Simulation of Switching Operation Based on Virtual Reality Method

Xianqi Li, Junwei Zhang, Jiankun Cheng, Qiang Luo
Guizhou Power Grid Co, Ltd. Training and Evaluation Center, Guizhou 550000, China

Abstract. Misoperation of power system switching causes many equipment failures and personal injuries every year. The switching operation simulation system is an important "five prevention" measure to ensure the correctness of operation tickets and prevent electrical misoperation. Based on the virtual reality method, the paper discusses the application of 3D simulation technology in high and low voltage trip operation, and analyses the function, structure and main technical scheme of 3D simulation training system for high and low voltage trip operation according to the particularity of standardized operation training. Finally, the idea of the future development of the three-dimensional simulation training system for high and low voltage trip operation is put forward.

1. Introduction
Due to changes in operating methods, equipment maintenance or fault repair, substation switching operations are often required. The operator performs the switching operation in accordance with the operation sequence of the operation ticket, that is, the operation sequence of the circuit breaker, the disconnect switch, the ground wire, and the secondary pressure plate. However, in the process of manual switching operation, due to the subjective or objective operator's lack of responsibility, inattention, inadequate operation techniques or external factors, misoperations sometimes occur [1]. Causes significant personal and property damage, so measures must be taken to minimize the possibility of misuse. Simulation and training are very important. At present, a feasible method is to develop an intelligent switching operation simulation system that can issue operation tickets and can be demonstrated on the simulation system. The operation process is simulated in real time and the operator is trained. The risk of accidents during actual operation is greatly reduced [2].

2. Virtual reality technology
The emergence and development of virtual reality provides a new analysis and calculation tool and solution for human beings to understand and transform nature. Use computer to make models, simulate the natural environment and imaginary environment, and use a variety of sensing devices to make users feel like they are there, to interact with the virtual environment, to facilitate the operation, reduce the burden, and improve work efficiency. Virtual reality has the characteristics of multi-perception, telepresence, real-time interaction, autonomy, etc., and interacts with the virtual environment through sensing devices to obtain feedback information such as vision and touch. It has a wide range of
applications, including modelling and simulation, education and training, telework and telepresence, medicine, art and entertainment, and many other fields [3].

As shown in Figure 1, virtual reality technology has three major characteristics: (1) Impressiveness. People integrate themselves as the main body of the environment with the virtual environment and interact with the virtual environment created by the computer in a multi-dimensional manner, so that people can truly integrate. Among them, the multifaceted interaction between humans and the virtual world can create an illusion of being in the real world. The traditional human-computer interaction is to rely on sound and images to interact with information through human hearing and vision, but the environment cannot give people a sense of real existence. This is the biggest difference between virtual reality technology and traditional human-computer interaction. (2) Interactivity. The ability of a person to face a virtual environment is the key to human-computer interaction. Interaction mainly covers the degree to which an object can operate, and the degree of real feeling experienced in a virtual environment. Visual change is the exchange of virtual worlds, called the autonomous reference frame of virtual reality technology. Real-time is the most important factor in the entire process of interaction, reflecting the state of user input, which requires a buffering process to enter. (3) Conceptuality, which combines virtual reality technology with specific environments, guides people to discover new ideas and fully demonstrates their own innovation capabilities. Virtual reality technology is not just an interface, but also users immersed in the virtual environment the knowledge acquisition mouth can improve the perception of sensibility and reason, and stimulate one's creative ability. This creation is input into the system in time, the system processes it, and feeds it back to the user through the sensing device. This is a continuous learning process that can continuously stimulate people's ability to create thinking. Therefore, the application of virtual reality technology in power systems is a very important initiative.

![Figure 1. Basic characteristics of virtual reality technology](image)

In major safety industries such as electrical, the training experienced by employees before they officially take up their jobs is very important. However, operating errors caused by unskilled people
receiving training can easily lead to major safety accidents. The losses caused by mistakes are often not intuitive enough. VR technology based on virtual reality makes the trainees feel as if they are immersive, and through the operation in the virtual space, the training effect is greatly improved at a low cost. At present, VR technology has been applied in power systems, mainly including: simulation training, three-dimensional distribution network, power marketing, power simulation experiments.

3. The particularity and operation content of high and low voltage switching operation

3.1. Operational specificity
The high and low voltage tripping operation can only be performed within a specific time such as equipment maintenance, and the learning demonstration operation time is extremely short. During the switching operation, if the switching operation is not performed in accordance with the correct operating sequence, it may cause the line protection to malfunction and seriously damage the switchgear. During the on-site switch-off operation, the risk points were not clear and safety measures were not in place, which could cause serious accidents such as personal injury and death [4].

3.2. Operation content
Firstly, the ABB high-voltage cabinet is switched off. The contents of ABB high-voltage cabinet reverse operation include: ABB high-voltage outlet cabinet is transferred from operation to maintenance operation, and ABB high-voltage outlet cabinet is transferred from operation to maintenance operation.
Secondly, the low-voltage cabinet is switched off. The contents of the low-voltage cabinet switching operation include: the low-voltage cabinet is transferred from operation to maintenance operation, and the low-voltage cabinet is transferred from operation to maintenance operation.
Thirdly, line failure judgment. ABB high voltage cabinet failure judgment, low voltage cabinet failure judgment.
Fourthly, the high-voltage cabinet operation of the whole forest opening and closing station. The contents of the high-voltage cabinet reversing operation of the Quanlin Opening and Closing Station are as follows: the transfer cabinet of the high-voltage cabinet of the Quanlin Opening and Closing Station is transferred to the maintenance operation, and the high-voltage cabinet outgoing cabinet of the Quanlin Opening and Closing Station is transferred to the maintenance operation.

4. VR-based intelligent trip operating system
This article introduces a simulation system for a switching operation ticket using VR technology on a traditional switching operating system, which mainly includes a simulated operating system and a training assessment system under the VR environment. Support operators to carry out interactive simulated trip operation training and assessment, visualize the operation results in the form of simulation animation, and evaluate the operator's operation, thereby improving the training effect and reducing misoperations in actual operation. Risk to avoid possible serious consequences. The application of VR technology to the simulation system of the switching operation ticket can further enhance the user's interactive experience to achieve better training results [5].

4.1. Block Modelling Structure
The modelling work of the virtual reality substation system is huge and needs to be completed with 3DMAX software. The drawings of the electrical equipment are imported into the 3DMAX software, the same scale modelling is performed, and a realistic electrical equipment model is established, including 220 kV, 500 kV Electrical equipment, control room and relay protection room, build a model in 3DMAX that can hide functions, use the form of sub-module modelling, establish a device model library, and then build a solid model, and use the three-dimensional models of each electrical Assemble and connect each voltage to build a complete 3D substation model, as shown in Figure 2.
4.2. Function-oriented

4.2.1. Task Wizard Function. The function of this module is to provide the user with the function of selecting the switching operation. This system provides job training in multiple equipment and scenarios. The equipment in each scenario is typical equipment, and its sequence of switching operations has its own characteristics. So, through the task wizard, you can enter different scenarios to simulate the typical device.

4.2.2. Sequence function of switching operation. All the switching operations must fill in the operation ticket. This function has already filled in the operation ticket, but the order of the assignment is disrupted. The purpose is to allow the trainees to master the filling of the work ticket by reordering.

4.2.3. Tool selection function. Through the selection of tools, strengthen the safety awareness of the trainees, master the inspection methods of safety tools, determine whether the tools can work normally, distinguish the types of safety tools to be worn at work, and prepare corresponding countermeasures for different equipment. Brake operating tools.

4.2.4. Simulation function of reverse operation. This module is a simulation module of the switching operation process. Entering this module enters the virtual scene of the switching operation. In this scenario, you can watch the operating status of the high and low voltage switchgear on the site. You can follow the steps in the operation ticket to remember the switchgear. Brake operation [6].

4.3. Functional simulation
The simulation function is mainly to establish a virtual environment, which is essentially 3D animation and sound, vibration, etc. are transmitted to the operator through VR equipment in the form of vision, hearing, touch and so on. Figure 3 is a 3D simulation animation of the substation.
This article uses a virtual reality device launched by HTC. Its VR helmet can follow the perspective and shift. The VR handle can replace the keyboard to interact with the virtual reality scene. The locator can capture the movements and gestures of people in the SXSm range. Manipulation, movement, etc. of characters in a controlled virtual scene. Due to the limitation of the control range of the locator and the data line of the VR helmet, it can only be within a certain range, so the function of controlling the movement of the handle is added in this article, and the movement of the character controller in the virtual scene can be controlled by the buttons of the handle. At present, the training methods of the immersive virtual reality substation training system developed in this article are limited to scene roaming functions, simple text and picture display, and audio playback. Other interactive operations need to be further studied to achieve a stronger immersive experience. Virtual roaming, as shown in Figure 4 [7].

5. **VR simulation of training system**

The system first reads and stores the original information such as the opening and closing status, charging status, and voltage level of all switching elements. The operator uses the VR device to enter the simulation screen. In the simulation screen, all components and the names and status of the components can be seen. When the operator performs the operation, he will see the detailed action process of the component, including sound, light, and the scene after misoperation. All operations will
be presented in text. If you open the circuit breaker, the screen that the operator sees will change to the animation process of the circuit breaker opening. At the same time, you will also see the text indicating the number or name of the circuit breaker floating in the air. When the circuit breaker opens After the operation is completed, the colour of the circuit breaker will change to the colour set when no power is applied, and at the same time, the text will appear to indicate the open state. If the operator has made an incorrect operation, he will also see the screen after the wrong operation. For example, if the disconnection switch is charged with electricity, an arc will be opened and at the same time, noisy discharge sounds and operation errors issued by the system will be heard. Alarm sound, flashes of red halo will appear on the edge of the background screen, and text prompts of operation errors will also appear in the screen. The VR gloves worn by the operator will also emit a certain frequency of vibration. In this way, the senses of the operator are stimulated from various aspects such as visual, tactile, and auditory senses, and have a strong sense of substitution, so that they can fully feel the danger caused by misoperation, which can serve as a warning and reduce errors in the actual operation.

6. Conclusion
Through a real inspection of the substation and training institutions, to understand the current operating status of the substation, use virtual reality technology to develop a simulation training system. Through the real and intuitive system, conduct simulation training for the staff, improve the professional skills of the staff, and ensure the stable operation of the power system, at the same time, can also play a role in protecting personnel's personal safety in actual work.

References
[1] Qiuhua Huang, & Vijay Vittal. Application of electromagnetic transient-transient stability hybrid simulation to fidvr study. IEEE Transactions on Power Systems, 31(4) (2015)1-13.
[2] Anand, M., Duffy, C. P., Vragovic, O., Abbasi, W., & Bell, S. L. Surgical anatomy of vaginal hysterectomy—impact of a resident-constructed simulation model. Female Pelvic Medicine & Reconstructive Surgery, 24(2) (2018) 176.
[3] V. R. Alekseev, & T. I. Kazantseva. The role of chemoreception in forming of daphnia longispina sustainable population (the simulation experiments) Zhurnal Obschei Biologii, 76(5) (2015)377-389.
[4] V. Kornilov, A. Mironov, & A. Zakharov. The wbvr photometry of bright northern stars. Journal of the Chemical Society C Organic, 5(2) (2017) 379-390.
[5] Okere, H. C., Sulaiman, S., Rambli, D. R. A., & Foong, O. M. A multimodal interaction design guideline for vr foot reflexology therapy application,. 7(3) (2016)74-91.
[6] Ahmed, M. R., Todd, R., & Forsyth, A. Soft-switching operation of the dual-interleaved boost converter over all duty ratios., 10(11) (2017) 1250-1258.
[7] Hyein Lim, Seungjun Lee, & Hyungsoon Shin. Switching time and stability evaluation for writing operation of stt-mram crossbar array. IEEE Transactions on Electron Devices, 63(99) (2016) 3914-3921.