Research on simulation platform of intelligent production lines

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Abstract. In order to improve the ability of teachers and students to comprehensively apply intelligent production line technology, this paper provides an intelligent production line simulation method and system, which can simulate the operation of intelligent production line, and is easy to control and has lower cost, so as to meet the teaching needs of cultivating intelligent production line application talents. This paper introduces the development technology and implementation method of intelligent production line based on C language of single chip microcomputer.

1. Introduction
In order to accurately connect talent training projects in the field of intelligent manufacturing, meet the demand of intelligent industry for application-oriented technical talents, and improve the comprehensive application technology ability of teachers and students, schools and educational institutions need some teaching equipments for intelligent production lines involving machinery, electricity, pneumatic, hydraulic, robot and PLC to promote the development of application technology education of intelligent industry. Due to the continuous update of intelligent industrial production technology, relevant equipment will be replaced in two or three years. Each set of intelligent production line system equipment includes software and hardware. If the system equipment is updated, it is often hundreds of thousands, or even millions, but colleges and educational institutions can not be replaced because of the limited budget, which has a negative impact on the application technology education of intelligent industry. Therefore, it is very important to choose a suitable virtual simulation system of intelligent production line.

According to the summary of existing research results, the implementation scheme of industrial robot virtual simulation experiment platform mainly relies on professional robot workstation and offline programming software, such as irai [1-2], robot studio [3-4], robot master [5], robcad [6], workspace [7]. The simulation software developed by the mainstream industrial robot manufacturers is mainly for production application, and the learning threshold is high, and the simulation software of different manufacturers is relatively closed source and not open to each other; Some of them are expensive and some of them don't support PLC well.

In view of the above technical problems, this paper provides an intelligent production line simulation method and system, which can simulate the operation of the intelligent production line, and is easy to
operate, low cost, so as to meet the teaching needs of cultivating intelligent production line application talents.

2. Basic Principles
Based on hardware development environment-Proteus and 89C51 MCU integrated development environment-Keil, one or more 89C51 microcontrollers are used to simulate the operation of ABB Robot, and one or more 89C51 microcontrollers are used to simulate PLC, so that ABB Robot and multiple PLCs can be interconnected and work together to complete the automatic assembly line of warehouse pick-up, numerical control processing, data processing, etc. Back and forth tool change or fixture and other operations, you can quickly grasp the coding rules of the intelligent production line, communication methods and methods, simple and direct; And it is also very easy to expand, using the same idea to build different intelligent production lines, as shown in Figure 1.

Fig.1. basic principles

2.1. Components of simulation intelligent production line
The intelligent production line simulation system includes ABB Robot Simulation System, PLC simulation system and sensor simulation system.

2.2. ABB Robot Simulation System
ABB Robot control module simulation: the main control unit controls other units to achieve various operations as required to complete the collaborative work of the entire intelligent production line; It includes control processing sub module, command and feedback communication sub module.

2.3. PLC Simulation System
PLC simulation system includes PLC execution module simulation, PLC automatic tool change / fixture change module simulation, PLC automatic storage module simulation, PLC and CNC machining center module simulation, PLC automatic grinding and chip blowing module simulation, PLC automatic visual recognition module simulation and PLC product sorting and warehousing module simulation
2.3.1. **PLC Execution Module Simulation.** 1) It is the execution terminal of product conversion and customized processing among various units, and is the core of the application platform; 2) Industrial robot can pick up parts or process them in different posture; 3) As the extension axis of the industrial robot, the sliding table expands the accessible workspace of the industrial robot, and can cooperate with more functional units to complete the complex process; 4) The motion parameter information of the sliding table, such as speed and position, is transmitted to PLC by the industrial robot controller through the field IO signal, so as to control the servo motor to realize linear motion; It includes speed and position control module of servo and step driver, communication module of command and feedback.

2.3.2. **Simulation of PLC Automatic Tool Change/Fixture Change Module.** 1) The tools used to store different functions are the subsidiary units of the execution unit, and the industrial robot can be controlled by the program to locate, install or release the tools; 2) Various types of tools are provided. Each tool is equipped with the tool end of the quick change module, which can be matched with the flange end of the quick change module; It includes control processing sub module, command and feedback communication sub module.

2.3.3. **Simulation of PLC Automatic Storage Module.** 1) Storage unit is used to store parts temporarily and is the function unit of application platform; 2) Each bin can store a part, and the bin pallet can be pushed out, which is convenient for industrial robots to pick up and place parts in an unnecessary way; 3) Each bin is equipped with sensors and indicator lights, which can detect whether there are parts stored in the current bin and display the status; It includes control processing sub module, command and feedback communication sub module.

2.3.4. **Simulation of PLC And NC Machine Center Module.** The machining unit is the functional unit of the application platform, which can carve the specified position of the part surface; It includes control processing sub module, command and feedback communication sub module.

2.3.5. **Simulation of PLC Automatic Grinding Chip Blowing Module.** 1) The grinding unit is the fixture in the process of grinding the surface of the parts, and it is the functional unit of the application platform. 2) the grinding station can accurately position the parts and stably clamp them, which is the main station to realize the grinding process. 3) the rotating station can drive the parts to realize 180° rotation while accurately fixing the parts ° Rotate along its axis to switch grinding area conveniently; It includes control processing sub module, command and feedback communication sub module.

2.3.6. **Simulation of PLC Automatic Visual Recognition Module.** The detection unit can detect and identify the parts according to different requirements, and it is the functional unit of the application platform; It includes control processing sub module, command and feedback communication sub module.

2.3.7. **Simulation of PLC Product Sorting and Warehousing Module.** The sorting unit can sort different parts according to the program, which is the functional unit of the application platform; It includes control processing sub module, command and feedback communication sub module.

2.4. **Sensor Simulation System**

Included in the above ABB Robot Simulation System and PLC simulation system of each module of the command and feedback communication sub module.

3. **Concrete Realization**

The core of the simulation system is single-chip microcomputer. Each single-chip microcomputer can simulate one or more ABB robots and one or more PLCs. The control module of ABB Robot is the main control module, which controls the operation of the whole process. Each PLC sub module cooperates
with ABB Robot to complete the process. There is continuous data interaction between multiple ABB robots, between ABB robots and multiple PLCs, and between multiple PLCs.

3.1. Simulation of ABB Robot System
We can use 89C51 MCU to simulate ABB Robot Programming Control and PLC programming control. The hardware simulation of ABB Robot control module is shown in Figure 2, and the control flow of control processing sub module is shown in Figure 3 and modules are analysed in Table 1.

![Fig.2. ABB robot simulation](image)

![Fig.3. ABB robot simulation program flow](image)

### Table 1. Module analysis of ABB robot simulation program.

| Module | Analysis |
|--------|----------|
| rInitial() | indicates the initialization of ABB main control module |
| rHome() | indicates that ABB Robot requires PLC control servo to return itself to the origin |
| rServo() | indicates that ABB Robot requires PLC control servo to send itself back to a specific position |
| rTool() | indicates that ABB Robot can take and place tools or fixtures according to requirements |
| rGetHub() | means to use the fixture to take out the workpiece (for example, the workpiece with the largest serial number) after taking out the fixture |
| rCNC() | means that the workpiece is sent to the CNC machine tool for processing after taking it |
| rPolish() | indicates the polishing unit processing |
| rCCD() | represents the processing of the visual recognition unit |
| rSorting() | indicates sorting and warehousing |

3.2. Simulation of PLC System
We can use 89C51 MCU to simulate PLC programming control, as shown in Figure 4.
3.3. Simulation of Sensor System

We can use button and switch to simulate the input action of sensors (photoelectric sensor, proximity switch, metal sensor, etc.), and switch state to simulate the on-off state of sensors; LED light, motor and relay are used to simulate indicator light, solenoid valve of control cylinder and forward and reverse rotation of motor. Please refer to Table 2.

| Sensor            | Simulation Device |
|-------------------|------------------|
| Photoelectric sensor | Button, Switch |
| Proximity switch  | Button, Switch |
| Metal sensor      | Button, Switch |
| Indicator light   | Led              |
| Electric machinery| Motor            |
| Solenoid valve    | Relay            |

In addition, 7-segment digital tube is used to simulate and display the current running process; The servo position feed is controlled by mathematical simulation and displayed on lm016l LCD; Some other driver chips or circuits are used to control the whole circuit in principle; LDR photoresistor can be used to simulate the light sensor, SHT11 temperature and humidity sensor to simulate the temperature and humidity input.

3.4. Communication between Simulation Systems

We can use serial, parallel or custom communication protocol to connect ABB Robot control core and PLC control core.

3.4.1. Communication Between ABB Robot And PLC Simulation System. We take the communication with the automatic storage PLC (hardware design as shown in Figure 4) to realize the automatic pick-up function rGethub() as an example, as shown in the left side of Figure 5. The processing flow of PLC automatic storage module control processing sub module and command and feedback communication.
sub module is shown on the right side of Figure 5, and the automatic storage picking process is completed by cooperating with ABB's automatic picking function rGethub().

4. Conclusions
This paper provides a simulation method of intelligent production line. Through one or more low-cost controllers, such as single-chip microcomputer, industrial robot control module and PLC control module are formed. Through their mutual cooperation, industrial robots can move, change tools, transport parts, process parts and other production actions, so as to simulate the operation of the production line. Moreover, the simulation code can be easily transformed into the programming language of robots and PLC, and downloaded to the robot controller and PLC controller of the real intelligent production line, Realize the same process as virtual simulation.

The intelligent production line simulation method provided in this paper is based on the easy-to-use controller similar to single-chip microcomputer. When the software needs to be updated, the user-defined update program and code can greatly reduce the expenses of equipment update software. Moreover, due to the strong autonomy of system software editing, it can be used for classroom C language, PLC or ABB Robot Programming Simulation auxiliary teaching. It can make students quickly master the coding rules, communication methods and methods of intelligent production line, and the programming operation is simple and direct; In addition, compared with the whole set of intelligent production line system equipment purchased, the intelligent production line simulation system provided in this paper is easier to expand functional modules, and has higher flexibility to build intelligent production lines with different functions independently. Through students' hands-on operation of low-cost teaching equipment of intelligent production line, the teaching function of the intelligent production line simulation system in this paper is really played. So it is helpful for students to quickly master the technical knowledge of intelligent production line and improve the practical ability of teachers and students.

Acknowledgments
This work was supported in part by the Program of Guangzhou Science and Technology Bureau project under Grant No.201904010121, in part by Department of education of Guangdong Province project under Grant No.2017GKTSCX011, in part by innovation team project of Guangdong Universities under Grant No.2020KCXTD048, in part by Guangdong science and technology innovation strategy special fund under Grant No. pdjh2020b0927.

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