Incorporating Virtual and Augmented Reality Technology into Cultural Architecture to Enhance Tourist Experiences in China

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Abstract. Cultural tourism is a significant economic and social contributor. A growing body of research is focusing on the application of virtual reality (VR) and augmented reality (AR) in cultural architecture. While previous studies suggest that VR and AR have the potential to enhance the design of architecture and visitor experience, they often fail to address how these technologies can be tailored to specific cultural contexts or how they can add value to architectural design. This study, conducted in China, use Activity Theory as a framework to understand factors influencing design of cultural architecture and tourist experience, with a particular emphasis on the roles of VR and AR technology. It contributes to the fields of cultural tourism by exploring how the new engaging technologies can facilitate architecture and enrich visitor experiences. Furthermore, the study highlights the need for further research into the purpose-driven development of VR and AR technologies, particularly in the context of China's rich cultural heritage and related architectural design.

Keywords: Cultural Architecture, AR and VR, Tourist Experiences, Heritage in China

1 Introduction

The surge in cultural tourism in China has largely been fueled by tourists seeking cultural awareness through meaning-creation [1]. This trend has prompted many cultural tourist attractions to explore innovative ways to enhance their on-site offerings, aiming to enhance architectural design and amplify tourists' engagement. Among the factors, self-motivated learning has emerged as a crucial factor driving tourists to immerse themselves in cultural activities, highlighting the potential for various tools to enhance architectural design of heritage. For example, traditional audio guides have long played a significant role in helping visitors to understand the historical background in the tourist place [2].

As technology continues to evolve, a growing number of studies are examining the benefits of augmented reality (AR) and virtual reality (VR) applications in the context of cultural tourism. These technologies hold promise in reshaping the visitor experi-

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ence by providing immersive and interactive ways to engage with cultural heritage [3]. Using AR and VR, tourist sites can offer unique and personalized learning opportunities, making cultural tourism even more compelling and accessible. This shift underscores the need for ongoing research and development to fully realize the potential of these technologies in enhancing architectural design and visitor experiences [4]. However, there is a lack of research in China to examine how these technologies are applied and what impacts they have on cultural architecture.

2 The Framework of Activity Theory and Correlates of Design

Activity Theory (AT) provides a robust framework for both researching and designing interactive technologies. Beginning with the works of Susan Bødker in the late 1980s, AT began to garner attention within the Human-Computer Interaction (HCI) community, particularly as efforts were made to move beyond the cognitive paradigm [5]. Among various psychological theories, AT is recognized as a powerful framework because it delves into the interactions between users and tools. This makes it highly effective for studying technology within the context of human activities [6].

According to Activity Theory, human activity is conceptualized as a form of action performed by an individual with the aim of achieving a desired outcome that fulfills certain needs. This interaction between the individual and the desired outcome can be mediated by a tool, which can be a physical artifact or an intangible entity such as ideas and procedures [2]. The tool, as a mediator, plays a dual role: it empowers the individual by enabling them to achieve the desired outcome but also constrains the interaction to the specific perspective of that tool [5]. For instance, technology can make activities possible that would otherwise be impractical or infeasible. It can also facilitate activities that would otherwise be impossible to achieve.

The rising interest in the tourist experience has prompted researchers to explore the fundamental elements that shape and define these experiences. In addition to the physical environment of heritage sites or destinations, a range of factors have been identified as antecedents of tourist experiences [1]. For example, one crucial element is attention, which involves focusing mental resources on stimuli deemed significant in the environment. Another important factor is involvement, reflecting a visitor's interest and personal connection to the offerings at a site [1]. In recent years, there has been an increasing recognition of the role of emotions in shaping tourist experiences and making them memorable [4]. Research has shown that emotional connections can significantly enhance learning and information retention within the context of cultural tourism [2]. Active engagement by visitors has also been highlighted as a critical factor that contributes to better retention of information, underscoring the importance of creating emotionally resonant experiences for tourists.

In recent years, numerous cultural tourism sites, including art galleries, museums, and heritage locations, have begun to embrace augmented reality (AR) and virtual reality (VR) technologies to enhance the visitor experience. These innovations include virtual reconstructions of historical sites and events, interactive content in museums, and virtual tours of remote destinations. Initially, many AR and VR initiatives started

as research or pilot projects [7]. However, a growing number have evolved into successful, commercial ventures. Cultural heritage sites are adopting varied strategies to integrate AR and VR into their offerings.

3 Artifacts Ecology

The research examined the concept of "artifacts ecology," which refers to the diverse range of artifacts present within a museum. Rather than analyzing a single technology in isolation, it is essential to explore how individuals engage with various technologies that serve distinct functions or share overlapping capabilities [6]. This approach is particularly relevant in the cultural tourism context, where different interpretative tools have been developed over time, and the way visitors utilize these tools significantly shapes their experience [7].

For example, at the Ara Pacis Museum, this ecology comprises the monument itself, along with various busts and sculptures that make up the museum's collection. Additionally, it includes interpretative tools such as scale models, informative panels, video screens, and augmented reality (AR) and virtual reality (VR) technologies [8]. The development of this ecology has been gradual, with new technologies often adding to rather than completely replacing existing tools and practices. This layered evolution of technology is exemplified in the Ara Pacis Museum, where the new "Ara as it was" tour is integrated within the museum's established context, using traditional resources like panels to enhance visitor understanding [9].

Study on museum visitors, found that many visitors preferred to read the informative panels after completing the tour to gain deeper insights into the monument and the museum [2]. This illustrates that AR and VR technologies are not intended to supplant traditional interpretative tools; instead, they should be seamlessly integrated into the museum experience as well as the architectural design.

4 Methods and Results

The characteristics and performance of various surveying technologies, including TLS, TDP, and UAVDP, differ, resulting in data that covers and encompasses different landscape elements or parts thereof. This study integrates UAVDP, TDP, and TLS techniques. Since data from different sources require a unified coordinate system for fusion, the UAVDP measurement data has been corrected to the geodetic coordinate system. Consequently, this section focuses on precisely aligning the TDP and TLS point cloud models to the geodetic coordinates for seamless integration.

The ground control points obtained from the data acquisition part are manually precisely located in the TLS point cloud one by one, totaling 7 ground control points. Using the “feature point alignment” function in the software Geomagic Studio, the TLS point cloud with the ground control points located is initially aligned to the UAVDP point cloud with corresponding ground control points. The alignment relationship follows the Bursa transformation model.

To improve the precision and accuracy of TLS and UAVDP point cloud model fusion, this study utilizes the global registration function in the software Geomagic Studio, combined with high-precision fitting, to finely align the preliminary TLS and UAVDP point cloud models, minimizing the alignment deviation between the two and achieving a more accurate alignment result. The algorithm follows the Iterative Closest Point (ICP) method. Table 1 shows the type of tourist places analyzed in this study.

Table 1. Summary of Type of Tourist Places (N = 37)

Types	N (%)
Museum	12
Archaeological Site	3
Heritage Site	11
Historical Centre	6
Others	5

The following table 2 shows the errors of georeferencing of point cloud from TLS for a traditional garden.

Table 2. Errors of georeferencing of point cloud from TLS for a traditional garden

GCP	Source			Target		
	X	Y	Z	X	Y	Z
GCP 18	-5.3289	-5.3289	-0.9320	551232.3412	346578.2892	5.1022
GCP 16	-7.3891	-7.3891	-1.0320	557232.9211	346560.2821	5.1029
GCP 23	3.2342	3.2342	1.7384	557431.9800	346581.1726	5.1101

The results in table 2 provides the positional discrepancies between ground control points captured from different sources and their corresponding target coordinates in the target system. Each GCP has its own set of X, Y, and Z coordinates in both the source and target systems. The GCPs listed, GCP 18, GCP 16, and GCP 23, demonstrate varying offsets in each of the three axes (X, Y, and Z) from the source to the target system, indicating the necessary adjustments for precise alignment of these points during the data fusion process.

Even for visitors accustomed to AR and VR technologies, navigating the tour requires them to learn how to use the headset properly and resolve any challenges that may occur. Therefore, ensuring a high level of usability is crucial, along with providing clear and effective instructional support to help visitors understand and effectively engage with the technology. Figure 1 shows the framework for understanding the roles of AR and VR in cultural tourism.

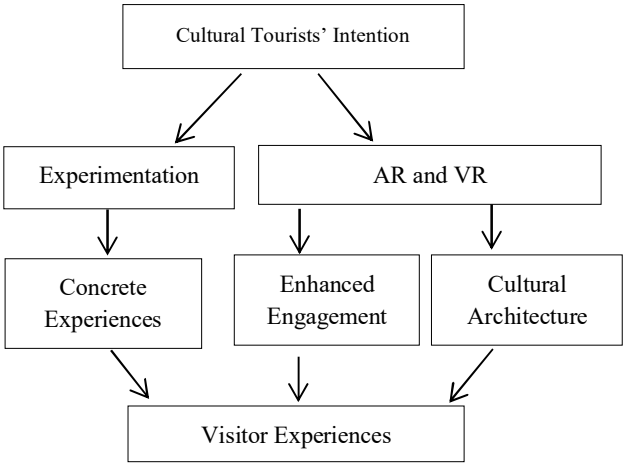

Fig. 1. Conceptual Framework for the Roles of AR and VR in Cultural Tourism

5 Conclusion

The integration of VR and AR technologies into the domain of cultural architecture has shown considerable promise in enhancing the visitor experience. However, as the abstract highlights, existing studies often fall short in addressing the nuanced ways in which these technologies can be adapted to specific cultural contexts and how they can truly add value to design of architecture and tourism experiences. This analysis, conducted within the framework of Activity Theory, provides a deeper understanding of the psychological and contextual factors that influence the effectiveness of VR and AR technologies in cultural tourism settings, particularly in China.

Examining the roles of VR and AR within the broader ecology of artifacts and psychological factors, the study underscores the importance of tailoring these technologies to the unique cultural architecture and heritage and social dynamics of different regions. It suggests that for these technologies to be effective, they must be purpose-driven, culturally sensitive, and contextually relevant. Moreover, the research emphasizes the need for further exploration into the development and implementation of VR and AR in the realm of cultural tourism. Specifically, it calls for more studies that focus on the purpose-driven evolution of these technologies within the rich and diverse cultural architecture and heritage of China. Such studies would not only contribute to the theoretical advancements in cultural architecture but also pave the way for more meaningful and enriching visitor experiences in the future.

While VR and AR technologies hold significant potential for transforming cultural architecture, their full potential can only be realized through a deeper understanding and integration of cultural context, psychological factors, and the practical implications of Activity Theory. This study not only advances the discourse in this area but also sets the stage for future research that can further refine and enhance the application of these technologies in cultural architecture.

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