Application of Augmented Reality (AR) Technology in Power Grid Emergency Training

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Abstract. Strong reality has been applied to training operations, and the use of virtual and augmented reality in aerospace, manufacturing and shipbuilding industries has yielded significant results. This paper mainly studies the application of Augmented Reality (AR) technology in power grid emergency training. This paper designs and implements an intelligent operation and maintenance system based on mobile augmented reality under the Android operating system. Augmented reality technology is applied to substation equipment operation and maintenance. Through the design and development of modules such as data management, equipment identification, holographic display of equipment information, integrated management and remote assistance, the application of Augmented Reality technology in substation equipment operation and maintenance is realized. Based on augmented reality and identification technology, the auxiliary information is transmitted to the intelligent terminal display of field operators in real time to assist the power grid emergency training and improve efficiency.

Key words: Augmented Reality, Power Grid System, Emergency Training, ORB Algorithm

1. Introduction
Augmented reality (AR) technology is a new technology based on the popularization and development of virtual reality technology. Virtual reality can only see the virtual scene described by the computer, while augmented reality technology allows the user to see the objects in the real world as well as the virtual scene. On the basis of the real world, the corresponding virtual objects constructed by the template of the real world are added [1]. The effect of AR technology emphasizes the combination of virtuality and reality, and truly achieves the fusion of virtuality and reality, combining two scenes. The introduction of augmented reality technology has greatly enriched people's lives. Users see different scenes all the time. Augmented reality technology can track the real objects that users see in real time through the computer, draw virtual objects according to the collected information, and superimpose virtual objects into the real environment in real time [2]. Immersed in it, users can not only see the kaleidoscopic changes in the real world, but also see the corresponding virtual information generated from it. With the rapid development of science and technology, people are no longer only satisfied...
with the transmission of two-dimensional information such as books and newspapers. In contrast, the more intuitive and vivid information experience of three-dimensional and three-dimensional space brought by augmented reality technology is easier to be received by people [3]. AR technology can effectively solve the hidden security risks and challenges in the power system when applied in the training level of power grid emergency trial training. Through this technology, power employees can better interact with the operating environment and make the training intuitive and three-dimensional. Employees are also more likely to immerse themselves, which significantly improves the effectiveness of teaching and training.

Augmented reality technology follows the human-centered technical thinking, improves the human-computer interaction relationship, and improves the user experience comprehensively through the clever integration of virtual and real. Although this is a new subject, it has become a hot spot of research in the industry, and has great application potential and market prospect. Augmented reality technology can be applied to surgical observation and operation guidance. With the help of AR technology, doctors can accurately determine the operation plan, thus helping to reduce the risk of operation and improve the success rate of operation. Whether it is communication, military training, or situational awareness, AR technology plays an important role [4]. In recent years, augmented reality technology has played an increasingly significant role in the military field, such as virtual combat scenes, battlefield command and armament research and development [5]. The integration of AR and industry is actually an embodiment of Industry 4.0. Fujitsu, for example, has used this technology to build solutions for urban waterway systems, as part of a broader smart city strategy. Using this technology, workers can also accurately judge the operation of the relevant equipment, and carry out preventive maintenance on the equipment by combining with the corresponding data analysis [6].

Based on the background of power grid emergency training, this paper applies augmented reality technology to mobile smart phones to realize the development of practical training system for safe operation of experimental equipment in a real sense based on AR.

2. Power Grid Emergency Training System Based on Augmented Reality

2.1. System Function Design

One of the essential processes in application development is to divide and modularize functions, reduce errors and bugs and improve development efficiency.

The system can be composed of three parts: image acquisition, image analysis, image output. Its basic flow: image ingestion → information conversion → feature point extraction → matching recognition → image binding → image output. Preset information and 3D models used for fusion should be dealt with first during development. The preset information can be modified.

Goal setting module mainly includes two parts, the identification of the map and virtual object production and upload, and adjust the position of the two display in Unity.

Images captured by camera, carries on the processing, will be matching with the default image recognition, the default target image information has been saved to the application in application development phase, when the application opens, first to read the information of target images by video camera, then its and bind a component, in matching recognition, this component can be used to obtain the information of the target image, and then match and identify the identity map.

Real scene image acquisition module, it is after the system is running, to get the image information of the real scene for image processing and analysis, and these operations can only be carried out under the condition of the device camera open, so the need to call the camera of the device.

Functions of the system are mainly realized through Unity3D, in which there are specific methods to connect and call Android. The function of the call is to directly obtain the camera in Unity3D and obtain the real scene image information captured by the camera. However, due to various factors such as environment and shooting, the image information captured will have great changes in saturation and intensity. Therefore, it is necessary to process these image information to reduce the impact of environmental factors on the image information.
The target object tracking registration module is needed to calibrate the real scene after the camera gets the scene and the matching recognition, so that the 3D virtual object can be more convenient to change with the camera.

In the process of matching recognition, the target image must be detected first. In order to detect the accuracy, need many ways to detect. First of all, the image needs to do edge, linear, center and diagonal feature detection. This detection can basically determine whether the recognized target image contains the feature points that can be recognized. In addition to the above features, some target pictures also need to be distinguished by different colors. At this time, it is necessary to detect the grayscale changes and local texture features of the image, so as to more accurately determine whether the target feature points exist on the target picture. For the pictures with feature points detected, it can be tracked and calibrated. The process of detection is complex, and the Vuforia plug-in can greatly simplify the process.

2.2. Augmented Reality Technology Realization

Track registration algorithm based on natural feature points, general is to bring forward the feature point information of target image input, and to save, and then work on the main frame camera image processing, the feature point information resulting from the calculation to compare the storage of the target image, using the feature point matching position and Angle for the access to video shooting device, at the same time, by tracking the target feature objects between adjacent frames of video images, the position and angle information of mobile devices can be refreshed in real time to ensure that the information to be enhanced can be overlapped into the real world in real time, stably and accurately.

(1) 3D registration method of mobile augmented reality

The complete process of the algorithm includes two stages: the pre-processing stage and the real-time processing stage [7]. In the processing stage, the ORB algorithm is used to extract the feature points from the reference image, and the feature descriptor is generated and stored in the feature database. In the real-time processing stage, it is necessary not only to detect the feature points of the video image, but also to judge whether there is an environment that needs to be enhanced in the video frame. Then, the pose of the smartphone camera is calculated based on the matching pair of feature points, and finally the complete process of 3D registration of the real scene is realized [8-9].

(2) Feature point detection

Centered on a target object pixels radius is R, draw a circle, the center circle algorithm will be located on the circumference of a circle all the pixel shading is and how the center pixel point of light and shade contrast one by one, if there are M each other neighboring pixels are better than center pixel bright or dim, so the center of the circle pixels can be judged as feature points. Specific discrimination rules are shown in the following formula.

\[
com(q_B) = \begin{cases} 
1, & I_q > I_B + \epsilon \text{(brighter)} \\
0, & I_q + \epsilon > I_B > I_q - \epsilon \text{(similar)} \\
-1, & I_q + \epsilon < I_B \text{(dar ker)} 
\end{cases}
\]

When the pixel value of the pixel point at the center of the circle is greater than the sum of the pixel value of the pixel point on the circumference plus the resolution difference, the pixel point at the center of the circle is judged to be bright. When the sum of the pixel value at the center of the circle plus the resolution difference is smaller than the pixel value at the circumference of the circle, the pixel at the center of the circle is judged to be dim. Otherwise, it is judged to be similar [10].

(3) Improved feature point matching algorithm based on ORB detection

The algorithm includes the following steps:

 Initialization operation: the initial value of iteration number is set to 0, and the threshold of internal
points, the error threshold of internal points and the maximum number of iterations are given.

If the number of current iterations does not reach the maximum number of iterations, the first X data from the sample set will be extracted according to the data quality, and Y data will be randomly extracted to calculate the model parameters. Meanwhile, the number of data whose errors extracted based on the model parameters are less than the error threshold of the interior points will be counted, namely, the number of interior points. If the number of iterations reaches the maximum number of iterations, then the group of interior points with the largest number of interior points is directly returned [11-12].

If the number of interior points is greater than the initial threshold of the given number of interior points, then the number of interior points is returned; if less, the number of iterations is increased by one jump to the previous step.

(4) KLT tracking algorithm

KLT (Kanade-Lucas-Tomasi Tracking) algorithm is an image feature Tracking algorithm based on optimal estimation. It is to determine the rough position of the next frame feature point by predictive estimation. The algorithm assumes that only a small movement of the target object occurs in the video stream, and the gray value of the target object is almost unchanged. Assuming that the same target object appears in two frames of images I and J, if there are two feature points matching in the image, then the two feature points are taken as the center and W is the window, and there is a minimal gray square deviation. Gray scale square deviation is defined as follows:

$$
\varepsilon = \int \int [I(X) - I(X - d)^2]w(X)dX
$$

(2)

$$
X = [x,y]^T
$$

(3)

$$
d = [d_x, d_y]^T
$$

(4)

$$
W(X) = 1
$$

(5)

KLT algorithm tracks the target object in the image, instead of calculating the offset value of the tracking box and every point in the target box, it screens out some corner points with unchanged features and takes different corner points with unchanged features as tracking points.

3. Simulation Test of Power Grid Emergency Training System

3.1. Development Environment

In this paper, the ORB under Ubuntu environment was first transplanted to the Android development platform when building the application. Ubuntu is an open source desktop Linux system, and software can be quickly installed by using the command line under Ubuntu environment. Android development environment using Google official provided by the AndroidSDK, AndroidBuildTool and other development kits. Gradle is an automated build tool based on ApacheMaven and ApacheAnt. It includes plugins to support Android application development. The IDE used is the officially recommended AndroidStudio.

As for the hardware environment, the desktop computer with 16GB memory, CPU3.74Hz and 6GB graphics card was used to compile the application in this paper. It can be achieved by building a common laptop or desktop for Android application, and the requirements are not high. But Android phones, where the app is packaged as an APK file, have certain requirements.

3.2. System Implementation

According to the programming language is applied in this article can be divided into c++ and Java layer, layer of c++ implementation have been described in detail in other chapters in this paper, including the ORB - SLAM2 each function module, for augmented reality of the more important is tracking module and relocation module, tracking module to the initialization process is optimized, the improved feature point extraction algorithm is widely used in every ORB module.
The JNI and Java layers are the key to put the research content into practice. The functions of each module of the JNI and Java layers are described in detail in the following sections. JNI is the bridge between ORB (i.e. C++ layer) and Java layer. The main function of JNI is to obtain real-time images from Java layer and transmit them to C++ layer, and meanwhile return the rotation matrix $R$ and translation vector $T$ calculated by C++ layer to Java layer in real time. Java layer includes: camera image call, model view projection matrix calculation, OBJ file parsing, OpenGLES rendering 3D model.

4. Simulation Test Results

4.1. Location of Substation Indoor Equipment

| Coordinates | A node | B node | C node | D node |
|-------------|--------|--------|--------|--------|
| Field measurements | X | 0 | -0.2 | 0 | 0.4 |
| | Y | 1.7 | 1.6 | 0.9 | 1.2 |
| RSSI positioning | X | 0.84 | 0.03 | 1.36 | 0.85 |
| | Y | 1.84 | 1.51 | 1.06 | 1.04 |
| ORB detection | X | 0.03 | -0.1 | 0.06 | 0.42 |
| | Y | 1.85 | 1.57 | 1.04 | 1.06 |

**Figure 1.** Comparison of positioning errors of different algorithms

As shown in Table 1 and Figure 1, it can be seen that the result of three-point positioning calculation after ORB positioning detection is less error than the result of direct three-point positioning, and the positioning result is more stable. Therefore, it is more suitable for accurate positioning of on-site operation and maintenance personnel of power equipment. The function test of system software is mainly to test each functional module of the system in the real electric field operation and maintenance environment, and the experimental environment of this test is the secondary equipment room of the substation.

4.2. Comparison of Inspection Training Time
As shown in Figure 2, this paper lists the time spent in traditional inspection and AR inspection training. Among them, 12 minutes can be saved in the relay protection room, 14 minutes can be saved in the 10kV high voltage room, 15 minutes can be saved in the 110kV equipment area, 20 minutes can be saved in the 220kV outdoor equipment area, 6 minutes can be saved in the 10kV outdoor equipment area, and 7 minutes can be saved in the main transformer area. The whole process of inspection and training was reduced from 217 minutes to 143 minutes, which greatly improved the efficiency.

5. Conclusions
This article first for mobile augmented reality application in the power grid emergency training to introduce the research background and significance, then analyses the application field of augmented reality, development course and status quo of development tools at home and abroad, finally choose in unity3D platform combined with Android development technology use in the development of augmented reality system. This paper studies the key technologies of augmented reality implementation, improves and optimizes the traditional natural feature point detection, description and matching algorithm, and proposes a fast natural feature tracking registration algorithm. Firstly, ORB algorithm is used to extract and match the feature points, and KLT algorithm is used to track the feature points in real time. The algorithm is applied to the enhanced display of the holographic information of substation equipment, and the test results of the system in the real environment of substation are given.

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