

Research on Smart Cultural Tourism Based on Virtual Reality Technology

Teqiao Shen, Jialei Rong *

Hangzhou Qianxiang Network Technology Co., Ltd., Hangzhou, Zhejiang, 311000, China

* Corresponding author: Jialei Rong (Email: 243730006@qq.com)

Abstract: In the context of accelerating digital transformation of the global tourism industry, Virtual Reality (VR) technology, as a key technology for the development of smart cultural tourism, is reshaping the modes of cultural heritage protection and tourism services. This paper systematically reviews existing research findings and case studies to map the application landscape and development bottlenecks of VR technology in smart cultural tourism. The research focuses on scenarios such as digital restoration of cultural heritage, immersive guided tour experiences, and virtual tourism promotion, analyzing the technical implementation mechanisms such as 3D modeling and digital twins, while revealing the core value of VR technology in breaking through physical space limitations and enhancing the impact of cultural dissemination. Meanwhile, it points out constraints on the large-scale application of the technology, including high equipment costs, data island phenomena, and the disconnection between virtual and real experiences. By integrating cross-disciplinary theories and industry practice data, the paper argues for a development path where technological iteration needs to be coordinated with user experience design, and proposes the necessity of building an open technology ecosystem and unified data standards. This research provides decision-making references for balancing cultural heritage activation and tourism service innovation, with both theoretical and practical significance for achieving the symbiosis of technology empowerment and cultural inheritance.

Keywords: Smart Cultural Tourism; Virtual Reality Technology; Digital Cultural Heritage; Immersive Experience; Technology Integration.

1. Introduction

Against the backdrop of the accelerated digital transformation of the global tourism industry, smart cultural tourism is emerging as a cutting-edge field for the integration and innovation of culture and technology. With the "14th Five-Year Plan for the Development of the Tourism Industry" clearly stating the promotion of the in-depth development of smart tourism, virtual reality (VR) technology, as a representative of the new generation of information technology, has formed exemplary applications in fields such as cultural heritage protection, scenic area tour guide services, and tourism marketing. At present, cultural and museum institutions such as the Palace Museum have achieved three-dimensional visualization of cultural relics through VR technology. The West Lake Scenic Area in Hangzhou has launched a night tour project that integrates virtual and real elements, demonstrating the practical value of technology in empowering the cultural and tourism industry.

However, the development of smart cultural tourism still faces the dual challenges of superficial application of technology and the fragmentation of user experience. On the one hand, the existing intelligent service systems generally have the problem of fragmented functions. On the other hand, the collaborative mechanism between the virtual and real Spaces in the process of digitizing cultural heritage has not yet been perfected. Therefore, systematically sorting out the application map of virtual reality technology in smart cultural tourism and clarifying the adaptation logic between its technical characteristics and industry demands is of practical significance for breaking through the bottleneck of activating cultural tourism resources.

This article focuses on the innovative practice of virtual reality technology in smart cultural tourism and reveals the

evolution path of technology application through multi-dimensional case analysis. Firstly, analyze the current situation and core contradictions of the development of smart cultural tourism. Then, starting from scenarios such as digital restoration of cultural heritage and immersive guided tour experiences, explore the implementation mechanism and performance boundaries of VR technology. Finally, combining elements such as technical economy and user experience, put forward systematic suggestions for the selection of the industry's technical route. The research integrates interdisciplinary theoretical achievements and industrial practice data to provide decision-making references for the sustainable development of smart cultural tourism.

2. The Current Situation and Problems of the Smart Cultural Tourism Industry

2.1. The current Development Status of Smart Cultural Tourism

At present, smart cultural tourism is at a crucial stage of deep integration between digital technology and traditional tourism, and a multi-level technological application pattern has been formed globally. Taking Cilacap Singkil Beach in Indonesia as an example, Damiasih et al. [1] proposed through a mixed research method that information and communication technology, through dynamic data collection and intelligent management systems, significantly optimized the efficiency of tourism resource scheduling and increased the tourist reception capacity by more than 30%. Similarly, Suresh et al.'s research in Sikkim, India, indicates that the integration of smart transportation navigation systems and intelligent dormitory management platforms not only boosts

tourist satisfaction to 89% but also reduces energy consumption in scenic areas by 22% through real-time crowd monitoring, demonstrating the synergy between technology and sustainable development.

At the level of service innovation, the interactive audio tour guide system developed by Galina et al. breaks through the traditional tour guide mode and uses neural network technology to achieve scene adaptive interpretation, increasing the proportion of tourists' autonomous itinerary planning to 76%. However, the research conducted by S. Qi et al. [2] in Macao reveals the limitations of the current development: Although 90% of scenic spots have deployed intelligent service platforms, only 35% of tourists have used interactive functions, and most services still remain at the stage of one-way information push. This "pseudo-intelligentization" phenomenon reflects the gap between technological application and user demands, especially in small and medium-sized cities, where the degree of infrastructure intelligence has not yet effectively matched the usage habits of tourists. Overall, the technical infrastructure for smart cultural tourism has been initially completed. However, how to achieve a service closed loop and upgrade the user experience remains the core issue for development at this stage.

2.2. Core Issues Faced by the Industry

At present, during the rapid development of the smart cultural tourism industry, it still faces a series of core issues that restrict its sustainability and innovation. First of all, the contradiction between cultural heritage protection and tourism development has not been effectively resolved. Although the Internet of Things monitoring framework proposed by Mario Casillo et al. [3] can accurately identify the damage of historical buildings, its technical implementation cost is high and it relies on cross-domain collaboration, making it difficult to balance the protection requirements and the pressure of commercial operation in actual promotion. Secondly, the digitalization process of cultural and tourism resources has the phenomena of data silos and technological fragmentation. For instance, although the AI image recognition system developed by Jovana Mitric et al. [4] has enhanced the interactive experience of tourists, the lack of decentralized data storage standards for cultural relics and interoperability protocols has led to low efficiency in cross-platform data integration and restricted the interactive development of cultural and tourism resources throughout the region. Furthermore, there is still a significant gap between the application of technology and user demands. Although the AR interaction system designed by Ali Ibiş et al. [5] has achieved high user satisfaction, problems such as the low penetration rate of wearable devices and the difficulty for elderly tourists to adapt to the technology have led to the difficulty in achieving large-scale coverage of immersive experiences. These issues jointly reflect that the industry has systematic shortcomings in dimensions such as technology integration, data governance, and user experience design. This not only affects the depth of innovation in cultural and tourism services but also restricts the effectiveness of the revitalization and inheritance of cultural heritage. How to build an open and collaborative technology ecosystem, establish a unified data asset management system, and design an inclusive human-computer interaction model has become the key path to break through the development bottleneck of the industry.

3. The Application of Virtual Reality Technology in Smart Cultural Tourism

3.1. Current Applications of Virtual Reality Technology

The current application of virtual reality technology in smart cultural tourism has presented diverse scenarios and innovative practices. Its core value lies in reconstructing cultural experiences and tourism service models through digital means. In the field of cultural heritage protection and display, Mariana Magalhaes De Andrade et al. [6] verified the reproduction ability of VR technology for historical scenes through the "Ara as it Was" project. This system enables users to participate in the reenactment of historical events in an immersive way through 3D modeling and spatial positioning technology. It simultaneously supports multi-sensory interaction functions, such as triggering background information of cultural relics through gesture operations, significantly enhancing the depth and interest of cultural cognition. This case shows that VR not only breaks through the limitations of physical space, but also enhances the appeal of cultural dissemination through the narrative method of integrating the virtual and the real.

In terms of the promotion of tourist destinations, the virtual tourism project designed by Yongkang Xing et al. [7] has demonstrated significant market appeal. The research team has built a high-precision digital twin scenic area, integrating three major modules: collection interaction, dynamic navigation, and multi-threaded story system. International tourists can conduct virtual Tours and complete interactive tasks through headsets. Test data shows that 78% of the participants developed the intention to travel on-site due to virtual experiences, confirming the guiding role of VR technology in tourists' decision-making. Such projects effectively shorten the decision-making cycle of tourists through preview experiences, and at the same time provide data support for the flow management of scenic spots.

The practice of F. Marasabessy[8]'s team regarding digital guided Tours of cultural heritage is exemplary. The VR tour guide system of the Sultan's Palace in North Maluku developed by it adopts a data collection method combining drone aerial photography and ground photogrammetry. It uses Blender to complete the three-dimensional reconstruction of the building complex and finally realizes cross-platform interaction through the Unity engine. User experience tests show that the system improves the efficiency of cultural information transmission by 42% compared with traditional guided Tours, and supports personalized tour path planning. This technical solution not only resolves the contradiction between cultural relic protection and open sightseeing, but also recreates the historical original appearance of the building through virtual restoration technology. Current application practices have fully demonstrated that virtual reality technology is reshaping the experience dimension and service ecosystem of the cultural and tourism industry, providing key technical support for the revitalization of cultural heritage and the innovation of tourism products.

3.2. Analysis of the Advantages and Disadvantages of the Technical Solution

The technical solutions of virtual reality technology in smart cultural tourism not only show significant advantages

but also have limitations that need to be urgently broken through. From the perspective of application effects, VR technology has restructured the presentation mode of cultural and tourism products through immersive experiences. For example, Zhitao Chen et al. [9] pointed out through the case analysis of Volvo and Audi that VR can break through the limitations of physical space and provide a 360-degree panoramic interactive experience, enabling tourists to visit virtual scenic spots or experience cultural heritage without leaving their homes. Significantly enhance user engagement and brand recognition. Furthermore, the Sora text-to-video model proposed by Zuyan Chen et al. [10] demonstrates a high ability to restore the laws of the physical world. This provides a new idea for the dynamic generation of virtual environments in cultural and tourism scenarios, enabling the rapid construction of virtual ancient cities that conform to the logic of reality, the reproduction of historical events, and other contents, significantly reducing the time cost of traditional 3D modeling. However, the limitations of the technical solution cannot be ignored either: Firstly, Zhitao Chen et al. [11] emphasized that the high purchase cost and usage threshold of VR devices limit large-scale popularization. Scenic spots need to invest in professional hardware and network facilities, while ordinary consumers may give up the experience due to the device price or operational complexity. Secondly, the research of Nils Daum et al. in the field of education indicates that the production of VR content needs to take into account both technical accuracy and user experience. Excessive pursuit of visual simulation in cultural and tourism scenarios may lead to physiological discomforts such as motion sickness, and the digital transformation of cultural connotations still requires deep human intervention and is difficult to rely entirely on algorithm generation. The more fundamental contradiction lies in the fact that although virtual experiences can break through the limitations of time and space, they cannot completely replace the multi-dimensional experiences of interpersonal interaction and sensory touch in physical cultural tourism. This gap between virtual and real experiences may weaken the depth of cultural dissemination. Overall, VR technology has created an innovative path for the integration of virtual and real elements in smart cultural tourism. However, the balance between its technological maturity, cost control, and user experience still needs to be continuously improved through hardware iteration, algorithm optimization, and content innovation.

4. Conclusion

This study systematically explores the application value and development path of virtual reality technology in the field of smart culture and tourism. At present, the basic technology layout of smart cultural tourism has been achieved. Through dynamic data collection, intelligent management systems and interactive navigation, the service efficiency has been significantly improved. However, there is a widespread phenomenon of "pseudo-smartness", which is manifested as the gap between technology application and user demands, data silos, and deep-rooted contradictions in the protection and development of cultural heritage. Virtual reality technology, through 3D modeling, digital twins and multi-sensory interaction, has demonstrated unique advantages in scenarios such as digital restoration of cultural heritage,

immersive guided Tours and tourism pre-experiences. Its virtual-real integration feature not only breaks through the limitations of physical space, but also enhances the appeal of cultural dissemination. However, problems such as high equipment costs, the complexity of content production, and the disconnection between virtual and real experiences still restrict the large-scale promotion of technology applications.

Future technological development needs to focus on hardware lightweighting and algorithm optimization, combine 5G edge computing to reduce device dependence, and improve the efficiency of virtual scene construction through AI generative models. The development of smart cultural tourism should build an open and collaborative technological ecosystem, break down information silos through unified data standards, seek a dynamic balance between the revitalization of cultural heritage and the innovation of tourism services, and ultimately achieve the symbiotic development of technological empowerment and cultural inheritance.

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