2018 4th Annual International Conference on Network and Information Systems for Computers

The Virtual Museum Based on HoloLens and Vuforia

Tian-Han Gao[1], Qiao-Yu Tian[2], and Shuo Zhou[3]
[1,2,3]Software College, Northeastern University, Shenyang, China
Corresponding author: 632920373@qq.com

***Abstract*- Based on the current development of VR, AR, and MR (3R) technologies, this article comprehensively considers the limitations of physical museums in digital applications and proposes a new generation of virtual museums that break the cognitive boundaries between 3R. The significance, innovation and technology of virtual museums based on HoloLens and Vuforia technology are discussed. The multiple dimensions are used to evaluate the application value and development direction of the virtual museum in the future.**

***Keywords*-3R Technology; HoloLens; Vuforia; Virtual Museum**

I. RESEARCH BACKGROUND

A. *3R technology development*

In 3R-enabled 4th generation digital technology, VR (Virtual Reality) is a completely virtual digital picture, AR (Augmented Reality) is a combination of virtual digital pictures and the naked-eye reality, and MR (Mixed Reality) utilizes digital reality and virtual digital scenes to present the effect[1]. With the aid of different devices, the three provide unique digital experiences.

Whether VR, AR, or MR, comfort and immersion are the primary user experience elements.

Comfort - to continue to optimize the user experience from a motion sickness perspective. The most important factor affecting comfort is vertigo, and the direct induction of vertigo is the mismatch between the visual observation and the actual movement state caused by device delay[2]. Compared to the virtual presentation of VR in all scenes, AR and MR applications have a stable background in the real world, which eases the conflict between the human visual system and brain processing.

Immersion - to enhance the user experience from a realistic point of view. In order to further improve immersiveness, 3R applications that have been continuously improved over the past two years to create virtual or semi-virtual scenes that are closer to life and reality, in terms of model accuracy, stereo sounds, perspective coordination, motion design, human-computer interaction, and interactive feedback and so on[3]. AR and MR are partially immersed, while VR is completely immersed. Therefore, it is easier to achieve and improve the users' vision by adjusting their vision in a small dose than in a wide range of changes in ergonomics.

3R technology has been able to provide a new way of experiencing.

B. *Virtual museum researches*

According to statistics, the number of movable cultural relics registered in China, coming from the unified census standard, is as large as 26.61 million pieces/sets, and a large number of cultural relics are still unearthed each year. However, due to the limitations of time, space, preservation conditions, and protection technologies, only a small number of artifacts that can be exhibited and provided for researches[4].

The most common types of museums currently in the public view are physical museums (or traditional museums). With the development of the times and technologies, physical museums have also become more digital. For example, 3D auto-imaging technology can synthesize a 360 degree animated image after capturing artifact plane images[5]. The photo stitching system can seamlessly connect sequence photos into a huge frame[6].

As a result, virtual museums came into being. On the basis of traditional museums, virtual museums are endowed with much more elements[7]: visual impact, big information, intelligent management, high cost performance, etc. First, virtual museums use full-virtual or semi-virtual effects. With 3R technologies, artifacts are restored through computer-based 3D modeling techniques and combined with real environments or fictitious scenes around them. Secondly, due to network interoperability and information sharing, virtual museums have recorded and analyzed a large number of data and research results in a clearer and more precise manner, allowing history to be truly documented and based on evidence, which further promotes cultural and educational in-and-output bidirectional processes.

At present, the world's virtual museums have entered a warming phase, and various countries are racing to use 3R technologies to develop new museums[8]. For example, Chinese Baidu Encyclopedia VR Digital Museum and Thailand's open-street VR museum have brought immersive excursion experience to the public. The 'Civilisations AR' application released by BBC in the United Kingdom has enabled mobile phone users to quickly and easily view lifelike cultural artworks. There is also a MR holographic exhibition launched by the National Museum of Cultural Relics in the Netherlands.

However, it is not difficult to find that, whether at home or abroad, the three types of museums are still concepts that are almost independent of each other and unilaterally developed, and there are few large-scale technology fusions and collaborations. This puts forward the thinking of a new generation of virtual museums: breaking the boundaries between technologies, and developing a richer, mixed-concept museum. The virtual museum of AR and MR hybrid concepts will be the first to become the latest test results.

978-1-5386-6956-3/18/$31.00 ©2018 IEEE
DOI 10.1109/ICNISC.2018.00084

This article presents the concept of a virtual museum based on HoloLens and Vuforia technologies. This is a new type of virtual museum that uses the HoloLens HMD device to scan 2D images and identify them so that the user can observe the virtual artifact models presented above the image. It not only uses augmented reality to scan the image presentation model, but also uses a hybrid reality device to achieve camera scanning and imaging.

C. Significance and innovation

Breakthrough limitations: Traditional museums mostly prohibit visitors from photographing and touching exhibits. Conversely, various virtual museums, including the HoloLens and Vuforia Museums, can adopt a new exhibition model, which requires only an empty exhibition space to provide the public with viewing and learning opportunities of cultural heritages. As the exhibits are three-dimensional modelling results and are virtually presented, their maintenance costs in the real pavilions have been greatly reduced. In addition, the optional multimedia voice presentations accompanied with cultural relics have also reduced the labor costs by traditional guides.

Enhancing the sense of experience: Specifically optimizing the user experience, the application has a more realistic and gorgeous visual effects, as well as innovative, technology-based operating modes (including gesture operations, voice operations, etc.), enabling users to have a more rapid and rich experience mode. Taking the interaction of the exhibits as an example, the user can rotate, reduce, and enlarge the exhibits by means of gestures and conduct comprehensive observation[9].

Industry expansion: The combination of HoloLens glasses and the Vuforia platform is not limited to museums, but other cultural fields. It can also be applied to the education industry, animation and game industry, and cultural tourism. In different application areas, products can create unique features that meet the area.

Breaking the established boundary: Augmented Reality and Mixed Reality are two different concepts. In the initial stage of development, they are divided into different fields and use different equipment. The HoloLens and Vuforia Museums are a brand-new concept that breaks the boundary between the augmented reality and the mixed reality, allowing the two to exert their respective advantages to achieve a special experience.

II. THE VIRTUAL MUSEUM BASED ON HOLOLENS AND VUFORIA: IMPLEMENT AND DESIGN

A. Application Design and Development

1) The main modules. Spatial Mapping Module: Spatial mapping provides a detailed representation of the real-world surface in the HoloLens environment which is always mapping the surrounding environment. It can also provide real-time monitoring of the user's movement in the space, updating the screen display, and stay fixed UI and other interactive elements in the space.

Gesture Recognition Module: The user can perform model rotation, scaling, and other interactive operations through several specific gestures.

Gaze Point Module: Gaze is the experience of interacting with an object by staring at an object with no input device such as a handle.

Image Recognition Module: Identify the specific recognition pictures through the HoloLens camera, and display the module as well as the interactive elements corresponding to the model.

Voice Module: This application has a built-in 3D voice system. The purpose is to play stereo surround sound with this application, including the introduction of exhibiting models and background sound effects.

UI Module: includes the application main interface and model function interface, which provide gesture-clickable function buttons.

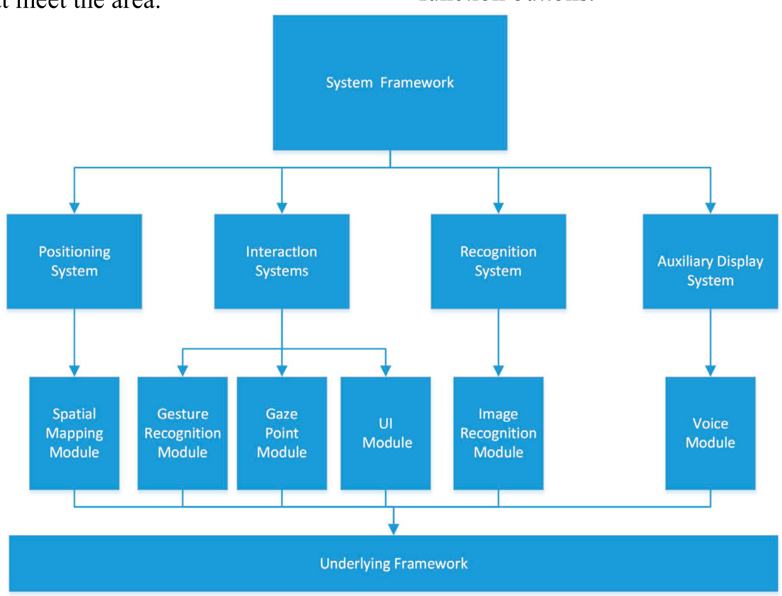

Fig 2. The Virtual Museum Based on HoloLens: System Architecture Diagram.

2) Development Environment

TABLE 1. THE VIRTUAL MUSEUM BASED ON HOLOLENS AND VUFORIA: DEVELOPMENT ENVIRONMENT TABLE.

Operating System	Windows 10	
Hardware Configuration	Processor	AMD Ryzen 5 1400
	GPU	Nvidia GeForce GTX1060 6G
	RAM	16GB
	Disk Space	2TB
Development Tools	Unity 3D 5.5.x	
	Visual Studio 2017	
	3DS Max 2016	
	Adobe Photoshop CC	
	Windows 10 SDK (10.0.10586 version)	
	Vuforia 6 SDK	

3) Implementation Process.

1) Create a new Unity project and name the new scene.

2) Import ‘Vuforia 6 SDK’ and ‘HoloToolKit’.

3) Configure the virtual camera and other components.

4) Take the twelve Chinese Zodiac heads of the Yuanmingyuan Garden (a Chinese historical site) as an example to make the corresponding virtual bronze models: First, collect the data, find the related data and pictures, and make the low-poly model according to the prototype. Furthermore, process and adjust the point, line, and surface structure of the model, to make a high-precision model. In this way, the final scene effect will be made as much as possible to restore the original appearance of the artifacts.

5) Make model content, scripting, and other application parts. The script-controlled content mainly includes: Sound scripts, gaze point scripts, and gesture scripts. Among them, ‘TextToSpeechManager.cs’ is a text and sound management class. In a virtual museum application, it mainly uses its sound part and overwrites part of the script on the basis of source code. Using ‘Media.SpeechSynthesis’, a speech library in Win10, the script can convert the text or SSML content into speech output. HoloLens currently only supports three English libraries: MSTTS_V110_enUS_MarkM, MSTTS_V110_enUS_ZiraFM and MSTTS_V110_enUS_DavidM. The Chinese library cannot be imported at present.

6) The gaze point script makes use of the principle of ray detection, which is achieved by projecting rays from the users in which HoloLens is located toward the direction of their advancement and determines whether the rays collide with them. In Unity, the user's head position and orientation are exposed through the Camera. Invoking ‘Physics.RayCast’ generates a ‘RaycastHit’ structure that contains information about the collision, including the 3D points where the collision occurred and another object that has collided with the ray.

7) The gesture recognition section uses a high-level API to recognize gestures through the input source. Each gesture corresponds to a ‘SourceKind’ input source. Most gesture events are system-preset events. Some events provide additional context information. Only a few steps are required to use the ‘GestureRecognizer’ to integrate gesture recognition: first create a ‘GestureRecognizer’ instance, then register the specified gesture type, and make events to achieve gesture recognition.

8) Save the scene.

9) Open the ‘Player Settings’ window from the ‘Build and Settings’, select the ‘Settings for Windows Store’ tab, and expand the ‘Other Settings’ group. In the ‘Rendering’ section, select the ‘Virtual Reality Supported’ check box to add new list of virtual devices and confirm that ‘Windows Holographic’ is listed as a supported device.

10) Export UWP (Universal Windows Platform) project from Unity. Set the SDK to Universal 10, target device to HoloLens, and UWP build type to D3D. Export the Visual Studio solution.

11) UWP project exported from Unity, need to open solution compilation with Visual Studio before running on the device. So set up Visual Studio: In the top toolbar, change the configurations option from ‘Debug’ to ‘Release’. In the platform option, ARM changes to X86, and the running target device is set to ‘Device’ to deploy to the HoloLens.

12) Observe in a HoloLens device and test the application.

Fig 2. The Virtual Museum Based on HoloLens and Vuforia: Main Interface.

4) User interface presentation. When the user wears the *HoloLens* HMD and opens the virtual museum application, the camera can be pointed at the identification pictures in the venue. At this time, the corresponding model will appear in the user's vision. By slightly adjusting the head angle, the user can align the gaze point moved with the point of sight on the model of the exhibits to achieve the purpose of selecting these exhibits. After selecting the exhibits, the user can raise his right hand to be located within the range of the forehead camera for further gesture interaction: Click on the virtual tap with the 'Air Tap' gesture to start playing the voice and text description, and use the 'Navigation' gesture to rotate the exhibits to experience multi-angle observation.

Fig 3. The Initial Effect of Using HoloLens Helmet to Scan The Picture of Yuanmingyuan Longshou.

B. Application Prospect

This type of museum is suitable for a variety of environments as a whole, with low overall requirements and no special venues. For culture and tourism, the physical museum can be put into use after the completion of site installation and equipment. And then, it will become a virtual museum without placing ancient artifacts in a designated exhibition location. Users visiting the museum will identify each booth through the camera lens. For the education industry, the identification pictures can be made into a set of cards for teaching demonstration, students can be close to various monuments in the classroom. And so on, as long as the equipment meets the good imaging conditions, other industries and environment can be applied with it. A piece of equipment and a set of cards make up a removable, portable virtual museum.

Through comparison of relevant information, the VR, AR, MR, and AR+MR types of museums have their own characteristics, each with advantages and disadvantages. However, it is not difficult to see that although VR products have gradually matured, they lack flexibility and potential. From equipment to interaction, there are still many inconveniences. It seems that VR has risen to a stagnant level, and it is difficult to erupt at this stage to develop more unique features.

The above table shows that:

In terms of immersion and harmony, images rendered in real-time tend to be delayed. The immersive experience of VR museum users can hardly be satisfying. Once the model rendering in the visual field is not real enough, or the human movement and the scene movement are deviated, the experience will be greatly weakened. The virtual museum based on HoloLens and Vuforia combines integrated and projective imaging features to double the advantages of these two; In this way, the application can better integrate models with the surrounding environment. It can be seen that the integrated and projective imaging methods used by AR+MR virtual museums are also more ergonomic.

In the facet of motion range, based on the removable and portable HMD used by the virtual museum of HoloLens and Vuforia, the space for the user's activities was greatly liberated; Compared with the traditional VR devices, the restrictions on the wiring of the equipment were reduced, and the handle as a cumbersome input device was also eliminated. Here, the input method of gesture recognition adopted by the AR+MR virtual museum shows its great excellence.

TABLE 2. COMPARISON OF VR, AR, MR, AR+MR FOUR EXISTING MUSEUMS.

Similarities and Differences of Related Museums at Home and Abroad				
Type	VR Museum	AR Museum	MR Museum	AR+MR Museum
Experience Method	Immersive	Projective	Integrated	Projective + Integrated
Motion Range	Limited	Movable	Movable	Movable
FOV	90°~ 110°	45°	35°	45°
Consumer Group	Mass Consumers	Mass Consumers (Mostly mobile users)	Mass Consumers, Professional and Technical Personnel, Cultural and Education Personnel	Mass Consumers, Professional and Technical Personnel, Cultural and Education Personnel
Popularity	High	High	Low	Quite Low

When using an AR or MR device independently, the FOV is 45°and 35°respectively. When using the HoloLens to recognize an image, the FOV can reach 45°, which means that the use of the AR can make the MR device enlarge the angle of view. The new museum application discussed in this article has, in a clever way, optimized the narrowness of the hardware perspective to some extent.

The overall superiority and flexibility of AR and MR are higher than those of VR museums. Although the cost of hardware is comparable to that of VR, the combination of the two is a novel way of avoiding weaknesses. The combination of AR and MR may become the orientation and motivation in the future market.

At present, there are still some unsolved problems in this application:

1) The HoloLens HMD relies on the camera to image on the transparent display screen, so the imaging effect is affected by the light intensity of the real environment. Too weak or too strong light will cause the imaging to be unclear. In this way, the user's perception is poor.

2) HoloLens glasses have small memory. The total accuracy of models and the limited lighting application directly affect the software development process and its visual effects. Therefore, in the subsequent development of virtual museums of other themes, attention must be paid to the total accuracy of internal models in the scene. Otherwise, flashback and other phenomena may easily occur. The problem is a hardware issue. In the future, developers will seek to optimize the software and try to weaken the impact.

3) HoloLens glasses have a narrow field of observation. HoloLens glasses are imaged in front of the human eye by a specific lens light. The imaging range is roughly equivalent to the size of a 15-inch display screen. The holographic diffraction waveguide grating technology has a technical bottleneck[10]. Therefore, in the process of watching, the visual field of the user is affected.

4) HoloLens weighs 579g. Due to its large size, it may be inconvenient to use and it is not suitable for long wearing.

5) HoloLens glasses are expensive and lack popularity[11].

III. SUMMARY

The virtual museum based on HoloLens and Vuforia technology is a new concept that combines mixed reality and augmented reality. It not only uses the equipment of the mixed reality to realize the scanning and imaging of the camera, but also uses the augmented reality to scan the image to present the model. Breaking the boundaries between augmented reality and mixed reality, the two can play their respective advantages, greatly enhancing the user's sense of immersion and substitution.

It can also be said that augmented reality with mixed reality is subversive. It is not only the process but also the design that changes. In addition to the advantages of traditional types of digital virtual museums, it also has features such as greater activity space, higher viewing angle range, more flexible operating modes, and more innovative technology ideas.

This application is not just a simple application, but also a completely new concept. This concept cleverly solves many practical problems, and the industry is highly scalable and can be extended to various professional fields.

However, due to hardware issues, certain aspects of the application may have limitations. With the gradual solution of the above problems, the virtual museum based on HoloLens and Vuforia technology will be widely used.

IV. REFERENCES

[1] Wang Siqi, The next stop for VR is MR?, *China Business News*, (2016-01-17).

[2] Cai Li, Weng Dongdong, Zhang Zhenliang, elta. Impact of Consistency Between Visually Perceived Movement and Real Movement on Cybersickness, *Journal of System Simulation*, **vol. 28**, pp. 1950-1956, (2016).

[3] Qiu Feng, A Research on Immersion in Virtual Reality, *Art Education*, vol. 05, pp. 99-100, 2015.

[4] China State Cultural Relics Bureau, The First National Census Work Report on Movable Cultural Relics, *China Historical Relic News*, (2017-4-8(2)).

[5] Liu Yizhen, Wu Jun'ou, Wei Jiayu, elta, 3D Automatic Imaging System, *Science & Technology Information*, **vol. 28**, pp. 18-22, (2015).

[6] Lu Yingtong, Li Wenqiang, and Wu Zhihong, Design of Parallel Panoramic Stitching System Based on InfiniBand Cluster, *Journal of Sichuan University(Natural Science Edition)*, **vol. 53**, pp. 1247-1254, (2016).

[7] Li Shuangjiang, Physical Museum and Virtual Museum Convergence: Wisdom Museum, *The Guide of Science & Education*, **vol. 12**, pp. 183-184+187, (2015).

[8] Shen Jiping, The Digitization of Museum Public Service under Internet-plus Background, *Software Industry and Engineering*, **vol. 34**, pp. 52-56, (2015).

[9] Luo Yiming, Hu Shan, Discussion about the Interactive Display Status of Virtual Museum, *PC Fan*, **vol. 12**, pp. 118-119, (2016).

[10] Zong Lei, AR Display Technology and Product Analysis from Patent Perspective, *China Invention & Patent*, **vol. 07**, pp. 41-47, (2017).

[11] Gao Yun, The Development and Inspiration of Virtual Reality Technology: Taking Microsoft HOLOLENS as an Example, *The Internet Economy*, **vol. 12**, pp. 50-55, (2017).