

Revitalizing the Digital Hometown of Overseas Chinese

Using Virtual Reality Interaction Technology - The Example of Jimei School Village

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ABSTRACT

Promoting the transformation and development of overseas Chinese hometowns through the inheritance of overseas Chinese culture and the integration of culture and tourism is an important research perspective in China's rural revitalization strategy. Nowadays, the development of rural cultural tourism through various digital means has effectively promoted the economic vitality of the region. This research takes Jimei School Village as an example and uses virtual-real interactive technology [Mixed Reality (MR) and an open-source electronics platform based on easy-to-use hardware and software (Arduino)] to build a "Phygital Game" - a virtual-real interactive platform. First, this research uses MR technology to display the characteristic content of the hometown of overseas Chinese, expand the amount of information displayed, and immerse tourists in the realistic scene of virtual-real fusion. In terms of interactive form, through the design of physical interaction of Arduino, visitors can participate in puzzle-solving games. This platform aims to encourage tourists to actively explore the architectural features and culture of the hometown of overseas Chinese, to provide a valuable perspective for the optimization and development of the immersive cultural tourism platform.

1 MR+Arduino operation instructions

INTRODUCTION

With the rapid development of rural revitalization activities in recent years in countries around the world, the transformation of villages into value-added cultural tourism plays an important role. Experts and scholars have also paid great attention to the introduction of digital technology services to help traditional villages realize sustainable development. In 2019, the Chinese government proposed a digital village strategy to narrow the gap between urban and rural areas, and rapidly introduce digital technology into traditional villages (Xinhua News Agency 2019). However, in the planning, design, and display of digital technology in rural areas, especially in the virtual interactive forms, there is still a considerable age threshold due to the diversity of technologies and the need for physical cognition. It is difficult for some people to understand how virtual reality operates, so the digital village service is not able to provide comprehensive coverage for users of all ages.

Extended reality (XR) technology is a general term for all immersive technologies that integrate the physical and virtual worlds (Lo and Schnabel 2020), which includes virtual reality (VR), augmented reality (AR), and MR technologies, and is gradually developed for mobile devices. These technologies first create three-dimensional virtual objects and then intersect with the real world to reconstruct a new fusion environment scene. In this environment scene, the virtual objects and the real environment can be superimposed on each other (Allen et al. 2011; Skov et al. 2013; Väikkynen et al. 2013). This allows the online virtual operation to be transformed into an intuitive offline visualization mode (Milgram and Kishino 1994), also completing real-time interaction with users, allowing users to immerse themselves in an actual area.

For traditional villages, XR technology cannot only protect and inherit a specific target's historical and cultural value, but also help users increase participation motivation, ensure that the participation process is easy to interact with, and make the overall experience exciting and attractive (Ahuja et al. 2022; Sadeghi Milani et al. 2022). Extended Reality technology can also complete the collection of big data remotely (Ratcliffe et al. 2021). However, non-professionals are not familiar enough with virtual operations on mobile devices, and the exploration process takes up a lot of time. Therefore, creating an intuitive and friendly communication method is an issue that needs continuous attention in XR technology. In recent years, there have been major improvements in wearable device technology, such as Microsoft HoloLens 2 (includes a 3D visual display, spatial correspondence, eye tracking, manual tracking,

collaborative work, a special interaction mode, and spatial depth perception) (Microsoft 2023). Extended Reality (XR) technology has been further improved to encourage public participation. This brings about new possibilities for digital rural revitalization methods.

Combining the Arduino UNO microcontroller with a high degree of programming capability for human-computer interaction research (HCI), is a solution to enhance the XR experience. Arduino greatly simplifies the C++ programming language and better bridges the information exchange and communication between users and machines (Shreevidya et al. 2020). The Arduino UNO microcontroller can cooperate with a variety of sensor interfaces, such as gesture recognition (Belgamwar and Agrawal 2018) and image recognition, etc., which can build a lower power, lower cost and more efficient human-computer interaction (Bakshi and Prabhu 2017; Myung-Jae, Dong-Kun, and Young-Man 2021), and this kind of human-computer interaction can become more user-friendly (Badamasi 2014).

To achieve a better XR interactive experience, this research will combine the MR technology of Microsoft HoloLens 2 and the Arduino UNO microcontroller to explore digital rural revitalization. This research uses the interactive design of real scenes and virtual objects. It will start from the offline interaction link to assist users in real-time puzzle-solving games through touch physical button input, image recognition, etc. Combined with MR, immersive overseas Chinese cultural display allows visitors to complete the entire interactive process naturally. This research summarizes the methods of virtual-real interactive technology participating in rural cultural tourism and the possibility of real-time interaction between rural revitalization work and the public. This provides new potential for digital rural revitalization, and proposes future development directions.

RELATED WORK

Digital Village Cultural Tourism

The development of digital rural cultural tourism is an active method to promote digital rural construction and rural revitalization. In recent years, digital technology is rapidly penetrating all walks of life including, but not limited to, artificial intelligence, blockchain, cloud computing, the Internet of Things, big data, and other digital methods. In 2018, the European Union (EU) formulated a framework for intelligent rural development, enabling different villages to combine regional characteristics and methods to develop digital villages (Zavratnik et al. 2018). In 2019,

the Chinese government proposed that the combination of network, informatization, and digitization technology applications can strengthen the modern information skills of public infrastructure, the digital transformation of rural hotels, and the improvement of tour guides, the creation of multiple scenarios and spaces, and the value of the service commodity industry. Emerging models such as chain innovation (Zhou 2019; Roblek et al. 2021), and the establishment of regional tourism cultural IP images (Xu and Yu 2022), have effectively accelerated the process of digitalization for small and medium-sized enterprises in rural areas (Lulu Nurul 2021). Digital rural tourism has not only changed the way of traditional rural tourism, but also used it as an attractive element to reactivate to reactivate the tourism path (Costantino et al. 2022). This tourism path has faced the challenges of the existing rural social economy, and has effectively promoted the development of the country and the economic vitality of the region (Kumar and Shekhar 2020). In addition, using Internet technology to develop digital rural tourism can construct a digital cultural heritage well (Król 2021). Making good use of various digital applications can also bring new tourism marketing channels to this culture (Schuhbauer and Hausmann 2022), and provide initiatives for sustainable tourism development in traditional villages (Laxmita et al. 2021). The development of digital rural cultural tourism can meet the rigid needs of people in the digital age today. Actively maintaining the relevant digital ecosystem in the countryside is an issue that cannot be ignored (Krol and Hernik 2022). Digital development results from a compromise and integration between globalization, nature, tourism, local, and human forces (Garau 2015).

Application of XR Technology in Digital Cultural Tourism Exhibition

In the research process of digital rural cultural tourism, many scholars have gradually begun to explore the application of new technologies to deal with the development of digital cultural tourism. As early as 1995, there were experts who proposed that tourism would eventually be accomplished in a complete manner without even leaving home. With the crowd born after the year 2000 becoming the main force of tourism, its acceptance of new technologies and the Internet is even higher. The concept of tourism has also gradually changed. Simply browsing tourist attractions on the Internet has been difficult in meeting the needs of the crowd, but they hope to eventually be able to combine virtual and real experiences into their overall travel experience. The emergence of VR, AR, and MR technology, with better interactivity, immersion, fun and imagination, can realize different degrees of integration of digital information and real tourism space. Among them,

XR technology has a broad development prospect in digital cultural tourism, thus attracting the attention of a large number of scholars. In the research on VR, AR, and MR, the research on cultural tourism mainly focuses on virtual tourism (Nyland et al. 2000; Martínez-Graña et al. 2019), cultural heritage introduction (Chung et al. 2015; Hori et al. 2019; Lin et al. 2020), tourism promotion (Salazar and Barroga-Jamias 2014; Campillo-Alhama and Martínez-Sala 2019) and tourism satisfaction improvement (Guttentag 2010; Gonzalez-Rodriguez et al 2020; Olya et al. 2020). However, VR combined with cultural tourism still has the disadvantage of not being able to experience the audio-visual sensation in a real environment.

The emerging XR has the hardware, software, methodology, and experience of immersive technologies that integrate the physical and virtual worlds (Lo and Schnabel 2020), to further broaden the boundaries of the senses. Users can gain a deeper sense of immersion in the experience and spirit of digital tourism (Jianming and Fei 2022). Some scholars have conducted applied research on XR; for example, Brandi Weber-Sabil and Han (2021) studied how to use the XR model for visualization of spatial art. Darwish, Kamel, and Assem (2023) utilize XR to visualize and manipulate architectural space to improve students' awareness of space.

In the field of digital cultural tourism, a few scholars have begun to try to advance the integration of XR with culture and tourism. For example, Mohammad Hossein Ronaghi discussed the acceptance of augmented reality for tourists in tourism (Ronaghi and Ronaghi 2022). Kourouthanassis et al. (2015) studied the mobile augmented reality travel guide and explored its effect on tourists' emotions. Chinese research mainly focuses on fixed area guides (Lijuan and Yi 2022), archaeological heritage (Zaia et al. 2022), and scene displays (Ping et al. 2019). For example, Liu et al. (2021) tried using XR Technology to exhibit cultural relics and historical sites, using well-marked AR cards to enable travelers to realize interactive and tour operations. In addition, with the combination of XR and cultural tourism, travelers can get more convenient navigation and high-quality information content, and can make more immersive travel and have a higher willingness to buy peripheral goods, which has a positive impact on promoting the development of tourism and local economic development. However, the popularization of XR and cultural tourism still experiences problems such as high learning cost and being difficult to use, so the virtual-real interaction technology can be further improved in the application of digital rural cultural tourism.

Application of Virtual Technology + Physical Model Platform in Digital Display

In the early days, virtual-real interaction technology mainly used a combination of physical interaction and different display tools. Users interacted with the virtual environment using physical objects in the virtual-real interaction system. Since users are familiar with various characteristics (such as shape and weight) of the material things, the interaction process can be made more efficient (Zuckerman and Gal-Oz 2013).

The tactility and simplicity of physical objects, combined with digital information display, can facilitate the cultural dissemination of interactive exhibitions. The interactivity of the early virtual-real technology is still relatively weak, and most activities use projection displays to directly project virtual information, such as images, onto the surface of physical entities. A particular kind of augmented reality was explored by Basballe and Halskov (2010). Their stone installations mainly project Roman alphabet texts and graphics directly onto the stones to present the stories that were engraved on the rocks 1,000 years ago to today's audience live, which combines the needs of physical display and information exchange (Basballe and Halskov 2010). Later, a "Tangible User Interface" (TUI) appeared increasingly, interacting with virtual objects through tangible objects. Nofal et al investigate the deployment of an interactive projection map site installation controlled by a TUI, aiming to enhance the display of temporal and spatial transformations in medieval churches through such interactive projections. This research TUI consists of a platform containing a Radio Frequency Identification (RFID) reader capable of sensing RFID tags integrated into different physical models. The projected content toggles to show the internal simulation of a specific physical model. This material model can be used as an operation mode to convey display information and enhance the communication between tourists and exhibits (Nofal et al. 2018). With the development of XR, many technologies combine enhanced XR display with intuitive operation and interaction of physical objects, which is also a natural extension of the application range of tangible user interface technology. Compared with the previous technology, the virtual-real interaction technology, combined with XR, has the following advantages:

- Direct interaction: Intuitive tangible objects help users interact more naturally in the cultural travel experience. Using physical devices as input, rather than virtual instructions, reduces barriers to understanding.
- Multi-person collaboration: Through the physical installation, tourists can use intuitive tools and methods to

discuss, collaborate to complete tasks, and participate in the cultural tourism experience together.

- Fusion of virtual and reality: The XR + entity installation tool connects the real environment with the virtual scene. Changes in the physical installation can lead to changes in the virtual location, promoting dialogue and exploration between experiencers.

The rural cultural tourism experience emphasizes tourists' actual on-site experience, so it is necessary to use virtual and real interactive methods to allow tourists to visit on the spot. Intuitive physical installations can also provide opportunities for tourists to communicate on the site, allowing tourists to participate in, and improve, the efficiency of cultural communication. Therefore, this research aims to develop an experience platform combining XR and physical devices to promote the cultural dissemination of rural cultural tourism. The platform aims to visualize the on-site environment in three dimensions, superimpose virtual scenes, and expand the amount of information displayed. In addition, it also supports real-time interaction between virtual scenes and physical devices, helping tourists participate in the cultural tourism experience and receive cultural knowledge simultaneously.

METHODOLOGY

Case study

This research takes Jimei School Village, Jimei District, and Xiamen City as an example. It uses virtual-real interaction technology (MR+Arduino open-source electronic prototype device) to build a "Phygital Game"—a virtual-real interactive mini-game designed to create an overall interactive cultural and tourism experience in Jimei School Village. Jimei School Village was founded in 1913 by Mr. Tan Kah Kee, a well-known patriotic overseas Chinese leader, and is famous at home and abroad. The school village has a total construction area of more than 3,000 acres, and has more than 100,000 teachers and students. It is a place of exquisite beauty and a scenic spot for sightseeing. Jimei School Village incorporates a strong overseas Chinese culture, architecture for the typical southern Fujian style, incorporating a blend of both Chinese and Western styles. Second, Jimei School Village also maintains traditional customs such as dragon boat culture, and often holds dragon boat races on holidays, with people beating drums and singing Nanyin (a musical performing art central to the culture of the people of Minnan in southern Fujian Province along China's southeastern coast) used to inspire athletes, making the village very lively. However, as an important tourist attraction in Xiamen, Jimei School Village has limited opportunities to display intangible cultural heritage, which not only affects tourists' experience of cultural tourism, but also affects the dissemination of Jimei School



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Village's precious cultural heritage (Figure 2).

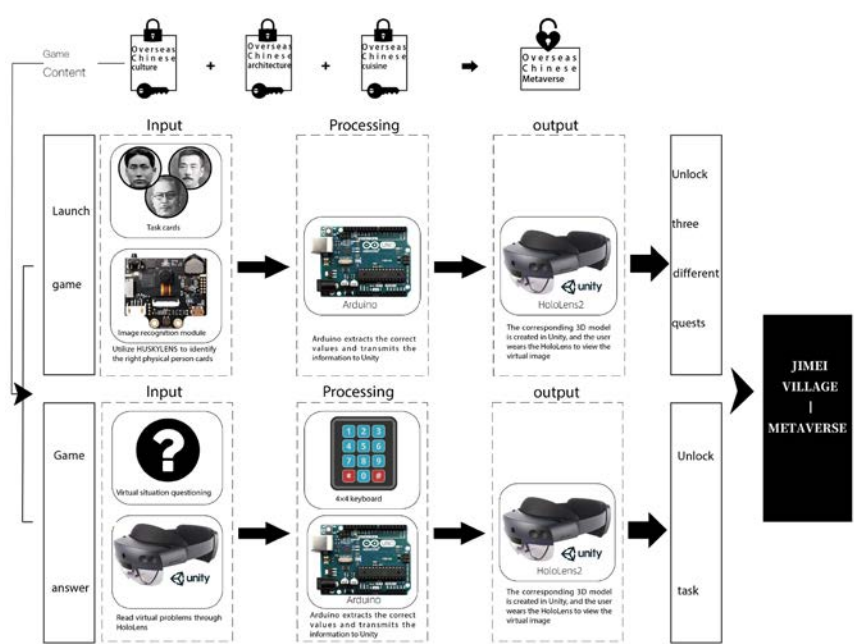
This research used the Phygital Game interactive platform to explore the impact of mixed reality interaction technology on the rural cultural tourism experience. "Phygital Game" is specifically a puzzle game system (Figure 3). Through learning and experience, tourists complete the set game links, obtain the three keys to pass the level, and complete the experience of Jimei School Village. One part of the game is learning the background knowledge of Tan Kah Kee's life. After the tourists visit the former residence of Tan Kah Kee, the relevant expanded knowledge content will pop up in the MR glasses. After the tourists have finished learning, they must pick out the portrait card. The Arduino portrait recognition module will judge whether it is correct or not. The portrait recognition module can pass this level when recognizing the right portrait card. Other links include knowledge of overseas Chinese hometown architecture, knowledge of specialty food culture, etc. After tourists have visited a specific place, they can use the physical answering tools to complete the game and see in combination with the extended content of virtual and real superimposition.

System Components

As shown in Figure 4, for the physical device part of the virtual-real interactive platform "Phygital Game", this research used an Arduino component (image recognition and keyboard input). This kind of physical card and number keyboard's input method is simple, easy to understand, and appropriate to the game's answering form. The virtual scene is modeled and developed using Unity3D, a cross-platform game development engine. All of the coding is done in the C language executed by Unity's compiler. Second, this research refers to the development of some ready-made components from the HoloToolkit software development toolkit. In addition, object control components such as gesture input have been introduced to the MR system in order to help the user adjust the virtual model. The display method of the platform is HoloLens2, which can superimpose the virtual model on a real scene. It can also establish the interaction between the virtual model and the real location, and tourists can use gestures and other operations to click and interact. The signal transmission between the virtual model and the physical device uses the Unity platform. It converts the signal transmitted by Arduino, prompts the virtual scene to change, and realizes the linkage reaction between the virtual and the entity.

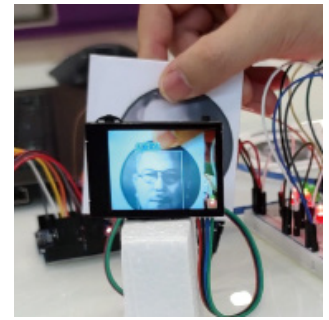
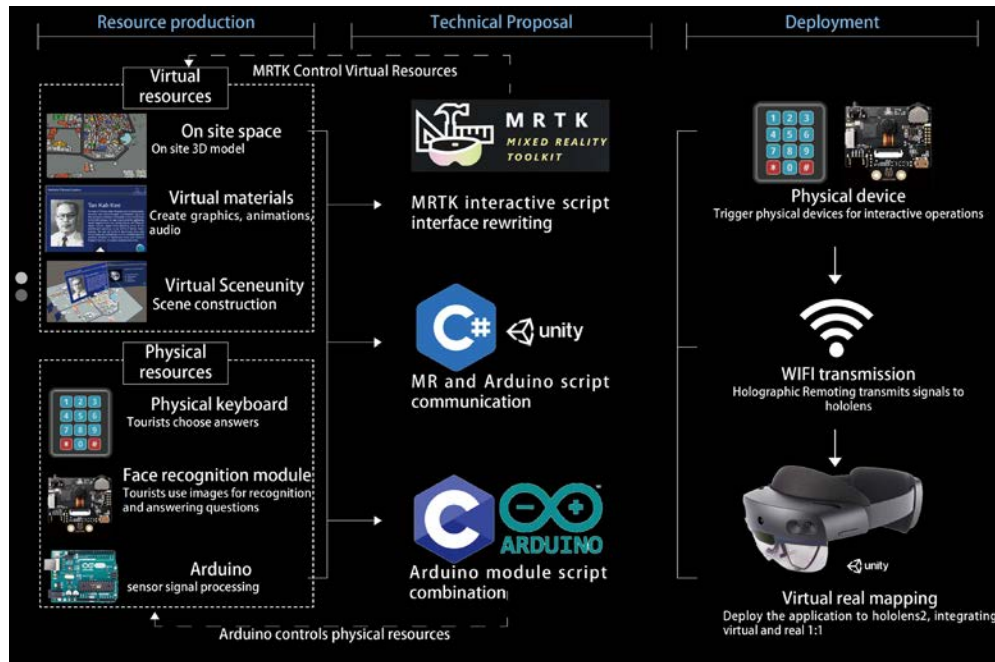
The space scene of the fusion of virtual and real

This research offers visitors the opportunity to experience in a live environment. Previous studies have used AR technology to experience through mobile phone applications. However, the display size of the mobile phone screen is too small to experience directly in the actual environment (Vainstein et al. 2016). This research goes a step further. It

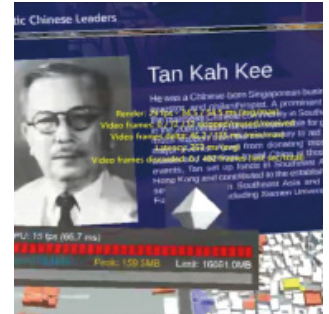


- 2 Status of Jimei School Village
- 3 Game Flowchart
- 4 MR+Arduino technical flow chart
- 5 Image recognition entity device
- 6 Image recognition virtual display

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can visualize the on-site environment in three dimensions, and the additional virtual model information is superimposed on the site in a real scale, so that users can obtain the greatest degree of immersion.

Interactivity between real and virtual scenes

Although the platform initially designed in this research is not fully realized with the linkage reaction between the physical device and the virtual scene, some of the interactions realized so far have already increased the fun of interaction. In the game session, this research has made some answering tools into physical forms, such as vivid cards and keyboards, which undoubtedly increase the sense of immersion in the game experience (Figures 5 and 6, respectively).

Simple physical device

The physical device part of this research is simple and relatively easy to operate. Most of the previous research used TUI as its physical operation portion. In order to realize the conversion of the TUI operation device from physical to virtual, it is necessary to arrange for the use of a camera, a projector, and many other types of equipment. This leads to the problem of an increase in preparation time and cost. In contrast, this research mainly uses the ready-made Arduino kits to cooperate with the game session to make simple cards.

Gamification of cultural tourism experience

This research proposes a new approach to enhance the cultural tourism experience through creative and interesting content. The main content is to design the rural

cultural tourism experience as a puzzle-solving game, and the dissemination of cultural knowledge is embedded in the game. In addition to the traditional 3D model, the virtual model also includes buttons, diamond rewards and other exciting game props, turning the rural scene into an enjoyable game experience. It is hoped that through this exciting form, the somewhat boring cultural knowledge can be turned into puzzles in the game to improve the efficiency of cultural dissemination.

DISCUSSION

This case aims to improve tourists' experience in rural cultural tourism. The existing AR technology and handheld devices used in cultural tourism need to meet the experience needs of tourists. We innovated from several aspects, such as the space scene integrating virtual and real scenes, the interactivity between real and virtual scenes, simple physical installations, and the gamification of the cultural tourism experience. This research summarized the methods conducive to improving the experience of rural cultural tourism. The virtual-real interactive system of the "Phygital Game" platform is believed to provide a new direction for developing the cultural tourism experience and rural revitalization.

CONCLUSION

The application of digital interactive technology in cultural tourism can effectively promote rural revitalization. This research takes Jimei School Village, Jimei District, and Xiamen City as an example and uses VR interactive technology (MR+Arduino open-source electronic prototyping device) to build a VR interaction platform. This platform

combines MR technology, Arduino physical buttons, and image recognition devices, which can display the rich local culture, promote active exploration and optimize the overseas Chinese cultural experience.

This article's primary purpose of building a platform is to improve the experience of participating in cultural tourism. Applying virtual-real interactive technology to rural cultural tourism can not only cover a broader range of cultural and travel routes, but it can expand the breadth of information available. This affords tourists and travelers the ability to understand the evolution of the entire rural culture and space experience. The goal is to allow tourists to be able to immerse themselves in the interactive experience of virtual and real integration, to increase their sense of fun, and to provide a valuable perspective for the optimization and development of China's rural revitalization immersive cultural tourism platform.

Although the research found that the application of XR technology to cultural tourism can enhance tourists' experience, the process and methodology of this experiment can be continuously optimized. This is accomplished by increasing the number of experimental samples, adding a control group of tourists who have not experienced the VR system, eliminating irrelevant influencing factors through rigorous analysis, and further refining the experimental data. The goal is to increase the statistical significance of the experimental results, thereby creating a more accurate statement.

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IMAGE CREDITS

All the drawings and images by the authors.

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