Research on the Semi-physical Simulation Maintenance Training System of One Engineering Equipment

Wei-jun CHU[1], Xiao-hui HE[1] and Zi-cheng ZHU[2]

[1]Army Engineering University of PLA, Nanjing, Jiangsu, 210007, China

[2]China Heavy Truck Group Co.,Ltd, Jinan, Shandong, 250116, China

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Abstract. In order to greatly reduce the operation frequency of actual equipment, shorten the training cycle, and improve the effect and credibility of equipment maintenance training. This system selected a type of engineering equipment as a research object. On the basis of the systematic analysis of this type equipment training assessment, failure phenomena, the cause of the problem and elimination method, the authors researched efficient acquisition, real-time reconstruction, visual processing of the equipment 3D model data, semi-physical simulation and virtual maintenance interaction technology based on the general virtual maintenance training platform of engineering equipment. And then the engineering equipment semi-physical simulation maintenance training system is developed. The application of this system shows that it provides trainees with the normative training courses, the believable and controllable training processes, and the economically applicable training means.

Introduction

Virtual maintenance training system combined with semi-physical simulation technology has such remarkable characteristics as visual visualization, rich and convenient interactive mode, unlimited application time and space, higher credibility, etc., which can shorten the training cycle, greatly reduce training costs, and improve the effect of equipment maintenance training. At present it is acknowledged to development semi-physical simulation and virtual maintenance training system based on general virtual maintenance training platform. The development method of maintenance training system has initially formed systematic and standardized. The general virtual maintenance training platform suitable for different professional and different equipment can initially solve these problems of process unifying, data sharing and configuration diversifying.

General Virtual Maintenance Training Platform

General virtual maintenance training of engineering equipment is a series of hardware and software system which is applied to content design, data development, training implement, training management of virtual maintenance training, and it supports maintenance training plan, management and evaluation, virtual learning of complex equipment all subjects, training and examination, quick graphical interface development, multiple types of virtual reality simulation software and hardware equipment. The general platform has standardized training data and normalized training process.

The platform framework is shown in figure 1. Virtual simulation data development related modules will be extended for immersive virtual interaction and GTENG virtual engine, and constitute the virtual maintenance training simulation development system together with four modules, namely 3d model reconstruction of scanning data, design data import, maintenance environment simulation library and damage mode library. Virtual maintenance training environment have desktop virtual maintenance training, semi-physical simulation maintenance training, immersive virtual maintenance training three interface modules, and expand the virtual training process control of maintenance operating, the virtual training process control of fault diagnosis,virtual prototype simulation and control, virtual maintenance interactive simulation and

control four modules, then develop the virtual maintenance training environment. The virtual maintenance training environment and the virtual maintenance training management system are combined with different hardware equipment to realize the immersion virtual maintenance training.

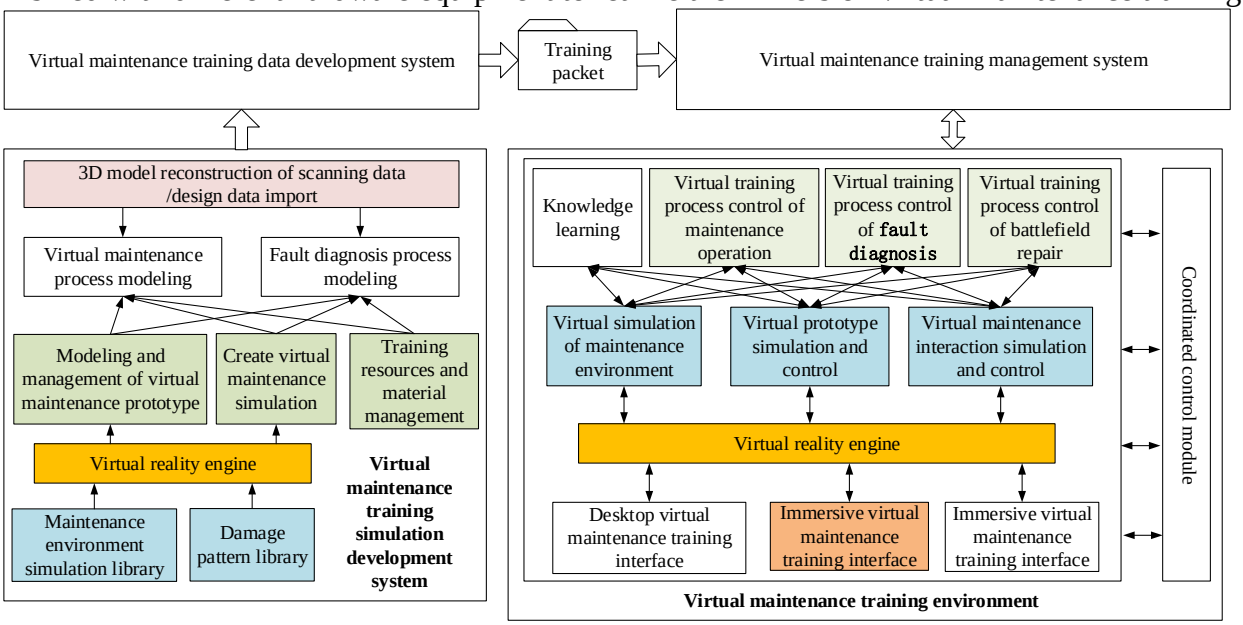

Figure 1. General platform framework

Virtual Maintenance Training Simulation Engine Development

GTENG Engine

The self-developed GTENG engine technology is a complete set of real-time 3D engine, based on the Windows operating system, and the underlying interface is for above directx9.0 version. GTENG engine adopts advanced real-time computer graphics algorithm, including computer graphics and highly optimized physical simulation algorithm set, suitable for a variety of hardware acceleration platform, to achieve scene management, 3D model rendering, dynamics calculation and other simulation functions. Its framework is shown in figure 2.

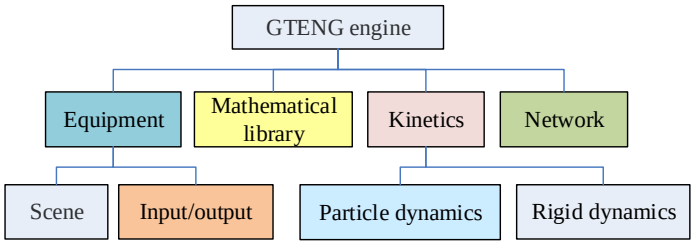

Figure 2. GTENG engine frame

The virtual simulation development system for virtual maintenance training is developed based on GTENG engine, and the basic data of maintenance training such as typical virtual maintenance prototype model library, typical maintenance training process model library, maintenance environment library, typical damage mode library and tool equipment library are embedded to support the development of virtual maintenance training simulation content. The developed virtual training content supports semi-physical simulation, desktop and immersive virtual maintenance training system, which can be aggregated and published in the virtual maintenance training data development system, and can also be browsed and operated independently on the platform.

This system adopts GTENG engine technology to improve the performance of various indicators and increase the overall efficiency, as shown in table 1.

Table 1. Some technical indicators of GTENG engine

Key technology	Index	Efficiency
Holodynamics	Real-time computing based on physical principles	Real time
Dynamic water	Plane mesh, refraction, reflection, shader2.0	Real time
Big model	Million triangles	Real time
Collision detection	GTENG engine	Real time
GUI	Rich interface elements	Real time
Vehicle simulation	New vehicle dynamics simulation engine	Real time

Simulation Environment Establishment

The GTENG engine supports unlimited scenes, usually 8192*8192 meters, and can support unlimited scenes with special scaling technology. Scenes are organized using scene diagrams, which is the loose tree structure. GTENG engine has two types of built-in and external nodes. Built-in nodes are classes that the engine has already built, such as sky nodes. When not in use, they are not added to the scene manager, and when they are needed, they are created using the scene manager's built-in functions and placed in place. The external node is controlled by the user, and functions such as add, remove, etc. of the CBaseSceneNode class are used to place it where it is needed. For example, add a child node to the next level of the built-in scene manager, m_pMeshNode, to form a new mesh child node. These nodes have their own Pointers or access interfaces that users can use to manipulate the nodes.

According to the actual situation of the training scene, the training scene is divided into static scene and dynamic scene, in which the static scene includes the ground, dry ditch, river, riverbed, beachhead, sky and so on, while the dynamic scene is mainly the water surface and so on. For each scene, the corresponding visual model should be built, that is, the following visual model should be built: different forms of ground, flat height and dry channels with height difference, rivers, riverbeds, sky, vegetation, trees, etc. In order to reduce the computer burden, many irrelevant details are replaced with approximate textures.

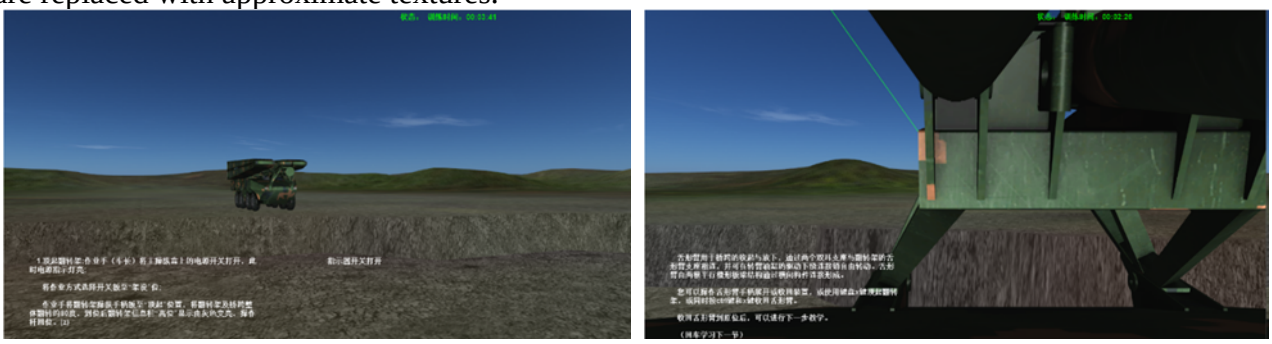

Figure 3. Visual simulation environment

Semi-physical Simulation Console

Overall structure diagram of the control console is shown in figure 4.The driving joystick, steering wheel, control box handles, and buttons and so on of actual equipment directly exert action control on the chassis and operating structure through mechanical, hydraulic or electric control devices. Although the training simulator sets up similar operating interfaces, these joysticks, handles and buttons are all "virtual", which need to convert the actual manipulation information into digital quantity through the software and hardware interface and send it to the simulation computer through coded communication. At the same time, from the perspective of the use of trainers, the interface design should maintain the sense of handle, force and position of the control rods, handles and buttons, etc. During the development of equipment, these aspects have been optimized to meet the

requirements of simulated operation.

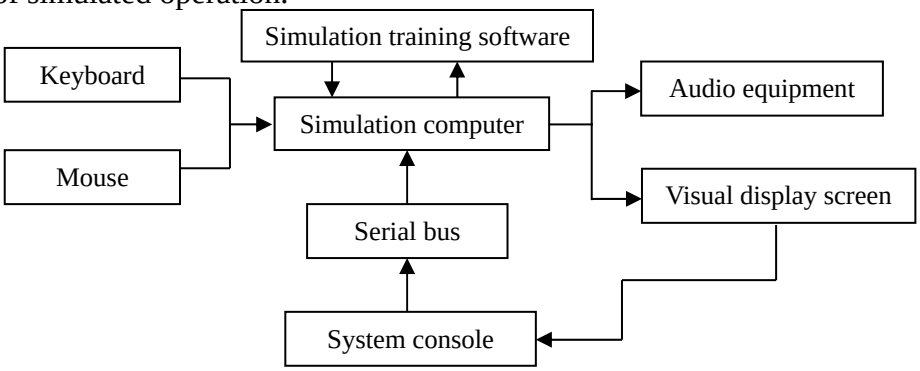

Figure 4. Overall structure diagram of the control console

System Console

The hardware of semi-physical simulation maintenance training system is mainly composed of system console, operation control box and visual simulation computer. The operation control box, visual simulation computer and operation display terminal are installed on the operating table, and the operation process is controlled by operating the control box. The operation process is displayed on the visual display, and all simulation operations are carried out under this interface, which includes several information prompt areas. Figure 5 is the photograph of semi-physical simulation training system console for one type engineering equipment.

Figure 5. Semi-physical simulation training system console

The simulated steering wheel, Joystick, keyboard and mouse are arranged below the display, and the data acquisition circuit and auxiliary distribution equipment are arranged at the back of the panel. The driving joystick is shown in figure 6.

Operation Control Box

The appearance size, handle, button layout and control logic of the operation control box are basically the same as those of the actual control box, as shown in figure 7. The operation control box collects the control signals of the handle and button in real time through the internal control module, transmits them to the simulation computer through the communication interface, and receives the feedback signals to drive the display of the relevant semaphore.

Figure 6. Joystick

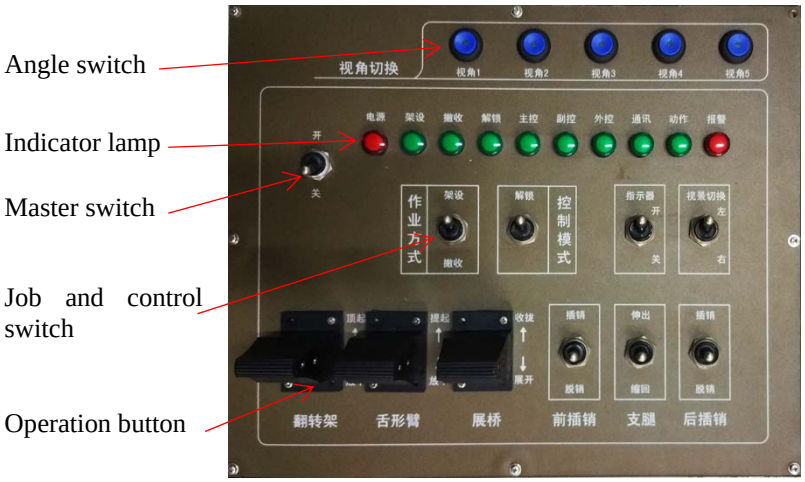

Figure 7. Operation control box

Visual Simulation Computer

In addition to the normal operating system, the specially developed 3d model driver and 3d model library of each moving component of the semi-physical simulation training system are also installed. According to the received instructions, the simulation computer runs the corresponding mathematical model, invokes the control simulation software, controls the output of graphics and sound, and reflects the simulation view and sound effect in real time. The simulation computer uses ordinary microcomputer with wide-screen LCD display screen, arranged in front of the driver.

The main display screen displays the 3d scene of the engineering equipment, the working posture of the operating structure, including the driver's cabin front view, the panoramic view from the side of the car, the local view, the view from the front and the view from the back. The operator can switch the view Angle at will through the switch. The display content of the main display screen is controlled by the operation switch and the main work control box in real time. Operation main interface is shown in figure 8.

Figure 8. Operation main interface

Conclusion

The development of virtual maintenance training system based on the general virtual maintenance training platform of engineering equipment can realize “unified process, common platform and shared data”, avoid repetitive technology research, and improve the degree of data reuse and sharing. On this platform combining semi-physical simulation, virtual reality, and the hardware and software engineering technology, research and development of the semi-physical simulation of engineering and equipment maintenance training system. This system implements the training and evaluation of these subjects, such as engineering equipment structure, working principle, and maintenance and fault exclusion. The training specifications, the training process is reliable and controllable, and the appraisal is automatic and recoverable which can provides trainees with the economical and

applicable training means, and have significant economic benefit and broad application prospects.

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