

# Development Framework for Gantry Crane Training System Based on Virtual Reality

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**Abstract** *With the rapid development of science and technology, and the improvement of production safety and management standards, the use of virtual reality technology to gantry crane operator teaching simulation to train high quality personnel has become a pressing need. This article points out that virtual reality technology will be applied to gantry crane operator teaching simulation, a virtual simulation on the gantry crane operator teaching system and the composition of achieving. This article focuses on the virtual simulation platform for the establishment and adopted by key technologies, introduces the 3D modeling, kinetic analysis of crane, and the control hardware system, and analyzes and forecasts the application of the simulation system.*

**Keywords** *Virtual Reality, gantry crane, simulation training system*

## 1.Introduction

In recent years, the national production safety situation is not optimistic. The gantry crane accidents have occurred occasionally. The main reason is that some gantry crane operators are lack of expertise and operating skills, poor quality of the safety operation, sometimes even wrong operation and so on.

At present, the gantry crane as the category of special equipment in China has established a very sound safety training management system for special operations, but the teaching process and method is much lagged. In the teaching process, as a result of outdated teaching materials and methods, the actual operation conditions is limited, leading to the problem that gantry crane operators did not really acquire advanced theoretical knowledge. The practice of operating capacity is not strong, resulting in ineffective training and mining a large number of potential causes of accidents.

Therefore, it is a pressing task to change the status quo of operating personnel training of the gantry crane, and to improve the quality of personnel in professional and operational skills to ensure the security.

Implementation of the system can fundamentally change the gantry crane operation training status, and improve the training effectiveness and economize resources, and improve the operating personnel quality and safety skills, and improve the existing examination procedures, and eliminate safety incidents occurring due to human factors, and provide technical support for scientific management to special equipment for operating personnel.

## 2.Virtual Reality

Virtual Reality (VR) is the modern hi-tech which can generate realistic visual, hearing, touch the specific scope of the integration of virtual environments with the computer technology. With the necessary equipment, users can interact with the virtual environmental object and exert the impact. In this way, the users can get the immersive experience of the real environment <sup>[1]</sup>.

VR technology is that users can immerse in an artificial virtual environment and then design and complete the mission by interaction with the computers fully through the virtual reality software and its external devices. See its concept in Figure 1.

It combines advanced information technologies (such as network computing, graphics and image processing, multimedia technology, the new sensors, simulation, etc.), and even psychology, bionics, arts and other fields of research. The purpose is to enable people to build an immersion combined with the actual situation, the efficient multi-dimensional interactions and more harmonious human-computer environment.

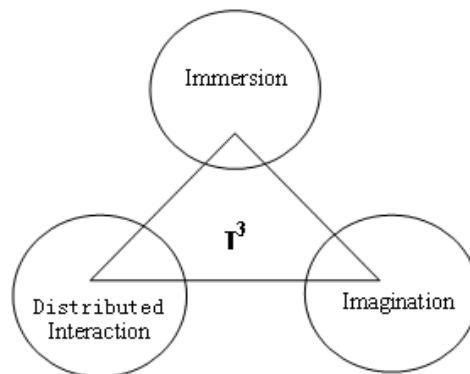


Fig. 1 I3 of VR

### 3. Research of Simulated System on Gantry Crane

The system is developed on OSG system. It is easy to develop all types of VR system.

The simulated system of gantry crane is composed of several parts, including visual system, human-computer system, hardware system. See the function of these parts in figure 2.

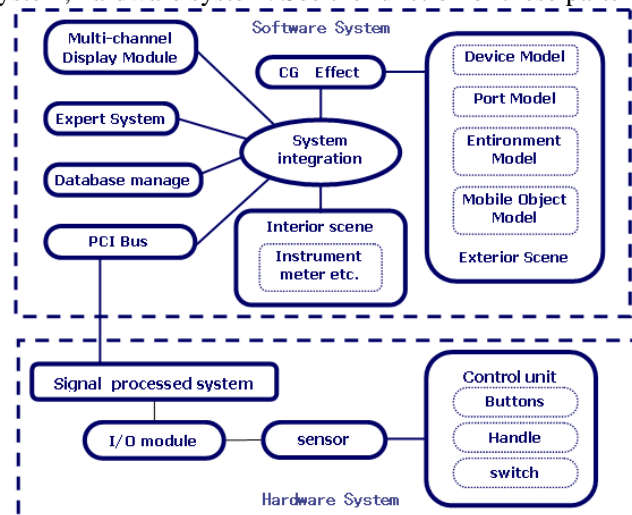


Fig.2 module of function

#### 3.1 Creation of Visual System

The system creates the visual system of gantry crane for the trained personnel. The visual scene includes the exterior and the crane. The factory, material, device and operators constitute the visual scene. And the scene is created by the technology of image processing, such as romance, texture, shade, lighting and so on. These technologies can immerse the operator in the scene. <sup>[3]</sup>

The main body of crane provides suppositional operation platform, and with organic anastomosis of true driver's cage together. The trainee can see operation action's looking at scenery effect in the true cab. See the scenes in figure 3~ 4.

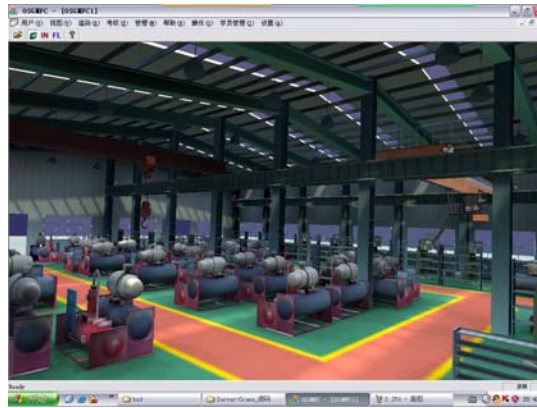


Fig.3 workshop scene



Fig.4 harbor scene

### 3.2 The Research of human-computer Interaction System

In order to obtain the real interactive training effect, the sway simulation testing based on physical property and virtual interactive study are to be carried out for the training and assessment system of gantry crane. They mainly includes:

(1) The research of elasto-dynamics system is to simulate the carrying sway and simulated failures and accidents of gantry crane under the circumstances of different carrying capacity, different braking time, and different running speed and so on. <sup>[2]</sup>

(2) Interactive simulation technology based on the collision detection technology is to achieve the real-time simulation of the gantry crane carrying objects and the collision avoidance of obstacles.

And, the stress analysis of wirerope is the key to solve the problem of carrying sway and collision detection during the carrying process.

Operating condition of gantry machine can be divided into the following parts: the start (i.e. to accelerate movement), the uniform speed movement, the brake (i.e. to decelerate movement). The system does not obtain acceleration during the uniform speed movement, that is, it is easy to carry out real-time simulation since there is no horizontal force attached to a crane and non-sway problem. As for the stage of startup or braking, it will not affect the forces of each other by taking into account the fact that the car and the cart are rigidly connected with the interactive movement.

In order to facilitate the analysis, we only take into account the forces on the wire rope during the running of the car when we analyze. When the car starts running or parking brake, the goods will make a sway which will foist additional horizontal forces on the crane structure. The emergence of such a dynamic load has a certain impact on the operation of the crane and will

produce sway problems. When the dynamic load calculation of the car braking operating is similar to the operation condition of the startup, the additional horizontal force generated is opposite to it.

Therefore, the mechanical condition of different car models and dynamic load calculations can be simplified for the car to start, namely the force analysis and the calculation of dynamic load during the acceleration. See the Fig.5.

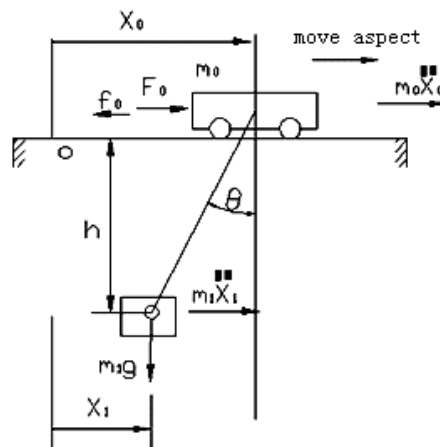


Figure 5 Force Analysis during the movement of the car

The dynamics analysis of large cart can be gradually worked out through the establishment of the above model and we can conduct calculating simulation. This system enables operator's to interact with the three-dimensional scene well. The operator can be trained to move cars or carts, high or low lift hook, and obtain all kinds of safety device skill in various scenes so that the operator acquires preliminary understanding of the basic principles and fundamental of the gantry crane, and experiences essentials to operate the gantry crane and taste the moving mode of all kinds of safety devices,.

### 3.3 The Research of Hardware Control System

Based on the present operating room of the gantry crane, the research of the system utilize the sensor, the data communication and acquisition techniques to design and develop a set of controlling and demanding system in accordance to a general-purpose gantry crane control mode (Controller mode), through which each sensor can collect control signal, and connect the main correspondence line through the interface I/O.

The hardware control system collect various types of control lever, button signal and control signal to put on processing through the transferring relevant dynamic link storehouse. The transferring procedure is as follows:

```
Hplx = pciclose(hplx)
Public hplx As Long
Public addr As Boolean
Public dwVendorID As Integer
Public dwDeviceID As Integer
Public fUseInt As Boolean
```

Apart from the signal acquisition system, the hardware control system also includes the driver's cab structural design, reasonable layout of the control box, and display devices, sensors, power supply, as well as the location of signal alignment, and so on. On the basis of the above, we focus on the timeliness and anti-jamming of the operation signal.

Through the research and integration of the above systems, we can enable the trainees to interact directly with the control system. The operating movement signal is gathered by the control system and carried on the real-time processing, then the control visual system responses and gives feedback to the trainee via display device of the visual system. Meanwhile the

operating movement signal is simultaneously delivered to the system of training and assessment, which enables the experts system to make judgments on the operating movements which provide the fundamental basis for the final appraisal training. These four modules are organically linked together to provide users with realistic training environment.

#### 4.The Application and Merits of Virtual Reality in Training

The system is a set of simulation operating system used in the hands-on training, skills training, safety education and practice of the gantry crane. It mainly promotes or improved the effects of training and assessment of the gantry crane operator in following aspects.

(1) The use of the immersion of virtual reality to improve the understanding of the structure and working principle of the hoisting machinery.

2) The use of the interactivity of virtual reality to enhance the actual ability of operating personnel.

3) Accident reappearance and case analysis

The trainees may observe and analyze their own hands-on training process through on-site reappearance during the operation training process, especially when there occur glaring errors, such as a collision, hitting obstacles, gnawing rails, and safety devices movements. The use of the reappearance effect can help to determine and analyze the reasons for the error. It is suitable for students without any experience of operating gantry crane to carry out hands-on training, and some green hands who have qualified to be operators to conduct the actual practice.

Compare with the previous methods of training and assessment, the simulation operating system of the gantry crane based on the virtual reality technology will have a powerful functions. The advantages are as follows in terms of conducting training, assessment, education of security techniques:

1) Be able to set a variety of conditions conveniently, efficiency, economy and high security

Compared by calculating, the training in terms of the present system can consumes only about one kilowatt in energy and occupies an area of within 10 square. While the previous real vehicle training consumes over 20 kilowatts in terms of energy and occupies over 200 square. If 3,000 persons will be trained each year in our city and 40 hours will be spent on each person per training hours, the present system only in terms of energy consumption will be able to save:

$$(20-1) \times 3000 \times 40 = 2280000 \text{ kilowatts hour}$$

In terms of the current electric charge of 0.5 Yuan/ kWh, the total savings on electricity amount to 1.14 million Yuan.

2) Good reproducibility

The factors concerning the working and operating conditions of the gantry crane is hard to manage, so the reproducibility of the real vehicle test is poor. While gantry crane simulator based on virtual reality technology can conveniently carry out the data acquisition, model selection and the environment settings of simulation model with a good reproducibility.

3) High Security

High-speeding and maximal driving, as well as very dangerous safety experiment can be safely carried out with the Utility of the simulation operating system of gantry crane, which cannot achieve in the real vehicle experiment.

#### 5.Conclusion

The virtual reality technology is an integrated multi-disciplinary technology. Its basic philosophy is to use the method of modern science and technology to create artificially a virtual space in which people can achieve interaction such as watching, listening, and moving and so on, just like in the real environment. The users may enter this environment through the computer and can control and interact with the object in the system with timeliness and interactiveness in the three-dimensional environments as its chief features.

The application of the virtual reality to the gantry crane operating personnel training is to design the idea of virtual scenes and conceive it to be viewable and feasible; to achieve the vivid spot effects; to provide simultaneously all kinds of direct-viewing and natural sensation interactive method such as the sensations of hearing, seeing, touching, etc. through the computer user's connection; to utilize the computer simulation trainer to train the operating personnel to the full while shorten the training cycle, and reduce the training expense, thus enhance training quality and efficiency of gantry crane operator.

Developed gantry crane virtual training system which based on virtual reality technology achieves good results in the process of actual use.

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