Title:
Research on Virtual Reality System of Gantry Dual-arm Welding Robot

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Introduction:
In the ship automatic welding industry, the staff welding robot monitors the automatic welding motion state [1]. However, the working environment of welding is relatively poor. Therefore, it is of certain significance to realize the remote monitoring of ship welding [2], so as to improve the working environment of staff. At present, the collected welding data will be displayed on the computer. The on-site staff can master the automatic welding data by observing the computer [3][4].

In this paper, a method of creating kinematic digital twins in virtual reality [5][6]is proposed to realize remote monitoring of the motion of gantry welding robot. This method establishes the virtual model corresponding to the real equipment with the help of solid works and 3DMAX, assembles the model in unity3d, develops the remote client, and establishes the virtual environment corresponding to the real environment. The motion data is obtained in real time from the site, transmitted to the site computer, and finally transmitted to the remote client through the Internet. Data processing is carried out in the remote client to achieve the effect of synchronous movement with the scene. Through case analysis, this method can be used for kinematic modeling of digital twins, and then realize the monitoring of welding motion.

Method of creating kinematic 3D model based on real-time position data:
The general idea of this method is shown in Figure 1. This method mainly realizes the synchronous movement of virtual environment and actual environment. This method adopts C / S architecture mode. In the C / S architecture mode, the data processing is completed in the application layer, and the transmission layer only needs to transmit the motion data, which can reduce the delay. This method consists of four main parts. One is the development of virtual monitoring terminal, which mainly realizes the establishment of virtual reality environment. The second is to collect the field data in real time. The third is to send the collected data to the remote virtual monitoring terminal through the Internet according to a certain protocol format. Fourth, complete the data receiving and processing in the virtual environment, and realize the synchronous movement with the real environment.

Virtual environment establishment:

The establishment of virtual environment is to establish a 1:1 virtual environment according to the real-world equipment. The establishment of virtual environment is the first step of the whole method. This method uses SolidWorks as a modeling tool.

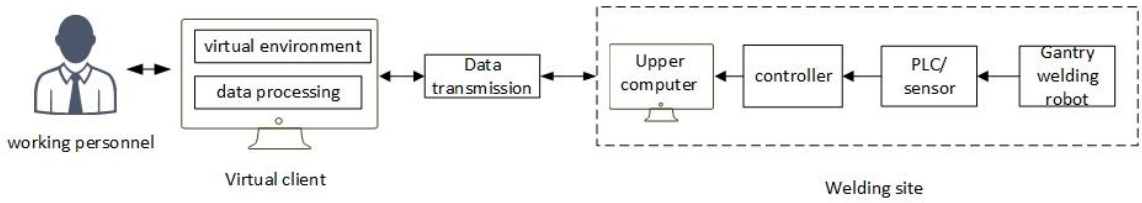

Fig. 1: Overall scheme design.

However, the 3D model drawn by solid works cannot be used by unity3d, so 3DMAX 3D model software should be used as intermediate software to process and convert the model. Save the model drawn by SolidWorks as Sta format, imported into 3DMAX. In 3DMAX, the unimportant components in the model are reduced to reduce the size of memory occupied by the model, increase its operation efficiency and reduce latency. After processing in 3DMAX, save as FBX format and import into unty3d.

After the model is imported into unity3d, the relationship between each model is independent and does not conform to the actual motion relationship. Therefore, according to the actual motion relationship, the parent-child relationship between models is designed. The design principle is that the motion of the parent object will drive the child object to do the same motion, while the motion of the child object will not affect the parent object.

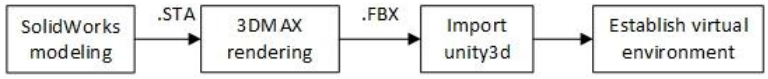

Fig. 2: Virtual environment establishment process.

Real time data acquisition:

Gantry welding robot consists of three parts: gantry welding robot body, controller and teaching pendant. The gantry robot body is composed of driver, transmission mechanism, joint, internal sensor, etc. The controller is the core of controlling the movement of gantry welding robot. It is composed of computer software, hardware and some special circuits. It has the function of collecting and storing data information. Various data information during the movement of gantry welding robot are stored in the controller. The process of gantry controller collecting data information is shown in the figure 3 .

In the process of data acquisition, the gantry welding robot controller sends the data to the application layer. The application layer adds necessary control information and transmits it to the transport layer. The transport layer adds control information and transmits it to the network layer. The network layer adds control information and transmits it to the network interface layer. The network interface layer transmits data to the host computer. Each layer in the upper computer completes the decoding of different forms of data according to the agreed protocol to realize the data collection

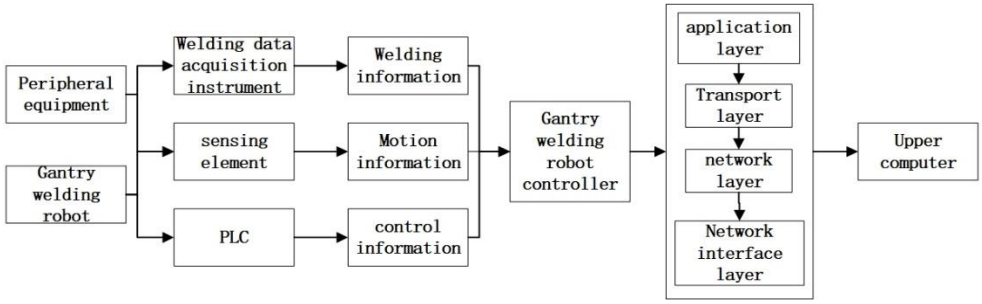

Fig. 3: Real time data acquisition process.

Real time data transmission:
In order to realize the remote monitoring of gantry welding robot, the upper computer needs to send the data information to the remote monitoring end in real time. The upper computer and virtual device use TCP protocol for data transmission. The connection between host computer and remote virtual client is realized by server. On the host computer, initialize a socket and send a connection request to the server. Start the thread to send data, package the data information into data packets according to the protocol format, and send them to the server. A socket is initialized on the server side, the thread is opened to monitor the request of the host computer in real time, and wait for the communication connection with the host computer. After the connection is established, start a new thread to complete the data receiving and forwarding function and send the data to the virtual client.

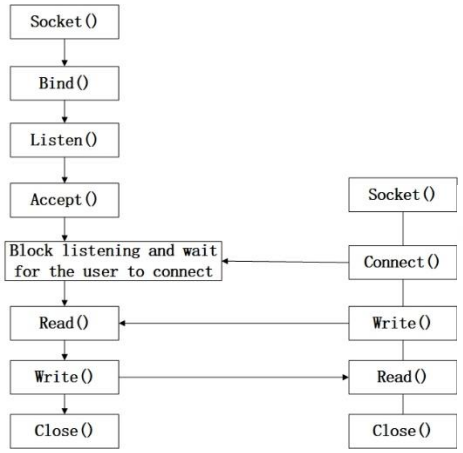

Fig. 4: Real time data transmission process.

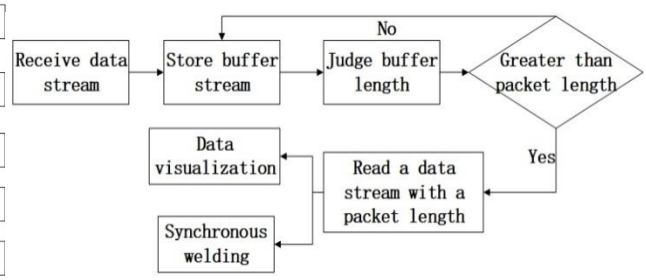

Fig. 5: Real time data receiving process.

Real time data reception:
After receiving the data packet sent by the host computer, the server forwards it to the virtual client through the Internet. The virtual client receives and processes the data, achieves the effect of synchronous welding with the site, and realizes data visualization. A data buffer is designed in the virtual client to store the data stream from the server. Judge the data stream length of the buffer in the virtual client. If it is greater than the length of a packet, read it, otherwise wait for reading. After reading a data packet, first read and judge what type of message its packet header is, and then read the data stored in the packet body. The read data is used to realize visualization and synchronous welding.

Case application:
Taking a weldment welded in a small and medium-sized assembly of a ship as an example, the method of creating kinematic 3D model based on real-time position data is verified. The verification process is carried out in the steps of the method. Figures 1 to 3 show the modeling process of the virtual environment, and Figure 4 shows the process of restoring the motion of the gantry welding robot in real time. As shown in figures 6 to 7.

Conclusion:
The case application shows that in virtual reality, the motion process of welding is restored based on real-time data. The method includes four parts. 1： Virtual client development; 2： Real time data acquisition; 3： Real time data transmission; 4： Real time data receiving and processing.

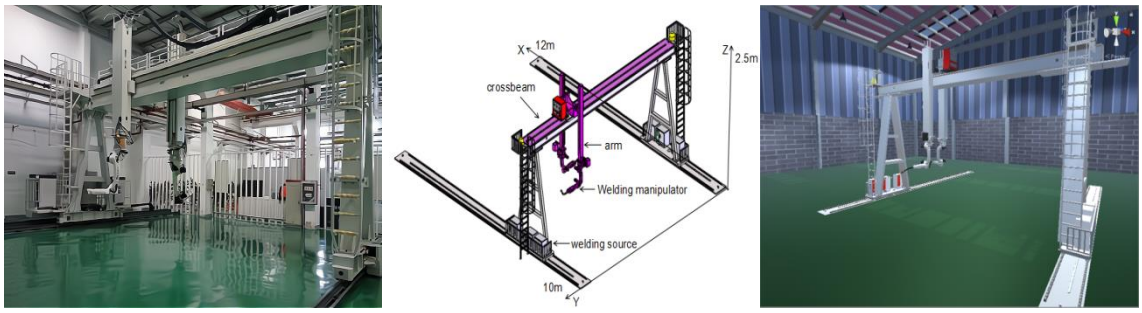

Fig. 6: There are three angles: (a)practical environment, (b) Solid-Works, (c) virtual environment.

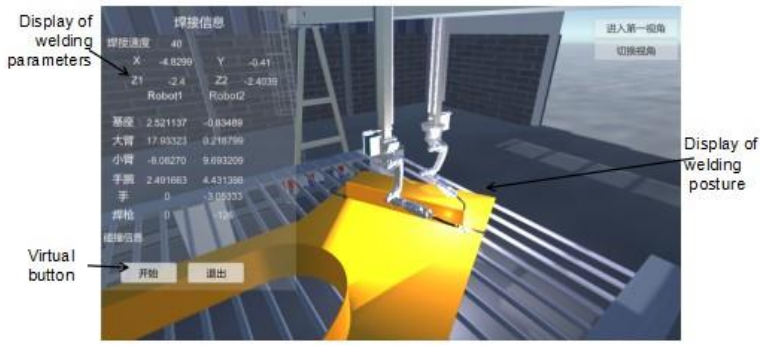

Fig. 7: Real time restoration process of motion information.

References:

[1] Locatelli, G.; Dutra, J. C: An integrated system for data monitoring and differentiated control of welding processes, Welding International, 24(7), 2010, 524-532. https://doi.org/10.1177/0142331217700703

[2] Afroz, A. S.; Digiacomo, F.; Pelliccia, R.: Optimization of a wearable speed monitoring device for welding applications, The International Journal of Advanced Manufacturing Technology, (5/6), 2020.

[3] Baraka, A.; Panoutsos, G.; Cater, S.: A real-time quality monitoring framework for steel friction stir welding using computational intelligence, Journal of Manufacturing Processes, 20(Oct. Pt.1), 2015, 137-148. https://doi.org/10.1016/j.jmapro.2015.09.001

[4] Mota, C. P.; Machado, M. V. R.; Neto, R. M. F.: Near-infrared vision system for monitoring arc welding processes, Welding International, 29(1/3), 2015, 187-196. https://doi.org/10.1080/09507116.2014.932975

[5] Ren, F.; Sun, Y.; Hu, Q.; Li, Z.; Sun, P.; Fan, Y.: Hardware-in-the-Loop Simulation System for Underwater Vehicle Based on Unity3D, Journal of System Simulation, 32(8), 2020, 1546-1555.

[6] Luo, Y.; Fang, Z.; Guo, J.: Research on the virtual reality technology of a pipeline welding robot, Industrial Robot, 48(1), 2021, 84-94. https://doi.org/10.1108/IR-04-2020-0074