Research on alternating low voltage training system based on virtual reality technology in live working

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Abstract. The request of improving in distribution network reliability is completely uninterruptive during the process of power distribution. This article targets on an existing training method which is inefficient during the process of live working for power distribution. A system based on virtual reality technology is proposed to simulate and train people to operate with low voltage alternating current. It will provide inquiry in theory of knowledge, on-line test, simulation training about operation project etc, and it will be of important application value.

1. Introduction

Equipments in power grid are massive and complex. Especially in transmission line, safe distance and the design of insulation coordination are effected by voltage level, altitude and location. Thus the postulates about safety of live working, quality and professional knowledge of technical staff engaged in the live working are very high. 10kV power circuit is electricity infrastructure direct-to-user. Complex network and large coverage are its' features. Because insulation level of distribution network is low, it will malfunction easily under the effects of atmospheric over-voltage, filthy, surrounding objects and other external factors [1-3], thus the workload of overhaul is very heavy. The request of improving in distribution network reliability is completely uninterruptive during the process of live working for power distribution [4].

Training of live working in distribution network currently is mainly theoretical training and on-site practical operation. However, theoretical trainings will take long time to organize, take high cost and have poor intuitive. On-site training will be affected by weather, site, equipment and many other factors, trainees have fewer hands-on opportunities, and workable live working projects are limited. The current training of live working is not conducive to carry out large-scale, which can not meet the actual needs of social production [4]. Therefore, a safe, efficient, low-cost simulation training system is urgent for live working of the distribution network lines.

Virtual reality technology simulates real-world 3D scenes used computer technology for manipulation and interaction behavior. Virtual reality typically includes displayer helmet mounted, computers, intelligent terminals, automatic virtual environment studio, large screen display systems and views. The biggest feature of virtual reality is that enable users to carry out interactive manipulation with variety of items in accordance with their expectations in a virtual world, users can touches a variety of operation environments and scenarios, virtual reality training can achieve good training effect when real-world scenarios for training have high cost and risk[5]. To build a virtual environment for live working training imitating power operating environment has lots of advantages like low cost, in line with the rules of psychology, high reuse rate, high safety, avoiding the occurrence of secondary injury in training, strong extendibility and so on[6]. So this simulation training system can serve as a strong complement to the daily training tools, in order to facilitate efficient safety training and enhance employee safety awareness, so that maximize avoiding habitual violation in their daily work and reduce safety accidents[7,8].

2. System Design and Function Module

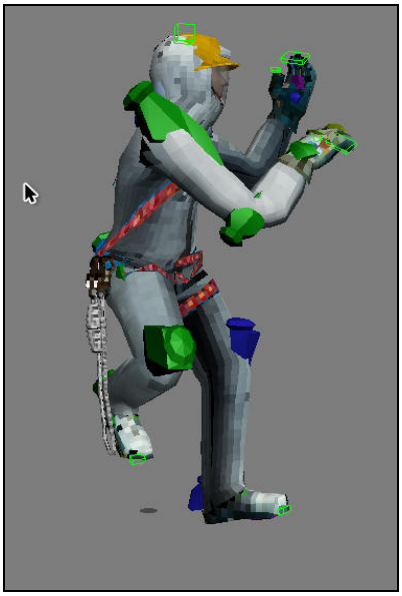
Animation of this simulation training system is designed through 3ds max. From creating, modifying standard model, to stake out and create a composite object model, and to advanced patch modeling, 3ds max can show more conveniently and veritably a variety of things seen in the real world. The functions of this simulation training system are virtual working, virtual testing, simulation maintenance, data query, training management, online exams and so on. Simulation operation target on that trainees are able to operate virtual workers to perform various live working projects in three-dimensional digital scene. The system can simulate multiple typical exchange live working projects of distribution network, trainees can complete "classes before the meeting", "Check tool", "wear and test safety equipment" , "insulator overhaul" "Removing the insulator string" and other operation links in software platforms, the whole operation will be recorded and scored. Trainees can use data query capabilities to access principle, methods, safety information of distribution network AC line live working, and watch the three-dimensional animation demonstration of tools using and project operation, training institutions can manage individual information of trainees, training results and training records using the training management, as well as carry out remote training via the internet, trainees can query their training records to impress mistaken point in simulation training.

2.1 Live working tools and instruments, project information and scene database

This paper collects the principles, standards, tools and instruments, research and other relevant information of live working, and establishes a digital database covering live working tools and instruments used and items of information, including basic principles, standards, technical regulations, tools and instruments data, work guide books and other content of live working, and use text, voice, video, animation and other ways to show the contents of the above information.

Establish the live working scene database including electrical equipment may be involved at live working point such as wire, towers, cross arms and nearby objects like trees near line and residence, and then combine them in different scenarios according to different operating projects. Scenes and character models are showed in figure 2-1.

(a) Community



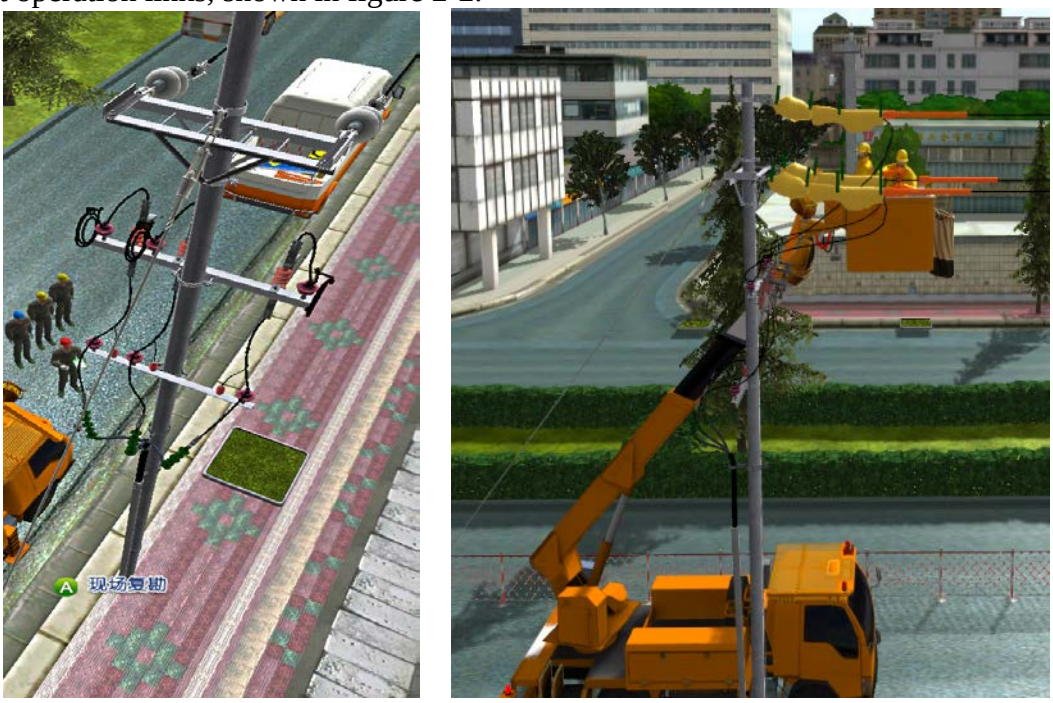
(b) Character

Figure 2-1 element model

2.2 Live working simulation operation module

This training system establishes the simulation operation module of distribution network typically live work projects using three-dimensional digital technology based on standard operating methods of live work projects, which is able to simulate the whole process of live working, show

the three-dimensional working condition to trainees, and carry out the meticulous presentation of important operation links, shown in figure 2-2.



(a) (b)

Figure 2-2 Typical live working project

2.3 Live working skills competition module

The system establishes a sound skills competition module which consists of two parts: live working knowledge test and simulation operation assessment. The content of examination is multiple choice based on "State Power Grid Corporation of safety regulations (power line section)", "live working management system", "live working operation guidelines" and other national standards and industry standards. The administrator can selected live working knowledge randomly according to a certain percentage for a knowledge test to form questions from the examination database. Simulation operational examination of live working adopts supporting hardware system for the media to assess typical live working projects operation, the contents of the assessment include the process of live working projects, tools and instruments inspection before the working, the selection of tools and instruments during the working and important details of the working.

2.4 Training management module

This system established the training management module with personnel information management of trainees (add, edit, delete), query management of trainees' performance and error and training state management of trainees.

3. System Implementation and Testing

The simulation operation module of simulation training platform makes full use of immersive and interactive features of virtual reality technology, the simulation operation process has rich working condition, standardized operating methods, comprehensive assessment and smooth animation. This simulation training system can achieve virtual working, virtual testing, simulation maintenance, query, training management, online exams and other functions.

3.1 Working scene preview

The system displayed the scene of surroundings, tower-type, and the operating point through "working scene preview", the scene shown in figure 3-1. The working scenes were designed according to urban distribution network exchange line.

Figure 3-1 Operation scene shown in the system

3.2 Pre-shift meeting

Pre-shift meeting is essential before live working operation, operator should know well about method of operation and the danger during operation. In the simulation training system, pre-shift meeting was designed accordingly to provide reading the operating instructions, querying the information of tools and instruments, watch presentations and other operations, shown in figure 3-2.

Figure 3-2 Pre-shift meeting

3.3 Project information query

Trainees can query basic information of live working and related information of specific operation item through "project information query". System managed such information by database. The basic information of live working includes live working basic principle, operating guidelines, live working standards, a variety of live operations research findings. The related information of specific operation item includes work instructions, tools and instruments and specific operational methods. In addition, trainees can watch project simulation operation using the "demo mode". And compared to "training mode" and "test mode", "demo mode" also adopts the virtual display technology to carry out the operation performance of specific projects, except that the trainees can not command workers, but can control 3D animation play, pause and replay.

3.4 Training Grading

In the process of "test mode", when trainees have finished simulation of operations, their operating results will be recorded by training grading system. Final grades of simulation operation assessments will be given by training grading system. It will list and explain every wrong point. Trainees can click details to query specific error. Training program and personal information of trainees will be recorded by module of performance evaluation, then save them to database automatically which make training management easily. Promoting standardized operations by grading system, trainees will be impressed by operating mistakes and then master knowledge of training.

4. Conclusion

In this paper, the low-voltage AC live working simulation training system based on virtual reality technology adopts modular structure, and can upgrade in the level of system design with the development of live working due to compatibility and expandability, such as increase or customize training programs according to grid development and customer demand. Provided an immersive virtual reality training environment to show realistic three-dimensional animation using stereoscopic display technology. Established digital database covering common live working tools and instruments and the project data to provides students with information inquiry and learning. The system will greatly reduce the work intensity of instructors in the grid or substation training, has important practical value.

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