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Original Paper

Design of Intelligent Storage Management System for Crops in Southern Xinjiang Based on Industrial Internet of Things

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Abstract

Aiming at the arid climate and backward crop storage and preservation technology in southern Xinjiang, an intelligent storage management system for crops in southern Xinjiang based on industrial Internet of Things is designed to realize the intelligent storage management of crops in southern Xinjiang and improve its storage and preservation efficiency. The system takes the lower computer PLC as the control core, collects real-time data on the environmental factors affecting crop storage, and the collected information is processed by PLC and transmitted to the touch screen and cloud platform through Ethernet and mobile Internet for centralized supervision. The system gives full play to the advantages of the IoT cloud platform and realizes real-time remote control of crop storage and management by managers through mobile APP, which is convenient, stable and reliable, and intuitive.

Keywords

Industrial Internet of Things, Smart storage, PLC, APP, Remote control

1. Introduction

With the development of Internet of Things technology, the way crops are stored and preserved has also undergone tremendous changes. As the western region of China, southern Xinjiang has a harsh environment and backward technology, and the collection of crop storage process information and data still relies on manual observation and recording, and the work efficiency and data accuracy are relatively low, which is not conducive to the storage and management of crops, so a southern Xinjiang crop intelligent storage management system based on industrial Internet of Things is designed.

The system takes PLC as the control core of the system, according to the environmental factors affecting crop storage, uses sensors for information collection, transmits the collected information to PLC for data calculation and processing, transmits part of the processing results to the touch screen, and the other part is transmitted to the mobile phone APP through the cloud platform to achieve real-time remote control. According to the storage needs of different crops, managers can set the environmental parameters suitable for storage and preservation on the touch screen and mobile phone.

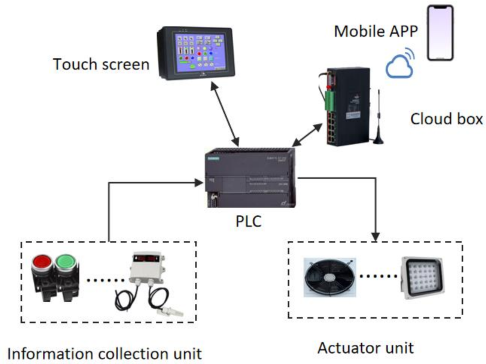

Figure 1. Block Diagram of the Overall Structure of the System

2. Overall Design of the System

The system builds an intelligent crop storage management system based on industrial Internet of Things technology, and transmits the collected data to the PLC through the analog conversion module and 485 serial port. The hardware of the system is mainly composed of PLC, temperature and humidity sensor, illuminance sensor, CO_2 gas concentration sensor, analog conversion module, touch screen, mobile phone, fan, pump, etc. Its overall structural framework is shown in Figure 1, which mainly includes four units: information collection unit, execution structure unit, data processing unit and remote control unit.

The main function of the information collection unit is to collect environmental signals (temperature, humidity, etc.) and command signals that affect crop storage, and its main signal sources are sensors and switch buttons. The actuator unit mainly refers to the equipment that controls the storage environment, mainly including hot and cold fans, water pumps, fill lights and other equipment. The data processing unit is the core unit of the system, which receives the signal collected by the information unit on the one hand, and transmits the processing results to the actuators to control its operation through internal program calculations. The remote control unit mainly includes touch screen and mobile phone end, and the touch screen and mobile phone end can realize the monitoring and control of the storage process through the design of the configuration interface; Mobile phone control is the mapping and extension of touch screen control, which is not limited by geography and can better meet the requirements of intelligent storage control.

3. Hardware Design of the System

For the control requirements and technical indicators that the crop intelligent storage management system can achieve, it is necessary to determine the wiring between the components of the system, and whether the connection between the components is reasonable is also crucial, then the wiring diagram between the hardware of the lower computer of the system is shown in Figure 2.

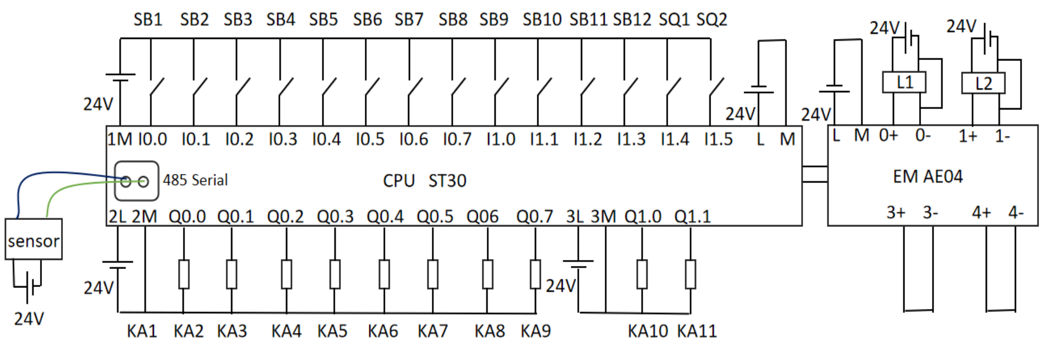

Figure 2. Schematic Diagram of Indirect Lines of each Component of the Lower Computer

3.1 Selection of PLC Model

As a controller, PLC has the characteristics of stable and reliable operation and strong anti-interference ability, and is widely used in production and life. The system mainly monitors and controls the environmental factors affecting crop storage, generally affecting the environmental factors of crop storage are temperature, humidity, illuminance, CO_2, gas concentration, so PLC needs to collect 4 analog signals; At the same time, the system is designed with two functions, manual mode and automatic mode, combined with the number of I/O points required by the system, and comprehensively considers the S7-200 Smart PLC ST30 of the Siemens series.

3.2 Assignment of I/0 Addresses

For the functions that can be realized by the system, the I/O address of the PLC is assigned, and the allocation table is shown in Table 1. The digital input signal mainly refers to the mode button of the control system operation and the manual button of each executive equipment (hot air fan, humidifier, etc.) signal. The acquisition of analog input signals is divided into two forms, one is the acquisition of illuminance and CO_2 gas concentration signals, which are acquired by analog modules; Another temperature and humidity signal is collected through the 485 communication port of the PLC. The output signal is mainly used to control the various actuators of the system.

3.3 Sensor Selection

In order to facilitate signal acquisition, the system shares a sensor for the acquisition of temperature and humidity signals, model is VMS-3008-WS-N01, which has the characteristics of stable acquisition signal, high sensitivity, long transmission distance, waterproof and corrosion resistance. It has a humidity operating range of 0-100%RH and an accuracy of ±3%RH; The temperature operating range is -40~+120 ℃, the accuracy is ±0.5 ℃, and the 485 serial port of the PLC is selected to communicate, and the Modbus communication protocol is supported. The CO_2 gas concentration is collected using the analog VMS-300-CO_2 sensor, its output signal is 4~20 mA, the power supply is 10~30 V DC, the measurement range is 400~5 000 ppm, and the accuracy is ±(50 ppm+ 3% F S).The acquisition of illuminance signal adopts analog VMS-3002-GZ sensor, the power supply is the same as that of the CO_2 gas concentration sensor, its range is 0~65535 lux, the working environment is -20 ℃~+60 ℃, and the accuracy is ±3%.

Table 1. PLC's I/O Address Allocation Tabler

Symbol	Address	Name	Symbol	Address	Name
SB1	I0.0	System turn on	SQ1	I1.4	Window opening limit
SB2	I0.1	The system turn off	SQ2	I1.5	Window closing limit
SB3	I0.2	Manual mode	L1	AIW0	CO_2 concentration sensor
SB4	I0.3	Automatic mode	L2	AIW2	Light intensity sensor
SB5	I0.4	Hot air blower turn on or off	KA1	Q0.0	Hot air blowers
SB6	I0.5	The air cooler turn on or off	KA2	QO.1	Air cooler
SB7	I0.6	The dryer starts turn on or off	KA3	Q0.2	Windows starts
SB8	I0.7	The humidifier turn on or off	KA4	Q0.3	Windows closed
SB9	I1.0	Vents turn on or off	KA5	Q0.4	Dryer
SB10	I1.1	Lighting	KA6	Q0.5	Humidifier
SB11	I1.2	Windows turn on	KA7	Q0.6	Vents
SB12	I1.3	Windows turn off			

3.4 Selection of Expansion Modules

Since PLC can only process digital signals, the illuminance and CO_2 gas concentration signals collected by the sensor are analog signals that cannot be directly transmitted to the PLC, so the analog conversion module EM AE04 needs to be selected to convert the collected analog signals into digital signals, and then transmitted to the PLC CPU for computing processing. The module has a total of 4 analog signal inputs, voltage or current signals.

3.5 Touch Screen Selection

In order to realize the visual remote control of the system, the embedded integrated touch screen with strong man-machine interface function is selected, model is TPC1061Ti, its power supply is 24 V DC, with 1 network port and 1 COM port. Users can realize remote control of the system on the touch screen according to the designed configuration user interface, and the monitoring screen can also be displayed on the PC in real time to meet the functional requirements of the control system.

3.6 Wireless Communication Module

In order to realize the remote control of the mobile phone of the system, it is necessary to establish wireless communication between the PLC and the mobile terminal of the mobile phone, and its communication is completed through the Internet of Things cloud box SuK-BOX-4G wireless communication module. The module networking mode supports direct network cable connection and

4G networking, and the interface includes 1 RS232 serial port, 1 RS485 serial port, and 3 network ports to meet various communication needs between devices. As a remote communication device in the industrial Internet, the IoT cloud box can not only conveniently realize the data collection of remote devices, but also use the 4G network to transmit information to the IoT cloud platform for big data analysis and sorting.

4. Software Design of the System

4.1 PLC Programming

The programming of the system mainly includes the main program and the subprogram. The main program mainly includes the following programs: the start-stop control program of the system, the manual/automatic operation program of the system, the comparison program of the collected data and the set standard value, the operation program of controlling each actuator, etc.; The subprogram mainly includes each analog information reading program, numerical conversion program, etc.

The system starts to perform self-test after power-on, and the operating mode of the system can be selected according to the command after the self-test is correct, and the system defaults to the automatic mode under normal circumstances. After automatic operation, each sensor automatically reads the environmental value of crop storage, compares the read value with the set value of the system, and starts the corresponding equipment if it exceeds the upper limit of the set value or falls below the lower limit of the set value to ensure the stability of the crop storage environment; At the same time, the management personnel can choose the manual mode, control the operation of each actuator according to the storage experience, and ensure the best storage environment for crops, and the program design flow chart of the system is shown in Figure 3.

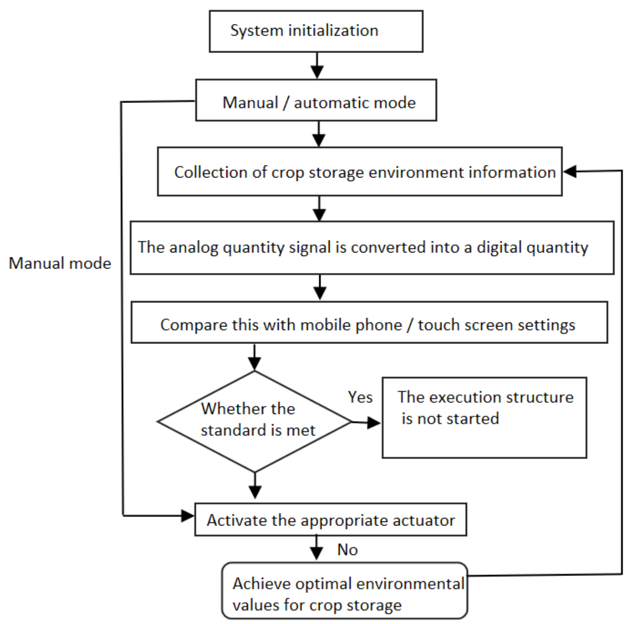

Figure 3. The Design Flowchart of the Program

4.2 Design of System Man-machine Interface

4.2.1 Establish a Connection to the PLC

First of all, create a new project, select the model TPC1061Ti of the touch screen, enter the configuration screen design window, select the type of PLC connected to the PLC - Siemens 200 Smart in the device window, set the local IP address and remote IP address respectively in the device editing window, and set them to the same network segment. Increase the channel of the device, establish the connection variables according to the parameters monitored by the system, and finally check the device configuration of the variables, enter the user window after checking that it is correct, and complete the configuration design of the screen after the connection.

4.2.2 MCGS HMI Design

According to the control requirements of the system, there are four main man-machine configuration interfaces designed, namely the main screen, the parameter setting screen, the real-time instrument screen, and the alarm picture, as shown in Figure 4. The main screen mainly includes output signal monitoring display area, environmental parameter monitoring display area, actuator working status display area, and manual button area.

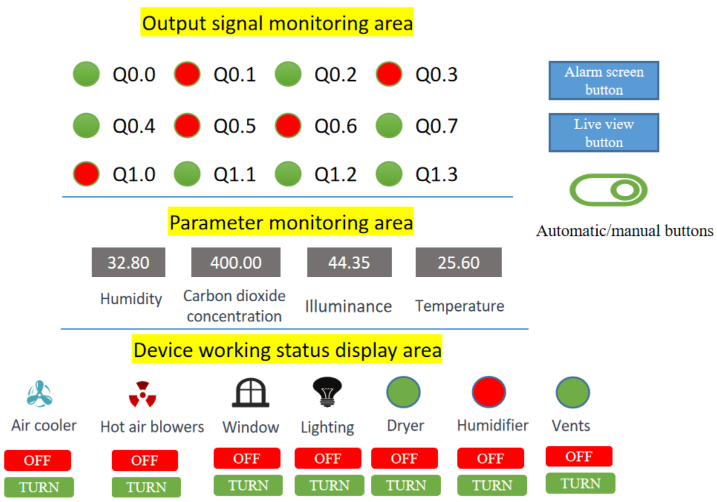

Figure 4. HMI Main Screen

Among them, the output signal monitoring area: mainly displays the working status of the PLC output signal, and the working state of the actuator corresponds one-to-one, in order to determine whether the actuator is damaged through the state comparison between them and ensure the stability of the working performance of the system. Environmental parameter display area: mainly real-time display of crop storage temperature value, humidity value, illuminance, CO_2 gas concentration value. Display area of actuator: shows the specific working status of each actuator in automatic and manual operation. The button area mainly contains the following: automatic buttons and manual buttons represent two modes of system work; The alarm screen button, the instrument real-time screen button, and the parameter setting button are all screen switching buttons; The start and stop buttons of various mechanisms control each actuator in manual mode.

5. Design of Mobile APP Remote Control Terminal

5.1 Establish a Connection to the Cloud Platform

In order to realize the function of remote control of mobile phone APP, the system needs to establish communication between PLC, IoT cloud box and cloud platform. First, the connection between the IoT cloud box SuK-BOX-4G and the PLC is established, and the IoT cloud box is connected to the PLC through the LAN port. Therefore, in order to ensure the normal operation of the equipment of the system, it is necessary to ensure that the IP addresses between the PLC, touch screen, computer, and cloud box are in the same network segment, and the IP addresses set cannot conflict.

Log in to the IoT cloud box module configuration software SuKConfig and set the following settings on the software configuration interface: select the connection method between the cloud box and the PLC, select the connected PLC model, and set the IP address of the PLC. After the basic settings are completed, these configurations are downloaded to the cloud box to realize the communication between the PLC and the cloud box. Secondly, add the variables controlled by the mobile phone APP in the software configuration interface, you can set its variable name, variable address, data type, etc., after adding the variable, download all the configurations to the cloud box for saving, and then upload it to the cloud to enter the cloud platform, where you can view the status and real-time data of the cloud box.

5.2 Cloud Platform Interface Design

After uploading all the configuration information to the cloud, the IoT cloud box needs to configure the screen on the cloud platform in order to realize the real-time remote monitoring screen on the mobile APP. The configuration design process of the screen is basically the same as the screen configuration process of the touch screen, which is equivalent to the mapping of the touch screen function, and the screen configuration is carried out according to the functions and variables of the system. The management personnel realize the functions of equipment monitoring, data monitoring, alarm monitoring, report management and other functions on the mobile phone, and the operation screen of the mobile APP is shown in Figure 5.

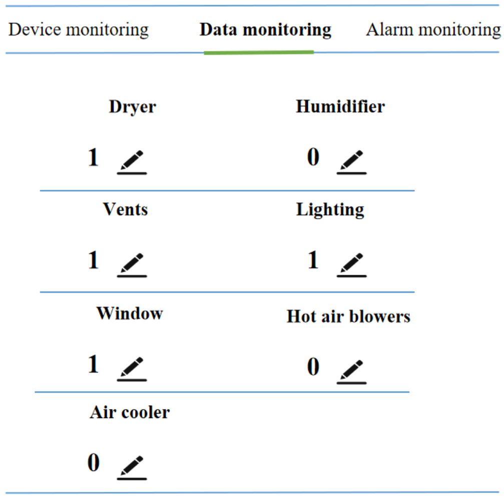

Figure 5. Mobile Phone Data Monitoring Screen

6. Conclusion

The application of sensor technology and Internet of Things technology in crop storage and preservation is conducive to promoting the development of agricultural information technology in southern Xinjiang. The intelligent storage management system of southern Xinjiang crops based on the industrial Internet of Things designed in this paper uses the intelligent gateway module and cloud platform of the Internet of Things to break through the geographical restrictions and realize the intelligent management of crop storage in southern Xinjiang on the mobile APP. The design greatly improves the freedom of administrators, reduces labor intensity, improves the intelligent management level of agriculture in southern Xinjiang, and is conducive to the development of smart agriculture in southern Xinjiang.

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