A Mobile Augmented Reality System for Exhibition Hall Based on Vuforia

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***Abstract*—Mobile augmented reality (MAR) is a newly-emerging technology which covers the real scene with virtual information by utilizing the mobile terminal and thus enables users to have a better understanding for and interaction with the real environment. The article makes a research on the application of MAR technology in the smart exhibition hall, expounds the technological principles and key technologies of MAR in detail and introduces the Vuforia augmented reality framework. Meanwhile, it also designs and realizes the MAR system of the exhibition hall based on Vuforia, explains the systematic structure, recognition of the creating method of the target library and working process of the system, conducts application experiments on the system and then makes summarizations and analysis on the system effects. Finally, the article discusses the deficiencies on the system and its further work.**

Keywords-mobile augmented reality; exhibition hall; mobile terminal; vuforia

I. INTRODUCTION

With the development of computer technologies and mobile internet technologies, the smart exhibition hall has become a necessity for the development of modern exhibition hall. The smart exhibition hall utilizes cutting-edge computer technologies, internet technologies and mobile terminals to give an intelligent display of the traditional exhibition hall through internet technologies, realizes the smart management and smart visits on the exhibition hall and thus improves the scientific and technological experience of the exhibition hall [9].

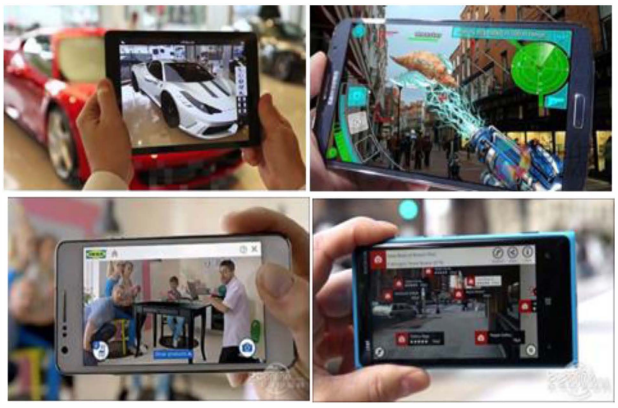

Figure 1. Applications of MAR

Since the advent of Augmented Reality (AR), many domestic and oversea scientific and research institutions including universities, experiments and research institutions have paid attention to and made researches on AR. Over the recent years, with the successive introduction of mobile smart terminals like iOS and Android and the rapid development of mobile internet technologies, the AR technologies, though limited to experiments, have gone public. A great number of mobile internet AR applications based on the terminal positioning and image recognition technology start to appear (see Figure 1) and they are called the MAR application.

The article to makes researches on the exhibition hall system using MAR technologies based on Vuforia. The system uses sensor devices including the high-quality camera of the smart phone, takes the display board of the exhibition hall as the AR recognition target, adopts technologies including the tracking register and highly-efficient rendering and thus realizes the MAR application targeted at the exhibition hall.

II. TECHNOLOGICAL PRINCIPLES OF MAR

MAR system is an augmented reality application based on the smart terminal. Users can utilize the mobile terminal camera to photograph the information concerning the surrounding real scene, combines the data of multiple senses (including GPS and gyroscope) carried by the mobile terminal itself and generate and load the AR data information in real-time, such as texts, images, sounds, videos and models. Then they can make an integrated display of the acquired AR contents and real scene photographs on the terminal screen and thus realize the organic combination of the virtual world and real world in terms of properties such as the location, time, sight and preferences [1-6].

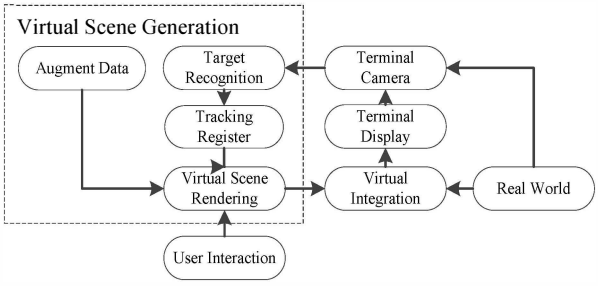

Figure 2. Architecture of MAR system

A typical MAR system structure is shown in Figure 2. There are totally three key technologies in the research on MAR system, including the target recognition technology under complex scenes, real-time robust tracking register technology and real highly-efficient tendering technology.

A. Target Recognition Technology

As an important procedure to understand the real scene, the target detection and recognition is to figure out the target in the scene. The target recognition can be divided into the following two kinds in the AR field.

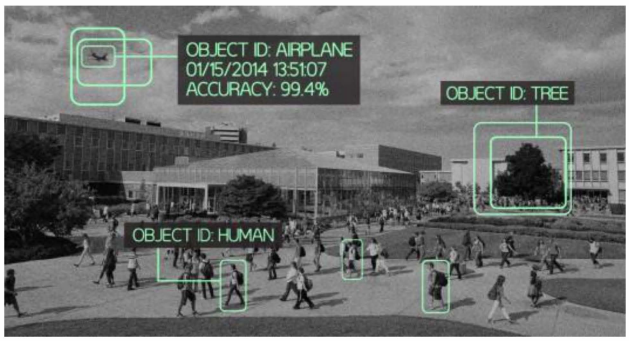

Figure 3. Recognition based on characteristics

From the perspective of categorization and detection, the data model can be generated by using the machine learning algorithm to acquire general characteristics of certain categories. Target detected or recognized by this method includes the following category including automobiles, human faces and vegetarians (see Figure 3). There is no accurate geometrical relationship in this kind of recognition, which is more suitable for the applied scene focusing more on the supporting information instead of the location.

Figure 4. Recognition based on image matching

From the perspective of image matching, the database has preserved the image features and corresponding information. Thus, in the actual using process, the image matching can be used to figure out the most relevant images and thus identify the target in the environment and further acquire the accurate position of the recognized image and target image (see Figure 4). Such recognition is suitable for the application scene that needs to track the environment accurately.

B. Tracking Register Technology

MAR system generally uses the tracking register technology based on the computer vision, which means to utilize image processing and other computer vision technologies to calculate the current location information of the observer. As present, the tracking register technology based on the computer vision can be divided into two methods:

1) One: marker-based method. It places specific recognized markers in the real scene and then recognizes the marker through edge detection and template matching on the video scene. According to the spatial geometry information of the recognized marker can be used to calculate the spatial transformation matrix of the virtual object in real time (see Figure 5).

Figure 5. Tracking registration based on target

2) Two: natural feature-based method. Independent on any marker, the method acquires the natural feature points that match with the real scene by analyzing the video images and then calculates the spatial transformation matrix of the virtual object through the feature points (see Figure 6).

Figure 6. Tracking registration based on natural features

C. Highly-efficient Technology

Mobile terminal uses relatively independent graphic rendering technologies to show augmented contents of the AR system including the virtual 3D model, images, videos and hypertext files on the real scene of the camera so as to generate the augmented effect of the seamless integration between virtual scenes and actual scenes. The MAR system utilizes the cross-platform open source OpenGL ES technology to render the augmented content. Based on the graphic rendering features of the mobile terminal, the MAR system needs to simplify the augmented contents, optimize the rendering process, enhance the frame-buffer operating process and thus increase the rendering efficiency. As for

complex augmented contents like the 3D model and 3D animation, MAR system can use the third-party professional rendering engines, such as Unity 3D and Ogre 3D. Likely, for augmented contents like complex 3D models and 3D animations, it can utilize professional rendering engines such as Unity 3D, Ogre3D and Rajawali to render images and thus improve the rendering efficiency.

III. VUFORIA

As a mobile device facing the augmented reality SDK (software development kit), Vuforia utilizes the computer vision technology to recognize and track graphic images and simple 3D objects in real time. Meanwhile, it also provides positioning and directed virtual capability for developers, including 3D models and other multi-media data.

The AR application based on Vuforia SDK takes the display screen of mobile devices as the hub to connect the AR world. Real previewed images in the camera are rendered by applications and displayed in corresponding devices so that it can turn into real images. Virtual 3D objects are added on real images and this combination gives people a sense of immersion.

The AR application based on Vuforia SDK can create good user experience, including the following four aspects:

1) Faster speed of local target recognition;

2) Supporting and use the technology that can recognize millions of targets;

3) Highly-robust target tracking that will not be affected easily by mobile devices;

4) More effective than other AR SDKs and supporting the recognition of low-light and partly-covered targets.

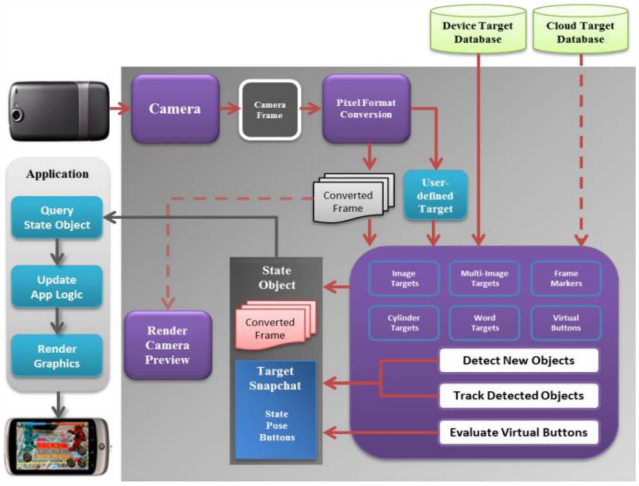

Figure 7. Vuforia augmented reality SDK

IV. EXHIBITION HALL MAR SYSTEM

A. System Structure

The article presents the exhibition hall MAR system based on Vuforia and the structure is shown in figure 8. The system consists of three levels, including data level, service level and application level.

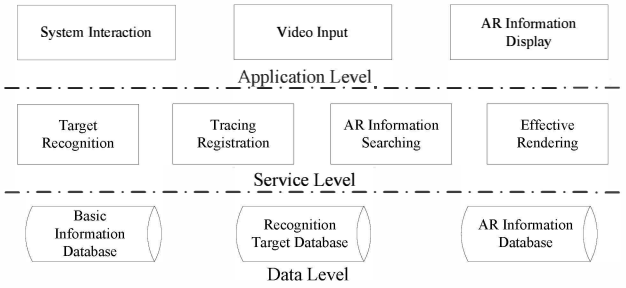

Figure 8. System architecture

Data Level: It provides basic data support for the whole system, with the man contents including basic information library, recognition target library and augmented information library. The basic information library stores the basic formation needed and generated by the operation of the system itself; Recognition target library stores the target feature model data needed by the AR application; AR information library stores AR content data, including texts, images and models.

Service Level: The service level is mainly responsible for the calculation based on the needs of the application level and the application for data level, thus realizing the intercommunication between application level and data level. The middle level contains core technological services of the augmented reality, including the target recognition, augmented information search and highly-efficient rendering.

Application Level: Targeted at the user, the application level is responsible for providing the input of basic video flow data for the service level and checking the system interaction requirements of users. When the service level recognizes the target and finishes the calculation of the data concerning the tracking register matrix, the application level will demonstrate the augmented information on the user interface.

B. Creation of Recognition Target Library

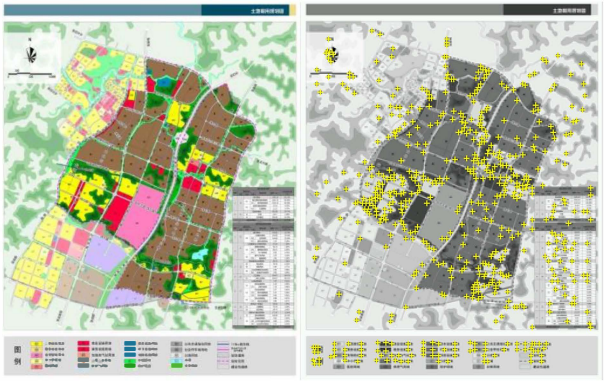

Figure 9. Feature model extraction

The system utilizes the target recognition technology based on image matching and the tracking register technology based on the marker and takes the display board image laid out by the exhibition hall as the AR recognition target. When the mobile terminal is target at the display

board of the exhibition, the system will demonstrate the virtual augmented information on the display board. To increase the efficiency and accuracy of AR recognition, the system needs to extract the feature model data of the display board image and create the feature model library for local target recognitions. The image feature model is based on the feature extraction method for the image grey-level co-occurrence matrix and the extraction effect is shown in Figure 9.

C. *Working Process*

The working process of the exhibition hall AR system is shown in figure 10. When using the system, the user aims the camera at the actual location of the display board before the system receives the real-scene video flow and makes recognition & check for every frame of the video flow. After checking the recognition data from the video flow the system will search for corresponding AR virtual model data. Based on the camera's position relative to the sign in the real-world coordinated system, the system then registers the augmented content of the city architecture model on the sign by means of 3D alignment and outputs the scene with integration between virtual and real world.

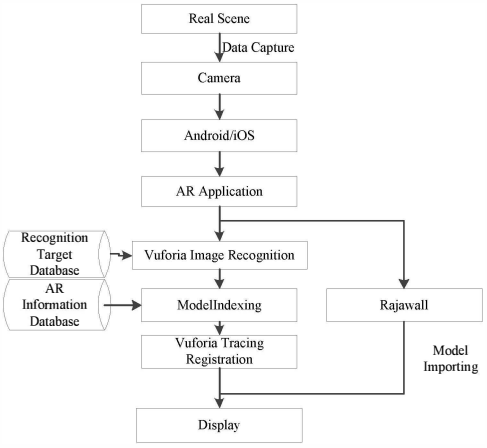

Figure 10. System working process

V. EXPERIMENTAL ANALYSIS

The article develops and realizes the proto-system of exhibition hall augmented reality based on Vuforia and even makes application experiments in a planning exhibition hall. The experiment is based on smart phone devices with an Android operation system while the system requires an device operation system of Android v4.2 or above, a camera of 5.0 MP or above, a processor with dominant frequency of 1.3GHZ or above and the ROM of 1G or above.

As is shown in Figure 11, the system aims the mobile terminal camera at certain planning achievement display board in the exhibition hall and automatically draws the augmented contents of the city model of the corresponding display board in the actual geographic location of the board. While the camera is moving, the interaction virtual model of the terminal reality will change correspondingly. In the whole process of the experiment, the effects of the mobile augmented demonstration are very stable with no model vibrations or delays of the recognition. The deficiencies lie in the small number of the AR model data, thus further experiments and improvements need to be made on the AR effects of the big data virtual model.

Figure 11. Augmented Reality of Display Board

VI. CONCLUSION

Though the MAR system has presented its wide application prospects in many fields including the smart exhibition hall, planning examination & approval and underground pipelines, the limited technological conditions and costs require further researches on the large-scale promotion and application. On the one hand, there is still strong potential to improve the accuracy and real-time feature of the key technologies of the augmented reality including target recognition and tracking register. On the other hand, AR needs a large quantity of augmented contents like 3D models and requires high production costs. The application of MAR technology is constrained by all the above mentioned uncontrolled factors.

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