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Campus Navigation System Based on Mobile Augmented Reality

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Abstract—**Due to the limited of precision, navigation technology in the local area cannot accurately locate each building and obtain the functions related to the building. This paper investigates augmented reality and navigation technologies and realizes the campus internal navigation on a mobile phone. In the campus, the exact position and detail data of every school can be obtained by using the augmented reality technology. The navigation system merged with augmented reality makes navigation technique in the local application more exact, humanized and convenient.**

Keywords- mobile device; augmented reality; campus navigation

I. INTRODUCTION

As computers increase in power and decrease in size, intelligent mobile phone and wearable devices are rapidly becoming feasible, providing people access to online resources always and everywhere. Augmented reality (AR) is a new rising research field in recent years. AR system integrates virtual information into the real world and enhances the users' visual experience and makes users more intuitive and more real understanding of the real world [1]. Mobile augmented reality systems (MARS) provide this service without constraining the individual's whereabouts to a specially equipped area. Ideally, they work virtually anywhere, adding a palpable layer of information to any environment whenever desired [2].

According to the identification and information acquisition, mobile AR technology is classified into location-based AR and vision-based AR. Location-based AR first positions an area by GPS in the mobile device, or using current location information achieved by network, and then obtains the virtual information corresponding to the current position [3]. The first successful location-based AR application is called iButterfly [4]. By using GPS, the iButterfly obtains the users' position and then users can capture the butterflies which are set beforehand to achieve business objectives. Other than location-based AR, vision-based AR must first obtain the images by the camera; then matches the captured images with a given template; and the last registers the corresponding virtual information on the images [5]. For example, a mobile augmented reality application for books described in [6]. By capturing the images in the books, it will provide more information to make the books more vivid. Compared with location-based AR, vision-based AR needs more compute and more powerful processors.

Vision-based AR provides more information for the specified target in real scenes by virtually adding texts, images and videos. However, it cannot accurately point out the target position. Conversely, location-based AR can acquire the target position in the real scene. However, its navigation is not able to generate accurate position data when the destinations are within a small area, e.g. the buildings in a university campus.

Considering the special scenario where the locating information in a university campus needs to be acquired, this paper investigates mobile location-based and vision-based AR technologies, and implements the campus navigation system by using these technologies. This system provides the related information for each building, e.g. teacher, research and teaching information of a faculty. Moreover, it aids navigation by directly pointing out locations in order to improve imprecise location in a local area and supplements latitude and longitude data without navigation. Hence, the system becomes more perfect and easy for user to operate.

II. SYSTEM DESIGN

A. Overall design

This navigation system is developed under Android system of intelligent mobile phones. According to the requirement, the navigation system will automatically obtain the current location wherever and whenever the users execute this system in campus. But the location data cannot always direct the right place. During the campus tour, the user can find the artificial markers pasted on each building at which the school, library or classroom is located. The marks are all different from each other and each building in the campus has a different marker to be represented. Markers carry on much information of the building which the marker represented. When user scans the marker by the phone camera, the detailed functions and position data of this building are presented on navigation interface. The data related to the building are provided in the way of images, texts and videos. At the same time, the virtue model of this building is also to be shown on the interface. In addition, the route guide can be generated according to the current position of the marker under the situation where the user cannot ensure the current position in the campus. The overall flowchart of the system is shown in Fig. 1.

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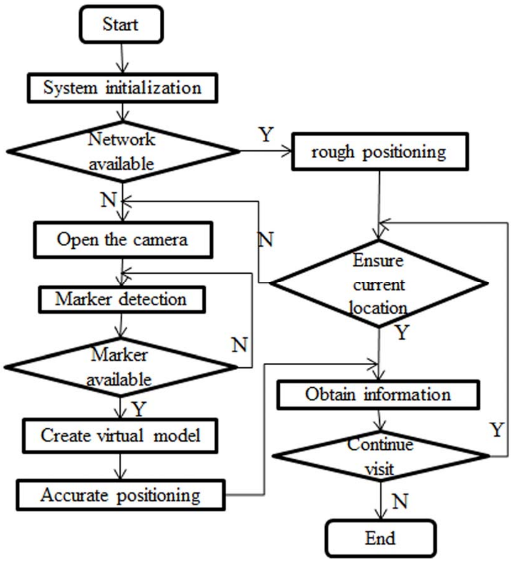

Figure 1. System overall flowchart

Mobile AR navigation system combines the augmented reality with the navigation technology. By using the function of obtaining detailed information, it not only makes the user to find him/her way while visiting the campus, but also shows the user a correct route to the target location. To get the goals, this system realizes the modules of user location, marker detection, three-dimensional (3D) display and campus guide. The function modules of the system are shown in Fig. 2.

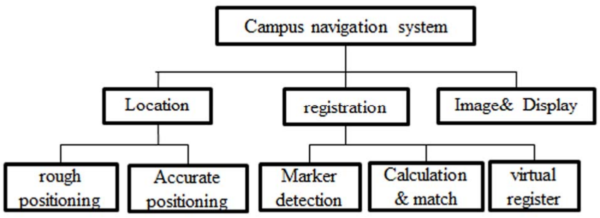

Figure 2. Function modules

B. Implementation

1) Location

This system exploits Map Android API provided by AutoNavi Company to realize the navigation. The API supports the digital map display and operation, interest point searching, geocoding, offline map and other functions [7]. Based on the precision of positioning, both rough location and precise location are designed in this system. The building's location provided by the API has a deviation from the corresponding real location, this leads to pointing to a wrong position where you would not go. Therefore, the rough location related to latitude and longitude of the building is first achieved using the satellite map. The precise location to the building is then adjusted by identifying the given marker.

In the case of a given current position, the user directly selects a destination on the system interface. According to the location of a guide marker, the system searches the vector map in the corresponding position, and then provides the user an optimal route in the navigation interface.

2) Registration

To achieve the data and precisely locate a building, the marker on the given positions is first recognized. It is then tracked in real time. The virtual data which involves in the building functions is registered on the marker. For that reason, the registration by vision-based AR technology is implemented in the following steps.

Step 1: Make sure the whole guide marker is involved in the video of camera. The guide marker in the video image is correctly detected by using edge detection.

Step 2: By using the image that is generated from Step 1, the guide marker image is matched with the template image which is built in the system beforehand.

Step 3: To register the virtual data on the guide marker, the marker in the image is identified by using AR technology. The camera external parameters need to be figured out. The mapping of world coordinate system to image plane coordinate is then calculated by the camera parameters [8, 9]. The transforming process is implemented by (1).

$$\begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \lambda M[r_1 \quad r_2 \quad r_3 \quad t] \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}. \qquad (1)$$

Where (u, v) is a point on the imaging plane; (x, y, z) is a point in the world coordinate system; M and [r1 r2 r3 t] are intrinsic and extrinsic parameters of camera matrix respectively; λ is a scaling factor.

Assume that each marker has a coordinate system, so that the camera parameters can be solved by using homography matrix H which is created in the process of marker plane mapped to the imaging plane. Calculating homography needs four or more corresponding point pairs. The more to the points, the higher registering accuracy is. This paper, according to the characteristics of the markers, uses 4 point pairs consisting of the vertex of the square on the marker to deduce the homography. Hence, Equation (1) is transformed into (2).

$$\begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = H \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = [h_1 \quad h_2 \quad h_3] \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}. \qquad (2)$$

According to (1) and (2), Equations (3) and (4) are deduced, that is

$$H = [h_1 \quad h_2 \quad h_3] = \lambda M [r_1 \quad r_2 \quad r_3 \quad t]. \qquad (3)$$

$$\begin{aligned} r_1 &= \lambda M^{-1} h_1 . \\ r_2 &= \lambda M^{-1} h_2 . \\ r_3 &= r_1 \times r_2 . \\ t &= \lambda M^{-1} h_3 . \end{aligned} \qquad (4)$$

Scale factor λ is determined by the orthogonal condition, i.e. λ = 1/|M^{-1}h|. Thus the camera pose is obtained by homography matrix.

Step 4: Since the process of generating the target scene by OpenGL is similar to the camera imaging processes, the virtual objects will be drawn by using OpenGL API and the camera external parameters.

After the target is successfully tracked and registered by visual-based technology, location-based tracking will be further adopted. The exact data of the marker on the target are given and showed on the navigation interface.

3) Image and display

The images in this system contain guide markers and data of each building. The marker designed is a black square within a pattern inside [10]. The pattern on the marker refers to the building. Each marker has its own feature for each building. These markers are stored as the template images and used for consequential image recognition. The images with data are given an identifier linked to data of the buildings. When the user utilizes the camera to capture a marker image, the user enters the image capture interface and directs the camera to the marker image. If the whole marker is not included in the image, the system will not provide the information for users.

A built-in camera and display which can meet the requirements have been completely equipped. The preferable interfaces are designed for the management of data display. To easily operate various functions provided by the system, the operation interface are designed by the button and drop-down list controls.

III. EXPERIMENTAL RESULTS

The system is developed by AutoNavi MAP API, OpenGL API and AndAR API, and tested on an android mobile phone. AutoNavi MAP API provides the system GPS support; OpenGL API provides the system display support and AndAR API provides the system identification support. The user executes this application if the network is available, and directly access to the interface. The rough positioning and navigation is presented as shown in Figure 3, i.e. the dark area in Fig. 3.

Figure 3. Rough positioning

Under the circumstances of getting lost, the accurate location can be obtained according to the guide markers pasted on each building. The user can observe a 3D virtual model of the building with the building's name. This virtual model is created by the designer beforehand.The virtual model (i.e. a cube with literal characters) is registered on the marker in the real scene (Fig. 4), and then presice position is presented on the map (Fig. 5).

Figure 4. Virtual registration

Figure 5. Precise positioning

Through accurately positioning to each school, the system will provide detailed information about the school, as shown in Fig. 6 and Fig. 7

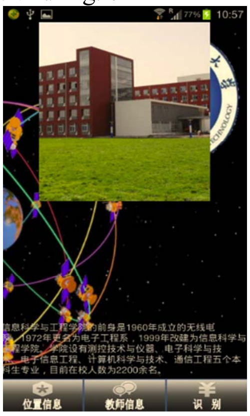

Figure 6. School information

Figure 7. Teacher information

Given the current position, the user can select the drop-down list box to the other destination; the system will provide an optimal path, as shown in Fig. 8.

Figure 8. Route selection

IV. CONCLUSIONS

The paper investigates augmented reality, navigation and image processing technology, and integrates them to develop a campus navigation system. Through the experiments, the system can guide users to visit the buildings within the campus, acquire more accurate information about the school. This contributes to better understanding school to some extent. This system can be further extended to the similar applications, e.g. large factories, the World Expo and large commercial areas.

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