Visualization of Virtual Indigenous Tribes Using Immersive Virtual Reality Technology

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ABSTRACT: The indigenous peoples have been living in Taiwan for thousands years. Comparing to the western-style science education, they have completely different pedagogy to establish and to pass their own environmental knowledge, living style, technology, science, and culture. However, the young generation of the indigenous people is losing their traditional point of view to their environment under current education system. Especially for the indigenous peoples who moved to cities for living, their young generation even barely recognize their original home tribes. The opportunities for them to learn how to interact with natural environmental resources, such as farming and hunting, with their parents are significantly decreased. In order to enable urban indigenous youths to learn the indigenous environmental knowledge in a more intuitive way, we proposed a novel concept called "Virtual Indigenous Tribe" in this study. Virtual Reality (VR) has flourished in recent years. It is also one of the common ways of digital learning. The immersive virtual reality technology is adopted to build "Virtual Indigenous Tribe" for visualizing the living environment of indigenous peoples. First, we take 360° panoramic photos for tribal environments, combined with the immersive virtual reality makes users feel as if they are in the local area. Then, we collect indigenous traditional environmental knowledge through interviews with elders. Multimedia such as recordings and demonstration videos of the elders can also be placed in the virtual reality. We develop immersive virtual tribe by the software - Unity, integrating 360° panoramic photos, indigenous environmental knowledge and multimedia. The Google VR SDK for Unity plug-in allows users to develop virtual reality apps with Google Cardboard as a display tool. In conclusion, the young generation of the indigenous people can experience immersive virtual tribe through low-cost Google Cardboard, understand the tribal environment, and learn the traditional environmental knowledge in a more authentic and intuitive way. We hope the "Virtual Indigenous Tribe" will motivate the younger generation of the indigenous people and improve the learning achievement.

1. INTRODUCION

Indigenous people have interacted with nature for a long time. Through their ways of understanding themselves in relationship to the natural environment and land, they have developed a set of traditional ecological knowledge (TEK) that includes experience, practice, society and worldview (Berkes et al., 2000; Cajete, 1999). Their lifestyle is very different from that of the Han and Western societies. "Participation" is the core of how indigenous people to generate and to pass down the traditional ecological knowledge, and emphasizes the process of "body" participating

in the locality. People exist because of the place, and places also have meanings because of people (Cajete, 2000; Kuan, 2013). However, under the dominance of national governance and the western-style science education, the young generation of the indigenous people is losing their traditional point of view to their environment under current education system. Especially for the indigenous peoples who moved to cities for living, their young generation even barely recognize their original home tribes. The opportunities for them to learn how to interact with natural environmental resources, such as farming and hunting, with their parents are significantly decreased.

Virtual Reality, VR is a three-dimensional world built by computer. The computer provides visual, auditory and other senses to fully simulate the human perception. Virtual reality allows its users to intuitively interact with the virtual environment and its object as if they were real (Shukla et al., 1996). Based on the characteristic of virtual reality, Burdea and Coiffet proposed the three I's in 1993, indicating the three connotations of virtual reality, including immersion, interaction and imagination (Burdea & Coiffet, 2003).

Virtual reality technology assisted teaching is one of the common ways of integrating information technology into instruction. McLellan (1996) argued that integrating virtual reality into situated learning is a very effective learning method. VR provides not only an interactive virtual scenerio that can be used to present abstractions with visual effects, but also an opportunity for learners to operate and practice repeatedly (Lai et al., 2009).

In the past, immersive virtual reality was often limited by cost. It could be operated by only one user at the same time, which was not very suitable for classroom teaching (Lai et al., 2009). Google launched Google Cardboard Virtual Reality Glasses in 2014, significantly reducing the cost of immersive virtual reality devices. Only need a simple movie box combined with smartphones and tablets, everyone can watch 360° panoramic images and videos, which is more applicable for classroom teaching (Brown & Green, 2016; Google, 2019; Lee et al., 2017).

There have been some researches on applying virtual reality on the inheritance of indigenous traditional knowledge. Digital Songlines, developed by ACID (Australasian CRC for Interaction Design), connected the spirit and culture of the indigenous people to their land. They built a virtual landscape with oral history and mythological stories (Wyeld et al., 2007). As for Taiwan, Lejen (2015) developed a Truku (one of Taiwan's sixteen indigenous peoples) traditional hunting game. Through 3D virtual reality simulation of hunting scenes and activities, he aroused the curiosity and interest of indigenous students in traditional ecological knowledge, and even promoted the cognition and attitude towards Truku traditional hunting culture.

However, both of them used desktop virtual reality system, which is less immersive and intuitive for users. Today's low-cost immersive virtual reality technology provides an opportunity for urban indigenous youths far from native tribes to understand the tribal environment and learn about the traditional environmental knowledge of their communities in a more intuitive way.

Therefore, we proposed a novel concept called "Virtual Indigenous Tribe" in this study. The objective of this study is to integrate indigenous traditional ecological knowledge into 360° panoramic images produced by panoramic cameras and the Unmanned Aerial Vehicle (UAV), and to apply immersive virtual reality technology on developing "Virtual Indigenous Tribe". Based on this objective, the three issues of this study is:

(1) Collecting indigenous traditional ecological knowledge.
(2) Producing 360° panoramic images of tribal landscape.
(3) Developing "Virtual Indigenous Tribe" based on traditional ecological knowledge.

2. METHODS

Based on the research issues, we collect geo-spatial information and traditional environmental knowledge by field surveying, including taking panoramic photos, taking UAV photos and interviewing the elders. Then, we combine the elements above to build the scenes in immersive virtual reality.

2.1 Field Surveying

PANORAMIC PHOTOS

We take panoramic photos by a 360° panoramic camera, combined with the immersive virtual reality makes users feel as if they were in the local area. For tribal landscapes in smaller scale (about 5 to 10 meters) and indoor scenes such as traditional house, barn, plants or crops, we take panoramic photos by a 360° panoramic camera, putting into immersive virtual reality.

In this study, “RICOH THETA V” from Japan is used to take 360° panoramic photos of the tribal landscape. It records 360° static images and videos with high-resolution and high-precision splicing image processing technology. The static image resolution is up to 5376 x 2688 pixels, and 4K video and 360° spatial audios can be recorded, making the virtual reality world more realistic (Ricoh, 2019).

UAV’S AERIAL PHOTOS

In this study, we also took aerial photos by the UAV. Compared with traditional aerial photogrammetry, UAV has many advantages like low-cost and high flexibility, etc., and can perform tasks at any time if the weather permitted. The low altitude of the UAV not only makes it less susceptible to cloud cover but also gets aerial photos in higher ground sampling distance. It is suitable for obtaining images of a single indigenous tribe. Therefore, for tribal landscape in larger scale, such as tribal buildings and the relative position of the tribe, rivers and hills, we took aerial photos to produce panoramic images which will be presented in immersive virtual reality.

"ANAFI" from Parrot, France is selected to conduct the flying mission. ANAFI is equipped with a high-definition camera of approximately 2 megapixels (5344 x 4016 pixels) with a maximum flight time of 25 minutes. The built-in Global Navigation Satellite System (GNSS) is a GPS and GLONASS binary system. Latitude, longitude coordinates and elevation are recorded when shooting photos (Parrot, 2019). The APP selected to control Parrot ANAFI for automatic flight mission is “FreeFlight 6”, which is able to produce panoramic images automatically.

ELDERS INTERVIEW

“Participation”, such as interaction between the body and the environment and the demonstration from the elders, is the core of how indigenous people passing down traditional knowledge and skills. It is even passed down from generation to generation by stories. Therefore, in addition to literature collection, first-hand interviews with the elders are necessary. When researchers are experienced, they can present the traditional environmental knowledge in

the virtual tribe correctly. Moreover, only by visiting the elders, can we get indigenous traditional knowledge in both Chinese and indigenous languages which will be presented in immersive virtual tribe, which helps indigenous people understand the original meanings of the environmental knowledge better.

2.2 Immersive virtual reality production

IMMERSIVE VIRTUAL REALITY

Virtual reality systems can be categorized into three main types according to the level of user's immersion and presence. They are non-immersive (desktop) systems, semi-immersive projection systems, and fully immersive head-mounted display (HMD) systems (Costello, 1997). In this study, we choose fully immersive head-mounted display systems because it features 360° full-view virtual screen, insulating interference outside. HMD system is mainly composed of two small screens in front of the eyes (Figure 1). When users wear it, stereo vision is produced. The core concept is that the virtual environment, like the real world, will rotate synchronously according to the direction of the user's head detected by the sensor (Costello, 1997; Sutherland, 1969).

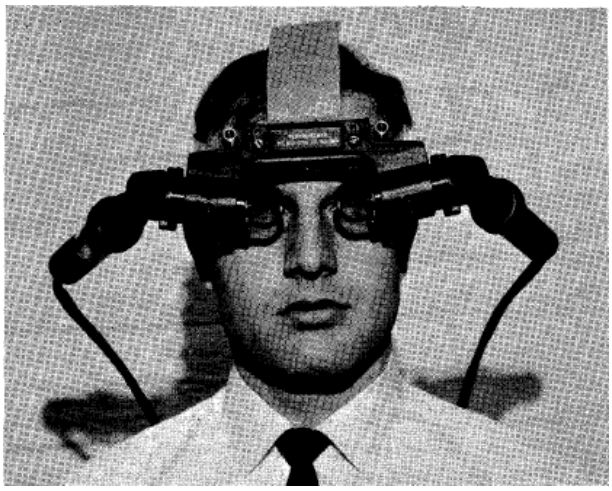

Figure 1. Head-mounted display system (Sutherland, 1969)

Figure 2. Google Cardboard

Google launched Google Cardboard Virtual Reality Glasses in 2014, significantly reducing the cost of immersive virtual reality devices. Only need a simple movie box combined with smartphones and tablets, everyone can watch 360° panoramic images and videos, which is the easiest virtual reality device available (Figure 2) (Google, 2019). Its low cost and convenient benefits overcome the limitations of the previous immersive virtual reality devices that can only be operated by one person at a time, which is very suitable for classroom teaching (Brown & Green, 2016; Lee et al., 2017).

VIRTUAL REALITY SCENES PRODUCTION

In this study, we use "Unity" for virtual reality development. Unity is a cross-platform game development engine which can be used to develop PC games for Windows, Mac and Linux, or games for iOS and Android mobile devices. It's main programming languages are C# and Javascript.

The benefit of using a game engine is that it saves time to develop, and developers don't have to program from scratch. Google VR provides a “Google VR SDK for Unity” plug-in, which allows users to develop virtual reality APPs using Google Cardboard as a display tool.

We import 360° panoramic images in JPG format into Unity as the virtual reality scenes, combined with traditional ecological knowledge which was collected from literatures and elder’s interviews. After building all of the scenes, we can export the APP to mobile devices. The users can put their phone or tablets into the Google Cardboard (Figure 2) to wander the virtual tribe and learn about the indigenous traditional environment knowledge.

3. RESULTS AND DISCUSSION

3.1 Traditional ecological knowledge

Our case study is the Atayal, one of sixteen indigenous peoples of Taiwan, distributed in the northern mountainous area. We visited an Atayal elder, Yukan, also as a teacher in Da-tung Junior High School, Yilan County. He provided us with a lot of Atayal traditional ecological knowledge, such as ways to eat traditional food like taro, millet and the use of traditional Atayal buildings (Table 1). More importantly, the environmental knowledge is presented in both Chinese and Atayal, which not only helps Atayal students understand the original meanings of the environmental knowledge, but also to preserve the language. Based on the knowledge, we can build the scenes in immersive virtual tribe.

Table 1. Bilingual traditional ecological knowledge by the Atayal elder, Yukan

English name	Atayal name	Descriptions in English	Descriptions in Atayal
Corn	Qetun	Corn is the food Atayal people usually eats, but it is used as a non-staple food rather than a necessary staple food.	Qetun qani ga nniqun krryax Tayal uzi,ana ga ini si trryax maniq, smoya maniq ga tmahuk cikah
Taro	Sehuy	Taro is the food Atayal people usually eats, but it is used as a non-staple food rather than a necessary staple food. There are many ways to eat taro. It can be cooked directly, or you can cook it with glutinous rice.	Qetun qani ga nniqun krryax Tayal uzi,ana ga ini si trryax maniq, smoya maniq ga tmahuk cikah. Piyux balay kinlgan nya nniqun qu sehuy qani,ini ga si nha puzi qsya, ini ga spgluw nha mami hrkil psxu.
Millet	Trakis	Millet is the Atayal traditional food and crop that be used as a staple food and making pastries. It is also a necessary fermenting material for pickled meat. The use of millet is not only in terms of food but also the most	Trakis hya ga nniqun Tayal aring squ sraral, alan nha pinhapuy ru klayan nha hekil. qutux lozi ga,galan nha stmami nqu qqsinu ru qulih uzi. Trakis qani ga iyat nanaq nniqun,hya ga piyang balay hupa spngsa nha utux

		important offering for their ancestors and lands. It is very important for the spirit of the tribe.	bnkis na nniqun,piyang balay hupa sn'hyan skura te Utux uzi.
Duli Hill	Rqenas	"Reqenas" is the Atayal name of Duli Hill. This name was given by the ancestors. The meaning is that the hill looks like a human's face	Rqenas ga cinllwan nqu nkis sraral,mira rqenas k'tan rgyax qani mha.
Barn	Khu	The barn is where to store millet, sweet potatoes, taro, corn, beans and all other food.	Khu qani ga,stwan trakis, ngahi, sehuy, qetun, balit ru kwara nniqun.
Firewood house	Tatak nqu plahan	When the weather is cold in winter, students will come here to burn firewood for heating.	Qmisan ghyaq kayal ga, mwah malah sqani nqu laqi.
Hunting house	Tatak nqu qmalup	Hunting house is the place where hunters rest when hunting.	Musa qmalup ga shngaw nha tatak nqu qmalup.
Traditional Atayal house	Muyaw Tayal	Traditional Atayal houses are subterranean buildings. The beams of the houses are made of cypress, and the walls are stacked with wood.	Muyaw Tayal sraral ga k'mihuy rhyal, lwax nya ga knalay nha qozit; qnryang nya ga knalay nha qhuniq.

3.2 Immersive virtual tribe

In this study, we built six scenes in virtual reality, including five scenes on the ground (corn field, taro field, red quinoa field, barn, and firewood house) and one scene in the sky (Figure 3). Each scene consists of a panoramic image and some text descriptions of indigenous tradition knowledge (Figure 5).

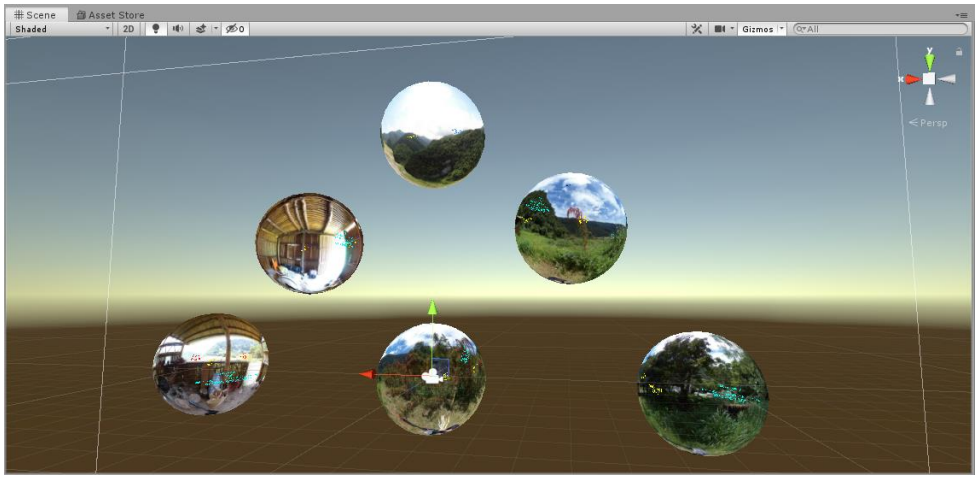

Figure 3. Six scenes in Unity (The top one is the scene in the sky.)

```
5   public class ChangePos : MonoBehaviour {
6
7       public GameObject Player;
8
9       public void OKGoTo(Transform TargetPos)
10      {
11          Player.transform.position = TargetPos.position;
12      }
13
```

Figure 4. C# script code to switch the position of camera between scenes ("Player" is the camera. "OKGoTo" is the function name we create. "TargetPos" is the coordinates of the center of the target scene)

In Unity, we can switch the position of the camera among six scenes by programming a C# script (Figure 4). As a result, when the center of the user's screen is aimed at the specific little circle of the target in the scene (Figure 5 right), the user can switch to the target scene by touching the phone's screen or pressing the button on the Google Cardboard.

Figure 5. User interface (The white dot in the left figure is the center of user's sight. When user turns around to let the white dot aim at the yellow circle beside "Firewood House", the white dot will turn into a small white circle. Then, user can switch to the scene "Firewood House" by pressing the button on the Google Cardboard.)

After finishing building all of the scenes, we can export the virtual reality APP to mobile devices. In the VR APP, the screen is divided into two (Figure 6). Users can put their phone or tablets into the Google Cardboard to create stereo scene, which makes users feel as if they were in the local area. Therefore, users can look around to wander the virtual tribe and learn about the indigenous traditional environment knowledge in a more intuitive way.

Figure 6. The interface in the VR APP

3.3 User feedback

To understand the preliminary effect of "Virtual Indigenous Tribe", we design some simple questions to collect user feedback (Table 2). Our test users were the visitors of 2019 Taiwanese Indigenous Scientific Festival. Held in National Science and Technology Museum, Kaohsiung, it is an exhibition of Taiwanese indigenous science and traditional knowledge. On that day, about 170 visitors experienced the immersive virtual tribe, but most of them are kids, so we collected only 20 valid feedbacks from adult users. Statistics are shown in Table 2

Results showed that most of the users felt the "Interactivity" and "Reality" of immersive virtual tribe was high. The users were also impressed and excited about the scene in the sky. However, the virtual tribe seemed not so helpful for them to understand the indigenous ecological knowledge, probably because they were easily distracted by switching among the virtual scenes. They did not spend enough time in a scene to read the indigenous traditional environmental knowledge. Therefore, combined with the result of the last question, we should add some audios and more interaction into the immersive virtual tribe in the future work to let users be more impressed with traditional knowledge.

Table 2. Questions and user feedback

Questions	Scores
1. How about the "Interactivity" of the immersive virtual tribe? (1~5)	4.70
2. How about the "Reality" of immersive virtual tribe? (1~5)	4.55
3. Is it helpful for you to understand the indigenous ecological knowledge? (1~5)	4.35
4. Which of the following elements do you think will make the immersive virtual tribe more real and intuitive? (multiple choice) (a) Audios (E.g. storytelling from elders or animal sounds) (b) Videos (E.g. skill demonstrations from elders, such as fishing or hunting)	(a) 90% (b) 50% (c) 65% (d) 5%

(c) Interaction with NPC in the scene (d) Audio Tour	

5. CONCLUSION

In this study, we proposed a novel concept called “Virtual Indigenous Tribe”. First, through the interview with the Atayal elder, we collected a lot of first-hand indigenous tradition ecological knowledge, such as Atayal traditional buildings and the ways they deal with crops, in both Chinese and Atayal. Then, for tribal landscapes in smaller scale and indoor scenes, we took panoramic photos by the 360° panoramic camera. For tribal landscape in larger scale, we got panoramic images by the automatic flight mission of the UAV. We used panoramic images as the scenes in virtual reality, add bilingual Atayal traditional ecological knowledge, and developed the immersive “Virtual Indigenous Tribe” successfully.

According to the user feedback, they felt the “Interactivity” and “Reality” of immersive virtual tribe was high, but it is not so helpful for them to understand the indigenous traditional knowledge. We will try to add some multimedia like audios, videos and more interaction into “Virtual Indigenous Tribe” and continue to improve the APP to make it more intuitive and real in the future work. We hope the “Virtual Indigenous Tribe” will motivate the younger generation of the indigenous people and improve the learning achievement.

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