Research on the Virtual Reality Simulation Engine

GUOXIAOLI
School of Information Engineering
Northeast Dianli University
Jilin City, Jilin Province, China
gxl@mail.nedu.edu.cn

FENGLI
Electrical Training department
Northeast Dianli Technician College
Jilin City, Jilin Province, China
48610830@qq.com

LIUHONG
LiaoNing Information Vocational Technical College
Liaoyang City, Liaoning Province
724752610@qq.com

***Abstract*—in this paper, we first have compared the virtual reality substation simulation with the traditional substation simulation in visualization. We know that the virtual reality substation simulation is necessary. Because the traditional substation simulation has the low efficiency in creating the virtual reality substation simulation, this paper gives the new mode which it is based on the components and the virtual reality simulation engine is the kernel. As the same time, it gives the frame construction of the virtual reality simulation engine and illustrates the functions of components in the frame construction. And it realizes the virtual reality simulation engine with the usage of common object model technology. The results show that it can improve the development efficiency of the virtual reality substation simulation.**

Keywords- virtual reality; frame construction; simulation engine; substation simulation

I. INTRODUCTION

In the recent years, it is great significant that the substation simulation is studying the power system and the substation simulation is training the electric staff. However, due to its approaches such as the 2D wiring diagram, the photos of equipments, the digit figure, the live recording and video, etc., the traditional substation simulation has many disadvantages in visualization, interaction, immersion and imagination, and it has the low efficiency in creating the virtual reality substation simulation, which lead to difficult understanding of the simulation processes and results [1].

The virtual reality substation simulation (VRSS) which is created by the virtual reality technologies can make the full use of texts, geometric figures, sounds, 3D animation and videos and other multi-media to demonstrate the simulation processes and results vividly and directly and improve the deficiency of the traditional substation simulation [2]. Therefore, it is necessary to establish the virtual reality substation simulation.

However, the current researches mainly focus on technical details such as 3D display, dynamic environment modeling [3]. As to how to use the virtual reality technologies efficiently, how to shorten the development cycle and how to improve the flexibility and extension of the VRSS, less researches are involved [4].

This paper analyzes the necessity of the virtual reality substation simulation, and it proposes a components-based and new flexible development-mode, it illustrates the frame construction of the virtual reality simulation engine in detail and introduces COM-based approach briefly. Application shows that the virtual reality substation simulation is necessary.

II. RESEARCH ON VRS-ENGINE

The traditional substation simulation has fixed scopes and equipment types, limited varieties and numbers of data models, which lead to difficult-extension and reusable of the simulation system, and then result in low-efficiency, long-cycle and high-cost in development each time [5]. With the establishment of Smart Grid, the scope and structure of realistic substation are changing rapidly. Obviously, the made-to-order development-mode hardly keeps up with the rapid change.

Opposed to the traditional made-to-order substation simulation, the flexible simulations has changeable models, architecture and combining patterns, which can be reused in the later developing procedures, hence improve its developing efficiency; meanwhile users can develop and modify the simulation system to accomplish different research and training on the ground of the existing simulation system [6]. Consequently, flexible simulation can catch up with the rapid development of substation [7].

Components are packaged, normative and reusable software modules, which can facilitate the realization of flexible development in the VRSS [8]. In order to acquire components, the main functional modules of VRSS have been classified into the following ones. It shows as fig.1.

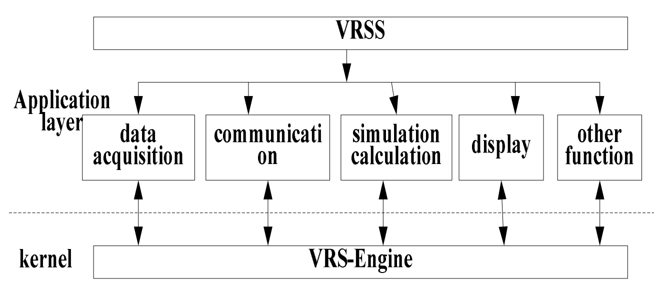

Figure 1. Functional module

1) Data acquisition module

Data acquisition module is so as to acquire the original simulation parameters.

2) Communication module

Communication module is so as to transmission the orders and messages between the different functional models.

3) Simulation calculation module

Simulation calculation module is so as to calculate the simulation results according to preset mathematical model.

4) Display module

Display module is for highly visible display of simulation processes and results vividly and directly by fully employing VR models of electrical devices, substation virtual scenes, 3D geometric graphs, data etc.

5) Other functional modules

Other functional modules have different functions.

6) VRS-engine

VRS-engine is the basis kernel of the VRSS system, integrating different key VR technologies to provide technical support in the pattern of Application Program Interface for the whole VRSS system.

Flexible VRSS based on components needs further reasonable classification of the above-mentioned functional modules into appropriate components, which can be adopted as basic elements to establish the needed VRSS. Fig.2 shows the development process of flexible VRSS based on components. As the prerequisite of realizing flexible VRSS, acquiring components of VRS-engine has great significance in that VRS-engine is the basis and kernel of VRSS system.

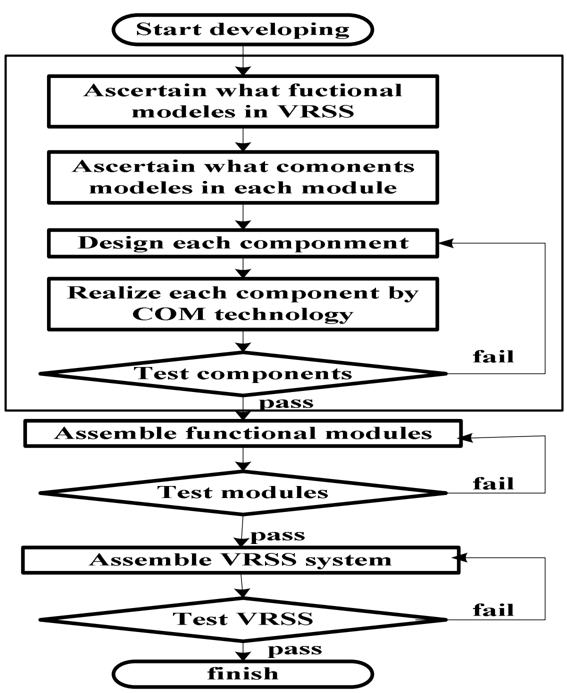

Figure 2. the development process of flexible VRSS

III. DESIGN OF VRS-ENGINE

With the key VR technologies stored in an independent, complete frame construction using components as its basic units, the VRS-engine can coordinate different technical components inside and provide plenty of Application Program Interface functions to harmonize other components outside [9].

Therefore, as the prerequisite of acquiring components of VRS-engine, establishing a reasonable frame construction has great impact on the flexible development of VRSS. Fig.3 depicts the frame construction of VRS-engine.

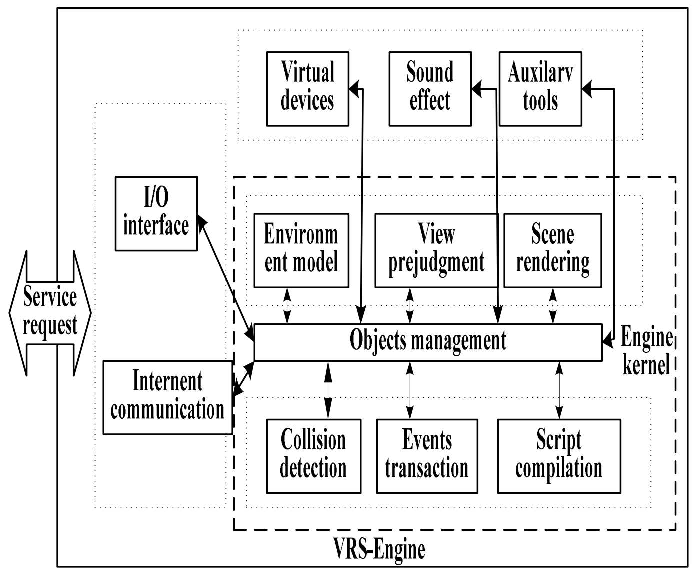

Figure 3. Frame structure of VRS-engine

A. The Kernel of VRS-Engine

The kernel is the most important part of VRS-engine, and provides the basic handling functions for VRS-engine. Components of the kernel can be classified as the following ones:

1) Objects Management

As the inter-bus of VRS-engine, it manages all the things in VRS-engine and regards them as objects.

2) Environment Modeling

On the basis of the appropriate data in the Scene-DB, it can set up a corresponding VR environment model for VRSS and then submit to View Prejudgment component.

3) View Prejudgment

It can prejudge the visible parts of VR environment model observed by normal human sight and then submit to Scene Rendering component.

4) Scene Rendering

It is responsible for depicting the basic 3D models and dealing with light and texture in the current and visible VR environment model and then generating VR scene. As one of the most important components in VRS-engine, it determines the performance of VRSS based on VRS-engine to a large extent.

5) Collision Detection

It is an inevitable element of VRS-engine. It can catch the interaction-events triggered in the VR scene, and greatly determine the interactive ability of VRSS.

6) Events Transaction

It can send different messages to the corresponding components according to different interaction-event.

7) Script Compilation

Script is data construction or language which can depict behavior of objects. Script in VRS-engine can be divided into 3 types:

a) Action Script, for modifying the location, direction and related attributes of objects;

b) Trigger Script, on an occurrence of interaction-events such as approach and touch, the script will trigger the relevant messages to deal with the event;

c) Connection Script, for the connection between output/input equipments and objects. It is much easy to control the electrical devices in VR scene with the help of these three scripts. This component compiles all the scripts for their exact execution.

B. Other Components

1) Virtual Devices

This component provides many VR models of electrical devices. As an important segment of VRSS, VR model is in charge of carrying and displaying messages in the process of simulation.

However, electrical device VR model is not a pure but compound one, including:

a) Electric Model, receiving and storing simulation data and reflecting the main parameters of electrical devices such as voltage, power;

b) Geometric Model, displaying simulation messages and reflecting the appearance of electrical devices;

c) Behavioral Model, referring to the relevant interactive mechanism and the coordinating rules.

2) Sound Effect

Dealing with the sound of VRS-engine refers to 3D sound effect of stereo to enhance reality- sense of VR scene. Such component can be accomplished on the basis of DirectSound API.

3) Auxiliary Tools

They mainly include editors of electrical devices VR model and substation VR scene. They can edit virtual module visually and store its results in the data bank with the usage of such editing instrument.

4) I/O Interface

It is responsible for receiving control-orders from input equipments such as keyboard, mouse, joy stick, data glove, and in charge of administering input/output functions such as printing, import/export data etc.

5) Internet Communication

It provides such functions as internet communication, data transmission for VRS-engine. The internet protocols adopted by VRS-engine are TCP/IP and IPX.

C. Workflow of VRS-Engine

The components in VRS-engine cooperate with each other. Fig.4 shows the workflow of VRS-engine.

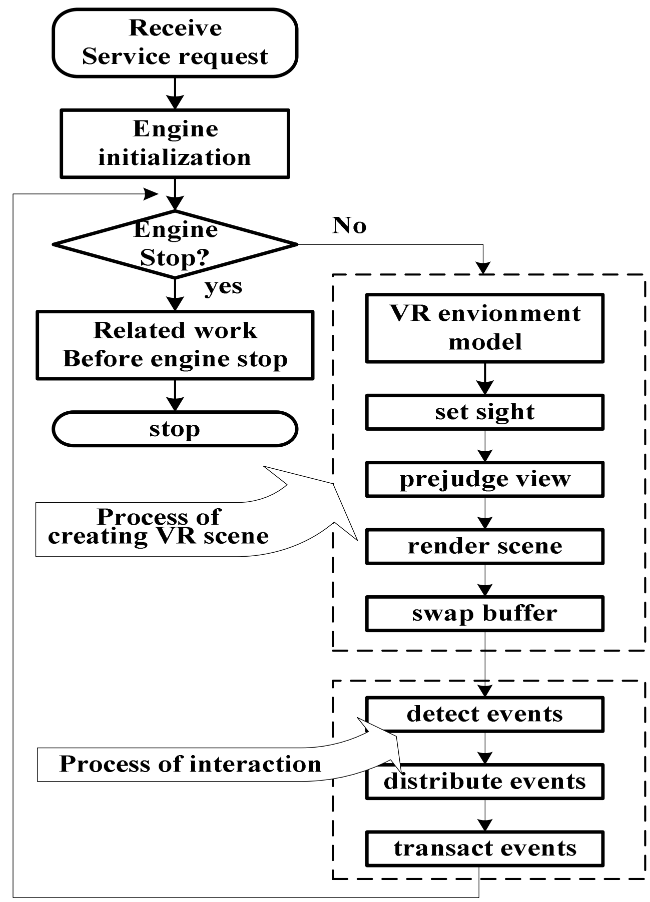

Figure 4. Workflow of VRS-engine

In this figure, the step of Receiving Service Request is done mainly via the components of I/O Interface and Internet Communication; the tasks of Initializing Engine and Stopping Engine are finished mainly by Objects Management component; the process of Creating VR Scene is mainly related to the components of Environment Modeling, View Prejudgment and Scene Rendering; the interactive process is mainly involved with the components of Collision Detection, Events Transaction and Script Compilation [10-12].

IV. REALIZATION OF VRS-ENGINE

The essence of realizing VRS-engine is to realize its components in its frame construction with the usage of COM technology. Grounded in the editing theory of Object Oriented Programming, COM technology stores all codes in independent classes. Fig.5 depicts the structure of Base Class in VRS-engine. Due to the diversity of the components which are regarded as objects by VRS-engine, we further classify the objects.

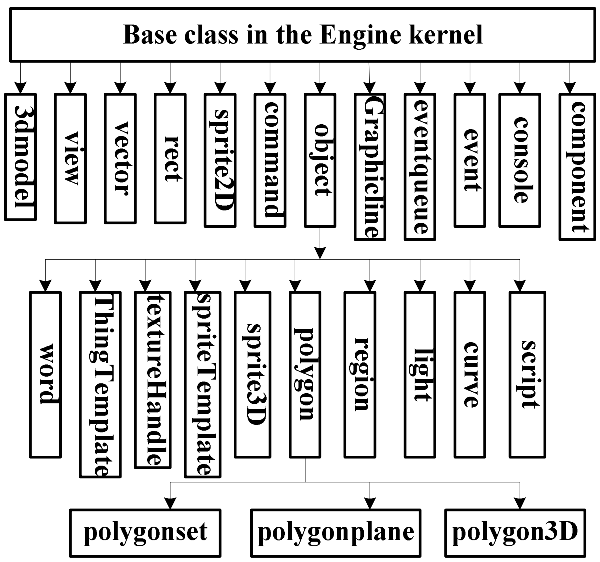

Figure 5. Structure of base class in the engine kernel of VRS-engine

It takes much time to develop VRS-engine in that it requires designing and editing many complex classes. An efficient way is to reform 3D-game engine which usually includes most of VR technologies developing VRSS needs. What we need to do is to modify or reedit a few classes. The engine mentioned in this paper is accomplished by reforming Torque Game Engine (TGE) which is an Open Source engine and adding the bank of electrical devices VR model. Of course, reforming methods and approaches are quite different in terms of different functions and structures of 3D-game engine. In addition, we have to take the expense of purchasing 3D-game engine into account.

V. AFFILIATIONS AND CONCLUSIONS

The VRS-engine which is realized by reforming TGE is successfully applied in the project of "substation training system based on VR technology". The project team built a VRSS by using the VRS-engine. As this engine provided many technical components which could be used directly in building VRSS, the process of acquiring components showed in Fig.2 was almost bypassed. As a result, the development-cycle of the VRSS was shortened 40% in comparison with other VRSS which were built by using traditional development-mode. In addition to, VRSS is better than traditional substation simulation in visualization, interaction, immersion and imagination, so that the development of VRSS is necessary. However, as an enormous and complicated software engineering, VRSS will cost much time and money if its development-mode is made-to-order.

The proposed flexible development-mode in this paper can enhance the efficiency and reduce the cost in developing VRSS , and VRS-engine based on components which integrates mainly VR technologies can support flexible development-mode very well. This paper designs and implements a components-based VRS-engine for VRSS. The results show that the VRS-engine can greatly shorten the development-cycle of VRSS. According to the actual application, the frame structure of VRS-engine is needs to be improved and perfected in the future.

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