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Research on Virtual Reality Based Equipment Operation Training Simulation with GL Studio

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Abstract. Aiming at the difficulty of large weapon equipment operation training simulation, GL Studio software tool was adopted based on VR technology. A hierarchy structure was put forward to simulate all kinds of integrating equipment system, single equipment and operation unit. Key technologies including Model database structure optimization, LOD, operation unit motion simulation based on DOF and screen show simulation based on switch are also put forward in detail. Finally, a simulation example of VR based large weapon equipment operation simulation training system was presented to prove its feasibility.

Introduction

Operations on large complex weapon equipment are always characteristic by complicated rules and higher requirement for operators. So daily operation training is mainly combined with actual equipment and limited by training field, funds and weather condition. But simulation training based on VR has been paid much attention from various countries and militaries for its special superiority such as security, economic, controllable and unlimited by other conditions.

For some certain tactical communication equipment simulation training system, equipment operation training is important basis component. And simulation for equipment operation based on VR is the key link for its realization. How to realize equipment operation simulation realistically has been a difficulty facing by simulation training system implementation. Therefore, equipment operation training simulation with GL Studio based on VR is proposed and its technology details are presented to solve the difficulty mentioned above.

Related Works

With the development of computer graphics, 3D simulation technology and virtual reality, equipment operation simulation adopting computer simulation method can shorten experiment period, improve development quality and save money. There are many equipment operation training simulation systems have been developed by different countries with simulation study going deep into all kinds of fields endlessly. Virtual reality training system using for maintaining aviation and satellite has been built by NASA in present time. Air command of US has begun developing the first distributed training simulation system named DMT since 1997 [1], and it connected different kind of simulation subsystem dispersing in different location. Equipment operation training can be carried out with DMT in common virtual environment. Desktop-VR system for preflight 3D navigation training is developed by Hirofumi Aoki at massachusetts institute of technology in USA [2]. A system for exploring open issues in VR-based education is also realized by Gustav Taxen at the royal institute of technology in Sweden [3]. VR-ENGAGE is implemented on the usability and likeability of virtual reality games for education by Maria Virvou at university of Piraeus in Greece [4].

Some conclusions can be made based on the related works mentioned above. Firstly, research on equipment operation training mainly concentrates on single equipment, and networking integrated equipment operation training is seldom reported. Secondly, hardware equipment operation simulator is more than pure computer software simulation system. Thirdly, current VR based equipment

operation training simulation pay more attention on vision effect and is short of operation rules support. So research on VR based equipment operation training simulation will be a defiant and innovative work.

Simulation Overall Thinking

According to different equipment structure characteristics, all kinds of equipment can be broken down into two categories naming single equipment and integrating equipment. Considering every integrating equipment is usually consisting of several different single equipments and every single equipment is consisting of several different operation units, the equipment simulation framework can be described with a hierarchy structure, which can be shown in Fig. 1.

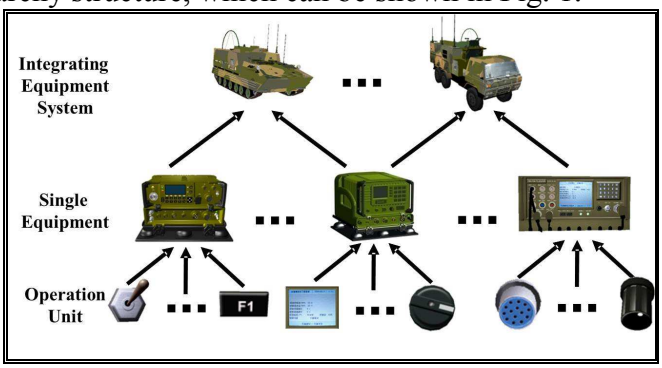

Fig. 1. The hierarchy structure of equipment operation training simulation

As it is shown in Fig. 1, operation unit in lowest layer has highest reusability, single equipment in the middle layer is second and integrating equipment system in the top layer has lowest reusability. So equipment operation simulation can be started with operation unit, and both single equipment and integrating equipment system can be started in turn. With the hierarchy simulation framework, simulation efficiency will be improved greatly [5].

For simulation to operation interface, operation action and operation rules of those integrating equipment systems, traditional simulation software tools including 3D Max have shortcomings such as more modeling working load, lower efficiency, and greatly difficulty. Additional works will be created when programmer designs data structure to read and rebuild 3D equipment model in simulation development phase. GL Studio developed by DiSTI is particularly fit for equipment operation training simulation by building real-time and interactive virtual scene simulation with Open GL graphic library. Its designer can create realistic 3D equipment model and its code generator can create C++ and Open GL source code from designed 3D model data [6]. The component development style of GL Studio is accordance with the layered simulation combination thinking reflected by the hierarchy structure mentioned above.

Key Technologies

3D Model Data Optimization

For real-time simulation system, excessive greater 3D model data will lower system rendering speed due to limited model data in per frame time, and fluency level of simulation running will also be affected. Therefore, by means of practicing repeatedly, three different technologies are adopted optimizing to equipment 3D model data.

1) Model Database Structure Optimization

The efficiency of ergodic operation performing by real-time simulation system will be affected in great extent by model database structure. So its structure should be organized in accordance with the fixed order named “Group-Object-Face-Point” according level of node in optimization process. In addition, model database structure should be organized based on its space relationship of model object in scene. For those model objects in shorter distance, it is means that its corresponding nodes should be set to the same group according to space distribution of model object. In this way, rendering efficiency will be improved owing to those model objects in visual scope can be selected quickly.

2) Level of Detail (LOD)

3D model of large equipment is characteristic by complicated structure, huge data quantity and numerous various nodes. Though its model has been optimized with the two technologies mentioned above, the model data magnitude still can't be reduced. Especially if equipment is moving and it must be located, rendered and collision detected in virtual scene, massive computational burden will be produced when a more precise model is applied. But details of 3D equipment model can't be identified with the naked eye when equipment is moving far from current viewpoint. So system rendering efficiency will be improved greatly and not disturb vision effect by adopting LOD technology, which loading dynamically different precision 3D model on the basis of distance between viewpoint and moving equipment. As it is shown in Fig. 2, two 3D models with different LOD have same vision effect and different rendering efficiency.

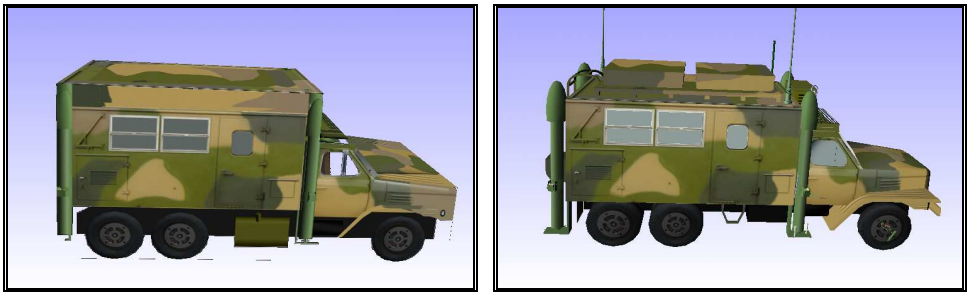

Fig. 2. The rendering effect of two 3D model with different LOD

Simulation for Dynamic Effect of Equipment Operation Training

Various dynamic effect of equipment operation training simulation including unit movement and screen switch are the direct reflection of reality. The dynamic node technology applied in this paper can be used to realize above-mentioned dynamic effect.

1) Operation Unit Motion Simulation Based on DOF

Most equipment unit has motion characteristics, which makes operation unit responding to operation of user by interaction such as press down and up of button in equipment operation panel. These unit nodes corresponding to movement unit and its movement is usually accompany with its attached parent model objects. With DOF (Degree of Freedom) technology, unit will gain motion freedom by setting local coordinate system for its node and motion simulation is realized in this coordinate system.

Take the example of a user terminal computer, DOF node can be set to its display and the coordinate origin is located to its rotation axis. So display will be turned off and turned on by setting pitch parameter range of DOF node from 0 to 180 degree. As it is shown in Fig. 3, the opening and closing operation effect of terminal computer can be simulated.

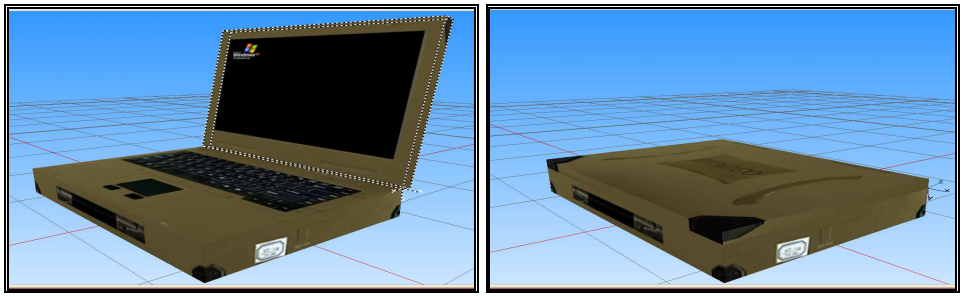

Fig. 3. The opening and closing effect of user terminal computer applying DOF

2) Screen Show Simulation Based on Switch

Screen show is an important information output interface for equipment, and it is also an important interaction channel between trainee and simulation system. Operation respond and running status are all reflected with screen show. For simulation equipment, the process of screen show is a series procedure with texture rectangle face switching dynamically according to some specific rules. So switch node of GL Studio can realize switching dynamically expediently.

Take the example of screen show in a terminal computer, it has four different display states including shutting down, screen saver, desktop and application. These states can be relevance with mask code of switch node, and value of mask code will determine its screen show state. Its state can be shown as Fig. 4.

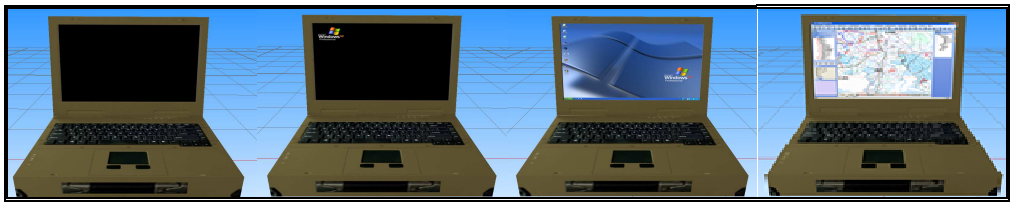

Fig. 4. Four different display states of user terminal computer applying switch node

Simulation Example

A VR based large weapon equipment operation simulation training system with GL Studio has been developed on account of technologies mentioned above. The simulation examples is shown as Fig. 5.

Fig. 5. Simulation example of a large weapon equipment operation simulation system

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