Application of Mixed Reality Technology in Education with the case of a Huangmei Opera Cultural Education System

1st Guangjun Wang
The University Key Laboratory of Intelligent Perception and Computing of Anhui Province
Anqing Normal University
Anqing, China
734386718@qq.com

2nd Zhichao Lu*
Institute of Network Technology
Beijing University of Posts and Telecommunications
Beijing, China
bathur@163.com

3rd Yufei Zhang
School of Computer and Information
Anqing Normal University
Anqing, China
1059764116@qq.com

4th Yu Qian
School of Computer and Information
Anqing Normal University
Anqing, China
2055182208@qq.com

5th Haiying Zhao
Mobile media and cultural calculation Key Laboratory of Beijing, Century college
Beijing University of Posts and Telecommunications
Beijing, China
1677319677@qq.com

6th Deyang Liu
School of Computer and Information
Anqing Normal University
Anqing, China
545247470@qq.com

***Abstract*—Mixed reality is an emerging technology that allows virtual world objects and real world objects to coexist and interact in real time. Its positioning lies between virtual reality and augmented reality, providing users with an immersive experience of combining virtual and real. In this article, we take the Huangmei Opera cultural educational system as an example, and use the current mainstream mixed reality hardware platform and its supporting content production softwares to implement interactive games and virtual museums about Huangmei Opera culture and knowledge. And to explore the application of mixed reality in education.**

Keywords—Mixed Reality, Hololens, Huangmei opera, Unity, Virtual museum, Cultural Education

I. INTRODUCTION

Mixed reality is the merging of virtual and real worlds to produce new environments and visualizations where virtual world objects and real world objects coexist and interact in real time[1][2]. It is augmenting the participants and surroundings with holographically enhanced displays and natural human-computer interfaces[3][4]. Information from the virtual world is combined with the real world through some holographic display. Microsoft HoloLens is one of the representative hardware of mixed reality[5][6].

Huangmei Opera, as one of the five major operas in China, has a unique cultural imprint and distinct regional customs. However, the cultural protection, inheritance, and development of traditional opera is facing many problems in competing with the rapid development of modern entertainment activities [7]. Today, traditional methods have not been effective in the education of Huangmei opera, and researchers have begun to seek help from emerging technologies such as mixed reality[8].

Using research from the efforts to support Huangmei opera culture, we apply a variety of digital media to design Huangmei cultural elements and use mixed reality technology to promote Huangmei opera. We use the Unity Engine to develop the main body of the system and HoloLens platform to implement an experiential program of Huangmei opera historical, cultural knowledge, characters, and costumes through artistic design, video animation, interactive games, and virtual museum roaming. This program can provide learners with historical knowledge and interest in Huangmei opera. Figure 1 presents the technical roadmap of our system.

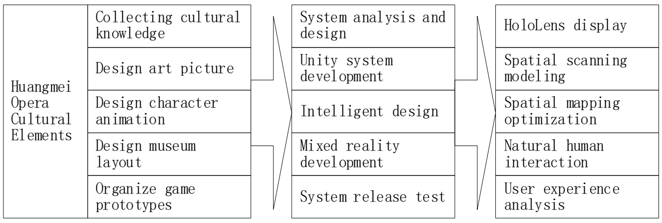

Fig. 1. Technical roadmap

The above roadmaps are all things that need to be considered when building such systems. In this article, the design and characteristics of the education system based on the mixed reality technology are introduced.

II. ADVANTAGES OF MIXED REALITY

Mixed reality has irreplaceable advantages in the field of education. Compared with virtual reality technology, it will be more comfortable and suitable for a wider range of people. Compared with augmented reality technology, it can free the user's hands.

For the mixed reality technology itself, its rendering method that superimposing objects in the virtual world into the real world can effectively reduce the occurrence of motion sickness, which will allow users who were previously unsuitable for virtual reality to use mixed reality. At the same time, it also means that the technology can be compatible with the original educational activities, not a complete replacement.

Mixed reality technology also supports spatial mapping and anchoring, which can establish the correspondence between virtual world objects and real world locations, so that the results of repeated running of the program are consistent. The above features maintain the spatial

*corresponding author: bathur@163.com

consistency in teaching, and more importantly, the virtual objects we set in the system can interact with the real world such as occlusion, collision, adsorption, etc., which gives us unlimited possibilities.

From the supporting measures of the platform, we choose, Microsoft HoloLens can also provide mixed reality capture and streaming, which can allow traditional display devices to simultaneously display pictures processed by mixed reality technology, expanding the audience's coverage. If cooperated with network distribution technology, distance learning can also be realized.

III. OVERALL DESIGN OF THE SYSTEM

This system realizes the display in the appropriate space, the interaction between the virtual world and the real world by using the HoloLens and presenting basic knowledge of cultural elements, model animations, and classic singsong video. At the same time, we design the mixed reality museum and cultural interactive games. Through the mixed reality technologies, we can let users experience culture in every space that meets the standards of use. Figure 2 shows the system design framework.

Huangmei Opera mixed reality display and function	System interface
	Historical introduction
	Aria demonstration
	Huangmei animation
	Mixed reality Museum
	Cultural experience game

Fig. 2. The overall design of the display system

We design the system interface with a uniform style. This interface provides the navigational features of the system, showing links to other content and modules plus the ability to return from or exit. The historical introduction module presents historical and cultural details using a mix of text and images. The vocal demonstration module enables participants to view and hear several classic Huangmei opera performances. The animation is a holographic display in a mixed space, presenting a 3D animation of opera made using AutoDesk's Maya modeling software.

IV. SCANNING OF INDOOR SPACE

Like traditional virtual reality or augmented reality technology, mixed reality technology also uses content production software for creation. The recommended software for Microsoft HoloLens is the Unity Engine. The content production software provides a series of tools to help developers combine multimedia content, including text, pictures, sound, video, etc.

In addition to common multimedia content, mixed reality technology focuses on scanning, mapping, and understanding of the real world. These functions are the core of this system. We hope to build a system that can reasonably utilize the real world space for virtual display teaching. This is inseparable from the following aspects of efforts.

A. *Scanning Technologies*

HoloLens uses SLAM and surface reconstruction to enable device to scan the real world and digitize it so that users can interact with objects in the virtual world with real objects such as desktops and walls.

We wrote a spatial observation program using the C# language for development in Visual Studio 2019 to monitor HoloLens's scanning of indoor space.

When HoloLens scans the spatial environment, it can present a certain density of triangular surfaces to cover the spatial environment surface, to provide a visual scanning progress. At the same time, these triangular surfaces are also recorded for future use. In order to run efficiently, we set that the user must thoroughly inspect the room when the application is initialized, so that the visual triangle covers the whole space, to complete the scanning modeling. The 3D view interface in device portal displays the data and parameter settings of indoor space scanning, as shown in figures 3 and 4.

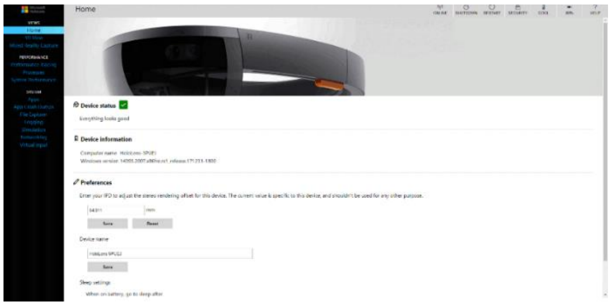

Fig. 3. Device Portal page

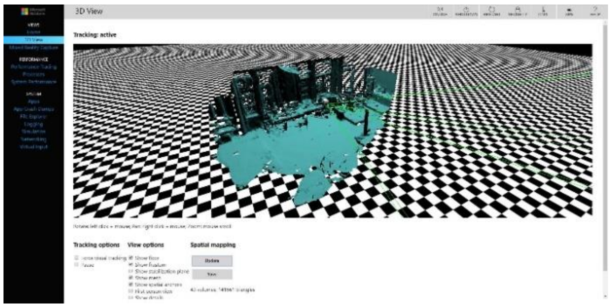

Fig. 4. 3D View interface

We import the collected spatial model data into Unity for further application development work. When the development is complete, the step of importing the collected spatial model data will be replaced by the real-time spatial mapping at program initialization phase.

B. *Scan and Process Spatial Data*

During the initialization phase of the entire program, we set aside time for users to scan the real world. After the initialization is completed, HoloLens obtains the 3D reconstruction data of the space in which it is currently located. Figure 5 shows the acquired spatial model.

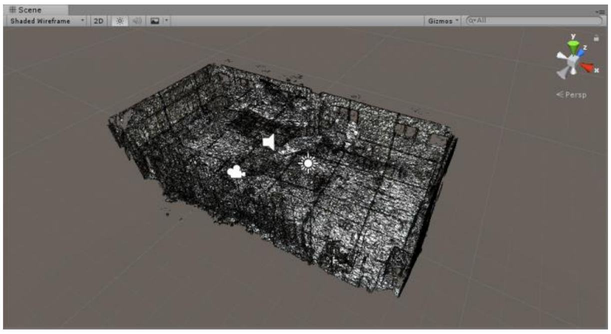

Fig. 5. Unprocessed spatial model after scanning

Unprocessed point cloud data are too redundant for our system, and a series of processes will be used to extract useful information. For a virtual display teaching system, most of the real-world information that needs to be understood is the plane in the real world.

After understanding the various planes, virtual objects can be placed according to the physical rules of the real world. For example, posters should be generated on the wall; headwear should be placed on the desktop. This is something that neither virtual reality nor augmented reality can do.

We divide the important interactive regions into the following categories: ceiling, floor, wall, table, and other large areas of flat surface. All remaining surfaces that do not meet the above conditions will be marked as unknown. The plane finding algorithm works as follows.

First, we read the model vertices in each fragment mesh.

Second, we calculate the curvature for every vertex.

Third, we flood-fill planar regions, and select the best regions as potential planes.

Fourth, we then generate plane equations for these regions as plane fitting using Principal Component Analysis[14].

Fifth, when we have plane equations, determine if this is an eligible plane.

After the above steps, each fragment mesh will be processed and output a collection of planes, each is a connected set of vertices and the plane equations. For planes with similar plane equations, further examine their position and other properties to determine if they can be merged into a larger plane. When all the outputs have been merged, we calculate their bounding boxes based on the position information of the vertices contained in each plane, calculate their orientation according to the plane equation and classify planes based on their properties, such as orientation and area, and preset thresholds. Figure 6 shows the flow chart of the algorithm.

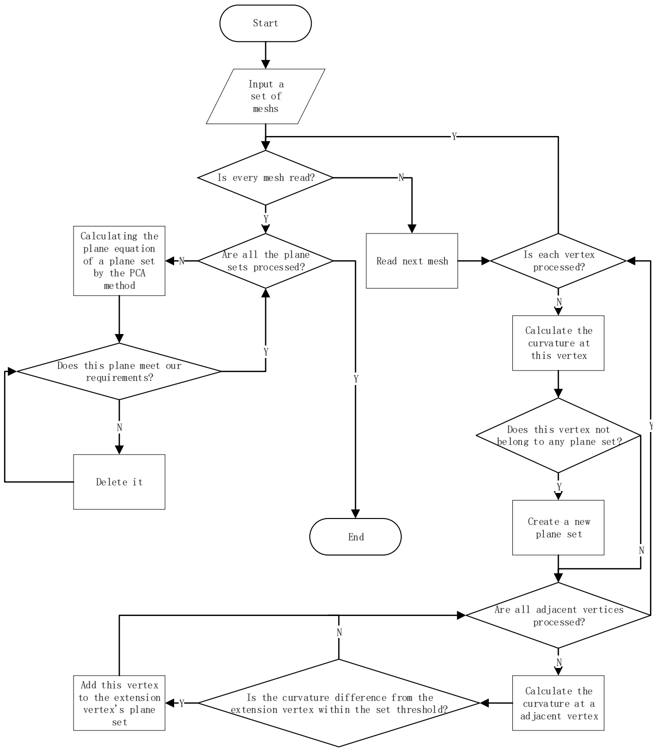

Fig. 6. The flow chart of plane finding algorithm.

According to the results returned by the above algorithm, we generate the corresponding Plane in the Unity Engine. Figure 7 shows the spatial data after initial processing.

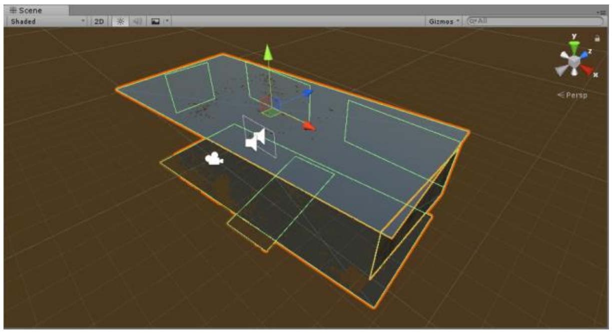

Fig. 7. The spatial data after initial processing.

Since the original space model is obtained by the user scanning from inside the house, and there is often many furniture in the user's house, we need to further process the extracted plane. Our specific optimizations are as follows.

First, keep the existing ceiling. Second, remove the existing floor and regenerate a new floor in place with reference to the size of the ceiling. Third, Our specific optimizations are as follows. Fourth, we remove all the planes that are outside or intersect the cube which constitute by the walls, the ceiling and the floor.

After performing these optimizations, we obtain a more accurate model of the scene as shown in Figure 8.

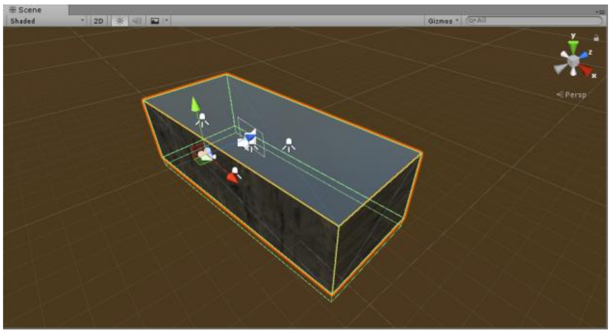

Fig. 8. The spatial model after processing by the optimization algorithm

Till now, the space mapping of the room has been completed. We obtained spatial data with balanced availability and complexity of subsequent virtual-real interactions.

V. Designing a Mixed Reality Application

A. Adaptation of Multimedia Content

Although the content production engine is consistent with virtual reality or augmented reality technology, due to the unique display method of mixed reality technology, we need to pay attention to the following aspects.

In a mixed reality application, in order to overlay a virtual object in the real world, the black displayed at design time will be transparent to the end user. Applying this flexibly results in a more immersive experience.

Mixed reality technology also brings a new concept of natural human-computer interaction. In this case, the traditional screen overlay user interface is only suitable for information display, and can no longer serve as an interactive function. We need a control panel that always follows the player's perspective in 3D space for interactive operations.

For mixed reality programs built for education, in addition to the significant changes described above, ease of use needs to be considered. In other words, the size of text, pictures, and videos must be reasonably arranged, and designed as much as possible in the physical size in the real world to prevent the destruction of immersion.

B. Application of Spatial Data

In mixed reality, the spatial data collected is mainly used to ensure the smooth progress of virtual-real interaction. Through a series of processing of spatial data in Section 4, we have transformed the original spatial data extraction into a simple cube whose availability and complexity are balanced.

These cubes will be assigned occlusion materials and colliders. The occlusion material prevents the virtual objects behind it from being displayed, which can ensure the immersion of mixed reality programs. The collider can support this cube to simulate the physical operation with the virtual object, to achieve the effect of virtual-real interaction.

VI. System Testing and User Experience

We design our system based on the physical content displayed at the Huangmei Opera Museum in Anqing City. After developing according to the above design concepts, we deployed the application to Microsoft HoloLens for testing. Figure 9 shows the content seen within the HoloLens, with the virtual objects superimposed on the real world. This main interface and other user interfaces that can be interacted with in the system will be followed in a 3D space within the user's field of vision.

Fig. 9. The main interface of the system

Figure 10 shows the HoloLens display of the historical and cultural knowledge seen by the user. Figure 11 shows the full-screen video of a classic Huangmei opera provided to the user. It covers all of the HoloLens visual screen.

Fig. 10. The history interface of the system

Fig. 11. Video demo (full screen)

Figure 12 shows the scene from the mixed reality museum of Huangmei opera as seen by the user. This virtual museum uses the collected spatial data to place virtual digital cultural relics in a reasonable position in the real world according to the type of cultural relics.

Fig. 12. Museum of mixed reality of Huangmei opera

Figure 13 shows the interactive self-learning process in our system. The user can complete the assembly of a set of costumes through the previous experience from other parts of the system. This part also uses the spatial data collected earlier.

Fig. 13. Mixed reality interactive self-learning process

VII. CONCLUSION

The development of mixed reality technology and related applications offers great advantages for innovative application to the preservation of cultural heritage. Using Huangmei opera as an example, we have used a variety of digital media technologies to design a mixed reality display system. By wearing the HoloLens mixed reality helmet, a user can learn about and experience Huangmei opera within their own familiar environment. We have provided textual and graphic explanations of Huangmei opera along with performances and cultural interactive self-learning process that are realistically presented to the HoloLens user.

The system in this article is based on the first-generation HoloLens device and utilizes most of the platform features it provides, including spatial mapping, gesture recognition, and voice interaction. This explores the application of mixed reality in the field of culture and education, and reveals the way of giving education that combines the virtual with the real.

The mixed reality device can be worn on the head of a traditional teacher, it does not interrupt the traditional teaching process, and can also provide additional real-time information for teachers. If the system is further developed for online functions, even the first person 's virtual and real combination of perspectives after the teacher wears the mixed reality device can be distributed over the network to make full use of educational resources.

This kind of device can also be worn on the students' heads, which will provide students with learning experience that they could not imagine. Virtual objects can be superimposed or covered on the premise of preserving the senses of the real world, which will help to improve students' interest and learning efficiency.

The mixed reality technology is booming. The release of the second-generation HoloLens device brings more advanced and natural human-computer interaction methods such as full-hand joint recognition and user eye tracking, which gives mixed reality technology unlimited possibilities and shows its The role in the field of culture and education.

ACKNOWLEDGMENT

This project is supported by Anhui philosophy and Social Sciences Planning Project (No.AHSKQ2018D74)

REFERENCES

[1] Ma H, Liu J, Yang M, et al. Influence of limited random-phase of objects on the image quality of 3D holographic display[J]. Optics Communications, 2017, 385:153-159.

[2] Furlan R. The future of augmented reality: Hololens - Microsoft's AR headset shines despite rough edges [Resources_Tools and Toys][J]. IEEE Spectrum, 2016, 53(6):21-21.

[3] Ghosh A, Nirala A K. Formation of high quality interference fringes from both sides of a suitably designed hololens in the laser Doppler anemometer measurement volume[J]. Quantum Electronics, 2017, 47(10):960-966.

[4] Wang S, Parsons M, Stonemclean J, et al. Augmented Reality as a Telemedicine Platform for Remote Procedural Training[J]. Sensors, 2017, 17(10):2294.

[5] Hanna M G, Ahmed I, Nine J, et al. Augmented Reality Technology Using Microsoft HoloLens in Anatomic Pathology[J]. Archives of Pathology & Laboratory Medicine, 2018, 142(5)：638-644.

[6] Lintong L , Youchun W , Ye X , et al. A Study of Mixed Reality Applied to Aerospace Intelligent Interaction[J]. Computer Measurement & Control, 2017(12):255-258.

[7] Min S . Emergence and Shaping of Huangmei Opera:From A Genetic View[J]. Academics in China, 2013(9):298-303.

[8] Zhen-Zhen Q. The Digital Branding Design of Anhui Huangmei Opera in the Age of Virtual Vision[J]. Art & Design, 2018:76-78.

[9] Chen Y R . An Investigation of the Huangmei Opera Film Genre: The Audience's Perception of Ling Po's Male Impersonation[J]. 2018:85-94.

[10] Ni Jing. A Study of Visualized Expressive Paths to Traditional Operas--A Case Study of Huangmei Opera [J]. Journal of Neijiang Normal University, 2017,32(3):124-128.

[11] Wang Guangjun, Qian Yu, Zhang Yufei, et al. Design and Implementation of Children's Games Based on Mixed Reality[C]. 2019 IEEE International Conference on Computer Science and Educational Informatization, 2019: 176-180.

[12] Kowalski M, Nasarzewski Z, Galinski G, et al. HoloFace: Augmenting Human-to-Human Interactions on HoloLens[C].IEEE Winter Conference on Applications of Computer Vision. IEEE Computer Society, 2018:141-149.

[13] Bahraini M S, Bozorg M, Rad A B. SLAM in dynamic environments via ML-RANSAC[J]. Mechatronics, 2018, 49:105-118.

[14] Feng C , Taguchi Y , Kamat V R . Fast Plane Extraction in Organized Point Clouds Using Agglomerative Hierarchical Clustering[C]// IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2014:6218–6225.