# Application of Electronic Operation Ticket for Intelligent Maintenance of Power Grid via Hololens

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*Abstract*—**This paper presents a successful case called "electronic operation ticket" applying Mixed Reality (MR) device HoloLens for intelligent maintenance of high-voltage power grid. Information visualization is proposed with typical AR environment/model settings and the identification/tracking technologies. Experimental results show that the maintenance of power grid using electric operating tickets could improve the accuracy and safety options in dangerous environments, especially for those wrong options must be forbidden, and operator wearing HoloLens can easily follow the options listed in the electronic tickets robustly.**

***Keywords—Information visualization, electronic operation ticket, intelligent maintenance, power grid, HoloLens application***

## I. Introduction

The safety operation of the sub-station equipment is guaranteed to the maximum extent through the inspection, maintenance and defect management of the equipment. Substation operation mainly contains inspection management, equipment management, defect management, hidden danger management, inspection management is one of the regular work of substation operation duty, through the inspection of the equipment can grasp the operation of the equipment in a timely manner, in the first time to find the defects of the equipment, take effective measures to eliminate defects, ensure the safety, health and continuous operation of the equipment. However, accidents or dangers remain to happen in the operation due to human errors. Therefore, it is necessary to take some protective methods to eliminate the hidden dangers and protect the severity, so as to ensure the safety of the power grid.

Augmented Reality devices provide users with a more natural way to interact with data through physical interfaces and immersive displays. Where physical interfaces can provide a higher degree of freedom (DOF), stereoscopic displays can provide a sense of depth, and augmented reality combines virtual content with the real world to create more forms of design for interaction. As a result, scholars began to enter the augmented reality-based data visualization exploration. As we know, traditional desktop environments consist of 2D screens and mouse keyboards, and in the field of visualization research, information visualization research based on desktop 2D conditions has developed a very mature system that includes visualization methods and visual interactions. In 2017, Microsoft's HoloLens representing Mixed Reality, can provide users with a new way of user interface and human-computer interaction, whether it is data visualization or mobile device development, there is an urgent need for a new way interaction to break the limits, and at the same time, given the huge amount of data in mobile smart devices, more and more scholars are beginning to explore how Hololens can be more scientifically applied to production and life into a very important topic. For instances, Figueiredo applies this to engineering, visualizing all types of parts through HoloLens. A mobile phone app developed by Schall et al. can show the interior of the building. Kollatsch uses HoloLens to visualize assembly lines of information. Geo-correlation: Many AR visualizations are geographically based on geographic information, and Schubert and others have conceived a city design tool that allows experts to collaborate in real time through MR visualization. Hedley et al. designed an MR geo-application. The tourism industry also benefited from AR visualization, and Fiore developed a mobile phone app that integrates historical and cultural information about attractions based on POI to provide visitors with an AR experience.

Currently, there is little research in visualization of augmented reality devices represented by HoloLens. The reasons for this are: First: In the past, many researchers have proposed desktop 3D visualization, and developed to a more mature degree. As a result, scholars in the field do not support the use of 3D visualization to analyze data, they believe that 3D diagrams can easily create optical illusions, lead to misreading of the data, and 3D icons are prone to occlusion. Two: augmented reality devices are not popular at present, the price is more expensive, and augmented reality equipment content development is basically dependent on computers. This paper explores HoloLens-based smart grid maintenance electronic operation ticket method, aiming at proposing a new mobile terminal-based power grid operating ticket concept, so that people in high-risk environment can not rely on experience, in a complete prompt to achieve the correct operation, to avoid danger. The research of this paper can be used as an exploration of the visual development platform migration of the future smart grid co-operation, and introduces visualization technology into the technical field required for engineering.

## II. Method of Imformation visualization

### *A. Enviornment Settings*

HoloLens is an official open-source device from Microsoft, which can be used to help developers applied HoloLens quickly. It includes directories such as input, sharing and spatial-mapping index. These components can help projects quickly integrate functions such as input,

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spatial mapping and scene matching. Figure 1 shows the framework of HoloLens development visualization.

- Input index: GazeManager.cs for fast integration of staring ray characteristics; GestureManager.cs for fast integrating gesture features; KeywordManager.cs for fast integration of voice command features;
- Sharing index: The sharing prefab component is used to quickly integrate scene sharing features;
- Spatial-Mapping index: Surface-plane component is used to describe and render real world surface; spatial-mapping prefab component is used to quickly integrate spatial mapping features; remote mapping prefab component is used to quickly integrate remote spatial mapping information import features.

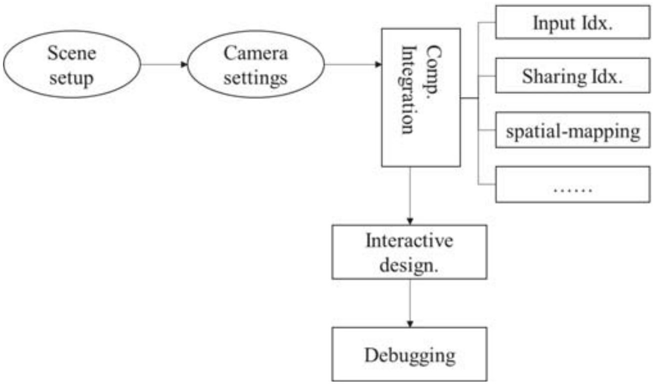


Fig. 1. Framework of visual interactive development.

*B. Model Settings*

The establishment of the model mainly includes three aspects: target, sensor and environment. For tracking target, we need to detect the shape and other features of the target; secondly, HoloLens uses the depth sensor to build the model of the collected target, which is different from monocular camera which takes the pixel as the unit to obtain information, and the depth camera uses frequency as the size information to build the model. Finally, we need to consider the environmental factors of the scene. The environment plays a key role in the accuracy of tracking. Generally speaking, the more stable the environment is.

*C. Identification and Tracking technology*

Visual information processing is mainly to extract and associate the target information obtained by sensors to update the state of the whole tracking system. In this paper, we need to choose stable tracking clues according to the characteristics of the target to be tracked. In the field of 2D / 3D, the corresponding shape features are taken as the research object, and the stable model is finally constructed through extraction and optimization.

When the data acquired by the sensor is preprocessed and input, the object can be located and tracked. The process can be divided into two stages: detection and tracking. In the detection phase, the prior information of the tracked object is taken as the initial value, and the model information is obtained by using visual processing technology, and the space attitude is determined by matching with the input data to realize the target tracking. Here, it involves the coordinate transformation between the real world and the virtual world.

In HoloLens, there is a space coordinate system based on Cartesian coordinate system, that is, virtual objects and real objects share the same coordinate system. Whether you're running and jumping in an environment that has already been built in virtual space, objects in real space are always stable. This is the static reference framework. In Figure 2, there is a deviation between holography and objects. If the space is too large and too complex, the image of the object in HoloLens may drift. In order to avoid this kind of drift, HoloLens introduces space anchor. When users open HoloLens, it will have the process of building space, that is, mapping the space around users. When users scan the environment that has been constructed in space, the space anchor will fix the holographic object there without changing its position. By capturing the user's visual gaze action to move the cursor, and then click the cursor with gestures to determine and select the target.

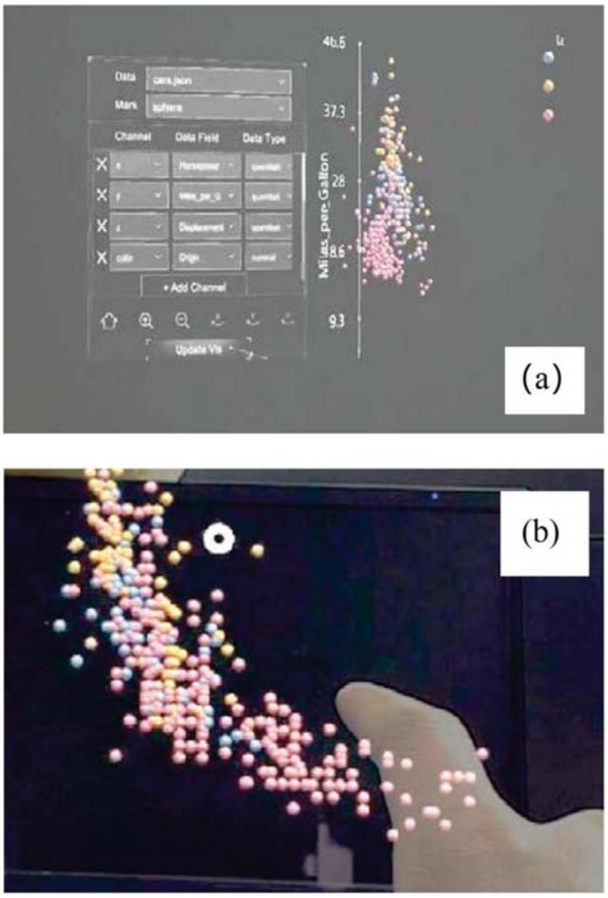


Fig. 2. Identification and Tracking operations in HoloLens. (a) capture the visual gaze action; (b) select the target.

## III. Application In Electronic Operation Ticket

TABLE I. Electronic Operation Ticket for GRID

| *No.* | *OPERATION list* | *Signature* |
|---|---|---|
| 1 | Turn the button off | |
| 2 | Open the ____ | |
| 3 | Check the electric ____ | |
| 4 | Roll the ____ | |
| 5 | Check the button ____ | |


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HoloLens is applied in this article for an exact dangerous scene to help the operator following the order list and then make a match track. In the experiment, the operations are listed in Table I.

In all environments, this article controls the actual size and resolution of the visualization. The application window on the desktop is set to have the same size (11 inches) as HoloLens, and all environments display visualizations at the same resolution (1268 × 720). Figure 3 presents the electric operation ticket for Power Grid in HoloLens, which was designed as maintenance guidance.

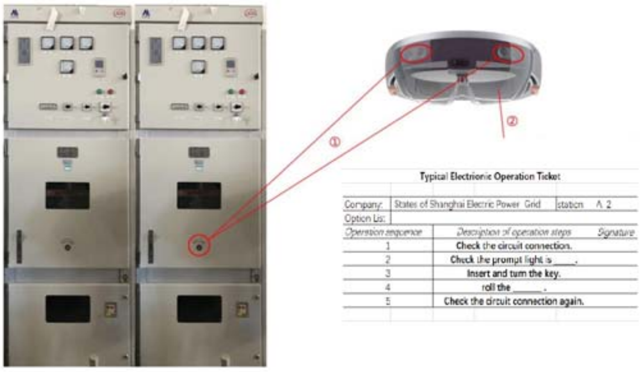


Fig. 3. Designed Electric Operating Tickets for maintenance guidance.

*A. Operation 1:Check the circuit connection.*

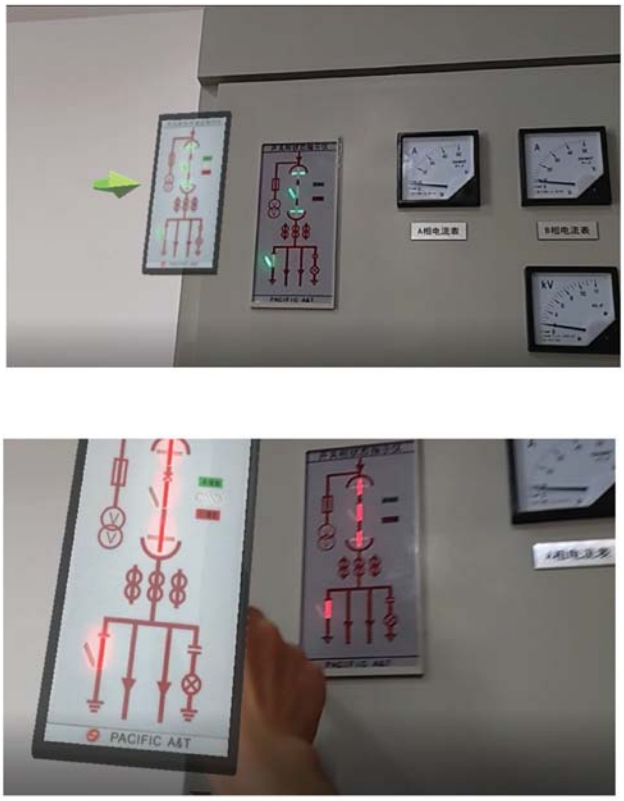


Fig. 4. Operation 1: Check the circuit connection.

Figure 4 renders the first significant operation in electric operation tickets for maintenance of power grid. Through the guidance of mixed reality scene, the circuit of the electric box is checked first. The electronic guide disk can be operated according to the scaling operation, which is convenient for the personnel to compare the physical and virtual scenes, so as to ensure that the circuit connection meets the basic requirements.

*B. Operation 2: Insert the key.*

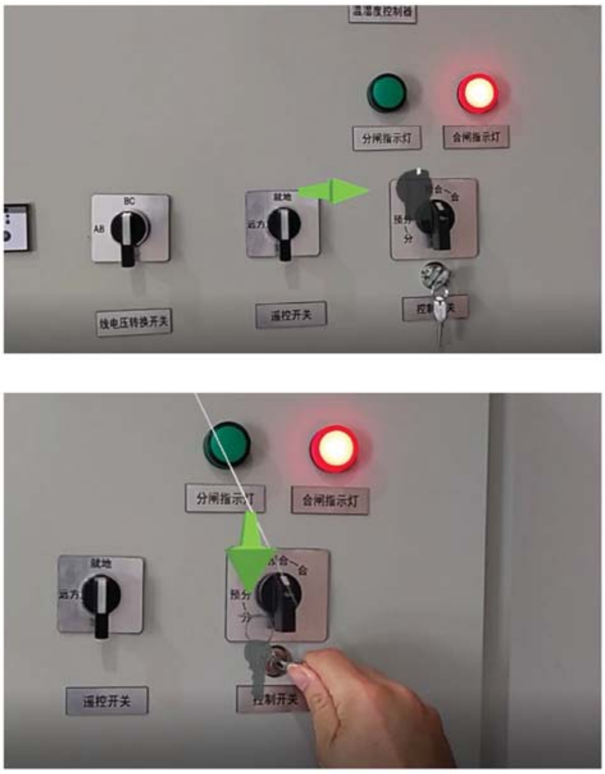


Fig. 5. Operation 2: Insert the key.

Figure 5 presents the following operation for switching the electrics to "maintenance" state. Due to the guidance of virtual scene animation, operators can avoid the possibility of serious accidents in the power grid system due to forgetting the operation process.

*C. Operation 3: Roll out the high voltage switch .*

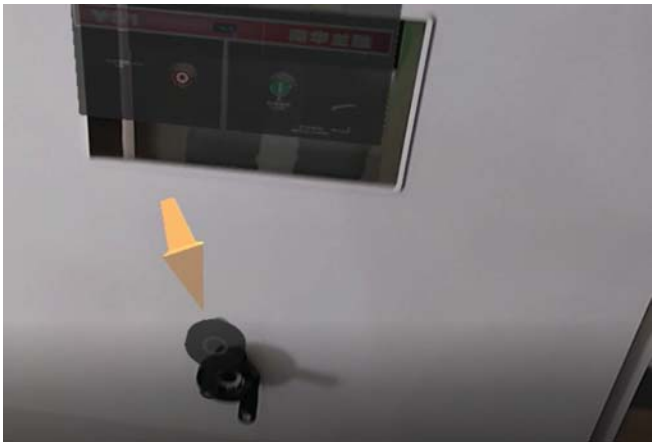

Fig. 6. Operation 3: Roll out the high voltage switch.

Figure 6 gives the last option for electric operation ticket. The operator rolls out the high voltage switch and confirm the on / off indicator matches the virtual scene. It is clear that the operator wearing HoloLens can easily follow the option



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and the high-voltage switch could successfully move the right position with the promotion of electronic image.

## IV. Conclusions and Futher works

In this paper, a method of information visualization via HoloLens is proposed. Experimental results show that the maintenance of power grid using electric operating tickets could improve the accuracy and safety options in dangerous environments, especially for those wrong options must be forbidden.

The following studies need to be considered in the future:

Add judgment function for the extraction of target features, therefor the image operation can be easy for assist operators. When the target information is clearer, the more accurate and safe the maintenance of power grid will be;

Test the backward function to ensure the usability of the program, making the hybrid reality technology applied to power grid maintenance more humanized.

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