Using Augmented Reality Techniques to Simulate Training and Assistance in Electric Power

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Abstract. In combination with the augmented reality (AR) technology and Hololens device, an electric power work assist system is developed to provide a more realistic and convenient training experience for electric power training. The training effect was improved, and help guidance information was provided in the actual operation of electric power work. Experimental results show that difficulty of electric power work is reduced and the efficiency of actual work is improved.

Keywords: Electric power simulation training · Electric power work assistance · Augmented reality · Image recognition

1 Introduction

In recent years, science and technology have developed rapidly, and people's living standards have been continuously improved. All of this is inseparable from the rapid development of the power industry. Nowadays, electricity, as the basis of almost all technologies, has long been an indispensable thing. Therefore, the importance of power companies that provide electricity and maintain electricity supply is self-evident. As a basic industry, power companies are prerequisite for the normal development of many other industries. Therefore, power companies must shoulder the heavy responsibility and develop steadily forward. And a sustainably developing company cannot do without are skilled technicians. Thus it's important for the companies to do well in training novice technicians and quickly acquire skilled technicians [1].

For the traditional training methods, there are two choices, the first is based on the actual operation and another one is textbook-based. Because the electric power project has the characteristics of not being able to easily power off and has high risk, the actual-operation-based training, once the operation is wrong, has the unpredictable consequence of personnel safety and property, so traditional electric power training is mainly

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based on theoretical training, using textbook-based method. Such training methods are difficult to provide practical training opportunity, and many technicians are not satisfied with these methods and they think it is dull and not real enough [2]. Thus the technical personnel usually have less opportunity to practice, and can only slowly accumulate experience in a long period of practice, it is difficult to master the operation skills in a short period of time, which leads to long period of technicians training, resulting in the situation of technicians shortage.

In order to improve the efficiency of the training process, in addition to improve the effectiveness of the traditional training, we can also find ways to reduce the difficulty of entry level for beginner by the newest technology. Some research results showed that by integrating AR technology into the instruction, the students took on a more positive autonomous learning attitude [3].

The development of AR (Augmented Reality) technology and emergence of Hololens device, combined with existing machine-learning-based image recognition technology, can solve both problems well at the same time. Hololens is a Windows 10 based smart eyewear product. It features advanced sensors, a high-definition 3D optical head-mounted full-angle lens monitor and surround sound effect. It makes the user interface in augmented reality to communicate with the user through eyes, voice and gestures. By using Hololens, user can see the real world like normal glasses, and have a scanning function that can scan and recognize real-world surroundings, with space recognition and positioning. Most importantly, it can load virtual information, use the high-transparency display on the both sides of the glasses, use retinal imaging technology to form a visual 3D effect in real space, and use image recognition technology to analyze the relative space of the corresponding components. The location, and the simulation data is combined with the data scanned by Hololens, users can see that the virtual model exists in the real world coordinate system [4].

During the training process, technicians can use the Hololens to perform more realistic operation training. At the same time, technicians can also see the virtual guidance information attached to the objects through the glasses, which provide great convenience for training. To mare training more efficient and achieve better training results. In the actual operation process, using image recognition technology, Hololens identify the corresponding positions of different components (such as main circuit breakers) on the actual objects(such as distribution box), combined with augmented reality technology, can provide some help information for technicians. Greatly reduced the difficulty of getting started in the installation and maintenance of the power equipment. This article will explain how to build an electric power work assist system based on image recognition technology, 3D modeling technology and augmented reality technology of Hololens.

2 Methods

See Figs. 1 and 2.

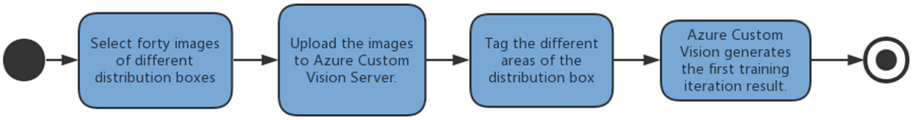

Fig. 1. The activity diagram of classification and training of images.

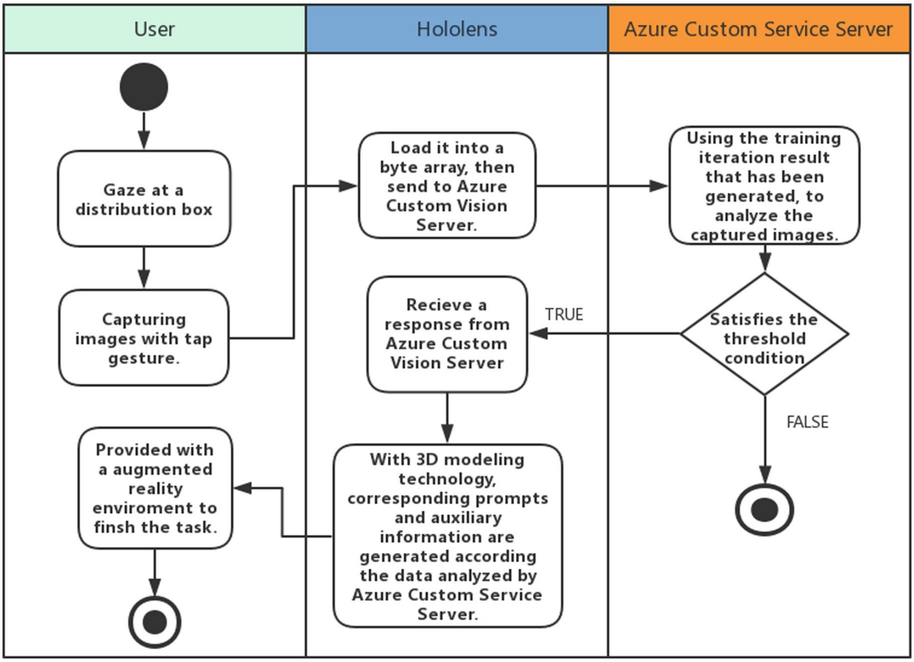

Fig. 2. Swim lane flowchart of image capture and object detection.

2.1 Classification and Training of Images

Build a custom image classifier using Microsoft's service, Azure Custom Vision. First create a new project, select forty images of the distribution box (no less than 15 images), after uploading successfully, then tag the different areas of the distribution box. To tag the images, use the mouse. As user hover over an image, a selection highlight will aid user to drawing a selection around the specific object automatically. If it is not so accurate, user can draw by himself. It is finished by holding left-click on the mouse, and then dragging the selection region to encompass the specific object. After that, a prompt will inform the user to add region tag. Then user can select the created tag (such as ‘main breaker’ and ‘other breakers’). Repeat the same procedure mentioned above until all the images is tagged.

As shown, the main breaker and the other breakers in the distribution box are tagged. When all the images have been tagged in turn, based on the tagged images as training set, Azure Custom Vision will generate the first training iteration result (Fig. 3).

Fig. 3. Classification of images.

2.2 Image Capture and Object Detection

Capture the current real-time image with the Hololens device, load it into a array of bytes using the already written unity script, and send the byte array to the Azure Custom Vision server, the calls to the Custom Vision Service mentioned above, are based on the Custom Vision REST API.

Using the first training iteration result that has been generated, and then the captured image will be analyzed. The settings of the training iteration: Probability Threshold: 50%. Overlap Threshold: 30%. When the analysis result of the image satisfies the threshold condition, it will respond in the form of a JSON string, and data would be deserialized and passing the resulting prediction to a SceneOrganiser class, to determine the specific location of the main breaker and all other circuit breakers relative to the Hololens device (Fig. 4).

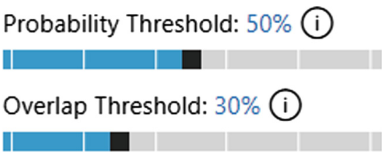

Fig. 4. Setting the threshold.

2.3 Image Capture and Object Detection

After determining the relative position of the main breaker and all other circuit breakers and Hololens device, the corresponding 3D model can be constructed based on the position information mentioned above and using Unity3D according to the specific application situation and added in the training exercise and actual operation. Corresponding guidance and auxiliary information to help trainee and electrical power industry practitioners to complete their learning and work tasks more efficiently.

First, the unity script would instantiate a corresponding virtual object (such as guidance and auxiliary information mentioned above) in the scene, (which at that moment is still invisible to the user). It places a quad at the same time (also invisible) where the image is placed and overlaps with the real surroundings. It is very important since the box coordinate retrieved from the Azure Custom Service server after analysis are traced back into this quad to confirm the object's location approximately in the real surroundings.

Finally, after receiving the analysis data from Azure Custom Service, the unity script in Hololens would set the virtual object with the tag of the prediction which has the highest confidence. Then it would call the specific method to calculate the bounding box on the quad object, positioned previously, and the virtual objects would be placed in the surroundings. To have a better effect to mix the virtual reality and real world, the unity script would even adjust the label depth, using a Raycast toward the virtual object's bounding box, which would collide the object in the real surroundings.

3 Methods

Using the aforementioned related methods, we finally built a mixed reality application that leverage Azure Custom Vision and the corresponding object detection API, which recognizes objects from the image and the provides an approximate location for the objects in real world.

The user performs the following operations: the user gaze at a distribution box (as shown in Fig. 5); then the user captures the image of the scene in front of the eye through a Tap gesture (Fig. 6); the application will send the image to Azure Custom Vision. The server analyzes the image. If the analysis meets the set threshold condition, that is the main breaker or other breakers is detected, Hololens will then receive a response from Azure Custom Vision, which will through the space tracking function of Hololens, corresponding prompts and auxiliary information are generated at the detected position of the circuit breaker (Fig. 7). Novice technicians can follow the virtual guidance information which is mixed with the real world to finish the task more efficiently (then talk something about error.)

The test mentioned above was performed on a actual distribution box to evaluate the effect of mixing true world with AR and confirm the accuracy of the whole system. The results show a mean Euclidean distance of 2.5 cm with a maximum error of 4 cm to detect the specific location of the distribution. The presented system created a more intuitive guidance system. With the development of AR technology, there will be more research to optimize the effect of visualization and a greater reduction in the error. Lots of electric power industry operation would benefit from the convenience of AR guidance.

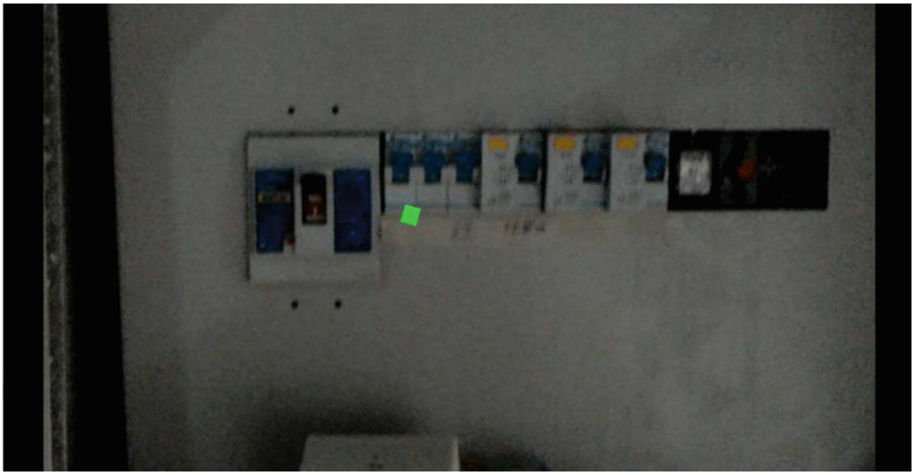

Fig. 5. Gaze at a distribution box.

Fig. 6. Capturing images with Tap gesture.

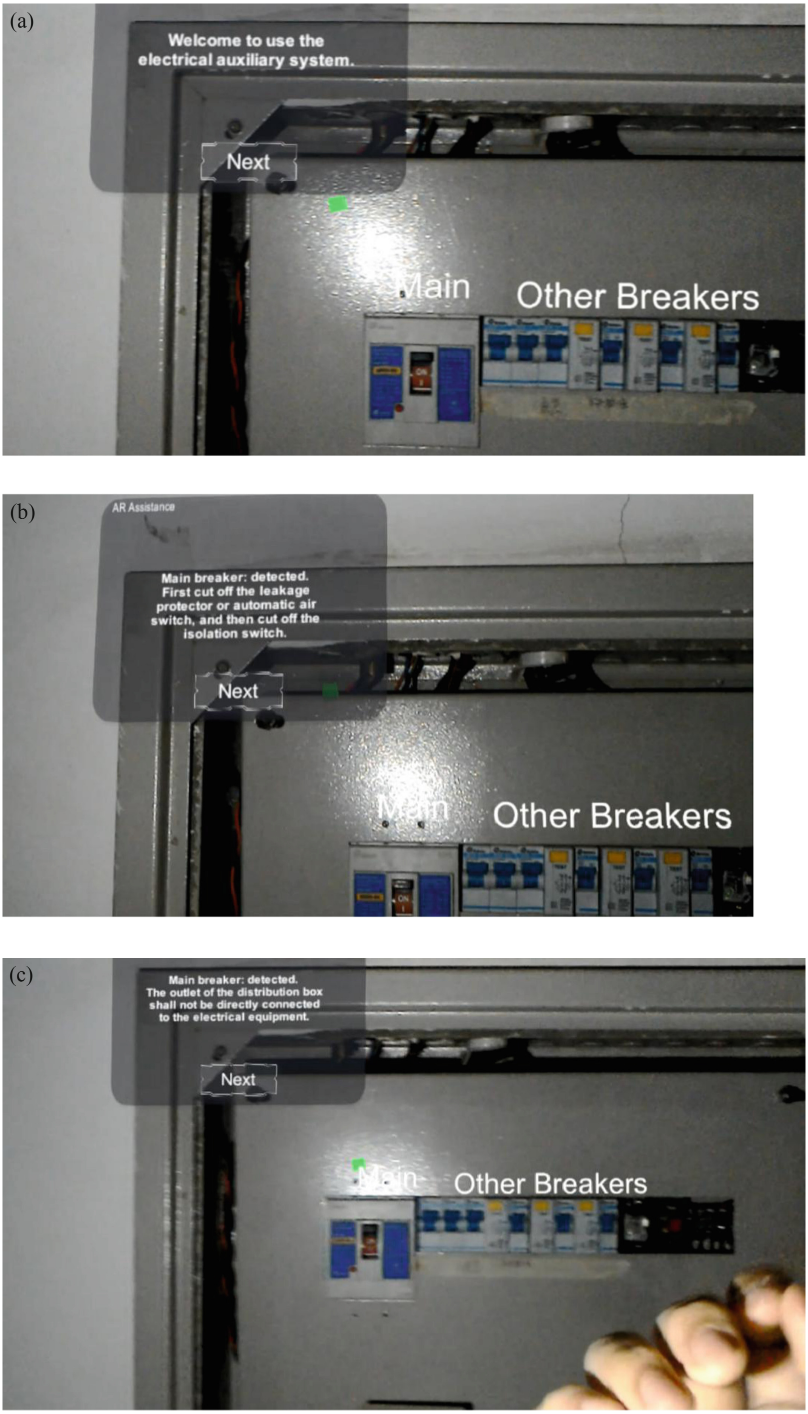

Fig. 7. (a–c) AR guidance.

4 Discussion

After the introduction of augmented reality technology, there are many applications, such as medical, manufacturing, maintenance, military training [7–9]. In the electric power industry, with the expansion of the power business and commissioning of new intelligent equipment, the manufacturing, installation, operation and maintenance of electrical equipment is faced with shortage of skilled technicians to fulfill tasks with cumbersome operation steps. The existing operation instructions are based on textbook. It is not intuitive to provide guidance to operators, nor can it provide the required information in real time in combination with the operating environment and progress. Electricity worker are inefficient in performing tasks, finding information, understanding information and communicating with each other due to different scope of business and capabilities. Even serious injuries or deaths may result from negligence [5].

The electric power industry involves many links such as power generation, transmission, substation, power distribution, and power consumption. In all aspects of electric power industry such as power monitoring, maintenance operation, engineering design, and simulation training, augmented reality technology has a wide range of applications. In the process of overhauling operations, due to many risks, in the maintenance of power systems, prevention of personal accidents is always the top priority of all work. How to familiarize with the complex maintenance environment before the start of the inspection work, to drill the specific maintenance operation, and identify the specific risks in the maintenance, is an urgent problem for the electricity workers.

Augmented reality technology combined with machine-learning-based image recognition technology is a training method. Using the Hololens, novice technician can have a better training effect and can get assistance in practical work.

The auxiliary images and prompt information generated by real-time scanning in Hololens can be well integrated with the actual object images transmitted through the glasses. The images obtained by Hololens enable the technician to obtain various parts of the power system during operation. Kinds of information, and intelligently identify the information in the environment, thus greatly assisting the technicians, can achieve the role of prompts, thereby helping inexperience technicians to distinguish each part that needs to operate and guide the operation.

The specific operation method is that the technician uses the Hololens device to activate the recognition function, and call the corresponding API to perform the recognition operation in the background, then Hololens will give a prompt information and fall on the recognized position. Through this basic method, the technicians can obtain sufficient prompt information without too much actual working experience, thereby facilitating the maintenance process.

Based on the research above, we can add more equipment information including the appearance information of the equipment from the outside, whether there is deformation caused by external force, cylinder oil leakage, and internal information, including temperature, pressure, etc., all of the information mentioned above is expressed in a visualized way.

Fig. 8. Equipment maintenance simulation [6].

In the equipment maintenance work, the maintenance technician face a large number of types of equipment, and need to carry out a large number of data query preparation work in advance. Using the registration tracking technology, the maintenance operation instructions of the 3D model are attached to the device, and the maintenance technicians can directly view and follow the instructions on the actual equipment, and quickly complete the maintenance work according to the steps. In the process of overhaul, if the basic guidance content cannot solve the actual problems on site, you need to consult the corresponding experts. The most flexible way for presenting remote imagery is via virtual reality [11]. An example of this is recent work by Lindlbauer and Wilson, who explored the concept of remixed reality, whereas user's viewpoint can be moved to an arbitrary location, while the scene's objects can be copied, moved, and removed on demand [12]. You can use the remote assistance method of augmented reality to share the work site perspective with the remote experts. The virtual guidance information such as "Error spotting" can be attached to actual equipment and presented to on-site maintenance technician to avoid error-prone language descriptions and improve communication efficiency. Equipment maintenance simulation is shown in Fig. 8 [6].

The appliance mentioned above could be also used in another specific condition, when the technician's direct view of an object is the object may be observed from some other perspective, using the augmented reality technology [11]. For example, endoscopic inspection cameras are commonly used in construction to provide a view inside of walls or confined spaces. Similarly, finger [13–15] and body-mounted [13, 16] cameras have been used to provide remote perspectives. We envision camera and sensor technology to shrink further, allowing systems to collect real-time visual data from anywhere the user wants to interact. With such data, occluded objects can be rendered into the user's visual field through augmented reality (AR) headsets.

Milgram and his fellows propose the concept of VR continuum to further define the augmented reality technology, that is, there are two kinds of technologies: augmented reality and enhanced virtual between the real environment and the virtual environment to form a whole area [10]. Integrating Hololens augmented reality technology and machine-learning-based image recognition technology into electric power simulation training is a trend of technology development, which will become a milestone in the intelligent development of the electric power industry.

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