Application Extended Reality Technology in Cultural Preservation and Virtual Tour APP Development

Chieh-Ling Huang[1*], Cheng-Liang Chang[2], Jwu-jenq Chen[3]

ABSTRACT

Extended reality (XR) technology has matured in recent years and been widely used in games, education, medicine and other fields. Which shows that XR technology is one of the most valuable technologies. Mature XR technology is very suitable as a medium for cultural preservation and reproduction, but XR technology has rarely used in specific cultures. Base on this, this paper applies novel digital technologies (such as augmented reality technology, 3D modeling and 360-degree panoramic photography) to the development of cultural preservation and virtual tour APP, and takes "Sugar Mill Culture" and "Ch'ien Mu Residence" as examples. This paper used XR technology to combine panoramic image, 3D model, video, slideshow, funny quiz and e-book to preserve and virtual tour the culture of "Sugar Mill Culture" and "Ch'ien Mu Residence". The application of XR technology in a specific culture, in addition to increasing the funny and knowledge of the virtual tour, but also expected to become an important medium for cultural preservation and promotion.

Keywords: extended reality, sugar mill culture, Ch'ien Mu residence, 3D modeling, panorama image, virtual tour.

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I. INTRODUCTION

The stability and maturity of virtual reality and augmented reality applications can be saw out from Gartner's annual report on the hype cycle for Emerging Technologies [1]. The hype curve is an emerging technology evaluation model proposed by the international research and consulting company Gartner in 1995. Figure 1 presents Gartner's hype cycle for Emerging Technologies Maps from 2014 to 2017.

In Fig. 1, we specially mark Virtual Reality (VR, blue box) and Augmented Reality (AR, red box). Figure 1 shows that VR and AR have slowly shifted back on the technology maturity curve over time, and are still staying on the maturity curve and are favored by the industry. Due to the software and hardware technologies of VR and AR rapid advancement, and their maturity today, VR and AR are extremely suitable for using as an important software and hardware medium for the reproduction of ancient cultures.

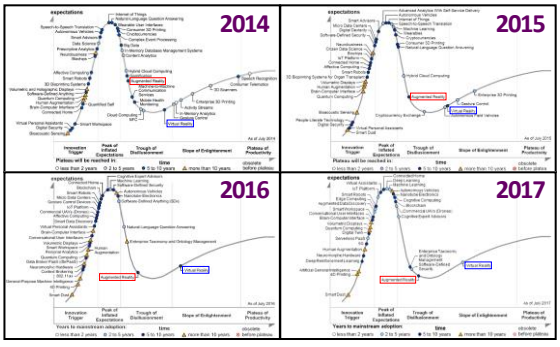


Figure 1. Gartner hype cycle for emerging technologies

Virtual Reality (VR) [2] is the use of virtual 3D objects and scenes to simulate a real space, giving users the illusion of being in a real environment in this virtual space. VR mainly focuses on visual virtual reality. If it can cooperate

with the human bodies other four senses of hearing, smell, taste, and touch-pressure, users will be more immersive in the virtual scene. Burdea proposed in 1994 that the application of creating a virtual reality must have imagination, interaction, and immersion, as shown in Fig. 2, the three characteristic elements [3]. Many enthusiasts of virtual reality view the immersive technology as "the ultimate empathy machine" that can help people relate to each other better than novels, TV shows or films can [4]. This is why virtual reality is an important software and hardware medium for cultural preservation and virtual tour, so that users can have an empathetic and immersive virtual tour experience.

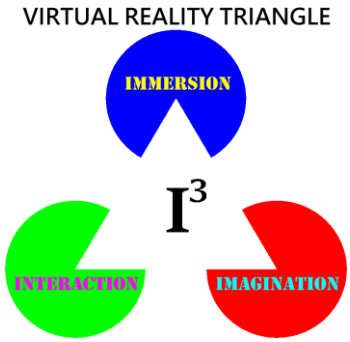


Figure 2. Elements of Constructing Virtual Reality

As mentioned above, VR is virtual completely. By combining with the actual scene, many related technologies of the intersection of virtual and real world had be derived, including Augmented Reality, Substitutional Reality and Mixed Reality.

Augmented Reality (AR) [5] is a technology that augments virtual objects into real scenes. It emphasizes the augmentation of virtual objects in real scenes, rather than replacing real scenes like VR. Image recognition technology has usually used to obtain spatial positioning through the real scene captured by a camera. Common image recognition and positioning technologies include QR Code, Frame Marker, Logo totem, or the use of specific real-world object contour recognition. After obtaining the location in the real space, the virtual object is corresponding to the appropriate position. Then the object size and placement angle has adjusted in advance, and the light and shadow changes of the virtual object has projected according to the real light and shadow.

In short, AR is to superimpose digital virtual information into the real scene and to superimpose the virtual information correctly in accordance with the time and place of the real world. So that the virtual information can be visually felt as if it exists in the real world; while VR is an attempt to replace the real world with a virtual world.

Substitutional Reality (SR) [6] uses a head-mounted display (HMD) to display real-time scenes based on the position of the user's eyes through the camera. In addition to displaying real scenes, it can also display pre-photographed video images or virtual scenes to replace real scenes, so it called substitutional reality. Through the interweaving of reality and alternative sceneries in the same place, users can experience the change between virtual and reality.

Mixed Reality (MR) [7] is a hybrid state between AR and VR. As mentioned earlier, AR is still in reality, with only virtual objects or information added; VR's goal is to replace reality with full vitality. MR is a more advanced combination of virtual scenes and reality to creating a user experience that is both true and false.

Extended Reality (XR) refers to a combination of real and virtual environments through human-computer interaction devices. It calculated using computer technology and wearable devices. There X represents a variable, which can be present or future space computing technology. These may include the aforementioned augmented AR, VR, and MR [8].

With the development of extended reality (XR), such as AR, VR, MR, SR and other "virtual imaging" technologies in the 1990s, a new learning and business opportunity for digital action learning launched. Especially as the software and hardware technologies of Mobile APP become more mature and popular, XR has gradually become the mainstream market for global industrial applications. XR is widely used in shopping, marketing, education, art, tourism, manufacturing and other aspects. According to a report from the World Trade

Center, the output value of the AR and VR market in 2017 was US$11.4 billion, and by 2021, it will grow rapidly, reaching US$215 billion, with a growth rate of 113.2%.

Mature XR technology is very suitable as a medium for cultural preservation and reproduction, but there are few applications of XR technology to specific cultures. Based on this, the purpose of this paper is to combine XR technology in the development of cultural preservation and virtual tour APP, and takes "Sugar Mill Culture" and "Ch'ien Mu Residence" as examples. Expect can help students learn and develop application plans for this skill, enhance their future competitiveness and build self-learning skills.

The remainder of this paper organized as follows. First, the relevant literature reviewer and briefly describe the "Sugar Mill Culture" and "Ch'ien Mu Residence" are described in Section 2. Section 3 describes the planning and development of the extended reality APP. Section 4 presents the results of our completed XR APP preserve and virtual tour the culture. Finally, conclusions presented in Section 5.

II. RELATED LITERATURE AND APPLIED CULTURE

The combination of digital technology and cultural tourism makes tourists no longer satisfied with passively arranging visits, but can engage in personal participation and experience more autonomously [9]. The mobile APP tour service and the combination of tourism applications are gradually increasing, not only gradually replacing the original travel mode, but also gradually diversifying the tour and learning modes, and driving the rise of the mobile digital tour mode. Therefore, combined with the mobile tour system of mobile devices (such as smartphone, tablet computer), visitors can conduct self-guided explanations of scenic spots, query related information, and expanded guided tours in museums, historical sites, school outdoor fields, etc. Therefore, those visitors are in a ubiquitous learning environment and enhance the gains of the visit. Regarding the design of digital guided tours, Chang [4] has some suggestions for digital guided tours in museums. In the evaluation aspect of the human-machine interface design-oriented, it is necessary to understand the reasons deeply, motivation and experience of the user's interaction between the museum display space and the digital tour system. Only in this way can be narrowed the distance between the user and the digital guide, and the needs of the visitors can be met, so that the artistic meaning of the museum exhibits can be effectively communicated and perceived, to achieve the main purpose of promoting the digital guide system. This is the main purpose of promoting the digital guide system. Due to the vigorous development of the smartphone market, more and more museums, cultural relics, science and education centers, tourist attractions and other areas have successively developed mobile tour applications for audiences to download. That allow visitors to browse and review the contents of the tour at any time according to their own progress, whether it is before going to the destination, during the visit or after the visit. Li [11] analyzed the design and application of the mobile tour application of the Museum of Modern Art in New York, the Toledo Museum of Art, and the Taipei Fine Arts Museum through literature analysis, case studies, and questionnaire interviews. It believed that the current mobile tour application using smartphones has gradually developed a model and structure with tour experience. In addition to providing rich museum visit information, appropriate display information page design, planning package tour itinerary and extending learning resources, it also gives visitors the opportunity to learn by themselves.

Chang and Liu [12] used MIT APP Inventor 2 to develop the APP, design a campus tour APP. Let students use the APP to learn about campus outdoor attractions in the school's characteristic courses through self-directed learning. The study found that students' use of the campus tour APP for teaching can significantly improve their learning effectiveness, and they have a positive attitude towards using the APP to learn campus attractions. Therefore, with the trend of digital learning, it is necessary and valuable to promote the

interpretation and tour of APP in various fields. Making good use of it can actually promote the innovation of education and the sustainable development of tourism.

The "Interactive XR learning aid", developed with XR technology, has multiple representational functions and interactive modes. Through mobile devices, learners can learn abstract knowledge concepts through visualization and modeling, and further can design and construct relevant knowledge in various fields. Wu, Lee, Chang, and Liang [13] believe that AR technology has the following characteristics and affordances, so it can used as a learning aid: 1. Let the learning content presented in a three-dimensional space to promote students' understanding of abstract concepts; 2. The use of mobile devices and contextual AR can increase opportunities for social interaction and cooperative learning; 3. Through human-computer interaction, students can get immediate feedback; 4. Through AR, objects that were originally invisible can presented through simulation; 5. It can be used to connect schools and non-standard (such as outdoor or museum) learning areas. Huang [14] pointed out that through the touchable AR tour system, it assists in the tour of cultural relics in the Natural Science Museum. Due to the high interactive and interesting nature of the digital mobile tour, it can attract users to use, and let users have a good learning effect. Xiao, Chen and Li [15] take the people and environment exhibition area of the National Taiwan Science Education Museum as the field, explore the differences between learners use AR technology to create 3D virtual exhibits in the tour learning system and traditional personnel tour learning teaching experiments. The study found that the application of AR tour learning system for mobile learning in museums does have significantly better learning effectiveness and peer interaction. Jiang [16] uses AR combined with SLAM (Simultaneous localization and mapping) map construction technology, takes Taipei Nishi Honganji Temple as the main axis, and designs experience content based on the four aspects of history, culture, space and architecture. By using SLAM AR method to restore and reproduce the historical features of the year and add relevant cultural learning and tour content. The experimental results show that the tour system not only helps to improve the learning effectiveness of visitors, also helpful for the technology of virtual reproduction of historical sites. Therefore, it can provide a reference for future cultural heritage maintenance and cultural tourism tour mode. Based on the above-mentioned literature discussion, it can saw that the mobile tour system can display relevant multimedia information, enhance visitors' understanding of the scene, and enhance the sense of interaction and interest on the spot, so it is conducive to cognition and learning. However, with the continuous innovation of emerging technologies, the APP displayed on it has special effects such as vivid scenes, cool sound, light and realistic situations. But it is also easy to cause great visual stimulation, causing learners to be unable to maintain their attention, deviating from the focus on topic cognition and hindering learning [17][18]. Therefore, how to improve the application of new knowledge of science and technology, properly design the content, and effectively integrate and plan is the key to high-quality digital tour. Therefore, this paper designs a digital audio-visual virtual tour system with XR technology that builds 3D model by using technology and equipment that are relatively easy to obtain today. The scenes and contents of the "Sugar Mill Culture" and "Ch'ien Mu Residence" used as examples to provide a reference for the establishment of a personalized tour mode.

The first applied culture is Taiwan’s sugar mill culture: The development of Taiwan's sugar industry gradually emerged during the Dutch rule (1624-1662). The main purpose of the Dutch occupation of Taiwan was to use Taiwan as a base economically, to trade with China, Japan and Southeast Asia, and to ensure the security of maritime trade militarily. By recruiting Han people to cultivate in Taiwan and export Taiwan's cane sugar, rice, and deerskins, the planting of sugar cane and the production of cane sugar have developed day by day. In the late 17th century, sugarcane was still the main crop. Only a few consumed on

the island, and most shipped to Japan, the Southeast Asian market almost interrupted. In 1683, the Qing Empire ruled Taiwan, and sugar was still an important export product. As shown in Fig. 3 [19], people set up sugar mill, squeezed cane and boiled sugar, and sold the sugar to merchants in Tainan and transported it to North China.

Figure 3. Taiwan Sugar Mill in "The Genre Paintings of Taiwan's Aboriginal Peoples"

The traditional production of cane sugar is sugar mill, and the production process divided into three stages: sugarcane squeezing, decocting, and finished products. First, the harvested sugarcane transported from the sugarcane plantation to the sugar mill with an ox cart, and the sugarcane squeezed into juice. The main method of squeezing sugarcane is to rotate a stone mill through the ox, and use the wooden teeth on the upper end to drive the wheel of another stone mill. Niu Po (squeezer) inserts several branches of sugarcane between two rotating stone mills, squeezes the cane into juice, and the cane juice drips into the stone plate of the base and flows into the barrel through the bamboo pipe (Figure 4) [20]. Next, the sugar master pours the squeezed sugarcane juice into a pot and cooks, adding lime to filter out impurities. The sugar cooking process is complicated and important. If it fails, all previous efforts will discard. After the sugar boiled, pour the sugar juice into a wooden box to cool, and after it has solidified, stir for a few minutes to become brown sugar. Then, the sugar cane juice made into white sugar through five procedures: "draining", "sampling", "running water", "squeezing mud", "loose sugar and decolor of repeated cover mud".

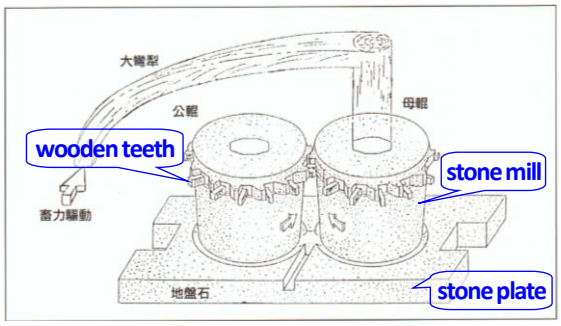


Figure 4. Stone mill

In 1860, Taiwan became the foreign trade port of the Qing Empire, and some foreign merchants came to Taiwan to buy cane sugar and sell it to European and American markets. In the early of the Japanese occupation, the sugarcane squeezing technology was improved, the stone mills replaced with harder iron mills, and the animal power replaced with machine, which resulted in a greater production process. After 1902, due to the establishment of the Sugar Co., Ltd. and the new-style sugar factory, the traditional sugar mills gradually declined, and the stone mill used to squeeze sugarcane abandoned, as shown in Fig. 5.

Figure 5. Abandoned sugarcane crushing stone mill

Turning to the history of Taiwan's sugar industry [21], it began approximately during the Dutch rule in the 17th century, when people planted sugarcane as material to produce cane sugar as Taiwan’s main export commodity. Therefore, sugar

production was Taiwan's main foreign economic focus at that time. In its heyday, Taiwan was the main exporting country of sugar, mainly exported to Middle Eastern countries and Japan, as shown in Fig. 6.

Figure 6. Taiwan's sugar mainly exported to Japan and the Middle East countries

The second applied culture is Ch'ien Mu Residence: "Ch'ien Mu Residence" is the residence of Ch'ien Mu, who is a master of Chinese studies. Mr. Ch'ien Mu was born on 30 July 1895. He was a Chinese historian, philosopher and writer. He is one of the greatest historians and philosophers of 20th-century China. Mr. Ch'ien Mu had a talent for learning and studying hard since he was a child. He has been a teacher in a rural elementary school at the age of 18. At the age of 36, he published an article "The Chronicles of Liu Xiangxin and His Son" to refute Kang Youwei's misrepresentation of "Xinxue Pseudo-Scripture", which shocked the academic circles in Beijing. In the same year (1930), he served as a lecturer at Yenching University, teaching Chinese. In the 1931, he transferred to the Department of History of Peking University and began to teach history. In 1949, he went to Hong Kong to establish New Asia College. In 1955, he invited by the Department of Oriental Studies at Yale University to give lectures at that school for half a year and awarded an honorary doctorate degree by Yale University. In 1967, Mr. Ch'ien Mu and his wife returned to China and settled in the Sushulou in Waishuangxi, Taipei. Elected as an academician of the Academia Sinica in 1968. Employed as a member of the presidential palace in 1975. It was not until 1989 that Mr. Ch'ien Mu moved out of Sushulou (Ch'ien Mu Residence) [22].

In order to introduce modern digital new media technology into the old humanities, history and culture, this paper is a combination of modern extended reality(XR) technology combined with novel digital media such as "panoramic images", "video", "slideshows", "3D modeling", "funny quiz" and "e-books" use in "Sugar Mill Culture" and "Ch'ien Mu Residence" for cultural preservation and guided tour. This paper uses augmented reality (AR) in extended reality (XR) as the main interaction mechanism of APP.

III. DEVELOPMENT OF AR APP

Augmented Reality (AR) as described in Section 1, AR usually uses the real scene captured by a camera and then uses image recognition technology to obtain spatial position. Early technology needs to rely on special patterns such as QR Code and Frame Marker for spatial positioning. Now the image recognition technology already can use any picture positioned in space. Therefore, this paper selects six images as shown in Fig. 7 and Fig. 8 for "Sugar Mill Culture" and "Ch'ien Mu Residence" respectively to make postcards. The ancient culture can reproduce before the eyes of the world through AR APP.

Figure 7. Reference images for six "Sugar Mill Culture" postcards

Figure 8. Six "Ch'ien Mu Residence" postcards

Due to the development of multimedia software and hardware technology in recent years, there are related software support to achieve augmented reality effect production, so development AR is not difficult. Therefore, the planning and development of AR APP and the pre-work of field explanation are the research design focus of this paper. This paper takes the history of "Sugar Mill Culture" and the construction, cultural relics and books data of "Ch'ien Mu Residence" as the planning content. Use Unity 3D [23] game engine to import AR technology into APP. AR AP combined with 360-degree panoramic photography VR scene construction, aerial photography and 3D model construction, recording and editing of graphics, text and audio-visual introduction, and presentation slide production, promotion of e-books and funny quiz functions for the preservation and tour of the "Sugar Mill Culture" and "Ch'ien Mu Residence". Provide visitors with a mobile device to provide digital interpretation and guided tours of the sugar mill culture and Ch'ien Mu residence. The flowchart of AR APP planning and development is shown in Fig. 9. Figure 9 shows that this paper uses XR technology to combine functions such as "panoramic image", "3D model", "video", "slideshow", "funny quiz" and "e-book" for "Sugar Mill Culture" and "Ch'ien Mu Residence" cultural preservation and Guided Tour. The following sub-sections explain the novel digital multimedia technologies such as panoramic images, 3D modeling, and AR virtual tour.

3.1 PANORAMIC IMAGE CREATION

In the early 18th century, British painter Robert Barker used the word 'Panorama' to describe his paintings. He painted while watching London from the roof, and painted on the wall of the cylinder, as shown in Fig. 10. Because this is the first complete panoramic image, his successful pioneering work made him rich overnight [24]. In the next hundred years, related works have appeared in various countries around the world. For example, in the Netherlands, the "Panorama Mesdag" Art Museum is currently the largest panoramic art museum. It can see the scenery of the 19th century coast from 360-degree canvas paintings.

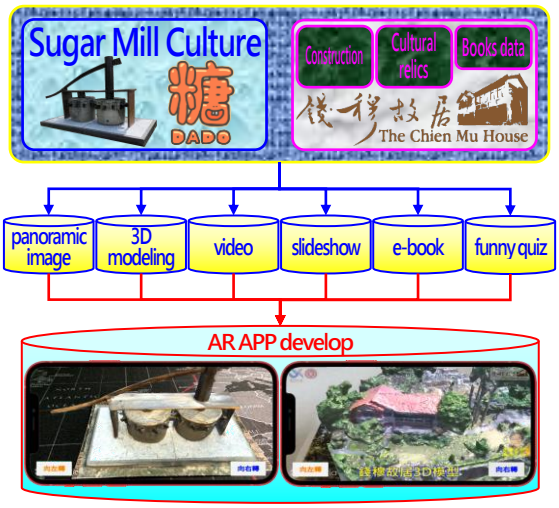


Figure 9. The flowchart of AR APP development

Figure 10. Panorama of London (Robert Barker 1792)

Thanks to the rapid development of digital software and hardware technologies, today's panoramic images can capture in real time with one click. Figure 11 is a panoramic image of the current location of Sugar Mill (Chang Jung Christian University) and the 2F study room of Ch'ien Mu Residence. The panoramic image can be displayed different view in screen by switching the user's perspective through the mouse on the webpage; The panoramic image can be tracked the head by mobile phone through the Cardboard, it can interactively present the view that the user wants to watch, making the user experience more intuitive and immersive.

(a) Sugar Mill's current site (b) Ch'ien Mu Residence

Figure 11. Panoramic image

3.2 3D MODEL CREATION

3D modeling currently commonly used 3D software modeling, 3D scanner modeling and 2D image conversion 3D model [25]. This paper uses 3D scanner modeling method to create small object models; and uses 2D images to convert 3D models to create large object models; and uses 3D modeling software to edit 3D models.

Common 3D scanning instruments are handheld style, such as sense 3D scanner, and turntable style, such as MarkerBot Digitizer scanner. Hand-held style 3D scanners often used for modeling larger objects and turntable 3D scanners often used for modeling smaller objects. In addition, there are also modeling using a iPad and a depth camera (Structure Sensor 3D Scanner [26]), as shown in Fig. 12(a). The principle uses an iPad camera to take a picture of an object, and cooperates with a depth camera to modeling the surface of the object to create a point cloud. Finally, a viewable multi-faceted 3D mesh generated. The new generation of iPhone 12 pro built-in LiDar optical radar scanner replaces the infrared depth camera shown in Fig. 12(a), and the mobile phone can instantly 3D modeling, as shown in Fig. 12(b).

(a) Structure Sensor **(b) iPhone 12 Pro with**

Figure 12. Equipment of 3D scanning

The common software for converting 2D images into 3D objects on the market is "123D Catch" from Autodesk and "Pix4Dmapper" from Pix4D. The "123D Catch" software takes photos of objects from multiple angles through the mobile phone, uploads them to cloud computing, and converts them into 3D model; Another "Pix4Dmapper" software also takes photos of objects from multiple angles and imports them into a program to calculate and convert them into 3D model. In addition to constructing 3D models of objects, Pix4Dmapper can also use for aerial cameras to construct 3D models of terrain and features.

The aerial photography modeling process first uses the aerial camera to shoot various angles of the modeling target. Then capture the key static images from the aerial video images. According to the experimental results of the paper [27], it recommended that the number of images be 300-600 images, otherwise it may take several times and obtain a slight quality improvement.

Pix4Dmapper software is a professional software dedicated to aerial telemetry, which can produce high-resolution orthogonal photos, accurate point clouds, numerical surface models, contour lines... etc. At the same time, it provides functions such as drawing 3D line segments, marking objects, and calculating volume.

This paper import Pix4D's "Pix4Dmapper" software to build a 3D model of the target. The software can download and try on the Pix4D official website [28]. The process of Pix4D software to create a 3D model from 2D images includes four steps: **(1) Creating a project**, **(2) Importing aerial images**, **(3) Parameter settings**, and **(4) Modeling calculations**:

(1) Creating a project: Run Pix4D software, the dialog as shown in Fig. 13, click the red box in the picture to create a new project; You can also open existing project, the blue box in the picture is the old project of "Ch'ien Mu Residence".

Figure 13. Create Pix4D software project

(2) Importing aerial images: Import aerial shot images in the project, you can choose image or video. If the selected video will capture the key images uniformly, according to the experimental results of the paper [27], it recommended that the number of images be 300-600.

(3) Parameter settings: the parameter setting includes camera model parameters, image geolocation setting and

selects constructing 3D map or 3D model.

(4) Modeling calculations: The modeling operation mainly includes two steps: (a) initialization and (b) point cloud and triangular mesh creation. The initialization is point cloud estimation. The point cloud position represented by the feature points calculated from the feature points between the images, and the location of the image shooting reversed. Figure 14 uses "Ch'ien Mu Residence" as an example to show the point cloud and image shooting estimated by Pix4D position.

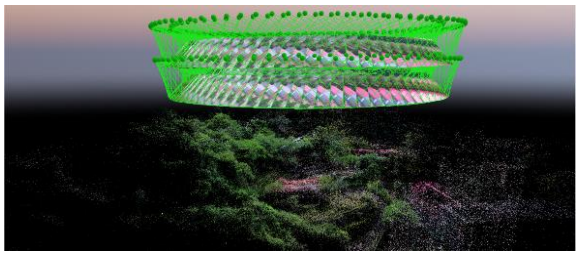
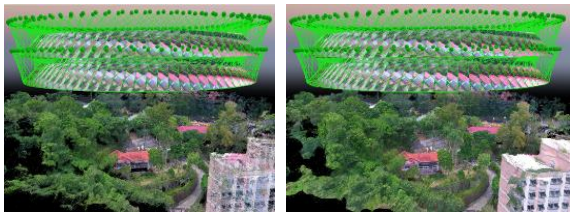


Figure 14. Point cloud creation and image shooting position estimated by Pix4D

From Fig. 14, it can be saw that the estimated point cloud is not dense. So through the second step: point cloud and triangular mesh creation to perform point cloud densification and generate a triangular mesh. Figure 15(a) is the result of point cloud densification; and Figure 15(b) is the result of building a triangular mesh. The point cloud (Fig. 16(a)), the point cloud density (Fig. 16(b)), and the triangular mesh (Fig. 16(c)) of "Ch'ien Mu Residence" can be seen in a magnified view from Fig. 16. The difference can more clearly saw.



(a) (b)

Figure 15. Pix4D results (a) Point cloud densification (b) Triangular mesh creation

(a) (b) (c)

Figure 16. Ch'ien Mu Residence (a) Point cloud (b) Point cloud densification (c) Triangular mesh

3.3 AR VIRTUAL TOUR

Based on the previous discussion, this paper uses XR technology to establish cultural digital preservation and virtual tour of "Sugar Mill Culture" and "Ch'ien Mu Residence" as the main axis. Let the "Sugar Mill Culture" and "Ch'ien Mu Residence" use XR technology to combine functions such as "panoramic image", "3D model", "video", "slideshow", "funny quiz" and "e-book" for cultural preservation and guided tour of "Sugar Mill Culture" and "Ch'ien Mu Residence". As mentioned in the previous steps, after understanding the history and culture of the sugar mill and historical background of Ch'ien Mu residence, use panoramic images, 3D models, historical video, introduction slides, related interactive funny quiz, and promotion of e-books. After the media built the historical culture, cultural relics and sugar-making technology related to the sugar mill culture and the buildings, cultural relics and works related to Ch'ien Mu residence, the XR technology was used to implement the XR culture preservation and tour app on the Unity3D game engine with the Vuforia [29] package. This paper uses the six related pictures in Fig. 7 and Fig. 8, respectively, with the XR APP to bring ancient culture back to the eyes of the world. The six related pictures are respectively expanded into 6 types of digital multimedia: "panoramic image", "3D model", "video", "slideshow", "funny quiz" and "e-book". Let the static postcard through the XR APP with the mobile phone to make the cultural preservation of "Sugar Mill Culture" and tour of "Ch'ien Mu Residence" lively, realize the purpose of cultural digital preservation and XR virtual tour.

IV. XR APP GUIDED TOUR RESULTS

The XR virtual tour built in this paper takes "Sugar Mill Culture" and "Ch'ien Mu Residence" as examples. The results include "panoramic image", "3D model", "video", "slideshow", "funny quiz" and "e-book" six kinds of digital multimedia extended effects. In order to individually expand these 6 types of digital multimedia, this paper uses the six related pictures in Fig. 7 and Fig. 8, respectively, and the XR APP can bring ancient culture back to the eyes of the world. Among them, because the styles of the pictures of sugar mill are different, the postcards made by hand painting for the second creation, which makes the styles of the postcards more consistent. Taking the first three pictures in Fig. 7 as an example, the second creation of hand-painted postcards shown in Fig. 17 respectively. The three pictures in Fig. 17 briefly explained as follows: The first picture redraws the "The Genre Paintings of Taiwan's Aboriginal Peoples" in the Qing Dynasty [19], which is the presentation of the overall structure of "Sugar Mill". The picture depicts the ancient people's overall process from collecting sugarcane, carrying by manual, squeezing juice from stone mills by the ox, decocting and concentrating, and crystallization and separation of sugar. The second picture is a repaint of an old photo taken in Showa 14 (1939) of the appearance of an old-style candy bar. Besides the candy bar, there is also the power of sugar mill and ox used in ancient. The third picture is a schematic picture of sugarcane collection. Sugarcane is the material for sugar making. In the early days, it relied on manual collection, segmentation, and transportation.

This paper uses XR to extend the exhibition of six digital multimedia: "panoramic image", "3D model", "video", "slideshow", "funny quiz" and "e-book". The augmentation results described in the following sub-sections.

Figure 17. "Sugar Mill Culture" hand-painted postcard

4.1 Panoramic image AR results

The panoramic image uses the Mi sphere camera, and the resolution of the panoramic photo is 6912 * 3456. In this paper, a panoramic photo as shown in Fig. 11 taken as a panoramic photo augmentation result. Figure 18 shows the augmentation effect of the panoramic image.

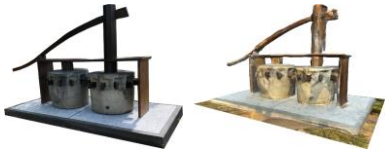
(a) Sugar Mill's current site AR result

(b) Ch'ien Mu Residence AR result

Figure 18. Panoramic image augmented reality results

4.2 3D model AR results

The iPhone 12 Pro with built-in LiDar optical radar scanner used to build stone mills that located in front of the CJCU Library of Chang Jung Christian University. The established 3D model of the stone mills after simple post-production shown in Fig. 19(a), where the left side of Fig. 19(a) is the photo of the stone mills and the right side is the 3D model created by iPhone 12 pro; Figure 19(b) shows the augmentation effect of the 3D model of the stone mills. In addition, the aerial images of Ch'ien Mu residence used to capture 346 images to Pix4Ddiscovery version 4.1.25 for modeling. The established 3D model after post-production shown in Fig. 19(c), and Figure 20(d) is the augmentation effect of the 3D model of Ch'ien Mu residence.



(a) Stone mills picture and 3D model

(b) Stone mills 3D model AR result

(c) Ch'ien Mu residence 3D model

(d) Ch'ien Mu residence 3D model AR result

Figure 19.3D models augmented reality results

4.3 Video AR results

Use virtual scenes to reproduce the 3D animation film clips of "Sugar Mill Culture", and use 3D virtual scenes to make the flat and static pictures of "The Genre Paintings of Taiwan's Aboriginal Peoples"(Fig. 3), and to dynamically navigate the sugar mill. The content of the film, in addition to the VR version of Fig. 3, also uses 3D models to guide the sugar mills, stone mills, ox carts, sugar cane, cattle power, and related sugar making equipment one by one. Through the video to activate the VR of Fig. 3, you can also understand the entire sugar production process in more detail. Figure 20(a) shows the sampled photos of the video part, and Figure 20(b) is the augmentation effect of the video of VR sugar mill introduction of Fig. 3. At the same time, it also edited the historical speech film of the master of Chinese studies, Mr. Ch'ien Mu, as the main video content. In addition to the original historical speech film of Mr. Ch'ien Mu and interspersed with the current film of Ch'ien Mu residence and the 3D guided video content. Through the video, you can enlighten the historical lecture footage of the master of Chinese learning, Mr. Ch'ien Mu and browse the current video of Ch'ien Mu residence and the content of the 3D guided video. Figure 20(c) shows the sampled photos of the video part, and Figure 20(d) is the augmentation effect of the historical film.

(a) Video of sugar mill

(b) Video of sugar mill AR result

(c) Video of Ch'ien Mu residence

(b) Video of Ch'ien Mu residence AR result

Figure 20. Videos augmented reality results

4.4 Slideshow AR results

"Sugar Culture" presents the AR effect of the slides with the visits to the nearby sugar factory, historical area and the rich "Sugar Mill Culture" introduction slides. The augmented

effect of the presentation slide of "Sugar Mill Culture" shown in Fig. 21(a). "Ch'ien Mu Residence" captures the information of the master of Chinese studies, Mr. Ch'ien Mu, including an introduction to the biography of Mr. Ch'ien Mu, an introduction to important works, an introduction to the Ch'ien Mu residence, and an overview of Mr. Ch'ien Mu's contributions to Chinese studies. Figure 21(b) shows the augmented effect of the slideshow in "Ch'ien Mu Residence".

(a) Slideshow of "Sugar Culture" AR result

(b) Slideshow of "Ch'ien Mu Residence" AR result

Figure 21. Slideshow augmented reality results

4.5 Funny quiz AR results

Based on the aforementioned four digital multimedia introductions to the "Sugar Mill Culture" and "Ch'ien Mu Residence", this paper simply designs several interesting questions about the sugar mill culture and Ch'ien mu residence. The funny quiz helps to deepen users' understanding of the "Sugar Mill Culture" and "Ch'ien Mu Residence". Figure 22(a) is the augmented effect of the "Sugar Mill Culture" funny quiz; Figure 22(b) is the augmented effect of "Ch'ien Mu Residence" funny quiz.

(a) Funny quiz of "Sugar Mill Culture" AR result

(b) Funny quiz of "Ch'ien Mu Residence" AR result

Figure 22.Funny quiz augmented reality results

(a) E-book of "Sugar Mill Culture" AR result

(b) E-book of "Ch'ien Mu Residence" AR result

Figure 23.E-books augmented reality results

4.6 E-book AR results

Because Chang Jung Christian University has temporal and spatial time history with the sugar mill culture, especially the Department of Interactive Design. Excluding the time gap, Chang Jung Christian University and the sugar mill culture exist in the same space. As time goes by, the sugar mill no longer exists, but thanks to the development of digital technology, the Department of Interactive Design uses novel digital technologies such as augmented reality, panoramic images, 3D modeling, etc. let the sugar mill culture reappear before the eyes of the world overcome the barriers of time. Therefore, while recreating ancient culture, AR APP also import e-book that introduces the promotion the Department of Interactive Design, Chang Jung Christian University. E-book introduces and promotes the Department of Interactive Design that is advancing with the times. Figure 23(a) is the augmented effect of the e-book for the promotion "Sugar Mill Culture". The residence of the master of Chinese studies Mr. Ch'ien Mu: Sushulou, currently managed by the Department of History and Geography, University of Taipei entrusted by the Department of Cultural Affairs, Taipei City Government. Therefore, we organized e-book that promoted the Department of History and Geography, University of Taipei. The content of the promotion e-book includes the introduction of University of Taipei, the introduction of the Department of History and Geography, the course content and promotion information. Figure 23(b) shows the augmented effect of e-book in Ch'ien Mu residence.

V. CONCLUSIONS

This paper proposes the use of extended reality technology as the application of cultural preservation and virtual tour, and uses "Sugar Mill Culture" and "Ch'ien Mu Residence" as examples. In addition to introducing and implementing various 3D modeling, panoramic images and other technologies, and using Unity 3D and other software to implement AR cultural preservation and virtual tour. The purpose of AR cultural preservation and virtual tour is to allow users to have an immersive tour experience without visiting the scene. The virtual tour results completed in this paper focus on visual interactive tour. In the future, a more complete modeling of the cultural relics in "Sugar Mill Culture" and "Ch'ien Mu Residence" can carry out, and a more specific virtual navigation tour system can introduce. In addition to improving the cultural preservation, it also allows users to have a more specific experience on the virtual tour that is also more immersive.

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