# Constructing Tourism and Protection of Ancient Architectural Communities Using Extended Reality (XR) Systems

## Case Study with Miao Stilted Buildings

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**ABSTRACT**

The preservation of ancient architectural communities, such as the Miao ethnic group's stilted buildings, faces significant challenges due to rapid urbanization and changing societal needs. Traditional methods for disseminating historical and cultural knowledge often fail to engage the public deeply, limiting their understanding and appreciation of this heritage. This study introduces an Extended Reality (XR) system, integrating Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) technologies, to create a more immersive and interactive experience of ancient architectural sites. The system enables users to explore the historical evolution, architectural styles, and cultural significance of these sites through a multi-dimensional approach, thus fostering a deeper appreciation of their heritage value. By seamlessly blending digital content with physical environments, the XR system offers unique interactive experiences that enhance both heritage preservation and tourism development. This research develops and evaluates a novel XR-based model for tourism and cultural preservation, providing valuable insights into how digital technologies can support sustainable heritage management.

***Keywords:*** *Extended reality, Interaction, Architecture.*

## 1. INTRODUCTION

Extended Reality (XR), encompassing Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), has emerged as a transformative tool for enhancing the preservation and appreciation of cultural heritage sites. XR technologies enable users to immerse themselves in digitally recreated environments, offering deeper exploration of historical and architectural details that may be inaccessible through traditional methods (Bekele et al., 2018). This capability is especially pertinent to the preservation and promotion of ancient architectural communities, as it effectively bridges the gap between physical sites and digital storytelling, making rich cultural histories available to a broader audience (Guttentag, 2010). The rapid advancements in XR technologies promise to revolutionize cultural tourism, providing interactive and engaging experiences that foster a deeper understanding and appreciation of heritage sites (Chung, Han, & Joun, 2015).

However, integrating XR into heritage preservation presents several challenges. A primary issue is maintaining a balance between digital enhancements and the preservation of the site's authenticity, ensuring that XR experiences remain true to the original cultural and historical context (ICOMOS, 1964). Traditional methods of engaging visitors—such as static displays and simple models—often fail to capture the complexity and nuances of these sites, offering limited immersion and engagement (Vlahakis et al., 2002). There is a critical need for designing XR systems that not only offer virtual tours but also enable deeper interaction with cultural narratives and architectural details, going beyond the limitations of traditional tourism (Chung et al., 2015). These challenges are particularly relevant to the Miao stilted buildings, which hold considerable cultural significance but

face the risk of being underrepresented in modern tourism due to the constraints of current preservation approaches.

Existing research has explored various applications of VR and AR in virtual tourism and heritage preservation. Digital reconstructions, such as those of Notre Dame Cathedral, have shown how VR can offer access to architectural wonders that are no longer physically accessible (Guttentag, 2010). Similarly, AR has been successfully used to overlay historical information on physical sites, enriching on-site experiences with context-specific digital annotations (Chi et al., 2013). These efforts have made significant progress in making heritage sites more accessible and engaging, yet they often treat VR and AR as separate applications rather than integrating them into a cohesive XR experience. Additionally, these studies frequently overlook the unique challenges of adapting these technologies to culturally specific contexts, such as the Miao stilted houses. This research aims to address these gaps by developing an XR system that integrates VR, AR, and MR into a seamless, immersive experience tailored to the preservation needs of ancient architectural communities, offering a more holistic approach to cultural preservation and tourism.

This paper presents a multi-dimensional approach to using XR technologies for preserving and promoting ancient architectural communities, focusing specifically on Miao stilted buildings. It details the development of a customized XR system, including its hardware, software, user interaction design, content management, and network integration. Through field investigations, user interviews, and comparative testing, this study assesses the effectiveness of the XR system in enhancing user engagement, preserving cultural authenticity, and supporting sustainable tourism.

## 2. BACKGROUND

The preservation of historical architecture in China, encompassing over 67,200 historical buildings, 142 famous historical cities, 312 historical towns, 487 historical villages, and more than 8,000 traditional Chinese villages, is a crucial part of maintaining the country's cultural heritage. This aligns with existing research emphasizing the role of built heritage in shaping cultural identity and collective memory (Pendlebury, 2013; Lowenthal, 1998). However, similar to global trends observed in heritage conservation, China faces challenges due to rapid urbanization. The increasing use of modern construction methods like reinforced concrete threatens the preservation of traditional architectural techniques and materials, a challenge noted in studies of heritage conservation amid modernization. This tension between conservation and development has led scholars to call for innovative approaches that integrate preservation with contemporary uses, particularly in tourism and education (Smith, 2006). Such approaches aim to maintain the historical integrity of heritage sites while adapting them to meet the needs of modern audiences.

Stilted houses, a unique architectural style prevalent among ethnic groups such as the Miao, Dong, and Tujia in regions like western Hunan, southeastern Guizhou, and western Hubei, offer a pertinent example of this preservation challenge. Research on indigenous architecture has highlighted the cultural and environmental adaptations inherent in such structures, such as their design for ventilation, moisture control, and protection from wildlife (Oliver, 2006). The adaptation of these traditional structures with modern materials reflects broader trends in cultural adaptation and continuity seen in vernacular architecture studies (Rapoport, 1969). Moreover, the symbolic elements of stilted houses, such as the use of sacred maple wood by the Miao people for central pillars, align with studies on the spiritual significance of architectural features in indigenous cultures (Lawrence & Low, 1990). This cultural symbolism reinforces their value not just as physical structures but as embodiments of intangible heritage, underscoring the importance of targeted preservation efforts that respect both their practical and spiritual dimensions.

## 3. RELATED WORK

### *3.1 Current Applications of XR Technology in Cultural Heritage Preservation*

Extended Reality (XR), encompassing Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), has become a pivotal tool in preserving cultural heritage and enriching tourism experiences. VR has been used to create immersive 3D reconstructions of historical sites, allowing users to explore detailed models remotely (Guttentag, 2010). This method enhances access to intricate architectural features, making cultural heritage more engaging for audiences. However, its primary focus on virtual environments can limit

real-time interaction with physical heritage locations, presenting a gap in contextual engagement during on-site visits (Bekele et al., 2018).

AR has proven effective in supplementing physical tours with digital information, overlaying historical data directly onto real-world environments. For example, Chi, Kang, and Wang (2013) explored how AR can provide tourists with real-time information about cultural sites, improving their understanding and engagement. This allows users to experience a seamless blend of digital storytelling and physical exploration. However, while AR enhances in-situ experiences, it often lacks the depth and immersion provided by VR, particularly for users who cannot visit heritage sites in person.

MR combines the strengths of both VR and AR, offering a more integrated approach to cultural heritage experiences. It allows for the blending of virtual elements with physical settings, making it possible to visualize the past in current landscapes (Vlahakis et al., 2002). Despite its potential, MR adoption is limited by high implementation costs and technical challenges, especially in smaller or underfunded heritage sites (Bekele & Champion, 2019). The need for a comprehensive approach that integrates these XR technologies remains largely unaddressed, particularly for unique architectural contexts such as Miao stilted buildings.

### *3.2 Theoretical Foundations for XR System Design*

The design of an XR system for heritage preservation is guided by multiple theoretical frameworks to ensure both cultural integrity and user engagement. Cultural Heritage Conservation Theory, particularly the principles outlined in the Venice Charter (ICOMOS, 1964), emphasizes the need to maintain the authenticity and integrity of historical sites. This framework informs the digital replication of Miao stilted houses, ensuring that the virtual models respect the original materials and architectural styles, thus preserving the site's cultural value while making it accessible through XR.

Experience Design Theory is crucial for creating user-centered, meaningful interactions within XR environments. Norman (2004) emphasizes the importance of designing experiences that resonate with users emotionally and intellectually. In applying this theory, the XR system aims to create intuitive interfaces and interactive elements that allow users to explore cultural heritage in a more engaging and immersive manner. This enhances the user experience beyond passive observation, enabling deeper interaction with both virtual reconstructions and physical contexts of heritage sites.

Educational Technology Theory and Interdisciplinary Integration Theory further strengthen the XR system's design. Educational theories such as constructivism suggest that learning is more effective when individuals actively engage with their environment (Vygotsky, 1978). By leveraging the interactive and multisensory capabilities of XR, users can construct their understanding of cultural heritage through immersive exploration. Interdisciplinary Integration Theory supports the collaboration of digital technology, cultural studies, and design, ensuring that the XR system is adaptable to diverse cultural sites while providing educational value.

### *3.3 Incorporating "Phygital" Concepts*

Building on recent advancements in "phygital" spaces, which combine physical and digital elements to create immersive environments, the XR system can address the conservation challenges of Miao stilted houses by reducing physical intervention (Lo et al, 2024). The principles of "Phygital Workspace" suggest that XR not only conserves the tangible aspects of heritage sites but also offers a sustainable method to engage users without overloading physical spaces. This aligns with the goal of enhancing preservation by minimizing direct physical contact while providing immersive, educational experiences.

Furthermore, the concept of "Phygital Recycling," which gamifies user engagement to encourage active participation, can serve as a model for increasing engagement in cultural heritage preservation (Lo & Bao, 2024). By enabling remote engagement with cultural heritage through XR, the system may lower tourism's environmental impact, especially for ecologically sensitive heritage sites. Additionally, the inclusion of interactive elements, such as task-based exploration that encourages users to uncover architectural details and cultural symbolism, would deepen user engagement, aligning with both conservation and educational objectives.

# 4. RESEARCH METHODS

## *4.1 Methodology*

This study uses the Miao ethnic group's stilted houses as a case study to develop a multi-dimensional tourism model that enhances the preservation of ancient architectural communities through virtual reality (VR) technologies. The research aims to address the limitations of current preservation methods by integrating advanced digital tools. The methodology comprises five key components: literature review, field investigation, user interviews, survey questionnaires, and AB testing. Each method contributes to a comprehensive understanding of the challenges and opportunities in using VR for heritage conservation.

## *4.2 Literature Review*

The initial phase of the study involves an in-depth analysis of existing literature in three primary areas. First, it reviews scholarly work on the preservation of historical buildings and architectural communities, focusing on the current practices, strengths, and limitations of existing protection methods. Second, it examines research on the architectural features and historical development of Miao stilted houses, providing insights into their cultural significance. Third, the review explores the latest advancements in VR technology and its application in heritage preservation, establishing a foundation for integrating VR with the protection of ancient architectural communities.

## *4.3 Field Investigation*

Building on the theoretical framework, the study conducts field investigations to examine the structural characteristics, historical context, and current preservation status of Miao stilted houses. On-site inspections verify the findings from the literature review and provide real-world insights into the architectural and cultural heritage of the sites. This process involves recording detailed images and videos of the stilted houses, which are then used for developing VR models and scenarios. These recordings serve as a basis for creating a realistic and immersive VR experience that reflects the cultural richness of the Miao stilted house communities.

## *4.4 User Interviews*

To gain a comprehensive understanding of stakeholders' perspectives, semi-structured interviews are conducted with a diverse range of participants, including residents, merchants, law enforcement officers, tourists, and tour guides. These interviews aim to capture their perceptions of current tourism practices and their openness to integrating VR into the heritage tourism experience. The insights gathered from these discussions inform the design of the VR system and help identify potential challenges and opportunities in user acceptance. The interview data also provide valuable input for developing targeted survey questionnaires.

## *4.5 Survey Questionnaires*

Quantitative data collection is conducted through structured surveys designed to assess the effectiveness of integrating VR technologies into heritage tourism. The survey captures participants' attitudes toward VR-based tourism, their knowledge retention of cultural heritage, and their overall satisfaction with the experience. The data provide statistical support for evaluating the feasibility and impact of the proposed VR-enhanced tourism model, offering a clear picture of user preferences and potential areas for improvement.

## *4.6 AB Testing*

To assess the effectiveness of the proposed VR tourism model, AB testing is employed to compare traditional tourism methods with the new VR-based approach. Participants are exposed to both the conventional and VR-enhanced experiences, and their responses are evaluated in terms of satisfaction, knowledge retention of the cultural heritage, and willingness to recommend the experience to others. Additionally, the impact of both approaches on the local community, including residents' satisfaction and acceptance, is measured. The results of the AB testing provide empirical evidence of the benefits and challenges of implementing VR in heritage.

# 5. CONCLUSION

This study has unveiled the transformative potential of Extended Reality (XR) technologies—comprising Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) — in

addressing the critical challenges that ancient architectural communities face in the context of rapid urbanization and evolving societal needs. The traditional methods of disseminating historical and cultural knowledge, often characterized by passive learning and static representations, have proven insufficient in engaging the public on a deeper level. This limitation has hindered the broader appreciation and preservation of valuable cultural heritage. the integration of XR technologies represents a promising pathway for the preservation and promotion of ancient architectural communities. It addresses the challenges posed by urbanization and societal change by offering a dynamic and engaging platform for exploring historical and cultural heritage. This research not only advances the field of cultural preservation but also highlights the potential of digital innovations in fostering a deeper connection between the past and the future. As we move forward, the continued development and application of XR systems will be crucial in ensuring that our cultural heritage remains vibrant and accessible for generations to come.

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