Development on Equipment Operation Training and Intelligent Maintenance System based on Virtual Reality (VR) Technology for the Passenger Boarding Bridge

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Abstract. In order to improve the automation level of passenger and freight ro-ro terminals and to build smart ports, an equipment operation training and intelligent maintenance system based on VR technology for passenger boarding bridges was developed. The system mainly includes VR operation guidance subsystem, data support and service subsystem, network connection and transmission subsystem, boarding bridge operation training subsystem and operation condition monitoring and diagnosis subsystem. This system can realize intelligent training of the boarding bridge and full-time operation condition monitoring.it will greatly improve the efficiency of operation and maintenance of boarding bridge.

Keywords: Virtual Reality; Operation Training; Passenger Boarding Bridge; Intelligent Maintenance.

1. Introduction

Virtual Reality (VR) is a new practical technology, which integrates the latest development results of the computer graphics (CG) technology, the computer simulation technology, artificial intelligence, sensing technology, display technology and network parallel processing technology. It is a high-tech simulation system generated by computer technology.

With the continuous development of social productivity and science and technology, VR technology and big data fusion for realizing the whole life cycle of equipment management is gradually applied to aerospace, automobile manufacturing and other high-tech fields as shown in Figure 1.

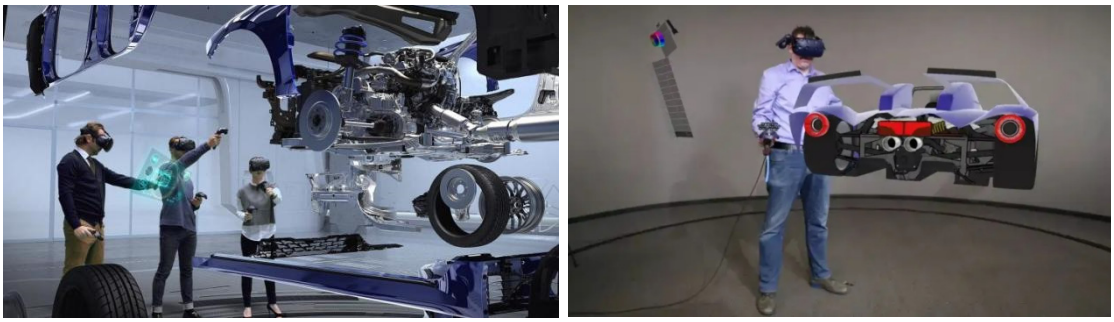


Figure 1. VR technology applied in automotive industry

As the most important equipment as shown in Figure 2 in the passenger and freight ro-ro terminals, the full cycle application of the operation process and status data of the passenger boarding bridge is of great significance to improve the high quality operation of the ro-ro terminals.

In order to enhance the management level of the passenger boarding bridge in ro-ro terminals, in this paper the passenger boarding bridge was introduced. The system based on VR technology for passenger boarding bridges was developed to enhance the level of equipment operation training and intelligent maintenance.



Figure 2. The passenger boarding bridge

2. Composition of the Passenger Boarding Bridge

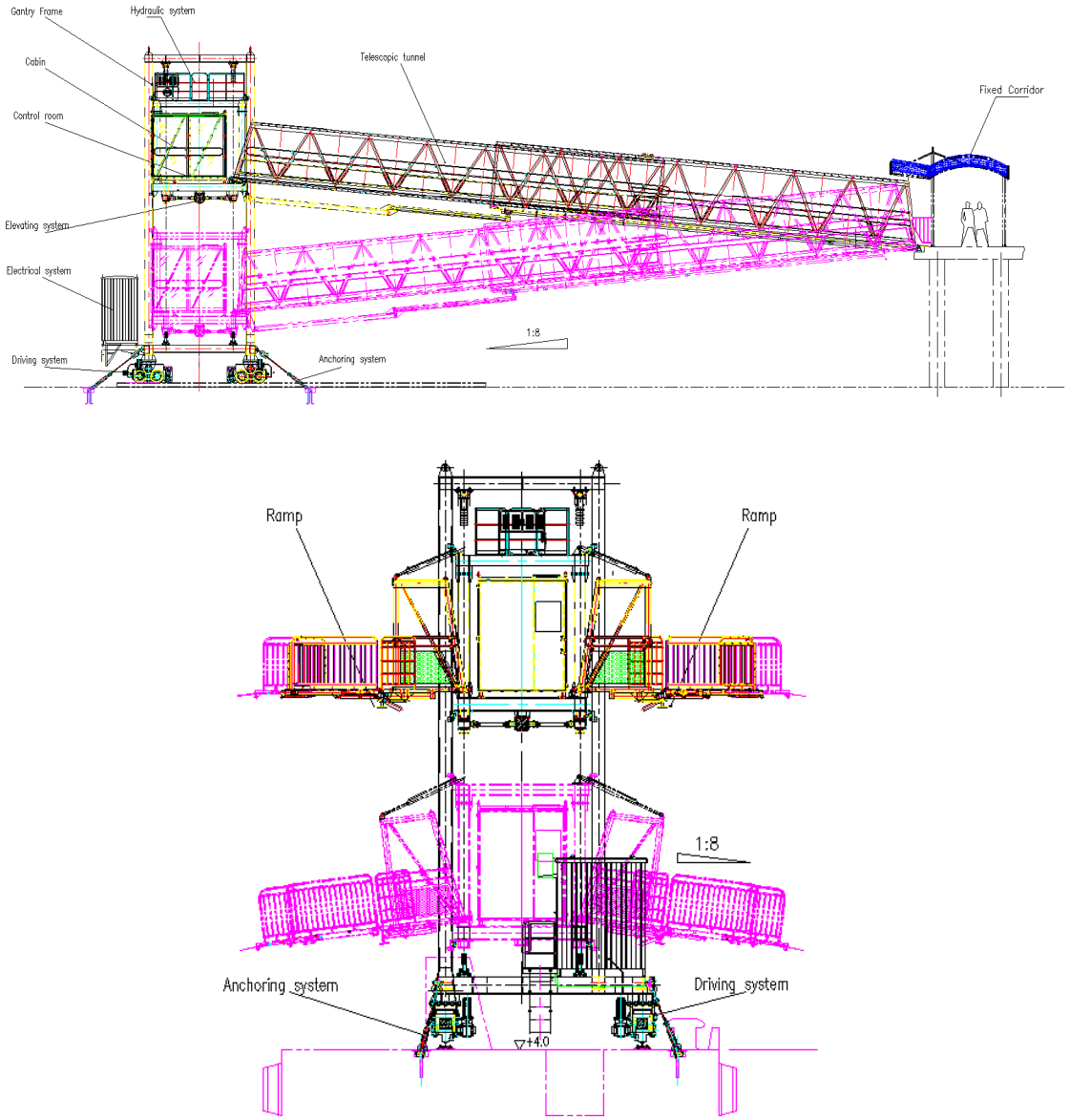


Figure 3. Schematic diagram of the boarding bridge with dual ramps

The passenger boarding bridge is specially designed for passenger and cargo rolling wharf. It is used for picking up and unloading passengers. It is mainly composed of the telescopic channel along the bank, turning channel, two docking channels, the mobile docking ramp, the walking mechanism, the screw lifting mechanism, the hydraulic system and the electrical system as shown in Figure 3. One side of the telescopic channel is connected with the fixed corridor of the wharf, and the other side is scalable under the drive of the walking mechanism to facilitate ships at different locations. Passengers can come out from the dockyard and pass through the fixed corridor of the dock, the expansion channel along the shore of the boarding bridge, the turning channel, the receiving channel 1 (or 2), and the ramp to the ship deck.

3. Framework of the VR-based Training and Intelligent Operation and Maintenance System

Based on full functional requirements analysis of the development and integration for the boarding bridge in the area of equipment training and running state monitoring, the frontier technology such as virtual reality technology (VR), big data and intelligent perception interaction were adopted. The system has the functions of three-dimensional model resource import, scene editing and resource merging, different scene model editing of boarding bridge, multi-view switching, model search and layout, and three-dimensional model cognitive annotation. It can meet the needs of boarding bridge equipment training and operation and maintenance.

The virtual three-dimensional structure model of the boarding bridge through Adobe Photoshop, Autodesk 3D Max and other modeling software were constructed. Based on the Android basic platform and VR virtual reality engine platform, a VR-based boarding bridge equipment training and running state operation and maintenance system was developed to realize the immersion training and equipment operation maintenance of the boarding bridge equipment. The framework of the VR-based training and intelligent operation and maintenance system was shown in Figure 4-6.

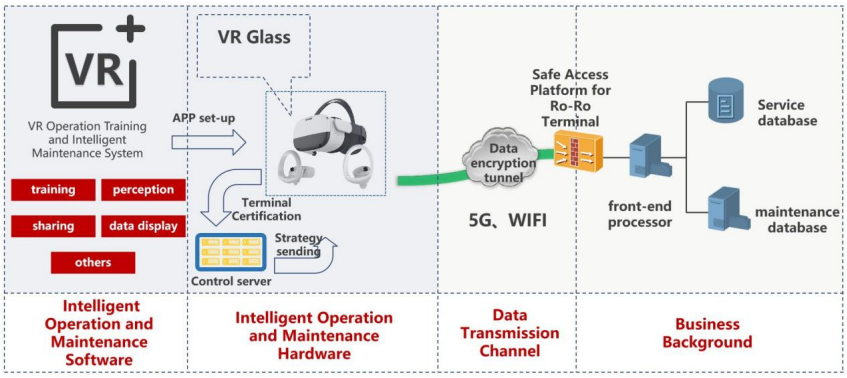


Figure 4. Framework for the intelligent operation and maintenance system

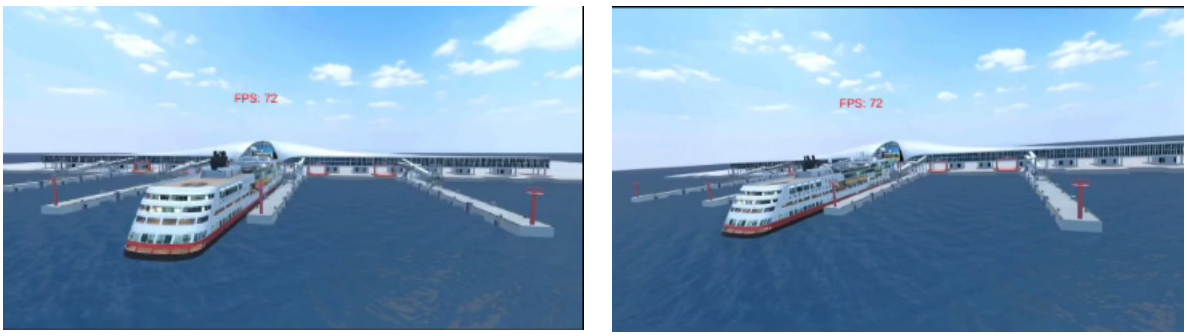


Figure 5. Integral model of passenger rolling wharf

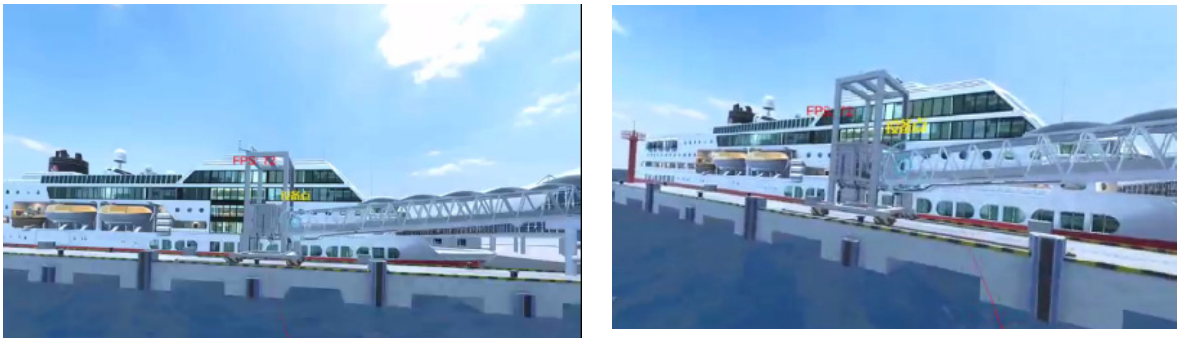


Figure 6. 3D model of boarding bridge



Figure 7. VR model of the boarding bridge ramp

4. Operation Training and Operation and Maintenance System Development of Boarding Bridge Equipment

This system mainly includes VR operation guidance subsystem, data support and service subsystem, network connection and transmission subsystem, boarding bridge operation training subsystem and operation condition monitoring and diagnosis subsystem. The software functions are shown in Figure 8.

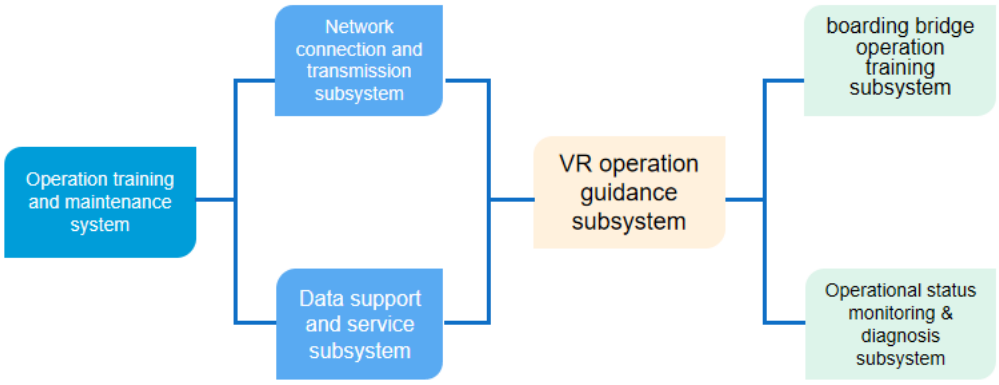


Figure 8. System Software Function and Extension

4.1 VR Operation Guidance Subsystem

This part of the subsystem is mainly composed of the head-mounted system, the back-loaded computing unit, the data transceiver module, the processing software and local data. Among them, the head-mounted system includes the helmet display as shown in Figure 9,the headphone, the microphone and the power supply. The system mainly realizes the capture and positioning of the real

operation scene and the fusion display of the real scene and enhanced information. Wearable computing unit mainly completes target recognition, registration, human-computer interaction, virtual-real fusion processing and data interaction with servers and experts. The parameters for the VR helmet were shown in Table 1.

Table 1. Requirements for the VR Integrated machine

Category	Content
Display Type	VR Integrated Machine
Refresh rate	120Hz
Resolution	3664×1920
Perspective	98°
Hardware Configuration	Qualcomm XR2 Platform Memory: High speed 6GB Flash Memory: 256G version 256GB UFS 3.0 System: Android 10
Configuration Requirements	Operating System: Windows 10 (64 bit) and above CPU: Intel Core i5 - 4590 / AMD FX 8350 with the same perfor mance and abov Video card: NVIDIA GeForce GTX 970 / AMD RX 480 has the s ame performance and above Memory : 8GB RAM and above Network Card: Gigabit Network Card Network wire: CAT-6 Gigabit six network wire Router: Double Gigabit Router
Communication	Wifi
Input interface	USB 2.0
Weight :	395g



Figure 9. VR helmets with two operating handles for the systems

4.2 Data Support and Services Subsystem

The system is mainly composed of data server and its database and data management and application software, which is used for permission control, data storage, management, customer, expert information management, customer request processing, data analysis, service evaluation, etc., to provide service support for field operators and remote experts. Database storage content includes user information, product operation manual (such as assembly instructions, maintenance manual), the case database, the virtual prototype model, the expert knowledge base, customer and expert information.

4.3 Network Connection and Transmission Subsystem

This subsystem is responsible for connecting the VR operation guidance subsystem with the running state monitoring and diagnosis subsystem. TCP / IP protocol was applied to achieve handshake and data transmission at both ends. This project uses the wireless network connection form to realize the communication and data transmission between the operation guidance subsystem and other systems.

4.4 Boarding Bridge Operation Training Subsystem

This subsystem is divided into the main menu, the immersion tour, knowledge learning, driving tour and product introduction modules as shown in Figure 10. In the process of operation training, the trainees can wear VR helmets to achieve their immersive driving experience, which can improves the effect of boarding bridge training and enrich the connotation of boarding bridge training.the immersion tour mode can provide users with a global perspective. Trainees can learn the structure of each part of the boarding bridge in detail from knowledge learning and product introduction mode. The driving tour module can provide a first-view driving experience for users, which can intuitively learn the driving use of the boarding bridge.



Figure 10. System main menu and training operation scene

4.5 Operational Status Monitoring and Diagnosis Subsystem

The system can establish a network connection with the server and remote operators, the required information can be downloaded from the server through the Interne. And the image, voice, and text information sent by the data support and service subsystem can be received, and the real scene images captured by the front-end operator and the enhanced images after virtual superposition in a local way can be displayed. Experts can freely browse the real environment and model information, change the observation angle, and even split the model. Keyboard, mouse and somatosensory input are used to

indicate the next step, and the indicator information is transmitted back to the field operator as shown in Figure 11.



Figure 11. Operation condition of the passenger boarding bridge

In the process of equipment maintenance, the staff can choose the corresponding component description in VR glasses to guide the staff to carry out on-site maintenance for training and standardizing the maintenance process as shown in Figure 12.

In the VR mode, in order to better judge the equipment failure, the digital twin function can be selected next to the fault parts, that is, to display a normal part content, and the two can be compared to find the fault or assist in judgment. The function of this part is also applicable to the inspection and maintenance of equipment in the operation and maintenance inspection of boarding bridges.



Figure 12. Gearbox Model used for Field Personnel Maintenance

5. Conclusion

The VR-based boarding bridge equipment training and operation and maintenance system developed in this project can provide immersive training experience in the operation training stage, and improve the training efficiency and effect. At the same time, in the actual operation, it can provide real-time operation guidance for field operators, automatically collect, record and transmit data to the " big data center " for analysis and processing. Through the remote consultation function, it can assist the field to solve the operation problems, realize the intelligent operation and management of the

boarding bridge can be realized, and the management level and work efficiency of equipment operation and maintenance can be improved .

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