Augmented Reality Application for Plant Learning

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Abstract-*Augmented* reality learning resources meet the requirements of contextual and adaptive ubiquitous learning and are gradually favored in the field of education. In om' previous work, **we** proposed a plant knowledge expansion learning system. This system used mobile intelligent terminal to take pictures of plants to get the text, pictures, audio, video and other information related to plants, On the basis of the existing system, this paper further explored the application of augmented reality technology for plant learning, and developed plants augmented reality information display module. **This** module can be used to scan a specfflc plant and obtain its 3D model and text information in real-time. Learners can interact with the model by rotating and scaling, which effectively enhances learners' interest in learning.

Keywords-plant learning; interactive learning; augmented reality technology (AR);

1. INTRODUCTION

Augmented reality *(AR)* technology is the extension of virtual reality technology. By acquiring the camera of the mobile device, AR technology can superimpose the model, picture, text and other information in the real scene to improve people's perception and cognition of the real scene. As early as 1990, Caudell first proposed the concept of augmented reality in the development of military training system [1]. After more than 20 years of development, it has achieved results in multiple fields.

Augmented reality technology has made a lot of contributions in the field of education, and it has been applied to learning systems in various fields. For example, Cai Su's team [2] from Beijing Normal University developed several cases, such as mathematics, physics, chemistry, language and other AR teaching examples. Li TM [3] developed an AR literacy system. East China Normal University [3] has developed an educational game named "Happy Treasure Hunt". A large number of studies show that the classroom supported by AR technology has the following advantages over traditional classroom [4]: (1) The teaching content is intuitive and can attract the attention of learners through a full range of sensory stimulation. (2) It is easy to simulate teaching experiments, and avoid waste and reduce danger. (3) It is conducive to cultivating students' multiple abilities, and promoting the development of students' multiple intelligence and improving students' innovation ability.

At present, plant knowledge learning, as a way for students to understand nature, gradually attracts people's attention. With the popularity of mobile intelligent terminals, learning systems based on mobile intelligent terminal continue to emerge, which provides a new way for learners to acquire plant knowledge. In the previous research, we designed and developed a plant knowledge expansion learning system based on mobile visual search [5]. This system used mobile intelligent terminal to take pictures of plants to get the text, pictures, audio, video and other information related to plants. However, the system was still lacking in interest and the leamer's immersion was not high. Therefore this paper further explored the application of AR technology in plant learning. And the plants augmented reality information display module was developed on top of the existing system to enhance learners' interest in the learning process.

II. TECHNOLOGIES & TOOLS

Augmented reality technology is a collection of real world and digital information. Persons who use it can see the virtual information superimposed in the real world, and they can also interact with the virtual reality world [6]. We will describe the classification of Augmented reality technology and its development platform.

A. Discussion on key technologies of augmented reality

AR can be divided into two types: geographic location-based AR and computer vision-based AR.

1) Geographic location-based AR: The design idea of the geographic location-based AR is based on the LBS system. LBS is location-based services, which can provide spatial location-based information services for mobile objects by using GIS (Geographic information system) technology, network communication technique and spatial positioning technology in mobile computing environments and heterogeneous environments [7].

The principle of AR technology based on geographic location is to acquire the geographic location of users through the built-in GPS positioning module of the mobile terminal, and wirelessly transmit the geographic location of the user to the LBS location server. And then, the user's current location information is matched with the location information pre-stored in the server. After successful matching, the LBS location server will send AR information to the mobile terminal.

The geographical location-based AR technology is applied in various business systems, such as Alipay launches the AR real red envelope [8]. Users need to meet two conditions of geographic location information and AR real scene scanning to be able to grab red envelopes. The real-world map based on AR augmented reality technology introduced by Baidu Map [9] will appear intuitive virtual landmarks on the real street scene

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captured by the camera to guide users to their destination. Pokemon Go [10], a popular AR game, follows geographic information in search of hidden treasures in the grass.

2) *Computer vision-based AR* : Computer vision-based AR technology includes 3D virtual object registration technology, camera calibration technology, camera tracking technology and video-based real-time space modeling technology [13]. It can establish a mapping relationship between the real world and the virtual world by using computer vision. It can be divided into two categories: maker-based AR and *marker-less AR.*

a) *Marker-basedAR* [11]. marker-basedAR technology requires pre-production of two-dimensional code or template cards, such a card is a marker. The maker is identified and its pose is estimated by the camera, and its position is determined. The coordinate system with the Marker center as the origin is called marker coordinates. We need to get a transformation to make the mapping between the template coordinate system and the screen coordinate system, so that we can draw on the screen according to this transformation. The graphics can achieve the effect of the graphics attached to the marker.

b) *Marker-less AR* [12]. Its basic principle is the same as maker-based AR. But it can use any object with enough feature points as a plane benchmark, without making special templates in advance. Its principle is to extract feature points from template objects through a series of algorithms and record or learn these feature points. Then the feature points of the surrounding scene are compared with the feature points of the recorded template object. If the matching result exceeds the threshold, it is considered that the template is scanned. Then, the graphic drawing is performed according to the corresponding feature point coordinate estimation matrix.

In this paper, the plants augmented reality information display module is designed and developed based on the *marker-less* computer vision AR.

B. *Augmented reality technology development platform*

AR technology is a new trend all over the world and has gradually become the mainstream. It is now being used in various industries to improve efficiency, simplify operations, increase productivity and improve customer satisfaction. There are many development platforms for AR technology. For example, Wikitude provides a suite of augmented reality software development kit, which has powerful functions to develop AR applications for recognizing, tracking and enhancing images, objects and scenes. And it supports extensible frameworks of Unity, Cordova and Titanium. ARToolKit [14] is a free open source SDK that uses a label-based video detection method for three-dimensional registration. The toolkit includes tools for camera calibration, marking and supports the helmet-mounted and other display devices. Vuforia [15] is dedicated to the development of AR technology, and it provides a first-class computer vision experience. It can superimpose images, scan and overlay on real objects, and carry out multi-platform development to ensure a reliable experience in various environments. Developers can easily add advanced computer vision function to any application to recognize images and objects, or rebuild real-world environments.

Although AR technology is in the stage of development, Vuforia is relatively mature for the entire market. Its application range is wide and the combination of virtual and real display in the intelligent terminal is quite good. Thus, in this paper the plants augmented reality information display module was developed by adopting the natural scene-based tracking registration technology in Vuforia.

III. IMPLEMENTAnON OF AUGMENTED REALITY INFORMATION DISPLAY MODULE FOR PLANTS

The plants augmented reality information display module mainly uses Vuforia SDK [15]. The CameraDevice class of the Vuforia platform is used to obtain the image. And the Image Converter, a pixel converter, is used to convert the image captured by the camera from the OpenGL ES rendering format of the camera into the tracking format required by the following image detection and tracking module. The Trackable Base class is used to identify objects in the real world that the Vuforia SDK can monitor in 3D space. The plants augmented reality information display module uses the camera of the mobile terminal to recognize, it can display information such as the 3D model and text of the plant that the learner is interested in. Learners can also freely interact with the 3D model by rotating and scaling. The realization of the plants augmented reality information display module involves four stages, the specific process is shown in Fig. 1.

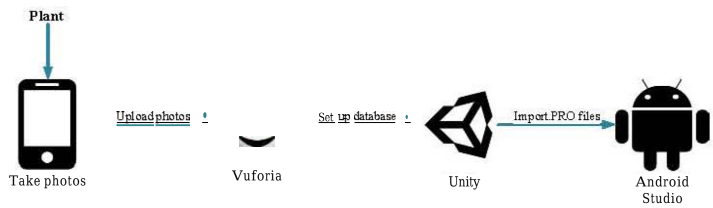


Figure 1. Flowchart of the plants augmented reality information display module

In the first stage, taking multiple 360-degree pictures of plants with the camera of mobile terminal. Then uploading all these pictures to the official website of Vuforia, and generating (* Od) file.

In the second stage, the (* Od) file is transferred to the Vuforia official network. Vuforia will establish the corresponding target database according to the imported data files. It can identify and track a wider range of objects. Object recognition ensures that users can scan real objects and create object targets virtual objects. Vuforia allows applications to identify and track complex rigid objects. In addition, it provides users' perception of the real world for target recognition.

In the third stage, the plant data package generated in Vuforia official network and the Vuforia augmented real-scene software development kit are imported into Unity to develop AR scenanos.

In the fourth stage, the developed AR scenario is exported as (* PRO) file, and the file is imported into Android Studio for further development to realize the interaction between Unity and Android Studio. It can also export a APP file for learners.

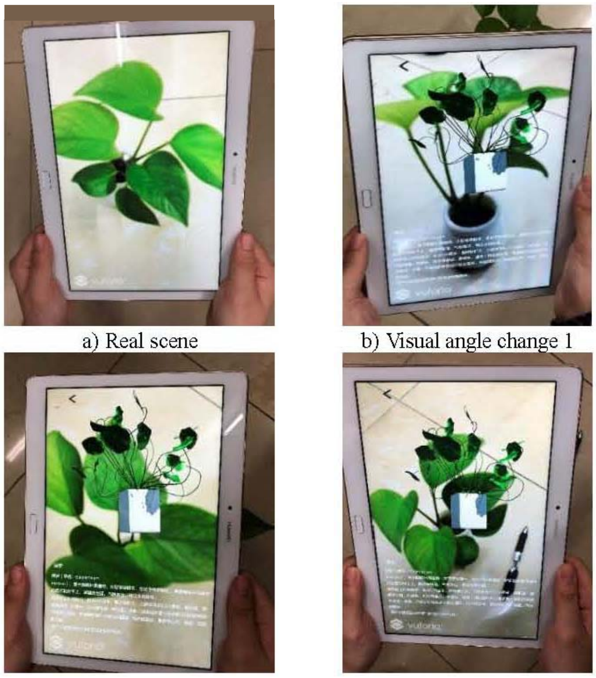
IV. EXPERIMENT RESULTS

Fig. 2 is the main interface ofthe plant knowledge expansion learning system. The right button on the bottom ofthe main page is the "AR" identification button, which corresponds to the plants augmented reality information display module developed in this paper. Select the "AR" button, the system will automatically call the phone's camera, and the learners can scan plants. The plant related information will be displayed on the screen. Fig. 3 is the interface of plants augmented reality information display module. The learners can interact with the 3D model by sliding the model left and right, or enlarging or narrowing, which can increase learners' understanding ofplants and increase their interest.

Figure 2. System main page

Figure 3. The interface ofplants augmented reality information display module

We used the tablet of the android system as the mobile terminal, and tested the effect of the plants augmented reality information display module in order to verify its accuracy and effectiveness. Firstly, we scanned the scindapsus aureus in the maker space, and it generated the 3D model ofscindapsus aureus instantly. When we clicked on the 3D model of the scindapsus aureus, it would present the text information of scindapsus aureus. This paper observed the test results from different perspectives, and did a visual interference control group. The results showed that the plants augmented reality information display module could recognize the scindapsus aureus normally, which can be seen in Fig. 4. Fig. 4(a) shows the real scene of scindapsus aureus, and Fig. 4(b) shows the effect of slight deflection to the right ofthe angle ofview, while Fig. 4(c) shows the effect of slight deflection to the left ofthe angle ofview. To test the effectiveness ofthe plant augmented reality information display module in the case ofvisual interference, we put a black neutral pen next to the scindapsus aureus. As shown in Fig. 4(d), the module can well overcome the visual interference.

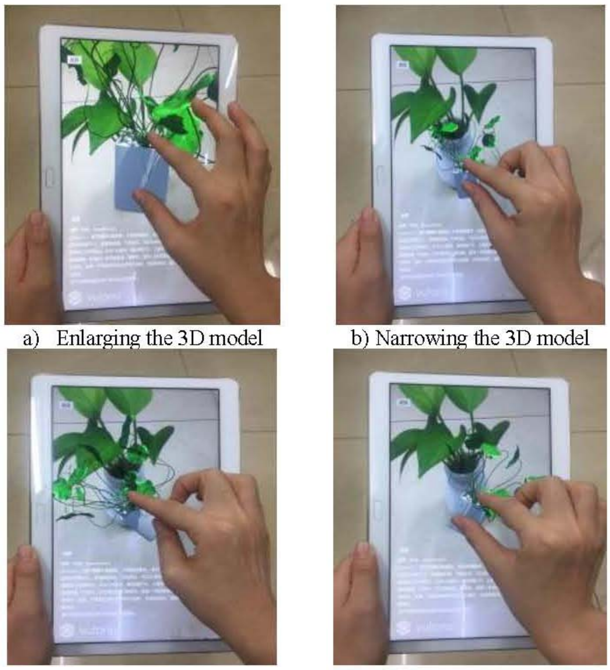


a) Real scene b) Visual angle change 1

c) Visual angle change 2 d) Visual interference

Figure 4. Scindapsus aureus augmented reality information display effect diagram

The plants augmented reality information display module has good interactivity. To verify the interactive function ofthe module, we performed scaling and rotation operations on the 3D model of the scindapsus aureus. Fig. 5(a) shows the effect of enlarging the 3D model of scindapsus aureus, Fig. 5(b) shows the effect ofnarrowing the 3D model of scindapsus aureus. And Fig. 5(c) and Fig. 5(d) show left rotation model and right rotation model, respectively. It can be seen from Fig. 5 that the plant augmented reality information display module is stable in the interaction process and the AR information is smooth.



a) Enlarging the 3D model b) Narrowing the 3D model

c) Rotating the 3D model to the left d) Rotating the 3D model to the

right
Figure 5. Interactive effect diagram

We also used the plant augmented reality information display module tested different plants. For some plants, the effect was not good. It was found that plants with more feature points had better recognition and display effect than those with less feature points. The reason may be that the fewer feature points lead to lower accuracy of feature matching. In addition, the environment may also has an impact because it will affect the extraction of plant features, which will cause the reduction of feature points.

V. CONCLUSION

In recent years, AR technology has become more and more mature, and it has made great achievements in various fields. With the maturity of educational information technology, AR technology has been gradually integrated into the field of education. In this paper, AR technology is combined with the previously developed plant knowledge expansion learning system to design an plants augmented reality information display module. The purpose of this study is to help learners improve their interest in plant learning.

AR technology is a new direction of modem educational technology. It is a long and arduous task to apply AR technology to teaching. Through this study, we hope that future research can integrate AR technology into teaching, and create a new learning environment for learners which is interactive, interesting, imaginative and intelligent.

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