

An Exploration of Augmented Reality Display Design for Youzhou Ancient City Based on Cognitive-Affective System Theory

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Abstract

A large number of ancient city ruins in China carry profound historical and cultural significance. However, traditional methods of exhibition and touring have become insufficient to attract visitors' interest and fail to ensure effective protection of these heritage sites. Based on the Cognitive-Affective System Theory, this study explores the AR (Augmented Reality) display design of the Youzhou Ancient City ruins. By integrating emotional narrative with cognitive construction, emotional arousal, and interactive participation, the design aims to foster users' identification with traditional culture. The AR-based representation of ancient city ruins offers an effective way for visitors to understand their ethnic identity and build a sense of cultural identity.

Keywords

Ancient City Ruins, AR display, Emotional Narrative, Cultural Identity.

1. Introduction

Amid the vast remnants of the Gobi Desert in northwest China, the rammed-earth walls of the Youzhou Ancient City ruins have withstood the test of time for over a thousand years, standing firm against wind and sand. The site not only serves as a cultural landmark along the Silk Road, but also bears witness to the military strategies of the Central Plains dynasties in their governance of the Western Regions. It carries the historical memories of civilization, frontier defense, and ethnic integration. However, due to its unique geographic and climatic conditions—aridity, sandstorms, and salinization, the site has suffered severe natural erosion, including wind abrasion, sand burial, and soil degradation. The significant temperature difference between day and night further accelerates the weathering of traditional building materials such as rammed earth and adobe. Today, few remains of the ancient city survive, and most artifacts are incomplete or lost, leaving behind only fragmented sections of the city walls. The lack of adequate tourism infrastructure and exhibition systems prevents visitors from fully understanding the cultural significance of the site. As a result, tourists can only rely on imagination to interpret the ruins, which fails to meet their growing aesthetic and spiritual needs.

Driven by the wave of digitalization, the exhibition and dissemination of cultural heritage are undergoing a profound transformation—from the reproduction of knowledge to the evocation of emotional resonance. AR (Augmented Reality) technology, supported by optoelectronic displays, interactive systems, a variety of sensor technologies, computer graphics, and multimedia techniques, integrates computer-generated virtual environments with the user's real-world surroundings. This fusion allows visitors to perceive virtual content as a natural part of their environment, thereby helping to overcome the temporal and spatial limitations of traditional site visits and enabling more vivid and immersive historical storytelling. The Youzhou Ancient City holds significant value for historical research and is supposed to play a greater role in the protection and dissemination of traditional culture. As both a physical space

for tourism and a medium for hosting cultural events and rituals, ancient city ruins serve as important venues and tangible resources for the construction of cultural identity. Cultural identity itself is an emotional experience: individuals develop a sense of belonging by affirming whether they are part of a particular culture, thereby fostering emotional attachment to it. By constructing emotional narratives around the ruins of Youzhou Ancient City and fully utilizing modern information technologies for content display and dissemination, it is possible to offer visitors enriched cognitive and interactive opportunities as well as deeper emotional experiences and resonance, effectively achieving the “revitalized representation” of the ancient city ruins.

2. Cognitive-Affective System Theory

In the 1970s, American psychologist Walter Mischel proposed the Cognitive-Affective System Theory, which posits that situational features activate a set of internal responses that include both cognitive and emotional components. Individuals categorize and encode situational features through both cognitive and affective processes, which in turn lead to subsequent behaviors [1]. The core idea of the theory is that human behavior results from the dynamic interaction of cognitive-affective units within specific situations. These units include encoding strategies, expectancies and beliefs, emotional responses, goals and values, and self-regulatory competencies. The Cognitive-Affective System Theory integrates external situations, individual personality systems, and behavioral outcomes into a unified research framework. It explores the relationship between situational contexts, personality traits, and behavioral motivations, emphasizing that an individual's behavior is influenced not only by external environmental features but also by internally activated cognitive and affective units [2].

According to the Cognitive-Affective System Theory, when individuals are faced with a particular situation, specific patterns of cognitive and emotional characteristics are activated, ultimately determining their behavioral choices. This theory has been widely applied in destination tourism research [3], where the cognitive dimension is associated with the attributes of the destination, and the affective dimension pertains to the emotions that the destination evokes in the individual [4]. The Cognitive-Affective System Theory aligns closely with the social cognition and emotional identification required for traditional cultural identity. The study of ancient city ruin display design can draw upon corresponding analytical dimensions-such as situation, cognition, emotion, and behavior-within this theoretical framework. Therefore, this research adopts the Cognitive-Affective System Theory as its foundation, leveraging emotionally driven narrative scenarios to highlight interactive cognition, interactive emotion, and interactive behavior. It aims to outline a practical pathway for the AR display design of ancient cities, with the goal of enhancing public interest in site visits and increasing the social influence of ancient ruins in the protection and dissemination of traditional culture.

3. Emotional Narrative Design

Emotion is a general term encompassing specific concepts such as feelings, moods, and attitudes [5]. As a fundamental characteristic of the individual, emotion influences instinct, perception, cognition, and social judgment, and significantly impacts various behaviors [6]. According to the Cognitive-Affective System Theory, features of the external environment can activate cognitive and emotional units within the personality system, thereby exerting a profound influence on individual behavioral representations. By drawing on emotional narrative techniques commonly found in literary works-such as scripts, plotlines, character dialogues, and activities-designers can vividly portray characters' experiences and complex emotional worlds. Integrating emotional elements into historical narratives helps to break the

boundaries of time and space, propels the narrative logic through emotional tension, and introduces conflicts, contradictions, and turning points that ultimately elevate historical and cultural themes such as ethnic integration. This approach enables visitors to shift from being passive “observers” to active “participants,” achieving deep resonance between cognition and emotion.

3.1. Emotion-driven Narrative Logic.

Based on historical records, the protagonist of the multimodal narrative script is set as “Old Kang”, born in 690 AD, living through the Wu Zhou period into the Kaiyuan Flourishing Age. As a descendant of the Sogdian Zhaowu Nine Surnames, his ancestors once participated in Kang Daibin’s rebellion during the ninth year of the Kaiyuan era. Due to the turmoil of war, his family transformed into Silk Road merchants, proficient in multiple languages and gifted in mental arithmetic. The story follows his caravan as it journeys through the Hexi Corridor toward Chang’an. Along the way, they encounter cultural conflicts, trade crises, and cross-ethnic cooperation. The narrative begins at the gate of Youzhou Ancient City, where Old Kang, leader of the Sogdian caravan, arrives with his camels. The setting sun dyes the rammed-earth city walls a reddish ochre, soldiers’ armor on the battlements glinting coldly, while the sounds of bargaining between Sogdian traders and Han locals rise and fall outside the gate. Tied to Old Kang’s camel bell is a coin inscribed with a double-moon motif, an Kaiyuan Tongbao from the Tang dynasty. The bell jingles softly with each step, unable to muffle the hesitation in his eyes as he gazes toward the gate. A decade earlier, his caravan was attacked by Tibetan raiders at this very place. A Han friend died protecting him, leaving behind only this coin as a keepsake. His movements betray an internal struggle—yearning to reopen trade routes, yet afraid of awakening painful memories. Just then, the Han gate soldiers begin inspecting the caravan, demanding a Sogdian-language travel pass. Due to an old injury, Old Kang is mute and can only present the coin as a signal. The soldiers misinterpret the gesture as Sogdian provocation, and tension escalates. The officer in charge glimpses the coin’s moon pattern and suddenly recalls his childhood: a Sogdian merchant once used such a coin to exchange for food, saving his starving family during a famine. He halts his men and declares, “This coin reaches Chang’an. Its bearer is no enemy”. The conflict is resolved, and Old Kang is granted entry. At this point, the narrative shifts from “Han-Sogdian opposition” to “cultural empathy”.

Through the characterization of “Old Kang”, the design links individual destiny with the broader historical context, allowing visitors to gain a deeper emotional experience within the virtual historical setting. In the AR interactive scenes, visitors are not merely passive observers but active participants. By engaging in role-playing and task-driven experiences, they can embody various virtual identities such as warriors, merchants, or dancers, and immerse themselves in historical events like escorting supplies or negotiating trade. These actions directly influence narrative branches and outcomes. This narrative mechanism—combining role-play with interactive storytelling—enhances immersion and emotional engagement. The “choice-consequence” feedback loop encourages reflection and empathy, bridging the gap between visitor and history. Key narrative clues and mission checkpoints are embedded to connect the storyline, constructing a multi-dimensional emotional experience that blends virtuality with reality. In terms of emotional expression, the system adopts literary language to evoke atmosphere, for instance, auditory imagery like “the jade flute whispers while the Hu flute resounds aloud” invokes the aesthetic of frontier life. Dialectical dialogue between characters further enhances the authenticity and locality of the narrative. Attention to micro-details such as “the patch on a warrior’s hem” or “the wear on a caravan bell” triggers visitors’ imagination and empathy toward historical circumstances.

Taking novelist Ma Boyong’s *The Lychee of Chang’an* as an example, the story unfolds through the perspective of a low-ranking official, Li Shande, revealing the hardships of the common

people and the corruption of the bureaucracy hidden beneath the surface prosperity of the Tang Dynasty. The novel frequently references historical government offices such as the Shanglin Bureau, the Imperial Food Bureau, and the Temple of Agriculture, demonstrating the author's skillful integration of historical authenticity and fictional narrative. Time and space are intricately woven together like warp and weft, with the lychee serving as a narrative thread that tightly connects all aspects of society into an interlinked web. This evokes a powerful sense of how a single event can ripple across the entire system. The interweaving of temporal and spatial dimensions lends the narrative a profound aesthetic tension, while the characters' trajectories become silent monologues within this tightly knit grid, projecting individual emotions and struggles against the grand backdrop of history [7].

3.2. Emotion-shaped Narrative Depth.

Referring to the narrative logic of "movement and gaze" in the dance drama Zhang Qian, the emotional thread of nostalgia can be set for the Sogdian caravan leader "Old Kang". Forced to stay in Youzhou for ten years due to war, he marries a Han woman and has children but continues to long for the vineyards of Samarkand. Through symbols such as the Persian silver pot he carries (engraved with his hometown's totem) and the solo performance of the Hu Jia tune late at night, the feeling of loneliness as a "foreigner" is intensified.

Using the caravan trade route as a link, a subplot can be designed around the collision of Han and Hu cultures. For example, the Han frontier soldier Li Shu and the Sogdian dancer Aisha meet through the Silk Road trade. The two cross the language barrier through gestures and music, ultimately collaborating to restore the lost Hu Xuan Ni Chang dance and music, symbolizing the Silk Road spirit of "harmony in diversity". A key object—a "Kaiyuan Tongbao" ancient coin—serves as a clue to connect the fates of different characters. Old Kang leads his caravan to Youzhou, using this coin to trade with a Han tea merchant for a pass. The double crescent pattern on the coin reminds him of the starry sky of Samarkand, while the Han merchant admires it, saying, "This moon resembles the Qujiang in Chang'an". After the An Lushan Rebellion, in order to protect the trade route, Old Kang melts the coin into a camel bell and hides it in a poplar tree hollow outside Youzhou. The double crescent pattern (Persian new moon and Han crescent moon) becomes a microcosm of Old Kang's dual identity—he carries the mission of a Sogdian merchant but also has deep-rooted emotional ties to the Central Plains through his Han friends. This conflict adds depth to his character [8]. These "scene stories", derived from historical facts, show visitors the mutual understanding, respect, and tolerance between different ethnic groups. This not only enriches the emotional narrative of the work but also gives it a deeper charm and broader space [9]. The dialogues and shared trade activities between characters of different ethnicities foster emotional connections. Visitors can immerse themselves in the experience, live through the process of interaction, and feel the warmth, beauty, and diversity of their exchanges.

3.3. Emotion-sublimed Cultural Theme.

In the city gate scene, the sounds of camel bells, the bustling market, and the drill of frontier soldiers intertwine. As Old Kang closes his eyes and listens, he suddenly hears the Sogdian folk song once hummed by his friend. The layering of realistic and surreal sound effects elevates personal sorrow into the collective memory of "displacement and return" along the Silk Road. The coin in his hand, passed through countless transactions, is eventually discovered at the modern Youzhou ancient city ruins, triggering the AR scene narrative. This helps visitors understand its "past and present", forming an emotional loop of "individual-epoch-heritage". Emotion is evoked through the scene, using visual symbols like the sunset on the city wall and the weathered camel bell to create a sense of historical wear and tear, allowing the audience to directly perceive Old Kang's sadness and mission.

It is a feasible principle that emotion is carried by objects. Due to the large number of “Kaiyuan Tongbao” ancient coins preserved at the Youzhou ancient city ruins, these coins serve as a consistent imagery, acting both as a vessel for personal memory and as a cultural medium for ethnic fusion. The city gate scene of Old Kang proves that emotion is not merely a decorative element of the narrative but the core engine that drives the plot and deepens the theme. Through symbolic details and cross-temporal metaphors, individual experiences are elevated into collective cultural memory, achieving a resonance between “lyricism” and “epic” [8]. These emotionally charged scenes allow visitors to hear the “voices” of different ethnic peoples on the grasslands, transcending time and space. This also gives visitors a more intuitive and in-depth understanding of the role that the Youzhou ancient city played in the interactions between diverse ethnicities along the Silk Road.

4. Specific Applications of AR Technology in Emotional Narrative Design

According to the Cognitive-Affective System Theory, external contextual interventions stimulate individuals to generate both rational cognitive responses and emotional impulses, ultimately influencing their behavioral choices, thus constructing a multi-level parallel framework of cognition, emotion, and behavior. With the application of emotional narrative and AR technology, visitors’ historical cognition and cultural emotional resonance with the Youzhou ancient city ruins can be activated, thereby achieving an immersive experience and interactive participation.

4.1. Cognitive Level: Building a Cognitive Bridge Between the Ancient City Ruins and the Visitors’ Appreciation.

Cognitive processing is an important part of the cognitive-affective processing unit, referring to the process through which individuals acquire, store, retrieve, and process information. Thinking, reasoning, perception, imagination, and memory are all part of the cognitive process [10]. Through multimodal interaction and contextualized storytelling, abstract historical information about the Youzhou ancient city can be transformed into perceptible and understandable cognitive schemas. Moreover, by encoding visual, auditory, tactile, olfactory, and proprioceptive stimuli, the connection between visitors and the ancient city is strengthened during their experience, enhancing their cognitive impact. Environmental psychology research suggests that, in a certain environment, immersive sensory experiences can influence both emotion and cognition [11].

In terms of visual encoding, 3D modeling is used to recreate the ancient city walls, marketplace streets, and both Eastern and Western caravans. AR tag UIs and 2D animations are then overlaid at corresponding locations to provide informational content, such as the advantages of the rammed earth walls, the uses of various items, etc. Virtual reconstructions of complete city gate structures are superimposed on the remains of the walls, with translucent materials distinguishing the physical and digital restoration parts. For example, the Youzhou ancient city walls contain enemy platforms, corner towers, and gate towers, and the existing walls were also built with rammed earth, preserving a moat as well. The rammed earth used for construction was typically local yellow soil and lime. The soil was placed between two wooden planks and tamped down with a pestle to become solid, a technique that dates back to the Shang Dynasty. The rammed earth walls constructed in this way are thick and solid, providing strong resistance to impact. See Figure 1.

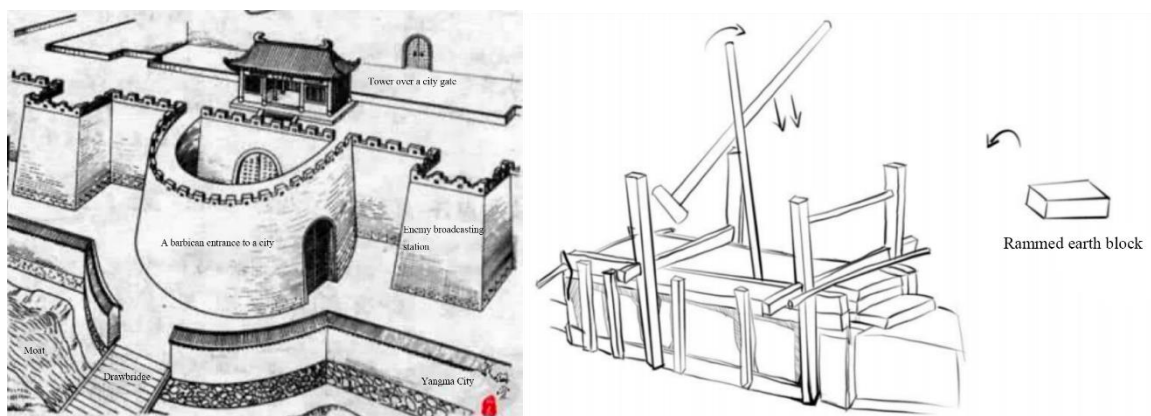


Fig. 1 Tang Dynasty local ancient city wall and rammed earth preparation process

In terms of auditory encoding, sound effects and background sounds (such as camel bell sounds, market vendors calling, labor sounds, etc.) are set for each scene. Appropriate environmental sounds from the surrounding ruins (such as wind, river, and bird sounds) are added, and dynamic soundscape adaptation is achieved through AR positioning technology. For example, when visitors approach the moat ruins, the sound of flowing water is triggered; when they approach the city wall gate ruins, crowd conversation sounds are added. Dynamic sound source tracking is incorporated, using SLAM spatial positioning technology to create moving sound effects for sound objects (such as virtual caravans). As visitors walk and watch with AR, the camel bell sounds from the caravan will change dynamically from far and near. This design draws on the soundscape experience design and virtual-real fusion technology used in the ancient city of Pompeii, where musical notes, a highly design-oriented element, create a unique audiovisual experience. In this design, interactive methods of sound, people, and buildings are used, ensuring the music closely aligns with the historical and cultural connotations of the Youzhou ancient city ruins. By integrating AR technology and introducing emotionally resonant design, these interactive sound playback and loops evoke emotional resonance in visitors, allowing them to gain a deeper understanding and experience of the historical value of the ancient city ruins.

Regarding tactile encoding, on one hand, the vibration and gravity sensing functions of mobile devices can simulate action feedback (such as the pounding process of rammed earth wall construction or the feeling of weight when picking up music and dance score plaques), strengthening the association with muscle memory.

Ancient city cultural heritage sites are not only tourist attractions for pure entertainment and viewing, but also places where people can learn and experience history. Providing a more relaxed, leisurely, and free way of learning and cognition is often more adaptable to the diverse needs of visitors. First, it must be able to attract visitors, and then convey knowledge in a more accessible and understandable way, allowing them to engage in a deeper experience. This approach enhances learning efficiency and improves the effectiveness of cultural heritage dissemination in ancient city sites.

4.2. Emotional Level: Expanding the Emotional Depth Between the Ancient City Ruins and the Visitors' Experience.

Emotional processing is another important part of the cognitive-affective unit, referring to the process in which individuals produce corresponding emotional responses after encoding and interpreting situational information [10]. The cognitive-affective systems theory also suggests that emotions stem from the evaluation of the surrounding environment, meaning that individuals' processing of external social information has the function of emotional arousal [12]. Numerous studies have shown that emotions can explain a large number of individual differences in cognition and behavior, and in some cases, emotions provide even stronger

explanatory power than cognition [13]. Human emotional experiences can lead to cognitive output. The Theory of Emotional Events also emphasizes the significant correlation between emotional events, emotional responses, and attitudes and behaviors [14].

In tourism scenarios, physical elements directly impact the sensory experience of visitors. The involvement of multiple senses enhances visitors' experiences, allowing them to obtain rich and authentic travel experiences, the importance of which is self-evident. On the one hand, the ancient city ruins serve as the space for tourism, a place for preserving and inheriting traditional historical culture, and they are an important stimulus for constructing the memory of traditional culture; on the other hand, the ancient city ruins are a practical space for the performance of traditional cultural activities and rituals. These traditional cultural activities and ritual performances, awaken the deep cultural consciousness within the audience through common symbolic signs and cultural narratives. Modern media methods for spreading these traditional cultural activities and rituals allow the emotional experience to transcend the limitations of time and space, resonating with a wider audience. Therefore, the ancient city ruins, as the physical medium for traditional cultural activities and ritual performances, are endowed with rich symbolic meanings and spiritual values in the process of ritual performance and media transmission. They serve as an "emotional field" for traditional cultural education and the cultivation of cultural identity.

Based on this, the AR display design of the Youzhou Ancient City ruins should emphasize the core role of emotion in the visitors' experience. First, sensory elements such as audiovisual stimuli should be used to evoke the visitors' first impressions, forming an intuitive emotional connection to the ruins. Visual immersion should be employed to achieve dynamic scene reproduction and virtual artifact display, while the auditory atmosphere is supposed to feature a unique AR soundscape system, incorporating character dialogues and music blending Han and Hu cultures. This enhances the sense of realism and visual appeal of the scene, creating an intuitive resonance between sensory stimulation and historical scenes, thereby prompting visitors to engage in deeper reflection on the value of the ancient city ruins.

In the design, attention should be paid to empathizing with visitors, integrating the historical characteristics of the Youzhou Ancient City, life stories, and emotional experiences, while stimulating visitors' interaction and engagement. This also involves awakening the core cultural, semantic, and emotional aspects, which can create long-lasting emotional projection, making the AR experience process rich with "emotion" [15]. By overlaying historical events of Youzhou with emotional narratives of characters and cultural integration in different scenes, the design aims to convey these abstract and hidden spiritual meanings to visitors, stimulating their emotional identification and proactive thinking. This, in turn, helps establish cultural confidence, forming a resonance between individual and collective memories, and enhancing empathy. At the same time, tracking visitors' emotional responses and distinguishing and studying the various emotional concepts generated during their emotional response process can help identify which emotional design elements and implementation methods effectively trigger different emotional reactions and attract visitor participation. This knowledge will contribute to better improving the AR-based emotional narrative design for ancient city ruins.

4.3. Behavioral Level: Creating an Interactive Platform Between the Ancient City Ruins and Visitor Participation

The AR exhibition design of the ancient city ruins should not only reflect the basic attributes of traditional tourist attractions—atmosphere, sense of occasion, evocation, and emotion—but also achieve interaction and participatory behavior between the ancient city ruins and the visitors.

At the behavioral level, interactive tasks and feedback allow visitors to deepen their understanding and emotional engagement with the ruins through active participation, creating

a deep connection between interactive participation and historical exploration. Currently, the remaining relics of Youzhou Ancient City are few, and relying solely on text and video introductions is not efficient, fast, or accurate enough to convey precise information to visitors of all age groups. Therefore, to improve the efficiency and methods of disseminating the historical and cultural significance of the ancient city ruins, it is necessary to present the information in a way that visitors can better accept and understand, such as adding task-driven exploration, dynamic feedback and reward systems, online platform sharing, and offline physical item exchanges. Visitors can perform these tasks themselves on the application, and through innovative design, trigger feelings of pleasure and novelty, creating an emotionally engaging viewing experience. This approach will give visitors the psychological satisfaction of wanting to return while also enabling the development of multi-pathways for the participation, practicality, and aesthetic dissemination of the ancient city cultural heritage.

The ultimate goal of the ancient city ruins' reconstruction design is to expand the cultural influence, enhance collective creativity, and transform cognition and emotion into preservation behavior through task incentives and social sharing. From the perspective of Actor-Network Theory, the activation of cultural heritage is a dynamic process involving the collective participation of community stakeholders. Relevant organizations could make full use of the media characteristics of AR technology to build a cross-subject collaborative narrative platform. By establishing an AR-based interactive narrative network, real-time collaboration among diverse actors (such as cultural institutions, technology developers, community representatives, etc.) can be promoted, transforming traditional one-way narratives into a participatory co-creation process. Establishing an experience-sharing mechanism allows each participant to contribute professional knowledge, share personal insights, and collaboratively construct a multi-dimensional narrative system [16].

Community participation is an important component in the current dissemination and management of ancient city cultural heritage. Enhancing the participation and connection of different community visitors can deepen their connection with historical heritage [17]. For example, the ancient city of Petra in Jordan launched the “#MyPetraStory” campaign, inviting visitors and Bedouin natives to share personal stories and historical legends related to the site on Instagram. Bedouin guides transformed traditional oral narratives into short videos, and young visitors used AI tools to generate creative content in “Ancient Nabatean script”. The campaign accumulated 500,000 submissions, and the Petra authority integrated the selected content into an online digital exhibition. Social media was used to activate citizen creation, building a multi-dimensional narrative network for the heritage site. Through active participation, sharing written and video posts, visitors realized the re-creation and re-dissemination of the ancient city's cultural heritage.

5. Summary

In the context of globalization, cultural exchange is becoming increasingly frequent, and people's existing cultural concepts are being challenged. Focusing on the dynamic formation and construction mechanisms of traditional cultural identity in different contexts, as well as exploring diverse pathways for the inheritance and transmission of traditional culture, is particularly important. Traditional culture relies on certain material carriers, and scenes, as a combination of hard elements such as places and objects, as well as related soft elements such as space and atmosphere, often represent traditional culture through structural arrangements and plot design. Visitors interacting with scene elements can awaken past cultural memories, stimulate emotions, and form their understanding of traditional culture during their “first experience” or “re-experience” of past historical events. As a landscape with distinct visual characteristics, ancient city ruins significantly stimulate and awaken visitors' cognition and

emotions during the tourism experience. A carefully designed and laid-out emotional narrative can serve as a “container” for preserving and displaying traditional culture, providing a foundation for cultural identity.

On one hand, through the display design, visitors who lack direct historical experience are introduced to national history and traditional cultural education during the ancient city ruins tour, allowing the cognition and emotions conveyed by these cultural elements to influence their values. On the other hand, cultural identity is constructed through emotional awakening, reflecting the “emotional turn” in the construction of cultural identity, emphasizing the connection between ethnic emotions and individual emotions through spatial display of the ancient city ruins and related cognitive and personal experiences. By relying on emotional narrative, cognitive construction, emotional awakening, and interactive participation, the AR exhibition design of Youzhou Ancient City not only enables visitors to form a traditional cultural identity, but also provides an exemplary approach for the “revitalized representation” of ancient city ruins as well as the protection and inheritance of traditional culture.

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