Research on the Application of Augmented Reality Technology in Museum Navigation System

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Keywords: AR Technology, Guide System, Museum, C# Programming Language.

Abstract: With the development of computer technology, people are no longer satisfied with traditional tourism guide modes. Mobile-based guide systems integrate advanced technologies such as positioning, virtual reality, and artificial intelligence, providing tourists with a more personalized and interactive guide experience. The application of AR technology in the museum navigation system is proposed in this paper. The key technologies of Augmented Reality (AR) are elaborated upon, including sensor technology, tracking and registration technology, and human-computer interaction technology. Taking the Yangshao Cultural Museum as an example, the design and development process of the brochure and tour guide system are introduced in detail. Models and materials are developed using tools such as Unity3D, 3ds Max, Adobe Premiere Pro, and Adobe Photoshop. C# programming language is used, supplemented by Vuforia tool, to achieve the mobile museum guide and interaction with cultural relic models. Enabling users to interact with artifact models through mobile phones or tablet devices, facilitating in-depth exploration of the charm of historical culture. This integrated application offers a novel experience for museum tours, expanding the possibilities for cultural heritage preservation and exhibition. The traditional visiting patterns have been disrupted by the AR-based guide system. The AR-based guide system enriches visitors' visiting experience and provides museums with new publicity channels.

1 INTRODUCTION

With the rapid development of science and technology and the continuous expansion of its application scope, museum navigation methods are also facing new challenges and opportunities. Traditional museum navigation methods usually use signs, exhibition boards, audio guides and other means. Although they provide visitors with a certain degree of information and interpretation, there are still some problems. Problems such as limited information transmission and insufficient interactivity. The museum navigation system based on augmented reality technology provides new possibilities for improving the shortcomings of traditional navigation methods. In 2015, the National Tourism Administration issued the "Notice on Promoting the Construction of "Tourism + Internet" Scenic Spots, which emphasized the importance of the construction of "smart scenic spots" (ZENG et al., 2020). In politics. With the support of government policies, smart tourism is the long-term development direction at present and in the future, and the development and construction of intelligent tour guide systems in scenic spots is the focus and an important part of building a "smart scenic spot" (ZHENG 2017).

Augmented reality technology is a technology that combines virtual information with real scenes. By superimposing virtual images, text, sounds and other elements on real scenes, users can interact with displayed items in a more intuitive and immersive way (LI et al., 2020). In recent years, domestic and foreign scholars have begun to conduct in-depth research and exploration on tourism and navigation systems based on augmented reality technology, and have achieved some positive results. (Tussyadiah et al., 2018) demonstrated how to use wearable augmented reality technology to enhance tourism

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Song, Y., Zhou, H., Wei, J., Qin and J.
Research on the Application of Augmented Reality Technology in Museum Navigation System.
DOI: 10.5220/0013632200004671
In *Proceedings of the 7th International Conference on Environmental Science and Civil Engineering (ICESCE 2024)*, pages 257-270
ISBN: 978-989-758-764-1; ISSN: 3051-701X

experience, including guided tours, interactive exhibitions, historical reenactments, etc., by in-depth study of some cases of actual tourism projects or attractions. (Chen et al., 2021) improved visitor acceptance and learning motivation by using augmented reality in museums, researching and analyzing relevant theories and empirical evidence, and integrating them into a functional research prototype and framework. (Xueqiu Z et al., 2022) studied an interactive navigation system combined with augmented reality technology to provide geographical location-based tourism services for tourists at tourist attractions and provide tourists with reasonable travel itineraries. (KG et al., 2023) introduced augmented reality into the navigation system and proposed an AR enhanced navigation system based on the location of automated teller machine (ATM) counters and bank branches selected by the user, so that the user can reach the ATM through the best path.

In the field of museum navigation, the navigation system based on augmented reality technology provides visitors with a new experience and interaction method, which greatly enriches the sensory and cognitive experience of museum visits. For example, the National Gallery in Berlin, Germany, uses augmented reality technology to develop a navigation system called "Unseen Art", which aims to enable visitors to see virtual paintings by superimposing virtual images on real oil paintings. Discover the details and colors hidden under the canvas to deepen your understanding and appreciation of the artwork. Domestically, the research team of Zhejiang University has also carried out research work on a museum navigation system based on AR technology. The system adopts a multi-level guidance method to provide users with a more intuitive and vivid navigation experience.

The exhibits in the Yangshao Cultural Museum are basically pottery, bone vessels and other fragile objects. They can only be displayed after being excavated and repaired. In order to prevent them from being broken again, they can only be placed in glass cabinets. There are small cards under the exhibits for introduction. Basic information such as the name and origin of the cultural relic is provided with graphic explanations of such exhibits on the wall behind the exhibit. This study designs and develops a museum navigation system based on key technologies such as real-time tracking, graphic registration and interaction of augmented reality technology, aiming to improve visitors' navigation experience and strengthen interaction and communication between exhibits and audiences. By overlaying virtual information and scenes in visitors' field of vision, the museum navigation system can realize real-time presentation, interactive display and interpretation of multimedia information, allowing visitors to have a more comprehensive and in-depth understanding and appreciation of the exhibits.

2 KEY TECHNOLOGIES

The augmented reality system has the characteristics of virtual and real combination, real-time interaction, and three-dimensional registration (WANG 2020). It uses display technology, interaction technology, sensing technology, and computer graphics technology to integrate the computer-generated virtual environment with the real environment around the user (XU et al., 2023).

2.1 Sensor Technology

Augmented reality systems require sensors to obtain environmental information and user interactions. Commonly used sensor technologies include cameras, gyroscopes, accelerometers, and GPS (HE et al., 2022). Cameras are used to capture real-world images, gyroscopes and accelerometers are used to detect the device's orientation and acceleration, and GPS is used to locate the user's location.

2.2 Technology for Tracking Registrations

Augmented reality systems need to be able to recognize and track real-world objects or images in order to overlay virtual content on top of them. The main tracking registration methods used are: tracker-based tracking of user location, vision-based tracking registration, hybrid tracking registration, etc. (HAN et al., 2019). At present, the research on registration technology based on computer vision is in a dominant position, which can be roughly divided into two categories: identification-based tracking registration and marker-less tracking registration, as shown in Figure 1.

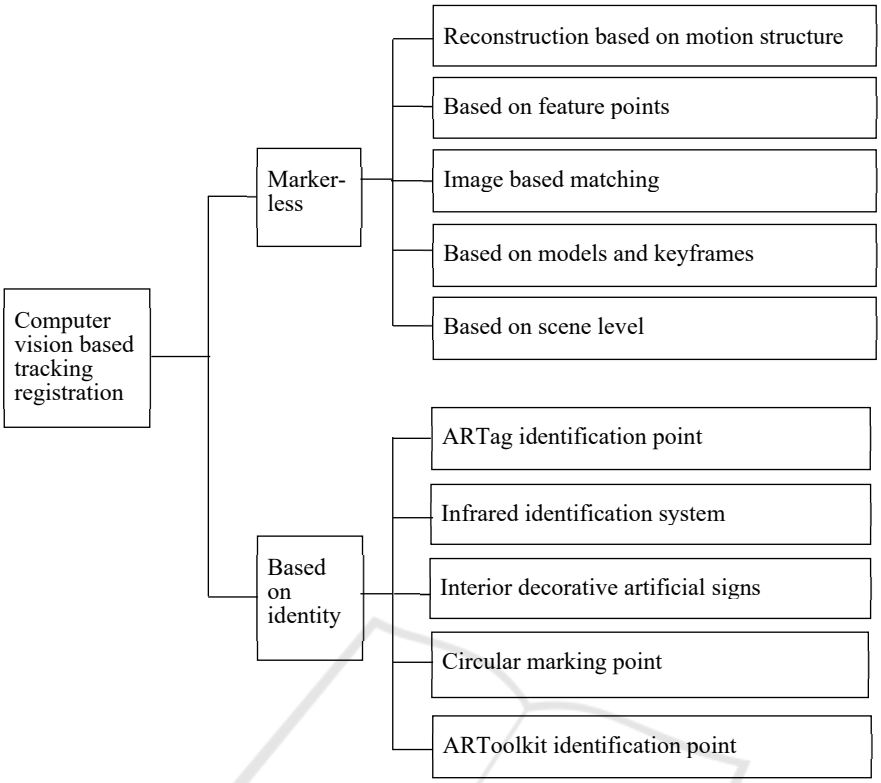


Figure 1: Computer vision-based tracking registration.

Identification-based tracking registration technology places artificial identification points with known spatial relative positions in real scenes that need to be registered, and uses cameras to track and identify identification points. Based on the known three-dimensional spatial position of the identification point, computer vision methods are used to calculate the six-degree-of-freedom posture of the camera relative to the real scene. With the development of augmented reality technology and the expansion of application fields, marker-less tracking and positioning can realize positioning in large-scale outdoor scenes. The main marker-less tracking and positioning methods include tracking and positioning based on key frame matching, model-based tracking and positioning, and tracking and positioning based on keyframe matching. Active reconstruction tracking and positioning, hybrid tracking and positioning, etc.

2.3 Human-Computer Interaction Technology

Augmented reality technology needs to provide ways to interact with virtual content. Common interaction technologies include gesture recognition, voice recognition, touch screens and controllers, etc. With the continuous innovation and development of single-channel human-computer interaction technology, natural human-computer dialogue interaction technology that integrates multiple modalities such as voice, vision, behavior, and emotion (Tao et al., 2022) has attracted increasing attention. These technologies allow users to communicate and interact with virtual objects in real time, enhancing visitor experience and engagement.

2.4 Mobile Augmented Reality System Tracking Registration Process

Making full use of the advantages of mobile devices and augmented reality technology, combining augmented reality technology with handheld mobile terminals has become a hot spot for innovative applications in the market.

The general process of tracking registration is shown in Figure 2. First, system preprocessing is performed to establish a virtual three-dimensional model (KONG et al., 2016), capture key frame images in advance, extract feature points, calculate descriptors, and store them in the database. Then a combined virtual and real image is generated

according to the matching algorithm, and finally the image is output to achieve fusion display (SONG 2022).

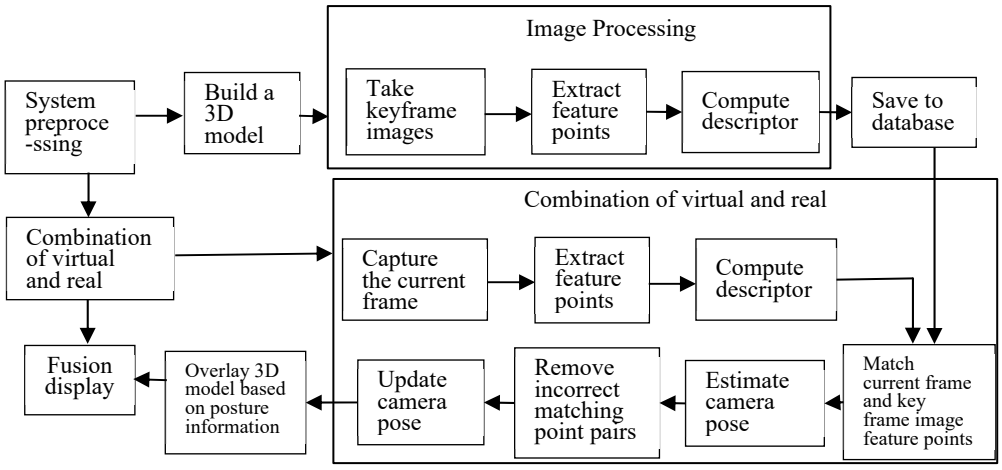


Figure 2: Flow chart of tracking registrations.

3 DEVELOPMENT OF NAVIGATION SYSTEM

3.1 Overall System Framework

Based on the purpose of solving the space and time constraints of physical museums and the inability to fully understand and observe cultural relics, a variety of interaction methods are designed in this system. In addition to the AR interaction module, it also includes a roaming module, a menu module, a navigation module, cultural relics data module and other functional modules. The overall functional design is shown in Figure 3.

In the roaming module, users can use virtual joysticks to control characters to walk freely in the virtual simulation scene in the three-dimensional simulation scene of the virtual exhibition hall, and freely control the viewing angle. The roaming path is completely dominated by the user. In the menu module, users can use their fingers or mouse to slide the screen to select the cultural relics they want to browse. The preview images of cultural relics are arranged in the center of the screen, and the menu can be infinitely slid left and right through scripts. In the navigation module, the roaming module is combined to realize the function of corresponding item navigation. The navigation function is designed in the menu module, because the menu function allows users to quickly and easily find the objects they want to view. Click the "Navigation" button, and the menu page closes. In the scene, a link between the user-controlled character and the object being sought is automatically generated. path. Since the system created in this article has many data transmission requirements in terms of interaction, the cultural relics data module is designed to quickly and conveniently provide various information about cultural relics. The design of the cultural relics data module mainly serves the above three module functions. Other modules call cultural relics data. The functions provided by the module can obtain specific information including cultural relic ID, cultural relic name, cultural relic description, cultural relic description audio, cultural relic model, cultural relic browsing map, cultural relic spatial coordinates, etc.

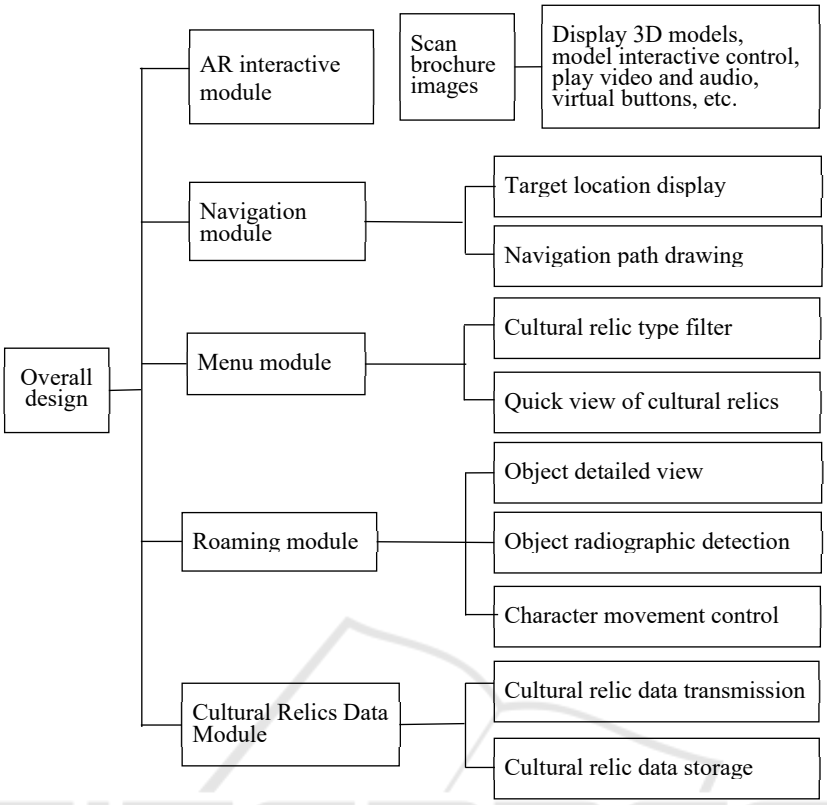


Figure 3: Design Diagram of Overall Functionality.

The basic function of augmented reality technology is to enhance the real scene, mainly relying on multimedia interaction such as 3D models, video, and audio (YI et al., 2018). The AR interactive module of this system realizes the display and interaction of 3D models of museum cultural relics by scanning the recognition pictures on the brochure. Through the automatic rotation of the model, visitors can see the displayed cultural relics from multiple angles. The finger slides control the magnification or reduction of the model, and the recognition Pictures control video and audio playback, virtual button interaction and other functions to enhance the interaction between tourists and cultural relics.

3.2 Brochure Physical Design

The brochure has a total of six pages and is produced using Adobe Photoshop. It is unfolded to the size of A4 paper (285*210mm), double-sided, and accordion-folded with two indentations.

The home page is the exterior view of the Yangshao Culture Museum. It has the charm of Yangshao Culture pottery, but is not completely restricted to the specific shape.The second page is the first part of the exhibition "Archaeological Holy Land". The third page is a national first-class cultural relic - a crescent-pattern painted pottery pot. The background and text introduction use colors similar to the pot, which looks more coordinated and beautiful. The fourth page has the theme of "Ji Ma Chao Silk", which is intuitively expressed through the four large characters at the top. The fifth page has the theme of "cutting stones into tools", which is represented by Chinese and English words and patterns at the top. Page Six returns to the museum's theme "Yang Shao and Her Era" and says goodbye to users through a concluding sentence, using both Chinese and English, to show the museum's tolerance for users. The actual picture is shown in Figure 4.

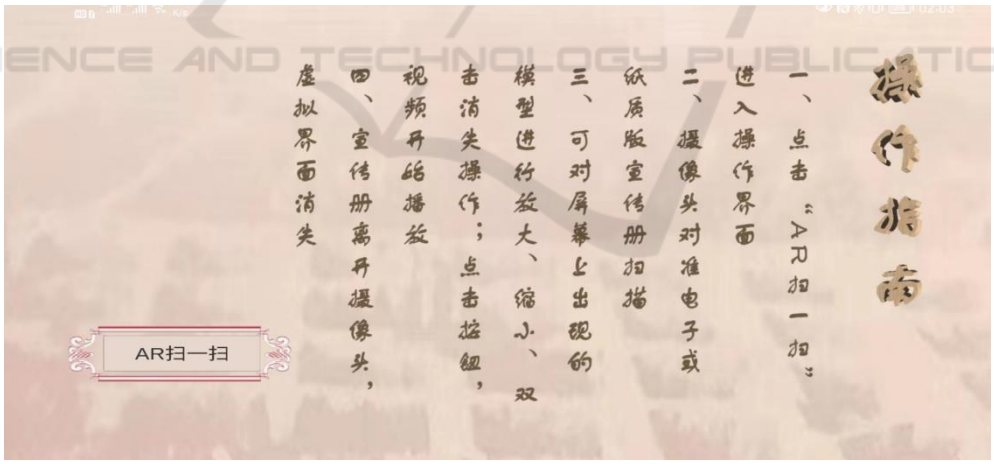
Figure 4: Brochure.

3.3 Visual Interface Design

Yangshao Culture Museum is the first archaeological cultural museum named after a site in Chinese history. This interface uses the clay color system as the main color of the interface design, with the Yangshao Village ruins as the background, and the seven characters "Yangshao Culture Museum" at the top. The theme is selected, and the border of the bottom button uses Chinese style elements. Users can enter the scanning interface and operation guide interface from the two buttons respectively. The right side is the Chinese and English introduction of this attraction, as shown in Figure 5.

The operation guide interface mainly introduces the usage method. The text format draws on the writing habits of the ancients and adopts vertical lines from top to bottom and from right to left. The four big words "Operation Guide" on the far right are concise and clear. Users can immediately know the purpose of this interface. The usage methods are expanded by bars, which is very intuitive. There is a button in the lower left corner. Click to jump to the scanning interface and start the AR tour of the museum.

a. cover



b. Operation instructions

Figure 5: Start interface.

3.4 Virtual Information Design

The content of virtual information plays a crucial role in the user's experience during the tour. The immersive virtual and real environment breaks the boundaries between reality and enhanced virtual content, creating diverse and interesting interaction methods for users. The virtual information studied in this article mainly includes 3D models, videos, and audios.

3.4.1 3D Model

Before formal modeling, it is necessary to fully collect the materials of the museum exhibition hall, including scene layout, display cabinet style, lighting, etc. In addition, it is also necessary to collect data such as reference models and introduction information of cultural relics, and create texture maps for subsequent modeling. be prepared. The 3D model is mainly produced by 3ds Max to ensure that it is as consistent as the cultural relics as much as possible, and uses 3D effects to vividly display the details of the cultural relics. As shown in Figure 6.

Figure 6: 3D models.

3.4.2 Scene Construction

Based on the existing materials, build the system scene. Drag the model of the Model folder into the Scene window in Unity3D to automatically create objects. You only need to adjust the position and size of the items to complete the basic scene construction quickly and conveniently. For the convenience of subsequent development and management, set up interactive items and static non-interactive objects under different parent objects.

After the scene is built, the realism of the scene is far less than that of the offline museum. The addition of lighting is a necessary step to enhance the realism of the virtual simulation. For this system, since the publishing platform is mobile, considering performance factors, the type of light selected is baked light. Baking refers to the process of storing lighting data in a lighting texture map before running the game, without spending extra performance to simulate lights while the game is running. Under baked lighting, only static objects can be illuminated by baked light, so all immovable objects in the scene need to be set to static. Then the lighting information can be baked into the lighting texture map by baking the lights in the current scene. The comparison of scenes before and after baking is shown in Figure 7.

Figure 7: Scene before and after baking.

3.4.3 Promotional Video

The video and audio design is produced by Adobe Premiere Pro and is a supplement to the content of the brochure. Since the content that the brochure can introduce is limited, the dynamic effects of video and audio are used to display content that cannot be expressed by the static text and pictures of the brochure.

This article designs a total of three promotional videos. Video 1 introduces the Yangshao ruins, which corresponds to the content shown on the second page of the brochure. The video size is 960*544 pixels and the duration is 27 seconds. The video material was shot during research at the Yangshao Cultural Museum. , edited in Adobe Premiere Pro, with a voice introduction; Video 2 is a supplement to the crescent-shaped painted pots, corresponding to the content shown on the third page of the brochure, the video size is 1280*720 pixels, the duration is 39 seconds, passed Typewriter effect, text appears one by one following the voice; Video 3 introduces the Jima silk reeling technology, corresponding to the content shown on the fourth page of the brochure, the video size is 720*576 pixels, the duration is 12 seconds, and there are a variety of pictures, texts and voices. The fusion of forms gives users an immersive feeling.

3.5 Interaction Design

3.5.1 Cultural Relics Data Module

Establish a data body of cultural relic data. The data body contains cultural relic ID, cultural relic name, cultural relic description, cultural relic description audio, cultural relic model, cultural relic browsing map and other information. Create a script to store the cultural relic data body in a list, and set up public functions to implement calls. And return the information corresponding to the cultural relic id data body.

Create a new script and declare a one-dimensional array of Item class to store different cultural relics. The order of the cultural relics in the array must be the same as the cultural relic ID. The calling function uses the method of applying for static public

functions to implement external calls. The formal parameter int id in the function is the id of the object being called. All information about the corresponding object in the data object array can be obtained through the id.

3.5.2 Roaming Module

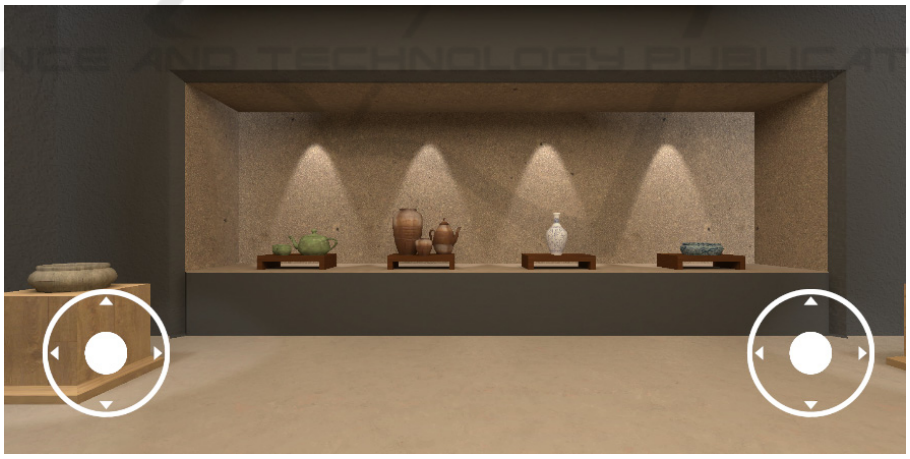
Since the system publishing platform is mobile, it needs to be considered that most mobile users do not use keyboard and mouse control, so a virtual joystick control is designed to take into account both operability and convenience. In this system, movement and perspective control are also set to virtual joysticks mode, the left joystick controls movement and the right joystick controls the perspective.

To achieve the function of obtaining objects within the field of view in the scene, the ray detection method is used. First, add a collider to the object that needs to be interacted with. There are many types of colliders, such as box collider, spherical collider, capsule collider, etc. Then define the ray, and the "View Details" button will pop up only when the tag of the object acquired by the ray is Item, set a stroke on the object detected by the ray, and set the text in the button to the name of the cultural relic.

After clicking the "Click to view details" button in the scene, set the depth of the secondary camera to be higher than the main camera to achieve the purpose of perspective conversion. During the conversion process, processing is also required to realize the function of item viewing, such as loading the object model and description to be viewed, and switching the UI interface. After entering the detailed viewing perspective, you can use your finger or mouse to slide the screen to rotate the cultural relics. You can also use the mouse wheel to zoom in and out. By adjusting the Field Of View property of the camera, you can zoom in and out of objects. The effect of the roaming module is shown in Figure 8.

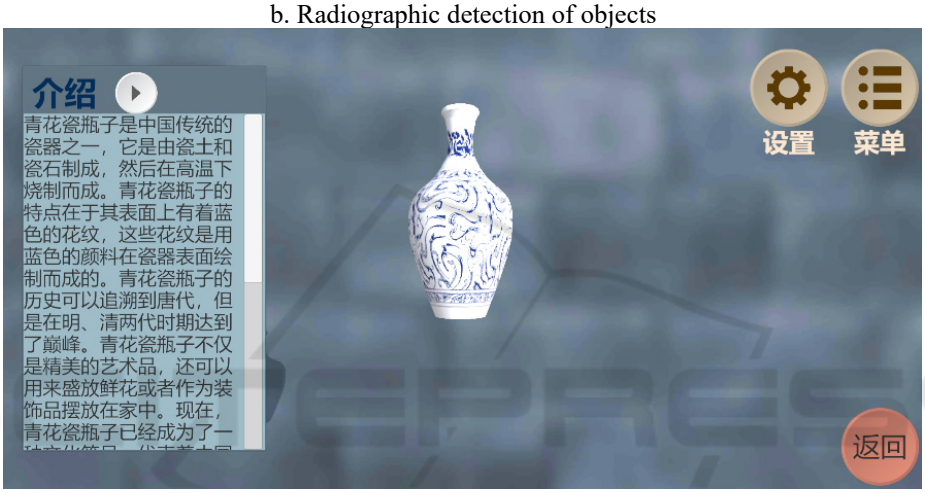
3.5.3 Menu Module

In order to facilitate users to view cultural relics quickly and efficiently, menu functions have been created for users to use, including quick viewing and item filtering. Considering that the beauty and creativity of the menu can bring users a good interactive experience, the menu is set to be infinitely sliding left and right. To achieve infinite sliding left and right, two points need to be created, one point each at the head and tail. Dynamically adjust the options in the menu by clicking a button in the menu and calling functions in the menu management script. As shown in Figure 9.



a. Joystick control

b. Radiographic detection of objects



c. View object perspective in detail

Figure 8: Roaming module.

Figure 9: Menu

3.5.4 Navigation Module

The idea of implementing navigation is to bake the navigation grid, obtain the path points between the target point and the controller, and use LineRenderder to draw lines based on the navigation path points, so as to display the path between the character and the target point.

In order to display the target object more intuitively, not only the highlight display effect of the target object is set, but also the navigation instructions of the UI layer are added, and the position and direction indication pictures of the UI are dynamically modified according to the position of the target object. Convert the world coordinates of the target object into screen coordinates, determine the screen coordinates of the target object relative to the screen, and change the positions of the displayed pictures and UI.

3.5.5 AR Interaction Module

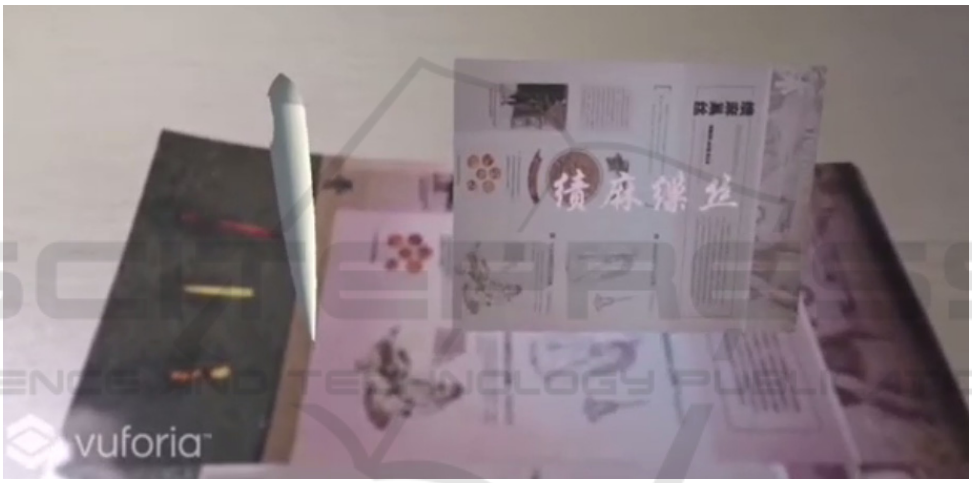
This article uses the Vuforia plug-in as a tool to implement AR technology. The identification object is an important tool needed for users to experience AR technology. The user uses the mobile phone camera to scan the identification object and obtain the enhanced scene. As shown in Figure 10.The main functions are:

1. Scan the brochure to display the video, with vivid video explanations of specific collections in the museum, so that visitors can have a clearer understanding of the collections;
2. Scan the brochure to display the 3D model of the cultural relics. Through the automatic rotation of the model, visitors can see the displayed cultural relics from multiple angles. They will not be unable to see other angles of the cultural relics due to glass obstruction in the real scene;
3. By comparing the sliding distance of two fingers on the mobile phone screen with the initial distance between the two fingers on the screen, determine whether the three-dimensional model is enlarged or reduced, and clearly display the details of the cultural relics;
4. Double-click the screen and the model disappears, enhancing the interaction between tourists and cultural relics;
5. Scan the brochure to display the audio, click the button, and the audio will play;
6. The interface jumps. The user clicks "AR Scan" to jump to the scanning interface. You can scan the brochure. Click "Operation Instructions" to jump to the APP's operation guide interface, where you can learn how to use it. Enter the scanning interface;
7. When the camera leaves the brochure, the virtual information disappears immediately.

a. Identify pictures

b. play video

c.Model interaction



d.image display

Figure 10: Interactive interface.

After the development of each module is completed, the corresponding APP icon and name are set in Unity for export, and packaged into an Android application (apk) file to implement the museum navigation system.

4 CONCLUSION

AR technology enhances the real scene, adds diversified virtual information, and outputs it on mobile devices. This article mainly studies the design and development of museum navigation systems. By using AR technology to get close to cultural relics and interact with them, users can not only obtain knowledge introduction of the cultural relics, but also enhance communication with the cultural relics, attracting users to spontaneously visit the museum. If they want to understand, Learn more about history.

Today, with the rapid development of digitalization, the application of AR technology in museum navigation systems is a historic leap in the development of the cultural tourism industry. It achieves a win-win situation for the cultural tourism industry and tourists. In the future, with the continuous advancement of technology and the ongoing innovation in AR technology, museum guide systems are poised for further development. Utilizing artificial intelligence and big data analysis to optimize the guide experience, the development of more intelligent and personalized AR guide systems is anticipated.

ACKNOWLEDGMENTS

The research work in this paper is supported by school-level teaching reform project (JG202324)；Jiangsu Province's sixth "333 Talents" training support project.

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