception, movement, and dynamic interaction with the environment. Through AR technology, the embodied cognition patterns in the physical space can be manifested in the virtual space. Maurice Merleau-Ponty's concept of body schema suggests that the body schema is the foundation of human interaction with the environment [7]. It encompasses not only the micro-level

dynamic control and behavioral patterns of the body but also the macro-level forms that organize bodily experiences. This provides crucial theoretical support for the interaction design and application of this work, emphasizing the user's body as the core of interaction and enhancing the user's sense of immersion and participation in the experience process [8].

Different interaction actions and participation behaviors of people constitute the core mechanism of recognition and interaction in AR technology. By capturing and analyzing these behaviors and interaction patterns, AR systems can identify user needs more accurately and provide more immersive and personalized augmented reality experiences. Therefore, when choosing the target audience, it is necessary to ensure the participation of diverse groups from three dimensions: gender, age, and geographical affiliation. In terms of gender, the audience can be divided into female and male; by age, into children, adults, and the elderly; and by geographical affiliation, into locals and non-locals, and Chinese and foreigners. The selection of diverse groups not only helps deepen the understanding of the diversity of the audience but also contributes to the continuous optimization of user experience in AR design.

In this embodied interaction experience, users can interact with characters through AR, view historical sites in Youzhou Ancient City, learn about cultural and historical stories, and experience its "past and present" in an immersive way. By using AR as a medium for cultural transmission, the spiritual core and cultural innovation can be integrated into the multi-dimensional interaction among viewers and creators, building a bridge connecting the past and the present. AR technology enables people to understand the evolution and inheritance of culture intuitively, feel the integration of history and modernity, and thus deeply appreciate the continuity and vitality of culture. Through active participation, users can not only perceive and experience the deep connotations of culture more intuitively but also enhance their sense of identity and belonging in the immersive interaction.

5. SUMMARY

By a careful consideration of the historical value, artistic and cultural value, and functional extension value of the ancient city of Youzhou in combination with the existing problems in the current protection of the ancient city, an AR display interaction design for the ancient city of Youzhou was carried out, which embodies the "deep integration of digital technology, artistic expression and cultural tourism". Through the design methods of narratively reconstructing cultural contents, designing scenario by combining virtual and real scenes, enhancing visual images with AR, and promoting embodied interaction experience of users, the narrative AR-based digital display interaction design work "Feng Hua (Cultural Essence)" of the ancient city of Youzhou transforms the traditional static display into a perceptible, operable and feedbackable digital experience. It not only provides a new practical solution for the digital protection and cultural tourism development of the ancient city of Youzhou, but also offers new ideas for the inheritance and protection of traditional cultural heritage. The multi-dimensional and immersive interaction design can not only precisely meet the emotional demands and cognitive needs of users, but also effectively stimulate their exploration interest and participation enthusiasm. This innovative experience model presents the "incomplete" ancient city heritage in a more intuitive and vivid way, enabling users to deepen their understanding of cultural connotations in the interaction process, thereby imperceptibly enhancing their sense of national cultural identity and pride, and injecting new vitality into the inheritance and promotion of cultural heritage.

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