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A Museum Guiding and Learning System Based on Augment Reality and Wearable Technology

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Abstract: The common ways of museum guide are manual guide and voice guide, but both ways can only make people passively absorb relevant historical knowledge, which can easily reduce people's enthusiasm for learning, and the learning effect after the guide is not good. With the rapid development of information technology, museums begin to use new technology to change the way to communicate and interact with people. In view of this, this study develops a wearable guide and learning system based on Augmented Reality (AR). Seven modules have been planned, including Teaching Material Download Module, Main Menu Module, Map Module, Object Identification Module, guide information module, test module and learning process module. Through the presentation of Smart glasses, it combines the real world with virtual information to create a new environment in which the learners can be immersed and interact with each other in real time. In addition, this study takes the monuments surrounding Tamsui District in northern Taiwan as the object, and designs five units of textbooks, and makes multimedia textbooks mainly on the historical allusions and cultural backgrounds of historical sites as well as museum collections, which extends the guide activities from single sensory stimulation to intuitionistic audio-visual experience, so as to enhance learners' willingness to learn and strengthen the effectiveness of museum guide education.

Keywords: Wearable device, Augmented reality, Museum guide, Mobile guide system

1. Introduction

Nowadays, countries around the world have been paying more and more attention to people's right to education. The scientific and technological development and the transformation of economic structure are accelerating, as a result of which, large amounts of information can be copied and spread widely and rapidly, leading to the phenomenon of "half-life of knowledge" in terms of the knowledge and technology needed in human life (Ho & Liu, 1997).As a result, increasing attentions have been paid to the view of lifelong learning. The meaning of "lifelong learning" lies in the continuous learning process in one's life and in the fact that everyone enjoys the opportunity of universal learning. Through self-pursuit and external assistance, individuals can adapt themselves to the environment and achieve their potential development and self-realization (Chung & Lee, 2000). Taiwan has been actively strengthening the promotion of lifelong education since the 1980s. In 1995, the government launched the "Education Report of the Republic of China: Towards the Vision of Education in the 21st Century", which set "establishing a lifelong education system and marching towards a lifelong learning society" as an important indicator of Taiwan's education system ucation(Lin, 1997), the most important function of museums is to provide the opportunities of lifelong learning. Therefore, in response to the national policy, the Ministry of Education issued a white paper Towards a Learning Society in 1998 (Ministry of Education, 1998), explicitly listing museums as important educational institutions for implementation of educational activities, which has become a common consensus in modern society(Lai, 2007).

At present, there are three kinds of common museum guide modes. The first one is to conduct museum guide activities by guiding the public through the commentators on the spot. The second one is to provide rental equipment to provide users with voice guide through pre-prepared introduction tapes. The last one is to place KIOSK system guide machines in museums for visitors to inquire about guide objects in the museums. However, no matter in which way, the public can only passively absorb relevant historical knowledge, and few customized interactive guide mechanism is provided in the interactive process, which may easily reduce the public enthusiasm for learning, and the learning effect

after the guide is not good either. In order to solve the above problems, researchers in related fields began to apply mobile technology to museum guide in order to improve the internal operation functions and external communication efficiency, and establish a new way of interaction with the public to provide a more friendly and convenient tool for information guide (Sung, Chang & Yu, 2006).

Among the numerous tools applying mobile technology, the use of hand-held mobile devices has been more common in recent years. For example, Lin (2017) has developed a mobile guide system using pervasive games based on AR. Taking the temple of New Taipei City as an example, visitors can hold mobile phones and understand the culture and backgrounds of the surrounding objects through pervasive games. Tung (2012) applied the mobile digital guide to the Chimei Museum. By scans the QR coded files with a camera application in the mobile device, the visitors will receive the guide screen with pictures and texts and enjoy the interactive guide experience (Tung, 2012). Most of these related research results show that, in the actual guide learning, if hand-held mobile devices are used in guide tour services, the learning effect is often higher than that with traditional guide tours. Therefore, the combination of museum guide tour service and mobile devices is in line with the expectation and development direction of modern society (Wang & Shih, 2012).

The increasingly mature mobile technology has gradually developed into wearable devices. The rise of Wearable Device has brought a new wave of technology applications. Researchers have begun to try to combine mobile guide with wearable devices in order to achieve more intuitive and amazing interactive effects. This kind of guide system is often considered to have the following advantages: 1) free the hands of learners, so that learners can take pictures and talk without holding a mobile phone; 2) free from the constraints of location and light, so that the visitors can clearly read the exhibit information; 3) virtual information can be superimposed on the real world, so that learners can receive information in a more intuitive way (Zheng & Li, 2015). However, the study of introducing wearable devices in museum guide is still in the beginning stage. The educational and application values of museum guide still have considerable potentials that deserve further exploration (Damala, Marchal & Houlier., 2007).

This research develops a wearable guide and learning system based on AR, and make development through Android platform and smart glasses Glass Enterprise Edition 2. It also plans seven modules, including Teaching Material Download Module, Main Menu Module, Map Module, Object Identification Module, guide information module, test module and learning module. Through the presentation of smart glasses, the real world is integrated with virtual information to create a new environment for learners to be immersed and interact in real time. Finally, this study takes the monuments surrounding Tamsui District in northern Taiwan as the object, and designs five units of textbooks, including Fortress San Domingo, Oxford College, Little White House (Tamsui Customs Officers' Residence), Tamsui Church, Mackay Memorial Museum. Multimedia textbooks are produced mainly on the historical allusions and cultural backgrounds of historical sites as well as museum collections including text narrative, pictures and films etc. Smart glasses with pre-camera lens can automatically detect exhibits and then directly present exhibits information on the screen. In this way, the guide can be expanded from a single sensory stimulus to a comprehensive audio-visual experience including audio and video elements, so that learners can carry out learning activities of historic site tour through the guide system provided by this study. It could not only enhance the learners' willingness to learn, but also strengthen the effectiveness of guided museum education.

2. Literature Review

2.1 Application of Wearable Devices

Wearable devices refer to the use of various perception systems to capture information from different environments or users through embedded devices, and timely feedback the information to users after fusion processing, or send the information to the cloud for further analysis and storage. Its purpose is to provide convenience, stability and portability. In most situations, hand-free operation is adopted (Huang, Lin & Chen, 2016). Wearable device has the following functions: 1) it has the sensing and networking functions, and can automatically detect, collect, display or transmit information for a long time; 2) it has the ability of data transmission on the Internet; 3) it is convenient for users to wear for a

long time without affecting their daily life and rest. Wearable device has a wide range of applications, such as criminal forensics and educational application.

For example, in the field of criminal forensics, Li (2018) integrates the concepts of "wearable device" and "forensic cloud", and designs system modules so that investigators can transmit 3D images of the scene to the crime scene command center and image database through wireless transmission by means of "wearable search equipment", and makes use of online "video conference mode" to invite experts from all fields to consult, discuss the best treatment strategy, integrate multiple resources and provide necessary assistance (Li, Fang, Lin & Huang, 2018). Swathi and Lanka (2015) also apply wearable devices to medical subjects, allowing learners to freely choose different tools (mobile phones, laptops, smart watches, smart glasses, etc.) for learning purposes. The results also show that the number of college students who are willing to use wearable devices has greatly increased compared with the past. Moreover, wearable devices can make teachers and students interact intuitively in different places, which could greatly improve the convenience and interesting of learning.

As mentioned above, wearable devices have been applied in many fields. The major application directions include medical, entertainment, sports, fitness and even some special application fields like military purposes. However, research on the introduction of wearable device into museum guides is still in the beginning stage and still has great potential for educational and application value of museum guides (Chiang, Yang & Hwang, 2014). Therefore, this research applies wearable devices to museum guide in order to provide more diversified and innovative guide modes for museums.

2.2 Application of AR

Augmented Reality (AR) is defined as a technology that combines virtual images with the real world and allows users to be immersed into it and interact in real time. AR should have three basic features: 1) combining real and virtual objects in the same interface; 2) displaying virtual objects in real environment in real time; 3) superimposing virtual objects on real environment, allowing interactions with users (Azuma, 1997). AR is not limited by time and space. It can make interactions more dramatic and stimulate sensory feelings through the integration of real scenes (Wang, 2006). With the development of information technology, the application of AR is more diversified.

In recent years, many scholars and researchers have tried to apply AR to various fields, such as medical research, education learning, military and police research, with great potential in all fields. In foreign cases, Shelton and Hedley (2002) combined nine planetary teaching experiments into the AR, so that teachers can use a small amount of teaching materials to teach and learners can construct abstract scientific concept with AR materials to improve their own understanding. In addition, Weng, Bee, Yew and Hsia (2016) used AR technology to introduce the biological sciences of Malaysian secondary schools, including cell mitosis, meiosis, respiratory function and their systematic relationships. They also used AR icons to scan the virtual stereo models and related photos to learn biology knowledge, so as to strengthen learners' memory and understanding of biological concepts. In Taiwan, many scholars have also applied AR to teaching. For example, Li (2011) built an AR guide learning system for museums, designed guide tours based on exploratory learning theory, and created interactive museum environment. Users can take guide tours and learning in museums through mobile tools, which can deepen users' impression of exhibits and enhance their learning effectiveness.

According to the above-mentioned cases, AR can integrate words and pictures to make exhibits more lively and vivid. Besides, it can also clearly and unambiguously present the subject knowledge which is difficult to express. Therefore, applying AR to many fields will have more creations and possibilities, and improve the learners' knowledge, memory and learning effectiveness. More importantly, it can foster learner's understanding of the learning content, satisfy the learner's sense of achievement in learning knowledge, and arouse the learner's enthusiasm and motivation for learning (Lin, 2009). In other words, AR has such advantages as the integration of the virtual and the reality, instant interaction, and operation in 3D environment. If applied properly, AR can communicate effectively with learners and improve learning effectiveness and interest (Kuo, 2008).

Therefore, compared with traditional guide with tour guides, this study combines AR with wearable devices. When the learners look at the exhibits, they are immediately provided with information and films about the exhibits, so that the learners can read the exhibits more intuitively, and interact directly with the exhibition information with their hands free.

3. AR-based Wearable Guide learning System

This study provides smart glasses for on-site guide of historic sites so as to assist learners in learning. In order to achieve the purpose of the study, a wearable AR guide system with a friendly man-machine interaction interface is provided to enable learners to obtain AR virtual information of observed objects in the real environment in a simple and intuitive way. It combines virtual information with reality in an accurate and real-time manner to strengthen learners' learning experience of historic sites in reality, and help learners to understand their own learning effectiveness with the help of a test system.

3.1 Hardware

Figure 1. Glass Enterprise Edition 2

Figure 1 shows the smart glasses named Glass Enterprise Edition 2, which is an optical head-mounted display introduced Google in May 2019. It uses Qualcomm Snapdragon XR1 processor to support computer vision and machine learning functions. The lens resolution can support 720p images. It displays all kinds of information in a hands-free manner similar to smart phones. It is based on the Android platform and can be applied simply by using Android system to compile apps.

3.2 Architecture and Functions of Wearable AR Tour Guide System

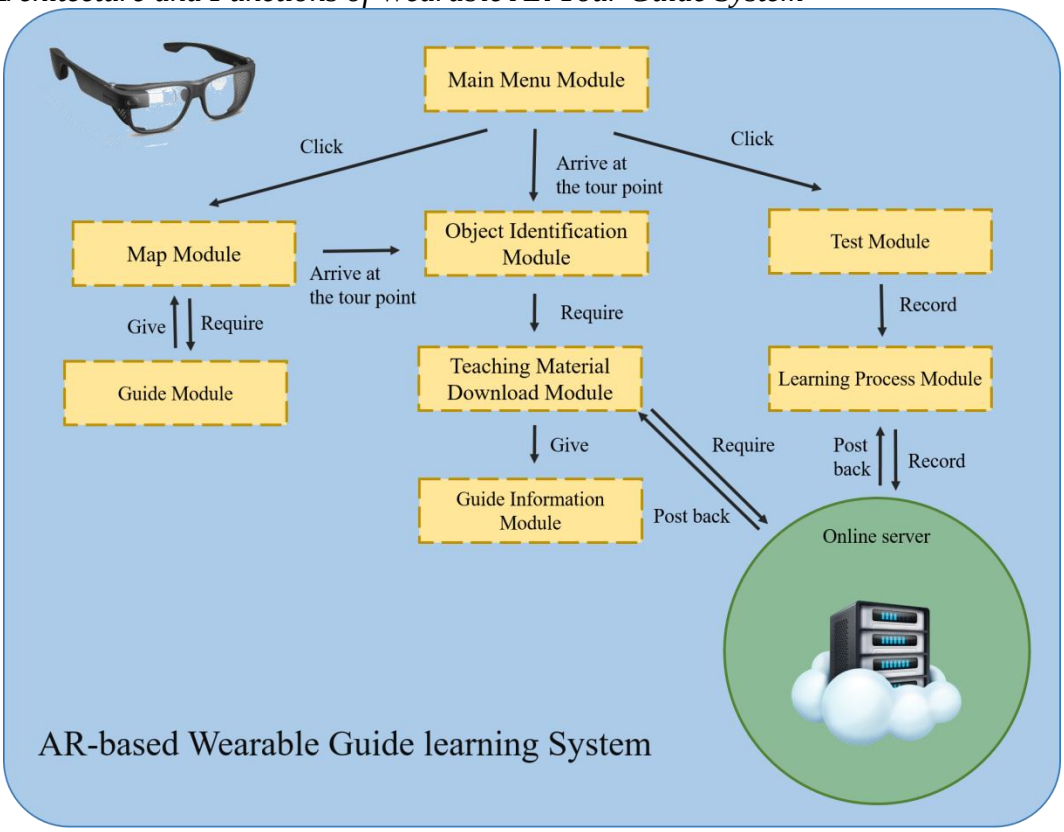

Figure 2. Architecture of AR-based Wearable Guide learning System

As shown in Figure 2, AR-based Wearable Guide learning System consists of eight modules, including Main Menu Module, Map Module, Guide Module, Object Identification Module, Teaching Material Download Module, Guide Information Module, Test Module and Learning Process Module. Firstly, the learner wears smart glasses and the image shows the Main Menu Module. When the learner chooses the Map Module, the picture will imported the Map Module interface, and automatically call the Guide Module to import the learner's historical learning record, so as to guide the learner to the required guide site. When the learner arrives at the guide site, the system will automatically require the Object Identification Module to identify the exhibits, and import the analyzed information into the Teaching Material Download Module, requiring the Teaching Material Download Module to grab the corresponding multimedia teaching materials from the online server, and pass the multimedia teaching material to the Guide Information Module for content playback. Next, when the learner completes the learning activities of a guide point, he can click the Test Module to make a test of the guide point. The test results can be imported into the Learning Process Module and stored in the online server to record learner's learning situation and allow learners to review the tested topics and learning records. The detailed module functions are as follows:

- **Main Menu Module**

The Main Menu Module mainly provides a main menu for learners to select the required module functions in order to complete the required learning work, including Map Module, Object Identification Module, Test Module and so on.

- **Map Module**

This module is mainly used through connection with the built-in Google Maps in smart glasses Glass Enterprise Edition 2. In addition to displaying the location of the surrounding attractions, the map can also locate the learner's location in time under wireless or mobile network environment, and instruct the learner to go to the surrounding guide sites.

- **Guide Module**

Record the guide sites that learners have already visited, and display the guide sites in the Map Module interface, as well as the sites that have not yet been guided, so as to guide users of the tours.

- **Object Identification Module**

It scans the exhibit objects through the upper right lens of smart glasses Glass Enterprise Edition 2 to identify the current object and locate the overlapping position in the teaching material. The information is then transmitted to the Teaching Material Download Module for downloading.

- **Teaching Material Download Module**

This module mainly obtains the information transmitted by Object Identification Module, analyses and processes such information, grabs the corresponding multimedia materials from the online server, and transmits the teaching materials to the Guide Information Module for content playback.

- **Guide Information Module**

After receiving the teaching material from the Teaching Material Download Module, projecting the teaching material on the smart glasses. The learners can read the multimedia materials of the exhibits and directly conduct the guide and learning.

- **Test Module**

The learner can take in-class test when the study at historic site has been completed. There are about 5 questions for each site, which shall be completed within specific time limits. If the learner answers the question correctly, he or she can go directly to the next question. Otherwise, he or she will have a detailed explanation on the question to deepen impression. The test results will be imported into the Learning Process Module for record.

- **Learning Process Module**

After receiving the information transmitted by Test Module, the Learning Process Module would analyze and process the information, and uploads the information to the online server. The learner can also review the tested topics or the learning process records in this module to deepen the learning impression.

3.3 System Interface

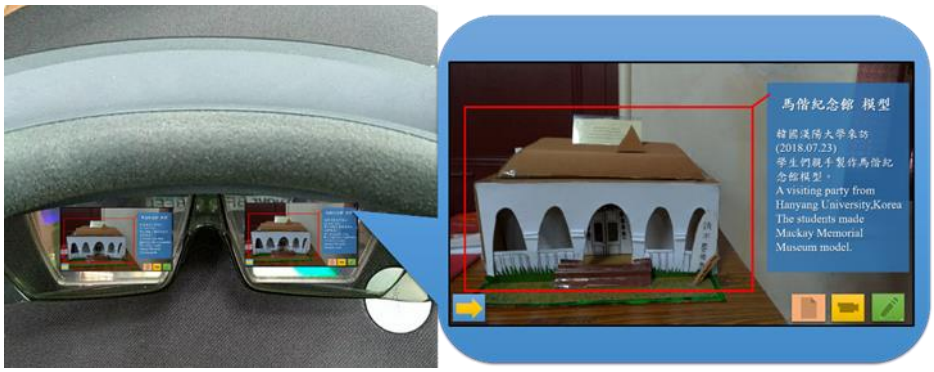

Figure 3. Display of the AR-based Wearable Guide learning System

The wearable AR guide system designed by this research provides learners with an intuitive operation interface by integrating virtual information into the real world and overlapping it on the smart glasses. In the process of using the system, learners will see corresponding learning materials popping out by looking straight at the object, which display images as shown in Figure 3. In addition, with the camera on the machine, the learners can operate to read relevant films or switch the screen. When the learner completes the guide tour, the system can put forward relevant questions to provide the learner with feedback on their learning results. When the learner has completed all the learning, he can also review his own answers to understand the learning experience.

Figure 4. Context of Use of AR-based Wearable Guide learning System

Figure 4 is a Scenario sketch for actual context of use. The learner only needs to wear the device and make the device capture the learning object. The relevant information will be displayed on the screen. The content of the information includes the history introduction, pictures, images and so on of the object, so that the learner can have a thorough understanding of the whole picture of the historical site, and can interact with the exhibits through the free hands.

4. Teaching Material Design

The teaching places of this study are five historical sites in the Tamsui area, including Fortress San Domingo, Oxford College, Little White House (Tamsui Customs Officers' Residence), Tamsui Church and Mackay Memorial Museum. The teaching materials of this study are divided into five units according to the historical sites, with each unit introducing a specific monument museum and its related historical content.

Table 1. Unit Themes

Unit Topic	Visiting Sites	Unit Teaching Objectives
Unit 1 Mackay and Oxford College	Oxford College	(1). To understand the historical allusions of the Oxford College. (2). To understand Mackay's story and contribution in Taiwan. (3). To understand the architecture structure and environment of Oxford College.
Unit 2 Little White House	Little White House (Tamsui Customs Officers' Residence)	(1). To understand the historical allusions of the Little White House (2). To understand the architecture structure and environment of Little White House (3). To understand the origins and designs of the objects in the Little White House
Unit 3 Tamsui Church	Tamsui Church	(1). To understand the historical allusions of the Tamsui Church. (2). To understand the architecture structure and environment of Tamsui Church. (3). To understand the origins and designs of the objects in the Tamsui Church.
Unit 4 Mackay Memorial Museum	Mackay Memorial Museum	(1). To understand the historical allusions of the Mackay Memorial Museum. (2). To understand the architecture structure and environment of Mackay Memorial Museum. (3). To understand the origins and designs of the objects in the Mackay Memorial Museum.
Unit 5 Fortress San Domingo	Fortress San Domingo	(1). To understand the historical allusions of the Fortress San Domingo. (2). To understand the stories of the Dutch coming to Taiwan. (3). To understand the architecture structure and environment of the Fortress San Domingo.

As shown in Table 1, the courses of this study are divided into five units according to five historical sites in the Tamsui area, including Fortress San Domingo, Oxford College, Little White House (Tamsui Customs Officers' Residence), Tamsui Church and Mackay Memorial Museum. The mainly objective is to enable learners to understand the historical allusions, architectural structure and geographical environment, of the historical sites. A quiz is provided after each unit has been studied. While doing the test, the learner can review the teaching content and clarify whether the knowledge has absorbed correct, so as to deepen the learner's impression of the unit's content.

5. Conclusion and Future Studies

This study constructed an AR-based Wearable Guide learning System which provides a friendly human-computer interaction interface enabling learners to acquire virtual information of exhibits in real environments in a simple and intuitive way and to have a better understanding of the museum. In addition, this study expects that the following work shall be completed in the future：

(1) Complete the integrity testing of the system

The technical development of wearable AR-based guide system proposed in this study has been constructed, and working on debugging. In the future, integrity testing will be carried out to ensure that the system can operate smoothly.

(2) Planning of experimental activities

Experiments on a regular teaching activity should be conducted. During the experiment, the wearable AR-based guide system is introduced into the actual teaching activities with the expectation to collect experimental data with equal emphasis on quality and quantity so as to evaluate the learning effectiveness and motivation and obtain substantial proof of effectiveness.

(3)Formal introduction of the system into museums to support tour guides

It is hoped that the wearable AR-based guide system proposed in this study will be introduced into the museums' guide and learning activities in the future to ease the shortage of guides for historic sites around Tamsui and make the museums' guide activities more attractive.

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EXTENDED SUMMARIES