The Application of Augmented Reality Technology on Museum Exhibition—A Museum Display Project in Mawangdui Han Dynasty Tombs

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Abstract. Augmented Reality (AR) technology currently is widely used in the fields of military, medical, entertainment, Tourism, industrial and etc. In our research, we applied the AR technology into the exhibition of the historical relics in the Mawangdui Han dynasty tombs China. Thousands of the unearthed historical relics have close connections with each other in both cultural and spacial value. However, they are exhibited separately in traditional exhibition way. In this research, we have promoted a new method by using the AR technology to exhibit the historical relics together through the mobile terminal. This project has achieved impressive results on a scaled down model test. This application first captures real scene and detects features, then loads the 3D structure or animation after building the real word coordinate system from the data obtained before. Through the real-time rendering, we are able to argument archaeological features onto the real word scene, enable the audience to get much realer and richer museum experience. This method not only demonstrates a clear position and historical content of different historical relics but also provides interaction between users and historical relics. It brings a new exhibition method in the museum and people would enjoy a more interesting museum experience.

Keywords: Augmented Reality · Mawangdui Han Tomb · Museum display · Mobile terminal

1 Introduction

Augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data. It is related to a more general concept called mediated reality, in which a view of reality is modified (possibly even diminished rather than augmented) by a computer [1].

With the development of network technology and mobile terminal equipment, Augmented Reality is no longer confined by fixed environment and additional equipment. Augmented reality can be realized through the tablet PC, smart phones and other equipment. The practical application of this technology is of great significance and will bring infinite possibility of utilization.

S. Lackey and J. Chen (Eds.): VAMR 2017, LNCS 10280, pp. 394–403, 2017.
DOI: 10.1007/978-3-319-57987-0_32

From the first mobile augmented reality system is emerged in 1997, in the past 20 years, many corresponding application development toolkit and application framework are produced [2]. As the mobile device hardware and software is updated and improved, more and more applications and technologies are designed based on mobile terminal equipment.

The museum is a site that conduct collecting, displaying, researching and classifying the material object which represent nature and human cultural heritage, it also provides a place for visitors to study research and entertain. Providing high-quality information services is the core value of museums.

Museum exhibits are often characterized by physical presence experience. However, it still requires the integration and support of new technologies. With the development of information processing technology, the audience's demand for information and experience are increasing continually, which has become the inevitable development of the museum direction. Currently, the construction and displayed design of museum have shown the trend of digital, network, and intelligent technology. Through the investigation and research on the display site of the Mawangdui Han Tomb of the Hunan Provincial Museum, it is found that the existing exhibition has the following problems:

It is found that the information of the exhibition historical relics are disperse and half-baked. Hunan Museum separates the unearthed historical relics into different groups and places these relics into different exhibition rooms with diverse conditions in order to protect them. The dead woman body, the coffin, and various kinds of funerary objects are displayed in different showcases. It makes the exhibits separated and the relevance of the exhibits is artificially cut, which is detrimental to the visitors' overall perception and knowledge of Mawangdui Han tombs. As the exhibits are out of the environment, experience perception is insufficient.

Unlike single unearthed cultural relics, there are strong connections among the historical relics in Mawangdui Han tombs in both spatial existence and historical background and meaning. Placing the cultural relics out of the original grave environment will reduce the presence experience of visitor.

In order to solve the above problems, this paper presents a museum display method by using AR technology based on mobile terminal.

2 Method

Based on the results analyzed on Mawangdui Han Tomb, we proposed the following plans:

With the widely used of mobile terminal, the audience can appreciate an combination display of virtual and reality scene. It can effectively strengthen the integrity and presence. In the real environmental conditions presented by Han tomb coffin, we add Virtual 3D Scene to restore the view of burial funeral. Through the display, the audience can not only feel the authenticity of the unearthed cultural relics itself, but also can learn more information and realistic experience through the simulated recovery.

The specific design scheme based on the visitor's perspective are showing as following:

Visitors arrivals the coffin display area with their own intelligent mobile phone or tablet computer. Visitors installed program in advance and use the camera lens to view grave at any angle. From the reality on the screen, the reality of the tomb in the real coffin and the virtual three-dimensional model of the female body and all the funerary can make a good fusion. Visitors will see all the unearthed objects in the Mawangdui Tomb under the same angle of view, light, chroma with an integral sense. In addition, when visitors moving, the display screen can be updated and can automatically make a match between the real-time virtual content and 3D model from viewer's angle. This allows the audience to completely visit the Han Tombs at Mawangdui in the whole moving process. The scheme has the following advantages:

1. Supply the missing part of the exhibit: Restore the original environment of the artifacts and display each part of the unearthed objects. Visitors can see the whole Mawangdui tomb, which can strengthen the relevance of unearthed objects [3].
2. Demonstrate the spatial relationship and the unearthed order of the cultural relics: Through using 3D scene to exhibit Mawangdui tomb sites, visitors can intuitively see the unearthed order of the cultural relics, and the position of cultural relics.
3. Enrich visiting experience: A combination of the virtual reality makes the visiting experience more authentic and amusing. The interesting, vivid and realistic process enhances the audience's willingness to watch and accept the results.
4. Avoiding the destruction of Cultural Relics: Although augmented reality technology is new media technology, it won't light and radiate on cultural relics and any artificial markers would not make on the cultural relic entity. This system avoids the destruction of the coffin (Fig. 1).

Fig. 1. The proposed effect of this project

3 Measures

3.1 Technical's Route

According to the workflow of the augmented reality system and the actual application process of Mawangdui Han tomb, We make a technique route flowchart (Fig. 2):

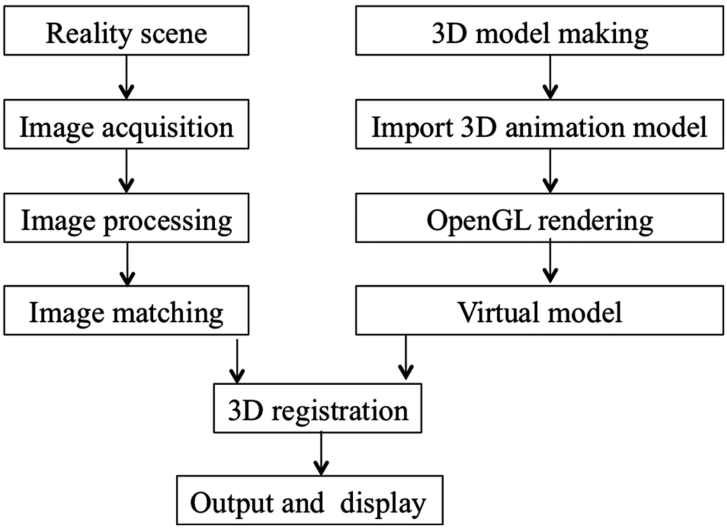

Fig. 2. Implementation procedure

3D virtual scene model making. In order to show the real-time rendering of the 3D virtual scene with high simulation degree, the animation character model and the scene model were built by Maya software. The process includes data collecting, conceptual design, model building, texturing mapping, skeletal skinning, motion animation, lighting production and rendering.

Image feature recognition and matching. After the image collection from the real scene, image feature recognition and matching technology between the images in the database and the image obtained from the camera is a key technology. Based on computer vision registration augmented reality system, there are two methods of image feature extraction matching: artificial labeling feature point method and natural feature points extraction method. In this paper, the cultural relics Mawangdui Tomb cannot be destroyed. Therefore, the method of artificial labeling is not applicable. Natural feature point extraction method is selected.

Three-D tracking registration technology. In order to make the virtual 3D model seamlessly connect with the real scene, the position of the virtual model in the real scene should be arranged correctly. 3D-tracking technology is the core technology of augmented reality system. There are two 3D tracking registration methods: 3D tracking technology based on hardware tracker (such as gyroscope, inertial navigation and positioning system) and 3D tracking technology based on computer vision. In this paper, 3D tracking technology based on computer vision is applied to the display of Mawangdui Han Tomb (Fig. 3).

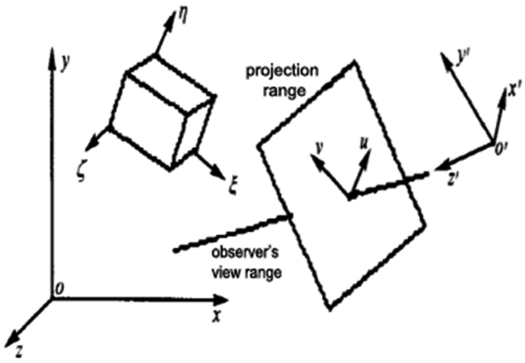

Fig. 3. 3D registration technology space coordinate system diagram

This paper applied 3D computer vision tracking technology to Mawangdui Han tomb exhibition. The application of the technology is shown as following: firstly, tracking technology needs determined the relationship between the virtual scene and real scene visitors. Then virtual model need to project into the observer's view range with correct projection. The 3D registration techniques usually use 4 coordinate system to describe, the x, y, z represent real coordinates; ξ, η, ζ represent the virtual space coordinate system; x′, y′, z′ represent the camera coordinate system; uv represent image plane coordinate system. The calculation of the transformation matrix are used to complete the three-dimensional registration technology [4].

3.2 Implementation of Augmented Reality Applications

3.2.1 Development Environment and Test Environment Settings

Development environment. This research builds a development system on a PC with excellent hardware, and Unity3D are adopted as the development environment. For OpenGL ES, this system provides very good channels for the optimization of graphics rendering. The applications of this system can be easily realized on Android system. It uses Maya dimensional animation software to build environments for virtual scene, which can highly simulate and restore female corpses and funerary objects. Additionally, we use Vuforia AR SDK, which is developed by Qualcomm as the toolbox package to implement augmented reality. It has the fundamental technology of mobile augmented reality, object scanning, 3D registration, and other functions [5, 6]. The SDK is the core technology package to achieve augmented reality.

Testing environment. Based on the actual situation of the coffin position in Hunan Mawangdui tomb, we restore the physical simulation setting in the test environment. Proportionally reduced Wooden solid coffin model is served as test realistic scenes. As a prerequisite, it is necessary to immune the natural light, keep light intensity and angle constant in the space environment tomb placed, and keep the location and surroundings of the coffin constant in the test process.

The procedure is conducted in Samsung Galaxy Mega devices above 4.0 versions of the system (Vuforia AR SDK 4.0 asks for testing mobile devices for Android4.0 above). Development of the special structure of the Android platform and greatly improvement of Graphics processing chip performance can be suitable for the development of augmented reality applications. 8-million pixel rear camera can clearly capture the features of coffin for feature extraction and recognition; 6.3 in. display, 720P Resolution allows viewers to clearly see the effect of fusion of virtual and real scene.

Three-dimensional scene modeling. In order to enhance the rendering effect of the practical application and increase the load speed, it is necessary to control the models and textures for a three-dimensional scene. First of all, Polygons was used to model and the model file should be of good compatibility. After completing the models, a further optimization should be made and the details performed by the performance of textures. When selecting the map, the resolution should not be higher than 1024 * 1024 dpi so that it can well ensure the effect of the viewing screen and the matching speed of the model. Finally, the 3D scene rendering was outputted for .fbx format, which can export animation, texture and mapping models to be imported to Unity3D to edit (Fig. 4).

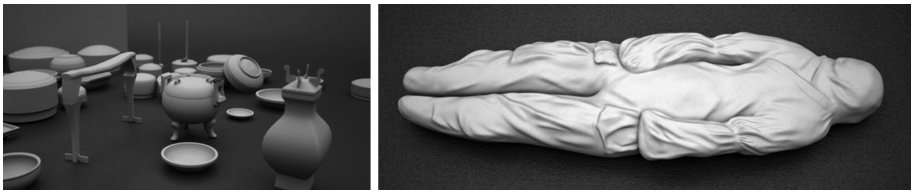

Fig. 4. 3D model of virtual scene

Image acquisition and processing. In this paper, in order to achieve image acquisition technology, comparative test was conducted on Single Image inVuforia SDK augmented reality toolkit and 3D Object model latest added. The specific implementation process is as following:

The coffin of the continuous image acquisition. 3D Object scans modeling implied 3D modeling scanning technology to the coffin model scan in realistic space, and it automatically is decomposed into 49 aspects captured in return. Images, which were printed and recognizable, were placed at the bottom of the coffin model. Mobile phone acquire feature points can be carried out after the viewfinder captured the three-dimensional coordinate system.

In order to ensure the practicality and authenticity of the viewing angle simulated the real world, instead of scanning all of the 49 surfaces, only the visual field was captured and collected.

After scanning and constructing model, it is necessary to test the real-time and stability of the model. Dragging green test points in the text, the sensitivity of its action shows the quality of the capture effect. It is shown in Fig. 5.

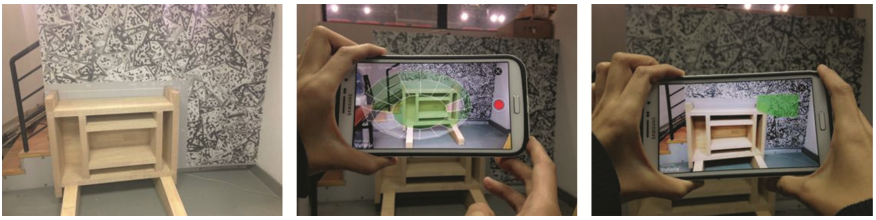

Fig. 5. Image acquisition process of "scanning modeling"

The coffin was identified as a.Ob file. Compared with the original Single Image, after capturing the different angle and height of the feature, the tracker can track different data sets at the same time, but only one can be activated at each time point [7]. It can reduce the work content and improve work efficiency, speed and enhance the application value.

Image feature point processing and 3D registration. Recognize and match image feature points and 3D registration are the key steps in augmented reality technology. After utilizing 3D scanning mode to extract image feature points, it follows uploading the acquisition target files to Add Target plate, and analyzing the object manager performs sample, making Vuforia SDK include in the sample registration matrix information downloaded, employing special algorithm to analyse and tab the feature points of the coffin model scanned.

The Vuforia SDK used tracker and its subclasses that can be track and monitor to the real environment in the space of 3D model, to identify the target of coffin. Deinit Tracker is responsible for initial recognition, and load Tracker Data is responsible for loading identification data to ensure that the image within the range of the viewfinder. If the images in the pre-realistic environment match with the sample matrix information successfully, the current real image will be tracked and rendered, and the three-dimensional tracking registration technology will be realized [7]. Otherwise, the three-dimensional tracking rendering of image will be exit and reload identification.

Compared with single image and 3D object, 3D scanning method is more suitable for the requirements of Mawangdui Han tombs existing display. Three-dimensional scanning coffin model generated a .ob file, the target images of different angles are identified as a whole target with fixed spatial relations. When the visiting position of the visitor is changed, the target manager can predict the range of the movement intelligently, pre-calculate the tracking rendering, so as to greatly improve the reading efficiency and application of real-time. In addition, as there is a larger flow of tourists with high intensity, the coffin is partially obscured by the visitor and cannot be recognized and tracking. In this situation, the image matching may fail because the information can not be captured by the system. At the same time we bind a three-dimensional scanning recognition method for an object file to fix the various entities of the spatial relationship. When part of the Target is identified successfully, the overall target file can be tracked. In the partially occluded environment, the tracking registration data can be obtained accurately, which can better adapt to the occlusion environment than single image recognition.

Virtual scene superposition. Importing the completed 3D model to the project file, the display of the project file does not recognize the specific image of the .ob file that was scanned. After manually importing 3D model, we need to generate mobile APP, repeatedly adjust spatial relationship between the virtual model and the real coffin, lighting simulation, so as to achieve better results of the actual situation fusion. As shown below, light control simulation in this research was performed with a cool color temperature close to the color temperature of the incandescent lamp, a directional light illumination type, and a 0.57 light intensity (Fig. 6).

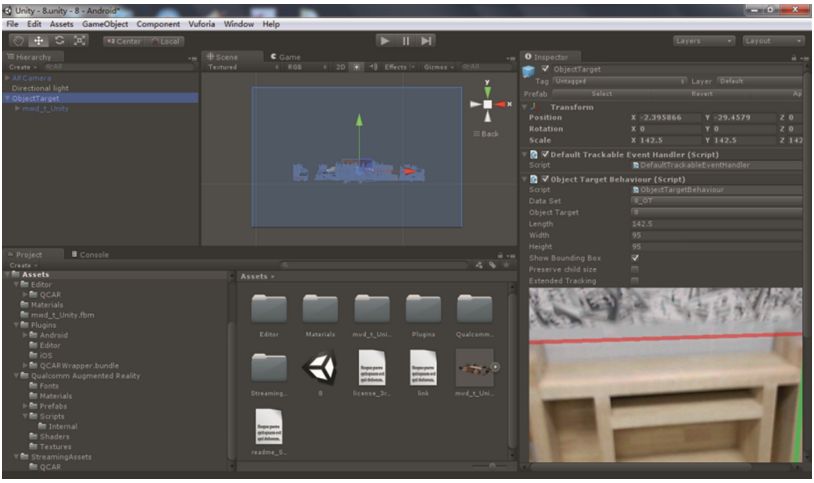

Fig. 6. PC virtual scene overlay debugging chart

4 Results

The test of the application program. The test is conducted in the Samsung Galaxy Mega phone Android4.2 system. A scale (1: 4) coffin model is designed to simulate the actual environment.

When the viewfinder finds the real coffin scene, the target Manager would capture images in 1–2 s. The screen can show the AR effect of the Mawangdui tomb. As shown in the Fig. 7, compared to the real scene without virtual integration, the image obtained

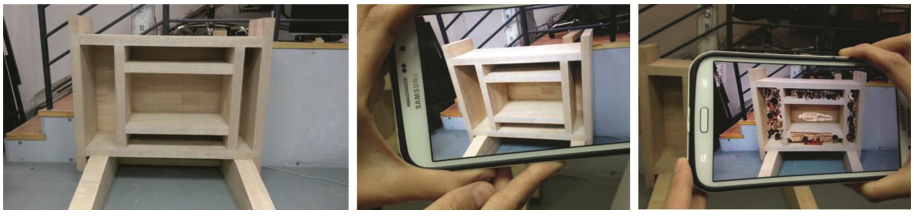

Fig. 7. Application test results

from virtual 3D model of women's corpse and their funeral restored the scene when unearthed, this method provide a intuitive and overall view.

This method can simulate viewing angle deviation. In different angles, height, distance and moving process, the mobile phone always displays the corresponding between virtual and real image. The audience can continuously watch from different angles in the movement.

When the moving speed is too fast and the coffin is completely separated from the viewfinder, the re-framing test can be made at any stop position to obtain the virtual and real scene fusion effect at current position. It has good real-time and strain.

Simulating the museum visiting process. When the coffin is shuttered partially by the crowds, the system employs the unobstructed area to catch and identify, calculate the space fixed relationship to achieve complete load tracking coffin model, so as to achieve seamless overlay virtual space scene. The image loss or malformed adverse effects do not affect the viewing process.

5 Discussion

Experimental results show that there are still short comings, in the follow-up work, which needs to be amended and improved:

At present, the experimental results show that the virtual 3D model lacks the corresponding shadow effect. After combining with the real scene, although the simulation is similar to the illumination, it would bring a sense of fragmentation without shadow.

As the virtual scene of the project needs to be placed in the coffin, it will generate occlusion when viewed from different perspective. Until now, the test results demonstrate that the edge of the coffin would cause spatial occlusion to built-in vessel. The authenticity of the viewing experience needs to be improved.

6 Conclusion

In this paper, through the investigation, analysis and design of Mawangdui Han tomb, the Application of Augmented Reality Technology on Museum Exhibition is designed and implemented. The program achieve the function that using of mobile augmented reality technology to accomplish seamless integration in a virtual three-dimensional scene and the real scene in the Android mobile device and constructing experimental scene based on equal proportional zoom entity model. In this scene, according to the coffin built in the Han Dynasty Xinzhui wife corpse and funerary objects by shape, proportions, patterns and other forms, a well virtual restoration are integrated, so as to make the visitors obtain a more holistic and comprehensive experience.

The proposal solves the shortage that the original augmented reality equipment is complicated and inconvenient to carry, and the problem of releasing and returning of the additional equipment. It also solves the problem that exhibition information of exhibits is scattered and incomplete, exhibits is out of the environment and the experience perception is inadequate in the museum display.

At the technical level, compared with the method of extracting the feature points from the original single image, the method of scanning and capturing the feature points of the whole real space object is more mature to identify the real-time, continuity and stability of feature points. Besides, partially obscured in museum exhibition also produced a better recognition effect in the actual prediction test.

Through the final model test, the results show that the program has a stable application. This method is possible to apply to the Mawangdui Han tomb in the live show. In the further study, we will improve the experimental results, as well as we optimize the design. On one hand, we can attempt to add dynamic content display and auxiliary instructions. On the other hand, we can also explore the possibility of developing virtual application based on cloud platform. The technology of this types of applications will certainly develop more digital display method in the museum display.

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