Strategies for the Application of AR Technology in Digital Humanities: A Case Study of the "Starting from Wukang Road" App (Postprint)

Authors: Dai Mengfei, Zhu Wenjing, Tan Miao, Wang Zhiying

Date: 2023-04-01T16:03:00+00:00

Abstract

[Purpose/Significance] In view of the substantial application prospects of AR technology in China, this study explores the utilization and practice of various AR functional categories in the digital humanities domain, thereby fostering innovative development of relevant cultural tourism industries.

[Method/Process] This paper systematically reviews AR applications for digital humanities both domestically and internationally, with particular emphasis on analyzing the functional categories of AR in European digital humanities applications, and proposes functional development strategies through the case study of the "Starting from Wukang Road" AR navigation application.

[Results/Conclusions] European digital humanities applications extensively leverage AR technology across historical virtual reconstruction, cultural tourism map navigation, knowledge-based interactive entertainment, and historical and humanities education and teaching, thereby providing tourists with more precise and diversified cultural tourism information. A series of AR functional development strategies are proposed specifically for the Wukang Road application, offering reference and guidance for application development within China's cultural tourism sector.

Full Text

The Application Strategy of AR Technology in Digital Humanities: A Case Study of the "Start from Wukang Road" App

Dai Mengfei, Zhu Wenjing, Tan Miao, Wang Zhiying Shanghai Library, Shanghai Institute of Science and Technology Information, Shanghai 200031

Abstract:
[Purpose/Significance] With the vast application prospects of AR technology in China, this paper explores the implementation and practice of various AR functions in the digital humanities field, aiming to promote innovative development in cultural tourism industries. [Method/Process] The study reviews AR applications for digital humanities both domestically and internationally, analyzes the functional categories of AR in European digital humanities applications, and proposes development strategies using the "Start from Wukang Road" AR navigation app as a case study. [Result/Conclusion] European digital humanities applications extensively employ AR technology in historical virtual reconstruction, cultural tourism navigation, knowledge-based interactive entertainment, and historical-humanities education, providing tourists with more accurate and diverse cultural tourism information. The paper proposes a series of AR functional development strategies for the Wukang Road application, offering references for domestic cultural tourism application development.

Keywords: digital humanities; augmented reality; cultural heritage; cultural tourism application
Classification Number: G250
DOI: 10.13266/j.issn.0252-3116.2021.24.005

Augmented Reality (AR) is a technology that integrates and superimposes virtual information onto the real world through multimedia, 3D modeling, real-time tracking and registration, intelligent interaction, and sensor technologies. With the rapid development of mobile internet and smartphones, the flexibility and convenience of devices have been ensured, allowing AR technology to penetrate various aspects of daily life. According to Statista's forecast report, the global AR market is expected to grow to $198 billion by 2025 [1]. By 2021, there were an estimated 1.96 billion mobile AR users worldwide, a number projected to reach 2.4 billion by 2023 [2].

Since the 18th National Congress of the Communist Party of China, the integration of culture and technology has become central to the development of the cultural industry. AR technology can overlay cultural information and historical backgrounds onto real spaces, enhancing people's perception of their surroundings and strengthening their touring impressions, thereby helping them discover history from new perspectives. On this foundation, AR applications can also provide information sharing and collection functions to promote user collaboration, communication, and entertainment competition, deepening social connections among people. The application of AR technology will also transform traditional information dissemination methods, enabling more active and enthusiastic participation. The rational use of these AR characteristics will bring new vitality to the cultural tourism industry related to digital humanities.

This paper systematically reviews AR applications for digital humanities both domestically and internationally, focusing on analyzing the functional cate-

gories of AR in European digital humanities applications. Using the "Start from Wukang Road" AR navigation application (hereinafter referred to as the "Wukang Road App") as an example, we propose functional development strategies.

1. Application and Implementation of AR Technology in Digital Humanities

1.1 Application Scope

AR technology in digital humanities primarily serves four functions. First, **information enhancement for cultural heritage sites**: Mobile devices enrich real-world scenes such as buildings, ruins, and cultural relics with historical background and cultural information, helping tourists explore and learn in real time. Second, **immersive navigation**: AR technology combines map guidance with real-time street views, using arrow pointers and overlaid text to help users reach destinations more conveniently and accurately. Third, **gamification through augmented reality**: Various types of AR games integrate entertainment elements into the physical environment of tourist attractions, enhancing visitor interaction with sites and artifacts, improving travel experiences and immersion, and promoting sharing among users to increase usage and dissemination rates. Fourth, **simulation of urban travel environments**: For constantly changing cities, AR technology can enhance or alter the environment in users' field of vision, displaying how specific areas looked in the past and providing background information on historical events.

1.2 Technical Implementation

Three main technical approaches implement AR functions in digital humanities applications. **Location-based AR** primarily relies on GPS positioning, suitable for urban navigation functions. **Marker-based AR** uses mobile device cameras to recognize specific markers and overlay detailed information or digital content. **SLAM (Simultaneous Localization and Mapping)-based AR** employs complex algorithms to identify physical objects' colors, patterns, and other features, detecting users' surrounding environments. This represents the most advanced positioning technology in the AR field.

For cultural information overlay and environmental reconstruction, 3ds Max software can be used for 3D scene modeling, while the Vuforia engine detects and tracks marker feature points, enabling real-time tracking and capture of buildings through mobile device cameras. Unity software can then design scene interactions, overlaying videos, animations, and special effects onto real scenes to achieve rich interactive navigation functions.

Personalized tour route guidance requires positioning and tracking technology, currently falling into three categories. The first is GPS and multi-sensor-based tracking registration technology, which tracks users' real-time locations and sur-

rounding information. The second is virtual object spatial positioning based on GIS spatial analysis, which reads spatial and attribute information from databases to calculate users' coordinates in virtual coordinate systems, enabling 3D landscape map navigation. The third is seamless integration based on AR technology, which obtains users' real-time positions through sensor data changes, uses mobile OpenGL ES to render virtual objects, and achieves real-time navigation through 3D environment registration technology.

Real-scene interactive games require collaboration among experts from various fields—including educators, art directors, game designers, scriptwriters, software developers, and audio-visual designers—to balance entertainment with serious knowledge, properly managing the relationship between game design and urban connotations, stories, and symbols, while designing feedback systems to understand users' knowledge progress and support game improvement.

1.3 Promotional Effects

AR technology provides plots and scenes for information simulation and contextualization, delivering immersive experiences for users and enhancing the entertainment value of historical and cultural learning. Particularly, AR applications on mobile devices add an information layer to reality, providing new interaction methods and highly vivid user experiences [3]. Information overlaid on real scenes is easier to understand and remember, and through multimedia technologies like audio and video, can recreate historical spaces and atmospheres in real time, strengthening touring impressions and helping people discover history in new ways. This enhances users' sense of belonging to historical sites and generates personalized understanding and emotional responses to historical culture.

Furthermore, AR applications' information sharing and collection functions can promote user communication, cooperation, and entertainment competition, deepening social connections. Interactive games combining location exploration with knowledge quizzes allow users to enjoy entertainment and competition with friends during their journey while acquiring historical knowledge. Traditional cultural tourism models feature one-way information creation and dissemination from professionals to tourists, whereas AR technology can transform information construction and dissemination methods, enabling more active participation and internal user group interactions. AR technology applications can also attract groups originally uninterested in or with difficulty accessing cultural heritage sites, such as young people and people with disabilities.

2. Research on AR Technology in Digital Humanities Applications

2.1 Domestic and International Literature Review

International scholars began researching AR technology in cultural tourism earlier, with more comprehensive research directions. U. Luna et al. systematically reviewed AR technology applications in European cultural heritage [4]. C. Dieck et al. studied the economic, social, cultural, and educational value of AR applications using British museums as examples [5]. J. Challeno et al. examined the promotional value of AR applications for history teaching [6]. D. I. Han et al. explored AR technology's contribution to urban heritage tourism in Dublin and summarized design principles for such applications [7]. C. D. Kounavis et al. discussed the value and technical issues of introducing AR applications in tourism [3]. Z. Yovcheva et al. summarized the advantages of AR technology in mobile cultural tourism applications and proposed improvements in interface design and functional convenience [8]. T. Jung et al. analyzed how AR digital humanities applications improve tourist recommendation rates at attractions [9].

Among domestic scholars, Du Yi discussed the protection, inheritance, and development of China's historical and cultural resources using AR technology under the "Belt and Road" initiative, taking "Reconstructing Yangtze River Civilization" as an example [10]. Yu Riji et al. explored the industrial development of intangible cultural heritage resources using the Yellow Crane Tower as a case study [11]. Shi Fengling examined from a communication perspective how virtual technology's strong presence and high immersion can bridge the temporariness and 异地性 of tourism to enhance experiential quality [12]. Qin Xiaozhu et al. proposed applications and implementation plans for VR and AR-based digital twins in tangible cultural heritage digitization [13]. Dai Keqing et al. developed a basic evaluation model for AR technology tourism product development conditions based on a study of the Palace Museum's AR science and technology tourism product development [14]. Bai Jiansong established a digital AR display mode for museums focusing on intangible cultural heritage content [15]. Zhang Huishu et al. proposed user experience design methods, models, and monitoring approaches for AR navigation products using the Capital Museum as an example [16].

2.2 Domestic and International Practice

Most domestic AR projects in the digital humanities field remain in the exploratory stage, characterized by low technological content, single product types, and limited innovation capacity [17]. Major domestic AR projects include the Old Summer Palace reconstruction project by Beijing Institute of Technology and the "Digital Dunhuang" project jointly developed by the Institute of Computing Technology of the Chinese Academy of Sciences, Wuhan University, and Zhejiang University. The former virtually reconstructed ancient buildings like

the Dashuifa and Xiefashan in the Old Summer Palace through virtual imaging, while the latter aims to virtually reproduce all cultural heritage including the exterior and interior sculptures of the Mogao Grottoes with millimeter precision.

In contrast, Europe introduced AR technology earlier in cultural heritage digitization work. With Europe's rich heritage resources, numerous and diverse application products have accumulated, warranting in-depth analysis. As early as 1997, the "Rome Reborn" project launched, using virtual reality and related technologies to reconstruct ancient Roman scenes for deep user interaction. Starting in 2000, the EU continuously funded AR project development, facilitating early AR projects such as Lifeplus, ARCHEOGUIDE, Itacitus, and Ancient Pompeii. The most representative was the ARCHEOGUIDE project launched in 2002, which enabled tourists to watch virtually reconstructed monuments on-site through Personal Digital Assistant (PDA) clients and experience immersive audio-visual tours.

With the development of the internet and mobile devices, AR technology applications began integrating with smartphones. In 2011, Italy's "Puglia Reality+" application launched on Android and iOS platforms, pioneering the fusion of mobile devices with AR cultural tourism products. Building on this foundation, new AR applications continuously improved in 3D modeling, interactive design, and user positioning, developing toward Mixed Reality. According to U. Luna's survey from February 2019, searching Google and Apple's app stores using combinations of "AR" with "cultural heritage," "museum," "archaeology," "architecture," and "art" in English, Spanish, French, Italian, and German yielded over 60 currently operating cultural heritage-related AR applications [4].

2.3 Analysis of European Digital Humanities AR Application Categories

2.3.1 Historical Appearance Reconstruction **Virtual restoration of ancient architectural ruins** is the most widespread application of AR technology. Through AR, tourists can see the original appearance of monuments at their original sites without damaging the physical remains, achieving a good balance between preservation and presentation. For example, Italy's Torino1911 project virtually reconstructed severely damaged ancient castles and created navigation maps [18].

Reconstruction of original environments. Beyond architectural restoration, AR technology can also reconstruct environmental contexts. Many major cities worldwide have rich historical sites, but urbanization inevitably changes environments. AR technology helps tourists experience more immersive visits. A typical case is the Museum of London's "Streetmuseum" app, where users can see historical images of an area—from paintings, lithographs, and photos dating from the 1666 Great Fire of London to the 1960s—superimposed on current streetscapes when they arrive at marked Points of Interest (POI).

Off-site display of cultural heritage sites. AR technology can enhance

reality based on specific locations or transfer cultural heritage to exhibition halls for off-site display. For example, Italy's "Rebirth of a Historical Square" project superimposed a relocated Baroque fountain onto its original location in Galaff Square through AR technology and mobile devices, achieving landscape restoration of the historical square [19].

2.3.2 Cultural Tourism Map Navigation For tourists visiting historical sites, map guidance is essential. AR-developed cultural tourism map navigation functions are highly practical, not only presenting virtual tour routes but also overlaying personalized cultural and tourism information by analyzing users' POIs.

POI recognition and information overlay. Italy's "Tuscany+" was among the earliest tourism applications using AR technology. By pointing a phone camera at real scenes, the system automatically identifies location names, positions, and distances. Another AR application, "Puglia Reality+," contains over 10,000 POIs covering various cultural tourism information from crafts to food and wine, including real-time updated events and news.

Personalized route guidance. Some applications offer more targeted and autonomous tour routes. Italy's "Smart Walk in Castro" application considers both the touring value of each attraction and users' personal circumstances, calculating suitable visiting routes through simple questionnaires that understand users' interests and physical conditions.

Combination of ancient building reconstruction and map navigation. Greece's "Old Town of Chania" tourism application combines virtual restoration of ancient buildings with map navigation functions. The app uses GPS and cameras for dual positioning, allowing tourists to see 3D models of ancient buildings reconstructed at their original sites while touring the old city, creating stronger historical immersion [20].

2.3.3 Knowledge-Based Interactive Entertainment With the rise of mobile video media and virtual games, simple text and image introductions can no longer satisfy tourists' needs. Digital humanities applications with knowledge-based interactive entertainment as their main function have emerged accordingly. Interactive games built on AR technology's real-world projection and immersive experiences can more intuitively convey cultural knowledge, enhance users' touring memories and experiences, and spark young users' curiosity about history and culture.

Knowledge quiz type. The most basic game form in interactive entertainment applications is location-based knowledge quizzes. Greece's "Heraklion Gate" application focuses on promoting ancient city history through games. Tourists follow app prompts to find target locations, and after activating the location's interface with AR functions, historical questions with four multiple-choice options appear on screen [21].

Story narration type. Building on knowledge quizzes, further AR interactive game development emphasizes story narration. Portugal's "Unlock Porto" game uses geographic location technology, AR, and 3D modeling to guide tourists through Porto's history as a wine port through narrative storytelling [22].

Era comparison type. Interactive games can provide users with more vivid era comparison experiences. The upgraded version of "Unlock Porto" called "Invicta" is based on the story of a famous Porto architect. The game's challenge requires users to explore the 21st-century city using an outdated 19th-century map. During this process, tourists can deeply perceive the city's history and changes.

2.3.4 Historical and Humanities Education Beyond practicality and entertainment, AR technology can serve as an ideal tool for historical and humanities education. The educational purpose is more serious, requiring AR applications to professionally assess users' knowledge mastery to achieve teaching significance. Since teaching objectives must be met, AR application content design requires expert participation, integration with curriculum examinations, and encouragement of teacher-student interaction during tours.

Italy's Veneto region "AR-CIMUVE" project incorporated AR applications into fifth-grade elementary school curricula, with content development complementing students' Roman civilization courses. When students visit ancient city historical sites in class, the AR application deeply integrates the user environment with teaching information through augmented reality and 3D model overlay, helping students obtain immersive learning experiences [23].

2.4 Summary of Domestic and International Research and Practice

Overall, domestic research on digital humanities AR applications remains in its infancy, with most studies focusing on the macro value of AR technology for digital humanities but lacking specific functional strategies and practical implementation. In contrast, European digital humanities applications feature richer varieties and broader target groups. The application system of AR technology in European digital humanities is shown in Figure 1 [Figure 1: see original paper].

Thus, domestic digital humanities AR applications have significant room for practice. The following sections discuss the Wukang Road App recently developed by Shanghai Library as a case study. This case sets the application object as an open road in the city center, where most buildings remain functional and pedestrian traffic is heavy—making similar applications relatively rare domestically. This typical urban cultural heritage case study and application strategy design will provide references for similar urban cultural site development.

3. Case Study and Analysis of the Wukang Road App

3.1 Application Introduction

Located in the northeastern Xuhui District of Shanghai, Wukang Road is an important historical and cultural street, designated as a "China Famous Historical and Cultural Street" by the Ministry of Culture in 2011. Wukang Road features over 50 outstanding historical buildings and former residences of famous figures, including the French Renaissance-style Wukang Building designed by László Hudec, the British garden villa-style former residence of Ba Jin, the Spanish-style brick-and-wood structure former residence of Zhou Xuan, and the red-tiled, white-walled former residence of Soong Ching-ling, all offering high touring value. However, unlike traditional tourist attractions such as museums or historical sites, Wukang Road is not a conventional tourist destination. Pedestrians passing through have weak awareness of site visits, and setting up guided tours is more challenging, making advanced technologies like AR essential for revealing and guiding attraction content.

The Wukang Road App is an AR navigation application developed by Shanghai Library for the "Shanghai Memory" project. Based on the library's rich collection resources, the app identifies and guides users through Wukang Road's historical culture, presenting content including historical building introductions, relevant historical figure backgrounds, and architectural historical events. Through AR technology, it connects historical figures and events along Wukang Road, helping tourists more intuitively experience the cultural connections throughout the neighborhood.

The Wukang Road App was planned during 2017-2018 and officially developed and released in 2019. The application primarily explores mobile visual search and AR technologies in library services and extended service scenarios, extending library services beyond physical space and time through technology. Through the Wukang Road pilot project, Shanghai Library will attempt to build its own platform for more architectural and cultural attractions, supported by linked data technology to enable unlimited divergent browsing and construct an online virtual cultural time-space of modern Shanghai through UGC/PGC content.

3.2 Current AR Function Development in the Wukang Road App

AR technology can transform cultural tourism-related historical information and knowledge into multimedia digital content (such as video, audio, 3D models, and text) and overlay it onto real scenes through simulation and other forms. Users can thus perform real-time, immersive interactions with real scenes, achieving multi-dimensional cognitive experiences of historical and cultural heritage.

The Wukang Road App's AR functions mainly include three types: (1) **Doorplate number recognition**: By pointing the phone camera at a doorplate number and using the "AR Scan Doorplate" function, the historical building's

name and image prompt appear on screen, as shown in Figure 2 [Figure 2: see original paper]; (2) **Building recognition**: Pointing the camera at a historical building allows the system to directly recognize it and display detailed information, linking to the building introduction page, as shown in Figure 3 [Figure 3: see original paper]; (3) **Map guidance**: In the "AR Exploration" function, selecting a building activates route navigation, with virtual arrows superimposed on the real road scene to provide walking navigation for tourists, as shown in Figure 4 [Figure 4: see original paper].

3.3 Usage Effects and Limitations

Following the recent "Reading + Walking" trend, the Wukang Road App provides users with a window to further understand buildings and history. The app's primary service targets include various tourists, citizens, or users interested in relevant architectural history. Since the initial version lacked statistical functions, the official version later added them, accumulating 480 users.

The Wukang Road App's application of AR technology is still in its infancy, with functions limited to simple image recognition and route navigation, offering limited improvement in user convenience and not yet addressing immersion and interactivity. AR technology's most prominent advantage lies in its use of computer information technology, represented by 3D registration technology, to display virtual-real combined scenes on mobile devices or wearable devices like HoloLens, enhancing people's perception of their surroundings and delivering immersion, pleasure, information satisfaction, and consumption desire. The application still has many shortcomings in these aspects and requires further development to meet the usage needs of more user groups.

Based on the above analysis of European digital humanities AR application categories, the following sections propose further development strategies for the Wukang Road App's AR functions to deeply integrate AR technology with cultural tourism connotations, enhance the uniqueness and touring value of cultural sites, promote smart city development, and expand the cultural and creative industry's development patterns and models.

4. AR Function Development Strategies for the Wukang Road App

Building on the existing AR functions of the Wukang Road App, this paper proposes several directions for further in-depth development to enhance the application's information enhancement and interactive stimulation of real scenes, enabling users to immersively experience corresponding historical periods and develop profound impressions and emotional connections with cultural heritage sites.

4.1 Cultural Information Overlay and Environmental Reconstruction

The Wukang Road App, based on Shanghai Library's collection, provides rich knowledge about architectural styles. For example, the introduction to the former residence of Tang Shaoyi states: "It is a three-story brick-and-wood structure with the main entrance facing north, featuring an arched doorway with Greek-style columns. The second floor has three-column French windows with large balconies. The exterior features roughcast walls and barrel-tiled sloping roofs. The interior is equipped with Western-style fireplaces and chimneys." However, such visual information is difficult to understand through text description and may be misinterpreted, burying the popular science value of the knowledge. Using AR's 3D registration technology, different colored frames can outline building components such as doorways, columns, and French windows, with text introductions overlaid on real scenes, as shown in Figure 5 [Figure 5: see original paper], or using "plus" signs and similar markers for users to select details. In the detail page, the system can link to relevant books in Shanghai Library's collection about that architectural style, helping tourists extend their reading on topics of interest.

Shanghai is a rapidly developing city. Although Wukang Road has been well protected as a famous historical and cultural street in recent years, the surrounding environment still differs greatly from when these buildings were first constructed. When touring individual buildings, it is difficult for tourists to imagine the historical environment of the late Qing Dynasty and Republic of China periods. Through AR technology's real-scene tracking function, users can see virtual environments that adapt to viewing angles from any position around a building. The Wukang Road App can use multimedia technology to overlay rickshaws and street vendors in front of the Wukang Building, antique furniture and past-style garden landscapes in the courtyard of Soong Ching-ling's former residence, and provide a "see-through function" to help users see POI buildings located on the other side of the street through real-scene obstacles, vividly establishing the overall cultural atmosphere of the Wukang Road neighborhood, as shown in Figure 6 [Figure 6: see original paper]. Furthermore, the application can use AR technology to project celebrity deeds onto physical landscapes in the form of videos, animations, and dynamic 3D characters. For example, it could 重现 the image of the famous Republic of China singer Zhou Xuan performing in the corresponding windows of the Wukang Building, helping users more intuitively "meet" celebrities and understand their era, personal characteristics, and historical context.

4.2 Personalized Tour Route Guidance

The Wukang Road App has already developed convenient walking navigation functions. Building on this framework, it can add identification of surrounding dining, shopping, and accommodation information, clearly distinguishing them with real-time markers and providing classification and filtering functions. These functions not only offer convenience for tourists but also promote com-

mercial operations in cultural tourism areas, achieving both economic and social benefits. Additionally, as users increasingly value personalized choices and customization, the app can understand users' basic information and preferences through simple questionnaires or registration login forms. Based on this, algorithmic calculations can present travel routes matching user preferences and actual conditions, with route options distinguished by color categories. Furthermore, the Wukang Road project's webpage has established preliminary social sharing functions. Extending this feature to the mobile app provides users with sharing capabilities, allowing them to share multimedia content from the app to social platforms like WeChat and Weibo, while adding rating and comment functions for attractions and travel routes to increase interactivity and social network dissemination for 引流 effects, as shown in Figure 7 [Figure 7: see original paper].

4.3 Real-Scene Interactive Games

The Wukang Road neighborhood possesses rich historical heritage, enabling the design of various AR games to increase interactivity and connect with users of all age groups. The design proposals in Figures 8 [Figure 8: see original paper] and 9 [Figure 9: see original paper] focus on integrating the Wukang Road App with Shanghai Library's collection, enhancing tourists' interest in in-depth knowledge and guiding them to explore more resources at Shanghai Library. In the game's initial stage, users see an empty library bookshelf that needs to be filled by completing tasks. After recognizing the Wukang Building with their phone, the system presents knowledge quiz questions about architectural styles and celebrity deeds, with answers found in other introduction functions within the app. Upon completing answers, users unlock the next scene and receive a book related to the question as a virtual bookshelf prize. This book exists both as a virtual reward in the game and as a real item in Shanghai Library's collection, whose collection information can be consulted. Users find the next location using a 19th-century map, experiencing Wukang Road's retro cultural atmosphere during exploration. The game's final destination is Shanghai Library located next to the Wukang Road neighborhood, where users can see all previous answers. The system scores users based on their successfully obtained virtual books and organically integrates with Shanghai Library's real-time promotional activities.

5. Conclusion and Discussion

Digital humanities AR applications feature rich functional categories, including historical appearance reconstruction, cultural tourism map navigation, knowledge-based interactive entertainment, and historical-humanities education. Mobile device-based AR applications can provide tourists with accurate location information, timely and diverse content updates, and flexible presentation forms including text, video, and images, with clear and easy-to-understand interactive markers based on maps. In-depth development of these AR function

categories, applying virtual technology to the historical and humanities field, brings users new ways to interact with cultural heritage and creates innovative approaches to popularizing historical and cultural knowledge.

Several aspects require attention during digital humanities AR application development and await future research and practice. These include designing integrated frameworks among different functional categories to ensure smooth user experiences, providing personalized customization menus for different user types, achieving precise positioning for seamless AR and real-scene overlay, and maintaining unified interface visual design with cultural heritage styles to enhance information without compromising the visual aesthetics of heritage sites.

The development of virtual technology integrates the traditionally opposing concepts of "science" and "humanities," promoting mutual advancement. As a medium between virtual information and the real world, AR technology's in-depth development and application in digital humanities can enrich pathways for human-cultural exchange and create profound humanistic value.

References

[1] LIU S. Augmented reality market size worldwide 2017-2025 [EB/OL]. [2021-06-13]. https://www.statista.com/statistics/world-augmented-reality-market-value/.

[2] STATISTA RESEARCH DEPARTMENT. Global mobile augmented reality (AR) users 2015-2023 [EB/OL]. [2021-06-11]. https://www.statista.com/statistics/global-mobile-augmented-reality-users/.

[3] KOUNAVIS CD, KASIMATI AE, ZAMANI ED. Enhancing the tourism experience through mobile augmented reality: challenges and prospects [J]. International journal of engineering business management, 2012, 4(10): 1-5.

[4] LUNA U, RIVERO P, VICENT N. Augmented reality in heritage apps: current trends in Europe [J]. Applied sciences, 2019, 9(13): 2756.

[5] DIECK C, JUNG T. Value of augmented reality at cultural heritage sites: a stakeholder approach [J]. Journal of destination marketing & management, 2017, 6(2): 110-117.

[6] CHALLENOR J, MA M. A review of augmented reality applications for history education and heritage visualization [J]. Multimodal technologies and interaction, 2019, 3(39): 1-20.

[7] HAN DI, JUNG T, GIBSON A, et al. Implementing augmented reality in tourism [M]//Information and communication technologies in tourism 2014. Springer, 2013.

[8] YOVCHEVA Z, BUHALIS D, GATZIDIS C. Overview of smartphone augmented reality applications for tourism [J]. e-Review of tourism research, 2012, 10(2): 63-66.

[9] JUNG T, NAMKHO C, LEUE MC. The determinants of recommendation to use augmented reality technologies: the case of a Korean theme park [J]. Tourism management, 2015, 49: 75-86.

[10] DU Y. Research on protection and development of historical and cultural resources based on AR technology under the "Belt and Road" strategy: taking "Reconstructing Yangtze River Civilization" as an example [J]. Journal of news research, 2016, 7(8): 54-55, 85.

[11] YU R, TANG C, HU S. Research on industrial development of intangible cultural heritage resources based on AR technology: taking the legend of Yellow Crane Tower as an example [J]. Hubei social sciences, 2014(4): 50-54.

[12] SHI F. On the integration and innovative application of virtual technology in tourism [J]. Journal of generalized virtual economy, 2019, 10(3): 71-77.

[13] QIN X, ZHANG X. Application of digital twin technology based on VR and AR in tangible cultural heritage digitization [J]. Information and documentation services, 2018(2): 103-111.

[14] DAI K, CHEN W. Condition model and evaluation of augmented reality technology tourism product development: taking the Palace Museum as an example [J]. Guizhou social sciences, 2019, 355(7): 142-149.

[15] BAI J. Research on digital display mode and industrialization of intangible cultural heritage content in museums [J]. Journal of Zhejiang Vocational Academy of Art, 2011, 9(2): 112-117.

[16] ZHANG H, LI S. Research on user experience design of navigation products based on augmented reality technology [J]. Mechanical design, 2014(12): 123-125.

[17] WU Y, ZHANG L, HUANG J. Research on Tujia cultural tourism product system based on AR application: taking Changyang Tujia Autonomous County as an example [J]. Journal of Hubei University (natural science edition), 2018, 40(5): 539-550.

[18] CHIABRANDO F, SPANò A, SPREAFICO A, et al. Hybrid 3D models: when geomatics innovation meets extensive built heritage complexes [J]. ISPRS international journal of geo-information, 2019, 8(3): 124.

[19] SCIANNA A, GAGLIO GF, LAGUARDIA M. Augmented reality for cultural heritage: the rebirth of a historical square [J]. ISPRS international archives of the photogrammetry, remote sensing and spatial information sciences, 2019, XLII-2/W17: 303-308.

[20] PANOU C, RAGIA L, DIMELLI D, et al. Outdoor mobile augmented reality application visualizing 3D reconstructed historical monuments [C]//4th international conference on geographical information systems theory, applications and management. 2018: 59.

[21] VASSILAKIS K, CHARALAMPAKOS O, GLYKOKOKALOS G, et al. Learning by playing: an LBG for the fortification gates of the Venetian walls of the city of Heraklion [J]. EAI endorsed transactions on creative technologies, 2018, 5(16): 156773.

[22] NÓBREGA J, JACOB J, COELHO A, et al. Leveraging pervasive games for tourism: an augmented reality perspective [J]. International journal of creative interfaces and computer graphics, 2018, 9(1): 1-14.

[23] PETRUCCO C. Teaching our cultural heritage using mobile augmented reality [J]. Je-LKS: Journal of e-learning and knowledge society, 2016, 12: 115-128.

Author Contributions:
Dai Mengfei: Topic selection, conceptualization, writing, and revision;
Zhu Wenjing: Paper guidance, data provision, and revision;
Tan Miao: Data collection and analysis;
Wang Zhiying: Data collection and literature organization.

Publication Ethics Statement:
To strengthen and enhance academic standards, research integrity, and academic ethics in paper writing, review, and editing, establish good academic atmosphere, promote scientific spirit, resolutely resist academic misconduct, and establish and maintain a fair, just, and open academic exchange ecological environment, *Library and Information Service* Magazine (including the editorial departments of *Library and Information Service* and *Knowledge Management Forum*) has formulated this publication ethics statement, officially released in February 2020. The statement commits that the magazines will strictly abide by and implement national policies and regulations related to academic ethics and editing and publishing, standardizing the behavior of authors, peer reviewers, and editors throughout the entire process, and accepting supervision from the academic community and society. The statement includes three parts with fifteen clauses covering author ethics, reviewer ethics, and editor ethics. The full text is available at: http://www.lis.ac.cn/CN/column/column291.shtml. (Journal News)

Note: Figure translations are in progress. See original paper for figures.