Virtual and real integrated industrial robot laboratory research

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Abstract: Virtual simulation technology has been widely concerned in the digitization of education. In this paper, a virtual and real integrated industrial robot laboratory was built in virtual simulation software. The laboratory consists of three parts: basic experiment area, comprehensive application experiment area and extended exhibition area. The laboratory can realize online and offline synchronous teaching, which improves the accuracy and safety of operation.

Key words: Virtual-real integration; Industrial robot; laboratory

1 Introduction

As early as 2012, the Ministry of Education issued a document on the Ten-year Development Plan for Education Informatization (2011-2020), which mainly promotes the popularization and sharing of high-quality educational resources, promotes the deep integration of information technology and education and teaching, and improves the quality of teaching. In 2022, the Action Plan for the Integrated Development of Virtual Reality and Industrial Applications (2022-2026) jointly issued by the Ministry of Industry and Information Technology and the Ministry of Education pointed out that virtual reality technology is an important development frontier direction of information technology, and proposed 10 "virtual +" multi-scenario applications. Among them, "virtual reality + industrial production" and "virtual reality + education and training" are used in production and teaching as an important part, becoming the vane of production and education. The rapid development of intelligent manufacturing has led to the wide application of industrial robots, and how to train robot professionals to meet the production needs is becoming more and more important. Experimental and practical training teaching equipment plays an important role in robot education, but the high cost and limited resources make the practical opportunities for students limited, the traditional teaching methods also limit the students' in-depth understanding of theoretical knowledge and the cultivation of practical application ability. The application of virtual simulation technology in the field of robot teaching represents a great progress in education technology. Virtual simulation technology can reduce the dependence on physical equipment, reduce misoperation, improve safety, and provide a more efficient, safe and cost-effective teaching method.

Through virtual simulation technology, real enterprise scenarios and operating environments can be constructed, teaching and actual production can be linked, and the needs of both theoretical and practical operations can be met. Lu Ye et al. Aiming at the difficulty of hybrid automated production of small and medium-sized parts, adopted RobotStudio virtual simulation software to obtain the position and pose of the workpiece by applying visual functions, and realized a workstation based on visual sorting and grinding through Smart component design and simulation. Many researchers used RobotStudio software to build a virtual simulation platform for industrial robot handling, and found that virtual simulation was of higher quality than on-site teaching. Jiang Kuisheng et al. Designed an automatic production line visual monitoring system to solve the problems of small and medium-sized production lines unable to grasp the real-time production information and low visualization. The system built a digital model and completed real-time data collection and real-time production mapping based on OPC UA to realize visual production operations. Liu Qinghua et al. Used Unity3D virtual environment to build a six-degree of freedom robot, and realized the synchronization of robot actions and virtual actions through socket connection.

Virtual simulation can make theoretical knowledge more concrete and practical operation more scene-like. Liu Zhilin et al. Used Unity3D to build a virtual robot arm and integrated forward kinematics and inverse kinematics calculation knowledge into it. Through immersive experience of VR equipment, the virtual robot arm and the real robot arm interacted and cooperated. Kang Guopo et al. Built a workstation model for the robot assembly workstation, conducted program design, communication setting, PLC linkage and verification, and effectively improved the assembly efficiency by 18.75% after optimization. Zhao Junying et al. Used Tecnomatix software to build a digital twin model of an industrial robot, aiming at the shortcomings of inconsistency between virtual and actual movements of the experimental platform and large amount of calculation. Through data collection and processing, coordinate system calibration and virtual and real synchronous control of robot movements and peripheral devices of the experimental platform could be carried out.

2. Overall design of virtual and real industrial robot laboratory

The virtual and real integrated robot laboratory is shown in Figure 1, including: basic experiment area, comprehensive application experiment area, expansion exhibition area. The three parts are differentiated and connected with each other, from shallow to deep, from single machine to system, and the technology has continuity. From the experimental platform simulation to the actual production field application, from industrial robots to special robots, so that students gradually master robot technology, industrial robot field application and operation, industrial control and motion control and other practical robot technology.

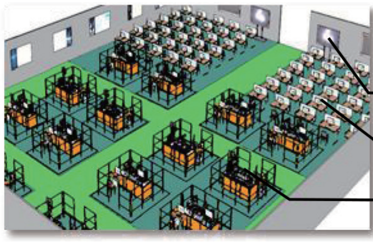

Figure 1 Virtual and real integrated robot training room

3 Virtual and real integrated industrial robot laboratory zoning design

3.1 Basic experiment area

The basic experiment area is mainly equipped with 60 computers, 60 sets of desks and chairs. The area mainly focuses on software operation and virtual simulation. Multiple computers are convenient for students to carry out virtual imitation real operation training online, which helps students to initially understand the comprehensive knowledge of robots. The virtual simulation platform of workstation is installed in the computer, and the 3D model of robot workstation is imported into the virtual simulation software of RobotStudio. For each training module, the simulation logic design, sub-component composition, attribute and signal connection, and signal interaction with the workstation are completed in the virtual software, among which the most complex Smart component is configured. Finally, pull and show the instructor to demonstrate the operation and verify its accuracy. Industrial robot RobotStudio virtual simulation software, in the software for several simulations, when fully master the operation skills, then the actual operation training. The basic experiment area is shown in Figure 2.

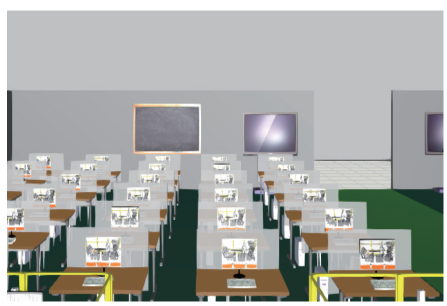

Fig.2 shows the basic experiment area

3.2 Comprehensive application experiment area

As shown in Figure 3, the comprehensive application experiment area is mainly composed of 16 workstations, each workstation contains 1 industrial robot, 1 protective grating, 1 operation module, 1 simulation welding module, 1 trajectory path function module, 1 grinding module, 1 assembly module, 1 palletizing module, 1 visual inspection system and 1 robot tool module. Each workstation is connected to a computer and equipped with a set of tables and chairs. The activity area of each workstation is securely isolated by a set of protective guardrail. The comprehensive application experiment area is mainly to simulate the hands-on operation of the robot and run according to the programming.

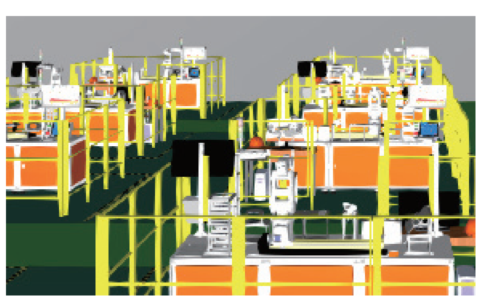

FIG. 3 Comprehensive application experiment area

(1) Industrial robot

The industrial robot on the workstation is IRB120 model produced by ABB. It can meet the requirements of course teaching, skill level assessment and 1+X training and assessment. IRB120 industrial robot combined with the surrounding automation mechanism can realize the robot palletizing, handling, welding, grinding, assembly and other operations, while equipped with machine vision system to guide the robot to work. The workstation is equipped with intelligent storage, which can carry out sensor and PLC debugging training and other operations.

(2) Simulation welding module

The simulated welding module configured on the workstation mainly performs welding operations. The workstation is equipped with a positioner, which can assist welding and find the best welding position. The positioner is driven by a motor and can be rotated with the workpiece to be welded. When welding, it is necessary to comprehensively consider welding materials, weld size and status quo, welding requirements, etc. Common welding in production are: CO2 gas shielded welding, argon arc welding, submerged arc welding, wire arc welding. In the practical training operation, it is necessary to clarify the welding speed, welding current, voltage, etc., according to the welding requirements, and set the parameters of welding starting point, welding end point, welding length, and interval on the demonstrator.

(3) Grinding and polishing module

The grinding and polishing module configured on the workstation is mainly composed of sand belt, a driving wheel, three driven wheels, motors, tensioning devices, etc. The irregular quadrilateral can be driven by the motor to run one-way. The principle of grinding and polishing is to remove the damaged layer when polishing with the maximum polishing rate. In order to prevent the abrasive belt from slipping and increase the stability of the abrasive belt during grinding and polishing, a tension device is designed in the grinding and polishing module. When grinding and polishing, it is necessary to consider the linear speed of the sanding belt, motor power, speed range and protection level, whether the motor works continuously or indirectly, and whether the working environment is clean or dusty. After the robot three-claw clamp holds the workpiece, it is close to the high-speed rotating sanding belt, and then analyzes the working face that needs to be polished and polished. The trajectory design of the polishing surface needs to be polished is carried out. When the workpiece is in contact with the grinding wheel, the robot six axes coordinate to make the workpiece completely contact with the sanding belt to ensure the grinding and polishing quality.

(4) Trajectory path module

Robot trajectory path module is mainly suitable for the application of common motion instructions, to achieve linear motion and circular motion. It mainly involves the programming of MoveJ, MoveL, MoveC, MoveAbsJ and other instructions, as well as the establishment and application of tool coordinate system and workpiece coordinate system. The shape of the trajectory path simulation board mainly includes circle, regular hexagon, straight line and semi-circular groove pattern formed by two semi-arcs, and irregular circular arc pattern formed by several irregular arcs.

(5) Assembly module

The assembly module mainly consists of tangram assembly and gear assembly, which mainly cooperate with vision and can detect the color and shape of tangram and be placed in different grooves according to requirements. Gear assembly has big gear, pinion, robot with three claw clamp to take the big gear into the positioning hole of the big gear, and then take the pinion into the positioning hole of the pinion, and then put the assembled pinion clamp back to the raw material plate, and then put the assembled big gear clamp back to the raw material plate, to complete the assembly task. The two assembly tasks have the characteristics of small assembly gap and high positioning accuracy. They all use three-claw clamp. The hole in the three-claw clamp requires a smooth clamping of the workpiece. If it is slightly inclined, it will lead to too much installation gap and can not accurately reach the position to be placed after assembly.

(6) Palletizing module

Handling palletizing is an important learning task in practical training. Mainly put the cuboid goods according to the requirements. There are 14 cuboids configured in this module, and the cuboid is drawn one by one and placed on the other side with the suction cup fixture. Mainly involved in the Set, Reset, OFF, FOR, TEST and other instructions programming, as well as the tool coordinate system, workpiece coordinate system establishment and application. According to the different placement of palletizing, the common palletizing is divided into three flower palletizing and five flower palletizing. According to the number of different layers of palletizing, palletizing is divided into single layer palletizing, double layer palletizing and multi-layer palletizing. According to the different position of palletizing, palletizing is divided into palletizing and unpalletizing.

3.3 Expanding Display area

The extended display area includes a cultural wall and an electronic screen. The cultural wall mainly describes the safety operation procedures and precautions of industrial robots, and describes in detail the common brands of industrial robots at home and abroad. The electronic screen can display the real cases of industrial robots.

4 Summary

This paper uses virtual reality technology to build a robot virtual laboratory, which is divided into three parts: basic experiment area, comprehensive application practice area, expansion exhibition area. The basic experiment area is equipped with computers mainly for virtual simulation and practical training, the comprehensive application practice area is mainly composed of 16 workstations to complete the robot teaching operation, and the extended exhibition area is mainly for robot case display. From virtual software, virtual real operation to the last typical cases, the whole robot lab is arranged in the hierarchy from easy to difficult. Virtual and real integrated robot laboratory can realize online and offline synchronous teaching, improving the accuracy and safety of operation.

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