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Research on distribution equipment training system based on holographic projection interactive simulation technology

Meng-Chao MA[1], Yan ZHANG[1], Guang-Lei LI[2], Nan-Nan GAO[1], Jin-Xin HUANG[1], Zhi-Guang Ma[1], Ling-Ling SHANG[1] and Liang-Feng GUO[1]

[1] Training Department of Grid Maintenance, State Grid of China Technology College, Jinan, China
[2] Department of Power Grid, Shandong Electric Power Research Institute, Jinan, China

15054104988@163.com

Abstract. This paper presents a three-dimensional (3D) interactive simulation training system based on holographic projection technology, nano-touch technology and interactive training mode, which realize the 3D display without stereoscopic glasses and touch type human computer interaction. 4 sets of holographic training courseware and 2 sets of fault presentation courseware was developed. Every courseware includes four parts: the cognition mode, the operation mode, the disassembling mode and daily maintenance mode. The system can carry out the training course of distribution automation equipment structure, disassembling and assembling, daily maintenance, operation, and the fault handling. A new training mode of power equipment training was created, which opened a new era of power equipment training.

1. Introduction

With the rapid development of power distribution network and the widespread application of power distribution automation equipment, the workload of power distribution equipment on-site operational maintenance increase rapidly. The staff's low degree master of distribution automation equipment and the lack of operational experience was expose gradually. Create a simulation training system of distribution automation equipment and carry out related training course can provide the State Grid Corporation of China (SGCC) staff opportunity to maintenance distribution equipment, and comprehensively improve the repair work level.

This paper studied on the distribution network equipment holographic projection interactive simulation training system. The system can holographic display [1] the common distribution automation equipment (such as column switch, switch, load switch, etc.) and achieve interactive [2, 3] courseware learning which makes students have more intuitive understanding of distribution automation equipment. By learning on the system the students can not only understand and grasp the internal structure of the equipment, the operation process and daily operational maintenance, but also understand the fault mechanism and master the common fault handling. Finally, the operational maintenance skill level of distribution network equipment inspection personnel will be improved.

2. The simulation system

2.1. Research significance

In electric power enterprises, with the power system reform and the deepening of the reform of state-owned enterprises, the modern power grid high voltage grade, highly automated and other large networking trend has become increasingly significant, every staff of the electric power industry is shouldering the arduous task. If there isn't a group of professional staff with high quality and high level skills, it is hard to imagine how to manage the modernized power grid and modern electric power enterprise. Enterprises need to train their employees, so that there will be more opportunity for the staff to get promoted and to inspire their potential, at the same time, their employees will be more initiative, enthusiasm, creativity and more valuable for the enterprise [4].

In short, the enterprise staff training is a key factor in the success of the modern enterprise, especially in power enterprises with crowded talent and fierce competition. In order to adapt to the future development of power enterprise, there is more demand to create a first-class quality, super excellent staff team through strengthening the education and training of staff. With the rapid development of the electric power industry and information technology, Enterprises requirements higher quality training work, and the forming and development of holographic projection touch technology provides a better direction for training. In the electric power system training work, we take the lead in introducing holographic projection touch technology. The equipment could be 3D displayed in the air virtually, which provides a better platform for training work, not only reduce the hardware costs, but also enhance the training effect by promoting students' awareness of training content.

2.2. Research content

This article researched a holographic interactive simulation training system, and developed interactive courseware and fault cases for distribution automation equipment, specific content is as follows.

- R & D interface between holographic courseware and nano-touch film. TUIO protocol [5] of nano-touch film should be researched on. So the holographic courseware could call the TUIO protocol provided by the interface to achieve interact between holographic courseware video and nano-touch film.
- Establishment of device model library. The structure and faults of various equipment, device's structures, equipment operation, equipment failure and its mechanism of repair and maintenance should be researched. 3D-MAX can be used to establish equipment structure and its faults model, VRay renderer can be used to render device model.
- Holographic interactive training courseware. Unity3D and other latest technology have to be studied to develop the courseware. New animation system and enlighten were used for global illumination. Visual effects of device materials processed by physics-based rendering (PBR). The performance of model engines has to be optimized and re-topology technology should be used to achieve high performance surface detail.
- Holographic fault courseware. The project should research on the causes of the device fault and the process flow to realize 3D all-round display for the relevant key content. The audio commentary, 3D video presentations and interactive operation has to be researched to achieve true multimedia training effect. Effects shade multi-dimensional view of the display and 64-bit new editor should be studied to improve system performance and the picture frame rate.

2.3. The research target

A holographic interactive 3D simulation training system will be developed based on holographic projection touch technology. The training system can be used in daily training class. The new training form and its distinct effect can make the students study be more interested in the training course and understand the training content deeply. The training mode will finally become the development trend of the talent training in the form of open the new era of power equipment training.
Specific targets are as follows:

- A holographic interactive 3D simulation training system will be developed to create a new type of training platform for the daily training of the distribution equipment. The training system can meet the need of 80 students' online training.

- A 3D model library of all components of the four types of equipment will be Developed including demarcation switch cabinet contains (model: VSR3-12/D630 (F)), outdoor high voltage permanent magnetic vacuum circuit breaker (model: ZW-12/D630-20), AC high voltage vacuum circuit breaker (model: ZW20-12F), automatic vacuum switch (type: FZW28-12 (VSP5)).

- 4 sets of interactive and holographic training courseware will be developed which is strongly visual impacting. The courseware contains complete demarcation switch cabinet (model: VSR3-12/D630 (F)), outdoor high voltage permanent magnetic vacuum circuit breaker (model: ZW-12/D630-20), AC high voltage vacuum circuit breaker (model: ZW20-12F), automatic vacuum switch (type: FZW28-12 (VSP5)). The 3D picture will be suspended in the mirror image to achieve the effect of holographic projection. The courseware can carry out the training course of the equipment structure, equipment action and operation, daily maintenance and so on.

- 2 sets of fault presentation holographic courseware will be set up. According to common fault of the switch cabinet (model: VSR3-12/D630 (F)), outdoor high voltage permanent magnetic vacuum circuit breaker (model: ZW-12/D630-20), AC high voltage vacuum circuit breaker (model: ZW20-12F), automatic vacuum switch (type: FZW28-12 (VSP5)), 2 sets of fault presentation holographic courseware will be established. The courseware could make the student understanding the occurrence and the process of the fault more easily. The common faults cognitive training, fault mechanism and fault handling training course can be carried out more efficiently. And the professional skills and professional ethics of the student will be enhanced.

2.4. Key technology

- The abstraction and establishment of the relationship model among equipment parts and motion.
- The abstraction and establishment of the relationship model of equipment operation logic.
- The analysis and establishment of equipment faults model.
- The display technology based on holographic projection.
- The touch interactive technology based on nano-touch technology.
- The research and establishment of the interactive channel between holographic imaging technology and nano-touch technology.
- The simulation exercise based on Engine Unreal 3.
- The model production and VRay rendering technology based on 3D-MAX model.

3. Realization

3.1. Design principles

- Universal property. Design of system structure should be according to the principle of universal. In the design process of system construction structure, data model structure, data storage structure and system expansion planning, both the universal and global principles should be observed. Database and interface design also need to obey the universal principle in order to ensure the consistency of the system interface, data storage and the efficiency of the system.

- Progressiveness. The system must be built using mature technology software products and device with the domestic advanced level and in trend of international development. In the design process, the international norms and standards should be observed, the mature mainstream network and the system structure of integrated information system at home and abroad should be used for reference to ensure that the system has a long life and expansion capabilities. At the same time, the system design is based on the security and stability of the advanced nature. Adopting advanced system architecture can provide convenience for future system upgrade which lay the foundation for future development.

- Reliability and safety principle. The security and reliability of the system should be fully considered in the system design and data structure design. For the high performance requirements of the platform system, we must ensure that the system is safe and reliable in order to obtain a stable and sustainable development.

- Standardization principle. The establishment of the data system should comply with the unified standard to meet the needs of development, lateral information expansion and macro management requirements, so that the system becomes an authoritative system. The standardization of the system operation, that is, the system has the detection mechanism to ensure the consistency of data maintenance and version control operability. Data import and export should use the unified standard interface, such as the most popular XML standard.

- Principle of maturity. In the selection of development tools, we should try to choose mature products and norms, such as Unity3D, 3DMax, V-ray and other mature, sustainable development tools. System architecture should be mature and international mainstream, so it is easy to achieve cross platform applications in future.

- Extensibility principle. System design should take the needs of future development into account, structural design should be concise, the coupling of functional modules should be reduce, and compatibility should be fully considered. At the same time, the system should support the storage of multi format data. For mass data storage, the efficient and separate deployment structure must be considered in design of the system, not only to ensure that the interface can be easily established, but also to improve the scalability of the database.

3.2. System structure

The simulation system was designed modularly, which comprises a model unit, a device information unit, a communication unit, a model display configuration unit, a phonetic system and a holographic projection system. The system architecture is shown in Fig 1.
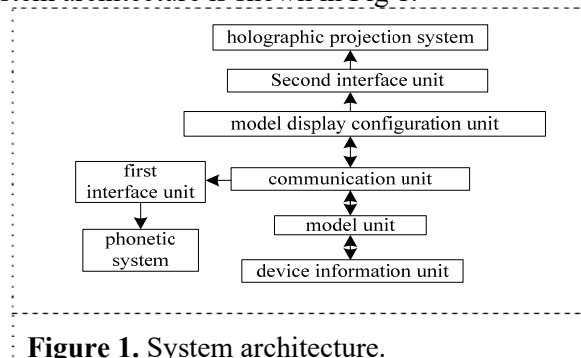

Figure 1. System architecture.

The model unit is used to store the component model of distribution network equipment. The existing model is modelled by 1:1, including the components model, the whole equipment model and the equipment failure model, etc.

The device information unit is used to store the information related to the operation of the distribution network equipment, including state information, action information, logical relationship, etc.

Model unit and device information unit are software units stored on the server.

The communication unit includes wired communication module, wireless communication module and communication switching module. Wired communication module and wireless communication module are used to interact information among model unit, device information unit and model display configuration unit. The communication switching module can realize the communication switch between the wired communication module and the wireless communication module through the program, and select one module to work.

Model display configuration unit is connected with model unit and device information unit through the communication unit. The function of model display configuration unit is control image and audio output according to the information of model unit and device information unit, the image and audio will

be output through the first interface and the second interface unit to the holographic projection system and voice system.

The phonetic system comprises a voice input module, a voice recognition module and a voice playing module. The voice input module is used to receive, filtering and amplification voice signal. Voice recognition module is realized by existing recognition controller and corresponding algorithm. The voice playing module is the speaker or other audio playback device.

The phonetic system configuration unit is connected with model display configuration unit through the first interface unit and communication unit. The voice input module receives the voice from model display configuration unit and transmit the signals to voice recognition module which is used to identify the audio signal and transmits the recognized signal to the voice playing module. The voice playing module will recognize the voice signal before sent it to the speaker through the drive circuit.

Holographic projection system includes a holographic projection screen and a projector. The projection screen is a nano imaging film mirror wall. The imaging film is a kind of high performance double projection display film using the latest coating sputtering and SI optical structure technology. The picture effect is gentler with more vivid details. The projection screen has the absolute visual angle close to 180 DEG and double-sided display performance. So the projection screen can realize 3D image effect and the nano-technology can realize information interactive from human touch. The holographic projector is connected to the model display configuration unit through the second interface. The holographic projector receives the data from model display configuration unit and projects the image to the projection screen.

4. Software and hardware configuration

4.1. Software
3D - MAX model making technology, VRay rendering technology and Unity3D engine technology are used to develop the system.

4.2. Hardware
The projector is a professional 3D engineering projector with 3LCD technology, brightness is more than 5000 lumens. The imaging film is high quality polyester full colour mirror imaging film and supports more than 2 points touch which can realize the holographic projection and information interaction. The host is consisting of I3 CPU, more than 4G of memory, 500g hard disk and GT703 graphics.

5. Courseware
4 sets of holographic training courseware and 2 sets of fault presentation courseware has established including demarcation switch cabinet, outdoor high voltage permanent magnetic vacuum circuit breaker, AC high voltage vacuum circuit breaker and vacuum automatic distribution switchgear. The courseware can realize equipment structure cognition, equipment disassembly, equipment maintenance, equipment operation, the accident mechanism and handling processing training course. The courseware can practice holographic effect in holographic projection interactive training simulation system. The courseware is developed with fine quality which gives people a strong visual impact, at the same time, it is easy to operate and can be operated by mobile gesture to select, zoom, disassemble and other operation. The courseware support gestures such as touch, click, batter, pounding, kneading, twisting, moving, etc.
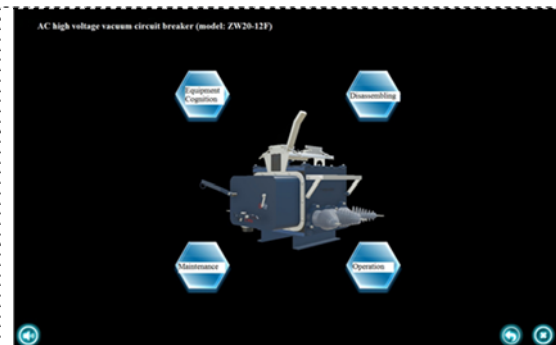
Figure 2. The courseware overview.

Figure 3. 4 sets of courseware.

5.1. Holographic courseware

4 sets of holographic training courseware was developed for complete demarcation switch cabinet (model: VSR3-12/D630 (F)), outdoor high voltage permanent magnetic vacuum circuit breaker (model: ZW-12/D630-20), AC high voltage vacuum circuit breaker (model: ZW20-12F), automatic vacuum switch (model: FZW28-12 (VSP5)). Every courseware includes four parts: the equipment cognition, equipment operation and action process, equipment disassembling and assembling, daily maintenance.
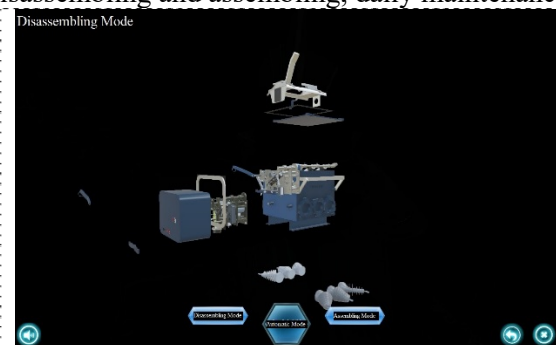

Figure 4. Cognition mode.

Figure 5. Equipment disassembling and assembling mode.

5.2. Fault presentation courseware

2 sets of fault presentation holographic courseware has been set up for complete demarcation switch cabinet (model: VSR3-12/D630 (F)) and AC high voltage vacuum circuit breaker (model: ZW20-12F). Every fault presentation courseware includes 4 common faults with fault judgment, fault cause and fault handling.
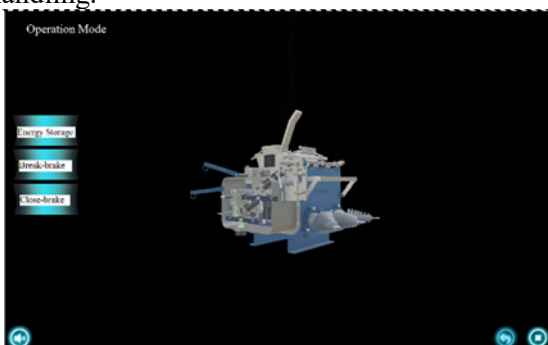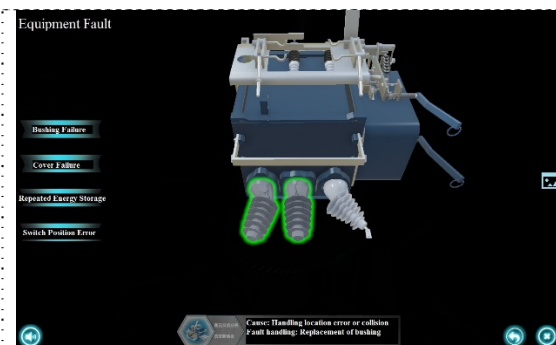

Figure 6. Operation mode.

Figure 7. Fault presentation courseware.

6. System effectiveness

The simulation training system was developed based on holographic projection display technology, nano touch technology and organic combination of interactive training model. The holographic courseware stereoscopic display without wearing 3D glasses and human-computer interaction was realized.

The 3D image of holographic courseware can be projected on the mirror nano film through the hardware system, the image presents 3D effect with a strong sense of reality. The whole system appeared fashion, beautiful and a sense of science and technology. The courseware image achieves real space imaging, colourful appearance. The contrast and sharpness of the image is high. The courseware image has a sense of space and perspective. Combined with nano-technology and interactive touch hologram, the whole system can carry out distribution equipment structure awareness, overhaul and maintenance training programs.

- The system can carry out simulation training course of the distribution equipment from the visual, auditory and tactile aspects, so that the trainees can feel the distribution network model as well as internal structure and the movement process intuitively.
- The holographic courseware achieves 360 degrees' realistic reproduction for the equipment components and relationships, equipment operation and movement process, disassembly and assembly methods, daily maintenance etc.
- The fault presentation courseware shows the fault course, process, results and appearance after the equipment failure. It will make the students understand the key problems of fault occurrence and technology required to handle the fault. So can the fault can be detected and eliminated in the initial stage of fault to prevent accidents.

7. Summary

The 3D simulation training system platform of distribution equipment improves the training model for students and provide a more intuitive and more realistic training experience. The system improves the training effect, realizes the interaction between students and equipment, at the same time, it reduces training costs.

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