Research on Key Technologies of Substation 3D Interactive Scene Simulation Based on Virtual Reality Technology

Dai Hao, Yang Zhenbao, Xue Zhicheng, Cui Zhiwen
Shenzhen Power Supply Co., Ltd, Guangdong Shenzhen, 518000, China,

Abstract. The application of virtual reality technology in power industry training has become a new trend. The realization of substation virtual reality technology simulation system based on three-dimensional interaction has a great role in promoting power system simulation training. In the absence of any operational hazards, the operation characteristics of underground substations are comprehensively understood and learned, so as to improve operational safety awareness and operational skills. Applying three-dimensional interactive technology to construct virtual environment for substation simulation system can greatly improve the reality of substation scene. At the same time, connecting power system simulation software with virtual substation to simulate various operation states of substation brings technological leap for substation simulation training. Users can draw the scene map of the two-dimensional substation and quickly convert the corresponding three-dimensional simulation scene. The simulation scene presented by the three-dimensional substation has realistic effect, which is more suitable for simulation training in practical application of the substation and has stronger practical significance and practicability in application.

1. Introduction
In the process of transmission and distribution of power system, substation is an important link, which is suitable for voltage adjustment. With the continuous development of substation system, its automation process tends to be complex [1]. There are abundant interaction activities among power departments, which is an important work for power operators, and directly related to the security, stability and economic operation of power grid [2]. To improve the normal operation and accident handling ability of substation operators, it is necessary to provide adequate training and operation exercises for relevant staff. Simulate the working process of main equipment in substation, provide functions of rotation, zooming, layer-by-layer display, stripping, restoring and dynamic display of principle, so as to acquire knowledge of substation more vividly and stimulate thinking [3]. Using the virtual reality technology training system, the substation environment is three-dimensional and realistic, and human-computer interaction is harmonious and friendly. Trainees can not only patrol in the three-dimensional interactive virtual substation, but also operate the virtual equipment at any time [4]. Static visual display can also show the working principle and working process of the equipment through animation and interactive technology. The system constructs a typical virtual substation scene so that users can roam and learn freely in the virtual substation scene [5].

Virtual reality technology refers to the environment that enables people to feel in the real world by using computers and a series of sensing aids. It is a seemingly real simulation environment [6]. Substation training simulation system is a new and effective means of substation training, which is a supplement to theoretical learning and field practice learning. Power system virtual environment is a virtual scene generated by computer. The scene can be either the reproduction of real power system application scene or the visualization of design and construction blueprint. Operators can be trained in
the simulation system, and a realistic three-dimensional scene can be displayed through a comprehensive simulation of various equipment in the substation [7]. Substation operators can observe and operate various virtual devices in virtual scenes to improve their familiarity with equipment and operation. To construct an interactive virtual scene, the following nodes are mainly used: modeling nodes, which are used to construct the appearance of the virtual scene; detector nodes, which are used to perceive users [8]. Integrated computer generation simulates the natural environment. Users can interact with the objects in the virtual environment in a natural way with necessary equipment and influence each other so as to obtain the feeling and experience of being in person, equivalent and real environment [9]. The training process has a strong sense of immersion and realism. In addition, the realization of virtual reality technology simulation technology not only needs to model the geometric model of electrical equipment, but also needs to add simulation to the surrounding environment of substation. Therefore, this paper studies the key technologies of substation 3D interactive scene simulation based on virtual reality technology [10].

2. 3-D interactive scene simulation of Substation

2.1. Virtual Scene Organization Based on Electrical Connection Characteristics

Typical substation arrangements include double bus with bypass wiring, one and a half circuit breaker wiring, single bus sectional wiring and other ways. Although there are many differences in various layout methods. By studying the three technologies of three-dimensional modeling, computer graphics and simulation scene generation, the rendering and generation of three-dimensional simulation scene, environment and substation equipment modeling and two-dimensional scene preservation and rendering are realized. Creating object and method libraries of interactive 3D graphics applications enables programmers to make full use of the performance of hardware graphics cards in applications, and to simplify and abstract the task of writing applications by using, expanding object libraries, or modifying them. According to the current operation situation of the substation, the firstly configures the three-dimensional virtual scene of the substation in the editing mode of the system, including the scene of the substation, electrical equipment of the substation and other auxiliary industrial equipment. To realize the description of various changes. The description of dynamic process corresponds to the use of interpolator nodes, and the description of time control corresponds to the use of time sensor nodes. When the result of the conception is input into the system, the system will display the processed state in real time or feedback it to the user by the sensing device, thus providing a learning environment for the user and creating an environment created by repeated learning.

2.2. 3-D Interactive Substation Simulation System

According to the typical substation design specifications, a Virtual Substation scene is constructed to show the real substation scene. Because of the convenience of binary space partitioning and the efficiency of approaching linear complexity, three-dimensional scenes often become an effective structure for organizing scenes. Virtual substation includes a variety of main equipment and wiring, grounding device, lightning arrester and buildings. Combined with the state description of virtual equipment, users of the system can access data from the business layer to realize the operation of the system. The final data is mainly presented to users in three-dimensional form, including web pages, text, lists and other forms. It is necessary to analyze the characteristics of the prototype of the modeling object in order to design the most suitable modeling method to model the underground substation scene and all kinds of equipment, so as to improve the realism of the virtual model. Nodes connected by routes form an event system. The design of the scene graph of the three-dimensional substation is realized through OSG technology. In this process, the scene graph of the substation is also converted from two-dimensional to three-dimensional. Event system is another basic component of scene graph besides hierarchical system. Through the event system, events can be propagated to cause changes in other nodes. During modeling, strict hierarchical relationships between different node types should be observed, and special attention should be paid to the suitability of current nodes.
Reasonable node organization is the basic guarantee for large-scale model construction, and will also bring great convenience for future modification and use.

The three-dimensional interactive substation simulation system is a set of three-dimensional simulation system that uses virtual reality technology to simulate substation operation. The structure of the three-dimensional interactive substation simulation system is shown in Table 1 and Figure 1.

| Node             | State |
|------------------|-------|
| Scheduling module| 10.35 |
| Simulation module| 9.85  |
|                  | 10.06 |

**Fig.1. Structure of 3-D Interactive Substation Simulation System**

In the process of real-time simulation, the polygon facing the viewpoint is always maintained. It can be used to create symmetrical objects such as poles or trees in the scene, or even a polygon can be used to represent model objects with a large number of details. In this hierarchical structure, each node can accurately describe the father-son relationship and its location in its environment. Before scene graph generation, each layer data should be modeled separately. The virtual scene adopts tree-type hierarchical structure, and the whole virtual scene is the root node. The basic drawing units such as light source, entity (or component), terrain, special effects and so on constitute leaf nodes respectively. When the corresponding node accepts the event, a series of actions will be generated. At the same time, it can also modify the domain of the node or cause the node to generate events. In this way, the corresponding objects are connected with common nodes and sensor nodes. The patrol of each key equipment in the substation is realized by using key frame animation. The patrol of the whole substation can be determined by setting a path while the patrol of equipment can be realized by using camera animation.

3. **Design of System Interaction Behavior**

3.1. *Nodes Implement Interactive Control*

The transformation of three-dimensional scene coordinates leads to a sequence of control points in three-dimensional space. A roaming path is a curve in three-dimensional space, which is determined by the control points in a certain interpolation way. The merged vertex can be either one of the original two vertices or a regenerated vertex. If the vertex is regenerated, additional work is needed to calculate the location of the vertex in order to better preserve the feature. Components at any other level should be combined to ensure the reusability of functional components. On the other hand, the functional components of the configuration function should be able to meet the needs of various possible virtual modeling objects, that is, to meet the scalability of the configuration function. Only by combining with physical modeling and behavioral modeling that truly embody the characteristics of virtual reality technology can the characteristics of virtual reality technology "look real and move real" be realized and a virtual environment that can realistically simulate the real world be constructed.
Nodes generate events, which can trigger an action at a specified time or generate events at fixed time intervals. The control program execution diagram is shown in Figure 2.

![Control Program Execution Diagram](image)

**Fig.2. Control Program Execution Diagram**

### 3.2. Functional Task Analysis of Virtual Power Station System

The autonomy of virtual reality technology simply refers to the activities and changes of dynamic entities and the dynamic relationship between them and the surrounding environment and other dynamic entities. They are not controlled by the user’s input and do not interact with them. Visual simulation applications not only require a realistic three-dimensional virtual scene image environment, but also require real-time acquisition of various important statistical data in the process of simulation applications. Users can make corresponding judgments according to the relevant real-time data, so as to achieve further interaction with simulation applications.

Group nodes are located at the lower level of the root node, including the control information of the object’s rendering state and its geometric information. Each group node and the root node have zero or more sub-members (Note: Group nodes are zero sub-members, without any operation). Spatial area perceived by nodes. The space covered by the equipment node is not the volume of the equipment itself, but the box area is surrounded by a space with the equipment as the center and the safe electrical distance as the radius.

Every time the observer enters this area, the sensor uses the event to output the current absolute time. Each time the observer leaves this area, the sensor uses the event output time. Data extraction is carried out from multiple systems, and the data synchronization strategy between the device status data server and each system is determined according to the actual situation to find a balance point between real-time performance and system load.

Generally, the generation of models is simplified step by step through the most precise model, that is, the most precise model of an object, and then simplified by using a certain simplification algorithm. By controlling the degree of simplification, a series of models with different degrees of fineness are obtained. Real-time three-dimensional scene reflects various states of real equipment in substation, including equipment temperature, line live information, switching status, equipment name, time of putting in person, etc. In the process of geometric modeling, the scale and size of the three-dimensional model should be kept consistent with the prototype. In the combination of the whole substation scenes, the workload can be reduced considerably, and the virtual reproduction of substation scenes and equipment can be guaranteed. Import the equipment model library and replace it at the corresponding position in the substation scene. The operation is simple and convenient, the reliability is high, the system does not need to be redeveloped, and the efficiency is greatly improved.

Time sequence is sent to the routing target node and processed by the target node. Such processing may change the node state, generate other events, or modify the structure such as scene graph, thus providing the world with dynamics. The transformation node can change its geometry coordinates to change its state according to the change of child nodes. All node classes have the same base class and have different functional methods. The inheritance mechanism of scene graph can provide diversity.
for nodes. The implementation highlights the selected scene elements in the specified color according to the specified mode, so as to carry out the next interactive operation more clearly. At the same time, this class also provides the function of simple transformation operation on the selected objects.

4. Conclusion

In this paper, the key technologies of substation 3D interactive scene simulation based on virtual reality technology are studied. Using three-dimensional interactive scene to construct virtual environment for substation simulation system can greatly improve the reality of substation scene. Distributed interaction of power plant system increases the amount of information needed to interact, so as to meet the needs more truthfully. The main problem in this part is whether the simulation application and network transmission capability can meet the demand when the amount of transmission information is very large. To promote substation staff to have a deeper understanding of its various parts, so as to improve its business ability and operational skills. It can roam the substation in an all-round way and intuitively understand the typical structure of the substation. Through the multi-angle multi-level multi-aspect dynamic display and scene conversion functions of the main equipment in the system, the structure of the main equipment can be observed and understood in depth. The perfect virtual reality technology system can be regarded as a distributed database system, each entity in the virtual environment can be regarded as a record, the state of the entity can be regarded as the content of the record, and the user's operation on the entity can be regarded as the addition, deletion and modification of a record. Interaction and dynamic capability are realized through event system. Nodes are composed of domains and events, in which the values of domains determine the current state.

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