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The Study and Development of Immersive Simulation Training System

Li Junfeng[1,*], Wang Qinruo[1] and Xiong Shan[2]

[1]*Guangdong University of Technology, GuangZhou, 510006, China*

[2]*Education Training Evaluation Center of Guangdong Power Grid Co., Ltd, GuangZhou, 510650, China*

Abstract: Constructing virtual environments about substation simulation system by immersive simulation technology could not only greatly improve the real scene of the substation, but also bring technological leap for training simulation work. This paper, firstly, analyses some key technologies and technical difficulties, then proposes implementation plan, and finally develops a good example of Immersive Simulation Training System about Guangdong Power Grid. The system is used to train personnel by interactive 3D engine technology and somatosensory interactive technology, and provide a strong personnel and intellectual support for the successful operation of the company's power grid.

Keywords: Engine technology, Immersion, somatosensory capture interactive system.

1. INTRODUCTION

Substation is an important part of the power system, its safety and reliable operation is of great significance to the power system. But the nature of the power system making it has lots of limitations to train substation personnel [1]. Therefore, it is essential to establish the substation simulation environment for training. Substation Simulation training System is a new and effective means, also it is an improvement of theoretical study and practical learning [2]. Operating personnel could be trained in all kinds of simulation condition, faults can be on the system, and the trainees would become qualified by repeated exercises in short term.

Currently, only some means are used in training simulation system, such as digital graphics, photos, live video equipment and so on. So the realistic, immersive and expression need to be improved [3]. With the development and application of three-dimensional graphics technology, it brings technological leap for training system by using three-dimensional graphics technology, which greatly increasing the real scene. With the better of computer technology and the rise of the NUI, more and more users want to interact directly to the system and abandon the traditional mouse, keyboard and other tools, which make their immersed in the experience, so that they can pay more attention to deal with things, promoting the development of somatosensory interactive simulation. The somatosensory interactive simulation is to use popular somatosensory equipment to identify real-world human skeleton node, whose location is use to determine the operations. Compared to the traditional one, it has new, interactive and other characteristics [4]. Firstly, this paper describes the overall structure of immersive simulation training system, and then explores various ways and difficulties of the technology; finally an actual system application is shown.

2. THE SYSTEM ARCHITECTURE

The overall system structure is shown as Fig. (**1**). Simulation training system consists of grid simulation, immersive substation scene simulation, substation run logic simulation, substation automation system simulation, and somatosensory capture interactive system. The teachers send task orders to the students, so that complete the simulation module coordination of various parts. Simulation training system functions of each part as follows [5]:

(1) Power grid simulation system: transient, medium and long process simulation methods are used to achieve real-time dynamic computing power, so represent the power system dynamic behavior. Flow calculation result is sent to each part through simulation support system, to ensure data consistency and system operation [6] .

(2) Immersion substation simulation system: It builds a three-dimensional scene using OpenGL-based interactive 3D engine technology, where two cameras were placed around. The left camera result is stored in area 1, while the right camera result is stored in area 2. Then the R channel region of area 1 image is extracted, the GB channel region of area 2 image is extracted. Finally, the R channel region of area 1 and the GB channel of area 2 are combined into a map by add operation. A master computer and a number of graphics computer are compose the hardware structure of multi-channel output technology. According to user needs, the master computer configures graph nodes and completes the goals of management and control via network. Three-dimension image are output on arc screen by two sets of graphics workstations and six projectors, and students could

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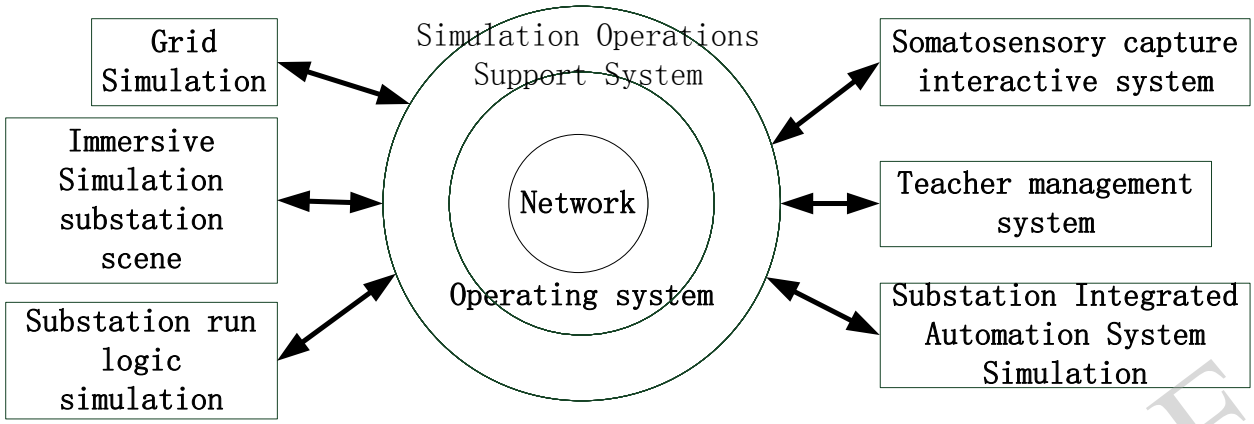

Fig. (1). The overall structure about immersive simulation training system.

experience the immersive feeling of systems operation, by wearing 3D glasses.

(3) Substation logic simulation system: Simulation of logic functions performed substation modeling and simulation. Which includes primary system of specific substations, control systems, measurement systems, error prevention systems, AC systems, and DC systems, relay protection and automatic means, and consider the impact of substation simulation model on an abstract model of the grid. Virtual devices could respond correctly according to user's order.

(4) Substation automation simulation system: It could simulate monitor function, human and machine interface and operation process, providing a virtual monitoring environment to students.

(5) Somatosensory capture interactive system: The system consists of Microsoft Kinect somatosensory interactive systems and power simulation software. Somatosensory interactive system is used for capture accurately the operator and his action information, which is use for tracking real-time and local body movements for accurate capture and passed to the power substation, driving virtual personnel make the same movement capture completing the simulation operation.

(6) Teacher system: It is a simulation platform supporting for the other subsystems over it. Using it, teacher send state data, and then data distribution management service automatically transfers data to the various parts simulation system. Each part of the system, through its own logic simulation and calculation, display the result on visualization platform. And the results are transported to the simulation system interconnected by platform the teacher system [7].

On the basis of the simulation support system, the various parts of the simulation module, check each other, and work together to build immersive training simulation systems. When accident or abnormal occur, substation equipment will response correctly and the data is sent to other simulation module. The power flow would change correspondingly and is send to other simulation module, which emit alarm information, protection action messages and automatic action, the user can complete training requirement by isolating faulty and recover power.

3. KEY TECHNOLOGY AND TECHNICAL DIFFICULTIES

3.1. Real-time Simulation Engine Technology of Power Grid

Engine technology of power simulation system focused on real-time simulation accuracy. In the simulation accuracy, the project established power and control system, the steady-state, transient model combined impedance and motor load, the transmission network, transformers, switches, and other network components, DC transmission systems and other equipment. On this basis on, integration simulation technology about transient and long-term process is used to achieve full dynamic simulation of power systems. Meanwhile, electromagnetic transient simulation technology is introduced by the surrounding grid of fault. At the same time, it uses a number of high robustness algorithm, differential equations and implicit trapezoidal network simultaneous algebraic equations algorithm, modified Euler method, automatic multi-breaking algorithm, to ensure that the simulation accuracy and numerical stability. Not only can calculate the system's power-frequency power, but also consider non-periodic and high-frequency components, fast transient process, accurate reproduction of various acts normal, abnormal of the power system [8].

3.2. Interactive 3D Engine Technology Basing OpenGL

Based on the three-dimensional cross-platform graphical language OpenGL, it developed a three-dimensional graphics engine support, and an OpenGL-based framework is provided, which is object-oriented. Key techniques and algorithms about improved efficiency and performance 3D engine is achieved, while realistic graphics package shown technology, three-dimensional scene management, sound management, collision detection, object interaction and real-time three-dimensional scene are completed, which provides a fast and efficient development interface to the development of three-dimensional scene. The engine technology consider the characteristics of the power system, and the personnel could set the device model and the three-dimensional status

Fig. (2) Kinect Sensor.

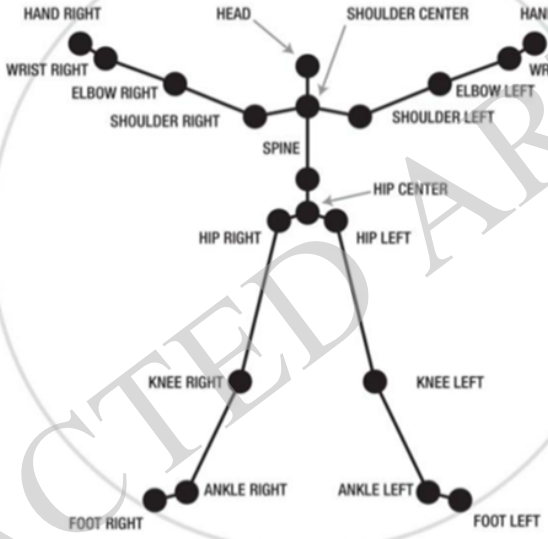

Fig. (3). Kinect skeleton track.

of each node using few code. By using tile segmentation and dynamic distribution strategy, Three-dimensional engine technology solves the problems, such as system performance degradation caused by massive data, and improves the realism displayed by the system.

3.3. Somatosensory Interactive Technology Based on Kinect

Kinect (Fig. **2**) is a human-computer interaction device perceived by Microsoft, is a new input device. User's movements can be captured in real time, by real-time motion capture, image recognition, microphone input, image and voice recognition function. This feature make users get rid of the traditional input devices, by limbs controlling terminal.

By infrared camera, Kinect captures human motion, and interact with substation virtual scene. The optical grating is located in front of Kinect somatosensory camera. And the camera record speckle space mark dispersed in space, and 3D depth information data are generated by the built-in chip. When the human body moves, complete can be recorded. 3D image data from depth information is transferred to human skeleton data Fig. (**3**).

According to body's skeletal features, the system records multiple sets of data to track the limb movements. Kinect will compare the capture images with the ones exist within the human body. If they are the same, a skeleton model would be established, and then drive virtual human model in three-dimensional scene, which can trigger action by identifying the key parts of the human skeleton, so that it can real-time acquisition and display. The flow chart of real-time collection and display about human motion is shown in Fig. (**4**).

The system can dynamically capture motion sensor data by somatosensory Kinect, and mapped them to the virtual

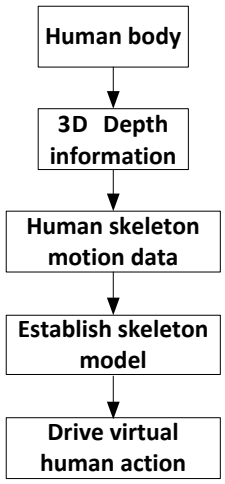

Fig. (4). The flow chart of real-time collection and display about human motion.

scene to achieve the interaction between virtual human and the virtual scene. Through accurate collision detection and gesture judgment about human and virtual substation operational three-dimensional object the system make trainees and virtual scene somatosensory interaction.

3.4. Difficulties of Technology Analysis

Kinect capture accuracy is limited, according to scene-driven virtual human action, we studied and compared two schemes: the real-time capture scheme and match scheme sample-based.

The first scheme is real-time capture scheme,it analyses scenario data, completes human skeleton tracking, Skeletal data from Kinect SDK development kit Skeleton stream. Event Mode KinectSensor has an event called Skeleton Frame Ready. When there is new bone Skeleton Stream, event is triggered. We get data from the bones Skeleton stream. Bones is a collection of Skeleton object. Each object contains data about the skeleton bones and skeletal joint position. Each joint has a unique identifier, such as the head, shoulder, elbow, 3D vector data and other information; it can obtain status information about the current track skeletal joints, so that the trajectory of the character models and users movement's response is consistent.

The second scheme is match scheme sample-based. Person's actual movements and virtual movements of people are matched. Virtual human movement in the sample library has been standardized; the key is to calculate matching accuracy. Sample identification method is to use skeletal tracking system in Kinect SDK, and the data is not used directly to drive the virtual human action, but the use of written algorithm generated image frame data matching to identify known frame data. This scheme can better identify the specific operation wanted to express, can be to identify the new action relatively easy. It is better than the first scheme of handling more complex operation, for example, substation scene roaming, then we do not need to move around, just lift the leg. However, this action is highly dependent on a lot of recognition sample data, the more the higher recognition accuracy. Therefore, the system requires a lot of CPU time and storage resources to find and match.

Therefore, it uses somatosensory operation in virtual substation scene, the more appropriate solution is to introduce a virtual person, and then capture the operator Kinect human data, and passed to virtual human, which making virtual human operator looks like in synchronous motion. Beat phenomenon might appear, if use the first scheme, leading to poor interaction feeling.

4. SYSTEM APPLICATION

The simulation study was developed by an immersion integrated simulation training system of Guangdong power grid, which is consist of immersive scene substation simulation, substation logic simulation, substation automation system simulation, somatosensory interactive system, teacher management system. Using it, personnel could be trained for normal operation skills, abnormal and emergency handling. Fig. (**5**) is a pictrue of them.

CONCLUSION

Immersive Simulation Training System is a comprehensive system. On the basis overview immersive simulation system structure, it detailed analyses the real-time simulation technology, interactive 3D engine technology based on OpenGL, Kinect somatosensory-based interactive technology and other key technologies. Then two schemes is introduced and analyzed according to difficulty problems. Finally, an immersive simulation training systems of Guangdong Power Grid is developed, to verify the correctness and its advancement. Operating results prove that the immersive simulation system is social and economic.

Fig. (5). Immersive training simulation.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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