DESIGN OF INTELLIGENT WAREHOUSING SYSTEM BASED ON DELTA CLOUND PLATFORM

Min Xie[1], Shan Guo[2], Danhao Qian[1], Maohua Xiao[2], Dan Wu[2], Haoyue Dai[2]*
[1]Nanjing Polytechnic Institute, Nanjing 210048, China
[2]College of Engineering, Nanjing Agriculture University, Nanjing 210031, China
E-mail: xiaomaohua@njau.edu.cn

Abstract - With the development of science and technology, intelligent control technologies such as big data and cloud computing have also flourished, and logistics management and warehousing links have also ushered in challenges. The industrial cloud technology-based warehouse management system will be an inevitable choice for technological development and intelligent manufacturing. This paper expounds the development status, research direction and existing problems of intelligent warehousing, and puts forward the overall design of the intelligent warehousing system based on Delta Cloud platform. To implement the corresponding functions of the warehouse system, the hardware of PLC control system was carefully selected and programmable controller programming was designed.

Keywords: Delta Cloud Platform; Warehousing System; Programmable Controller; Programming.

1. Introduction

China's three-dimensional warehouse technology research began in the 1960s. With the development of information technology, the timeliness of logistics services in human society is becoming more and more demanding [1-3]. In order to meet the demand for modern industrial output capacity, smart warehousing systems need to be further optimized [4]. In recent years, researchers have carried out a study on wireless network communication, path planning, multi-AGV operation strategy, servo control and other aspects of storage system [5-6].

The specific application in warehouse system overall structure, warehouse management module and logistics management module, has been analyzed [7]. More specifically, the automatic reading of the RFID tags on the items, and the calculation, communication and control of the relevant logistics information [8-9]; however, in the specific implementation phase, the related software systems and hardware systems lack effective support [10], and there are problems such as motion instability and vibration, and inaccurate motion and position control of servo motors and manipulator [11-12].

The intelligent warehousing system based on Delta Cloud platform is mainly composed of two parts: control system and mechanical equipment. The control system primarily consists of three parts, namely 1 upper machine cloud platform, 2 middle-end control system, and 3 end effector.

1. *Host computer cloud platform:*

   With Delta Cloud platform and industrial cloud router as nodes, SCADA monitoring software connects with PLC host through cloud platform and industrial router to realize industrial data management and remote monitoring functions;

2. *Mid-end control system:*

   PLC controller, touch screen and sensor are the main components to realize data information processing, real-time inventory management and teaching function of the material module of the intelligent storage system;

3. *End actuator:*

   The scanning code gun intelligently recognizes the material number, and the servo motor is used as the actuator of the storage system. The servo motor drives the manipulator to transport the material to the specified location through the X-axis, Y-axis, and Z-axis [13-14]. The man-machine interface operates the outbound storage with one button, which realizes the storage and delivery of the material module of the storage system terminal [15]. Mechanical equipment mainly includes shelves, material conveyor belts, handling equipment, and pallets.

2. System Solution Architecture and Working Principle

The system mainly consists of four parts: industrial cloud design, PLC control system design, the control system of servo motor design and HMI control interface design. The intelligent storage system of the whole cloud platform is thus constructed, as shown in figure 1.

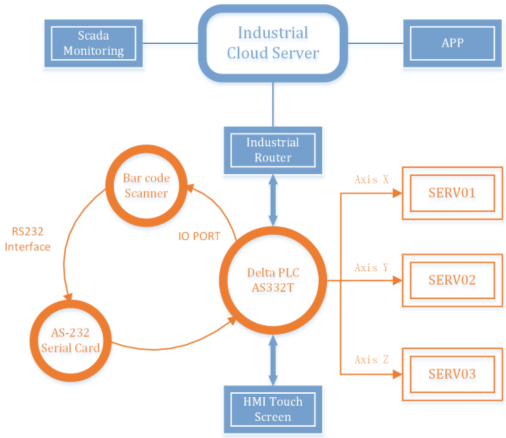

Figure 1: Intelligent warehousing system

With the latest Delta AS332T PLC as the core, Delta's DOP series human-machine interface, Delta DX series industrial router and mobile APP as a monitoring system, and Honeywell 3310g scanner as material resolution system, the intelligent warehousing delivered the materials scanned by scanning gun to the PLC.

After receiving the signal, the PLC determines the storage address of the materials through internal program calculation, transmits the corresponding signal to the end actuator servo motor, and then sends the material to the address by controlling the servo motor to drive the material tray.

Finally, the materials are sent to the warehouse through the pneumatic suction cup to complete the storage access [16].

3. PLC Control System Design

The design idea of the PLC control system design is to convert the barcode recognized by the scanning code gun into an electrical message and transmit it to the PLC.

T PLC receives the calculation and then sends a signal to make the servo drive system work, and then the cylinder tray will be lifted and lowered through the screw drive part, as shown in figure 2.

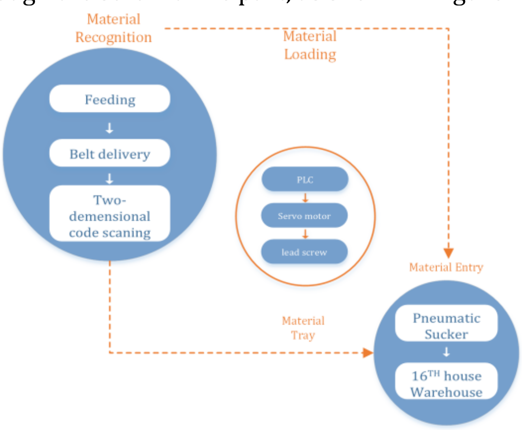

Figure 2: Implementation process

4. PLC Control System Hardware Design

4.1 Delta PLC selection and design

Taking into consideration the design requirements of the control system and other factors, i.e., the number of useful I/O pins, the functional requirements, the development cost, the software interface, etc., the PLC selects the Delta AS series (AS 332T).

With the professional and straightforward editing software interface ISP Soft V3.0, the hardware and network settings can be quickly completed, and multiple sets of industry-specific function blocks are built internally.

4.2 Touch screen and router selection

The touch screen chooses a resolution of 800 × 480 pixels, built-in 2M / 82M Flash Rom, Delta touch screen (DOP-B07S411) [17] supporting RS-232/422/485 communication. The router uses a Delta Industrial Router (DX-2100) that supports two-way data acquisition and transmission in the cloud.

4.3 Hardware wiring diagram design

Figure 3 shows the hardware wiring diagram of the design.

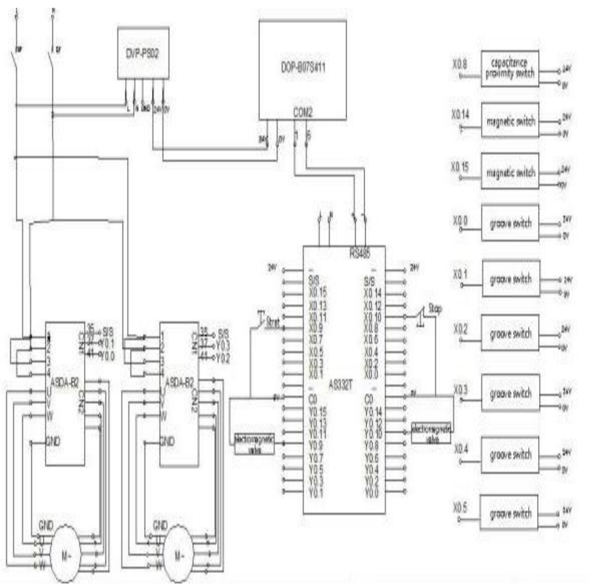

Figure 3: Hardware wiring diagram

The controller in the figure is Delta PLC AS332T.

The motion drive consists of two servo drives and servo motors.

Since the design is positioned by the pulse number, only two PLC output terminals need to be connected to the control terminals of the servo motor, one output controlling direction and the other transmitting a pulse to the servo motor.

The slot switch is used as the limit switch and the origin signal switch of the motion axis, the capacitive proximity switch is used as the detection material, and the magnetic switch is used to detect the cylinder in-position signal.

A 24V stabilized voltage supply (DVP-PS02) provides a 24V power supply. The touch screen communicates with the PLC via RS485.

5. PLC Control System Software Design

5.1 Intelligent storage system I/O allocation table

Table 1 shows part of the I/O allocation table.

The output terminal sends a high-speed pulse to control the speed and position of the motor [18].

Table 1. I/O allocation table

A	B	C	D
X0.0	Axis 1 homeswitch signal	Y0.1	Axis 1 direction signal
X0.1	Axis 2 home switch signal	Y0.2	Axis 2 pulse signal
X0.2	Axis 1 positive limit	Y0.3	Axis 2 direction signal
X0.3	Axis 1 negtive limit	Y0.4	Reserve
X0.4	Axis 2 positive limit	Y0.5	Reserve
X0.5	Axis 2 negtive limit	Y0.6	Cylinder electromagnetic value
X0.6	Axis 1 servo system fault	Y0.7	Sucker electromagnetic value

5.2 Program flow chart

Figure 4 shows the flow chart of the design, which is divided into two processes: depositing and reclaiming.

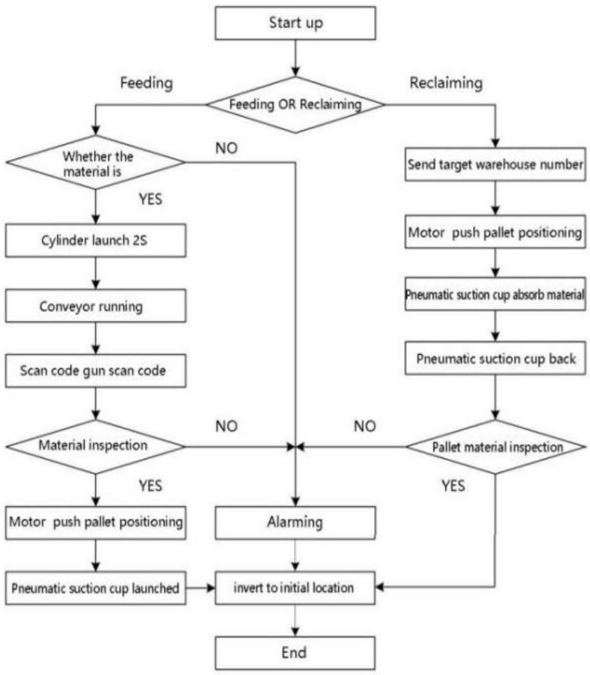

Figure 4: Flow chart

5.3 Program design

The following mainly introduces the scan code gun program, the debug program, the position calculation program, and the function block program.

- Scan code design

According to the design requirements, the scan code gun with serial communication is chosen to connect the scan code gun with the PLC through the AS-232 serial port card, and the program is changed to the ladder program of the scan code gun.

Through this program, the scan code gun completes functions such as power-on self-start, timeout alarm, and alarm reset.

The scan code gun converts the QR code or barcode information into ASCLL code and stores it in registers including the verification scan code registration.

The data obtained by the scan code will be used as the material positioning information, and the number of pulses of each axis reaching the destination is calculated by the formula in the position calculation program, thereby achieving the positioning function.

- Position calculation program design

The software of the servo motor drive system is designed to perform zero-point positioning by the number of pulses received, and its real-time position can be fed back and displayed through the display screen [19]. This program is calculated to get the number of pulses of each axis of the storage grid.

The process of reaching the destination position is divided into two parts: the first part travels from the origin to the first grid in the lower left corner; the second part goes from the first grid to the destination.

The number of pulses in the process is calculated as follows: the number of destination pulses (horizontal axis, vertical axis) = the number of the first horizontal (longitudinal) pulses + horizontal (longitudinal) adjacent lattice pulse number * (destination horizontal (vertical) coordinate -1).

When there is an emergency stop or over travel, the servo drive will have a position offset pulse, which needs to be cleared by pulse [20-21].

Table 2 shows part of the calculated variables defined in the program calculation.

Table 2. Register comment

Device name	Device annotation
D0	A 1 abscissa
D2	A 1 ordinate
D4	Pulse of distance between two space in abscissa
D6	Pulse of distance between two space in ordinate

• Debugger design

Debugger design is aiming to measuring and testing the equipment, including zero return instructions, relative positioning, absolute positioning.

A touch screen controls the program and works in collaboration with function blocks.

The function block will complete the specific action to trigger the signal.

• Function Block Programming

Table 3. Function block parameter table

M0	Axis1 JOG + relay	D20004	Axis 1 return home low-speed
M1	Axis1 JOG-relay	D20006	Axis 1 increment location distance

Table 3 shows the form of the function module in the program.

The function block is equivalent to a bridge, and the blue font is the external parameter of the function block, which is associated with the program in the module.

It demonstrates that the function block has zero return, relative positioning, and absolute positioning.

The speed and parameters of each function can be changed to make it modular.

It is designed to write the result of the position calculation to the module by calling the function block twice to make the PLC drive the servo motor operate.

Table 4. Function block variable table

Type	Symbolic name	Address	Data type	Initial value (take effect when down load)
VAR	Acc_pulse_ 10ms_jog	N/A [Auto]	REAL	N/A
VAR_ INPUT	Command_ pulse_freq_ jog_FWD	N/A [Auto]	DINT	N/A
VAR	Command_ pulse_freq_ jog_real	N/A [Auto]	REAL	N/A

Table 4 is part of the internal parameter customization of the function module.

This function reduces the utilization of PLC internal resources and facilitates the flexible use of programming.

The module is mainly designed for the commissioning of the servo motor, but the program will also be used as the execution program of the main pulse number.

When the material preparation is completed and the scan code is finished; the result of the scan code will be written into module, and the function module is used to perform the absolute positioning of the axis 1 and the axis 2 to achieve the target positioning function.

The system integrates the advantages of both touch screen and PLC.

Therefore it is easy to operate and is powerful [22].

6. Running Debugging

6.1 Overall design of Warehousing

Figure 5: Whole structure

Figure 5 shows the overall three-dimensional design of the storage system:

The upper part is composed of a sixteen square grid, a servo motor dual axis, a touch screen, a scan code gun, etc.

The lower part consists of two compartments:

The left cabin is mainly equipped with an air pump, a solenoid valve and a power source are installed; a right cabin is placed with a control panel [23-24].

The whole equipment employs aluminum alloy as experimental equipment.

Figure 6: Control panel

Figure 6 shows the structure of the control panel, which is mainly composed of Delta PLC, 24V regulated power supply, servo drive, industrial router, and other equipment.

6.2 Operation and commissioning of equipment

Figure 7: Performance record

Figure 7 is the operation diagram of the material stored in the equipment.

When the scanning code starts running, the servo motor-driven screw device sends the tray to the destination coordinate, and then be pushed into the material bin by the cylinder.

Then the tray returns to the origin to complete a storage process. The section of the cylinder is composed of a pneumatic suction cup with a diameter of 5 cm. When the coordinates of the material to be taken out are selected in the touch screen, the tray will run to the target and then the cylinder is pushed out, the suction cup reversing solenoid valve acts, and the suction cup will suck the material and drag it into the tray. Then, the tray returns to the origin to complete a reclaiming process.

7. Conclusions

The overall design of the intelligent storage system based on the Delta Cloud platform was completed, and the data communication between Delta Industrial Cloud and programmable controller was realized. As for the programming of the programmable controller, the action and position control of servo motor and manipulator turns out to be accurate and reasonable; Moreover, the problems of motion instability and vibration are solved through debugging optimization. The debug results are consistent with the expected control results.

Acknowledgments

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Competing Interests

The authors declare that there are no competing interests regarding the publication of this paper.

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