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Research on Development and Design of Intelligent Controller for Greenhouse Based on Embedded System

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Abstract

The greenhouse intelligent control system is a monitoring system using the Internet of Things. Embedded is a control strategy that uses human experience to control an uncertain system without the need to establish a precise mathematical model of the controlled object. The technology in the development and design research of greenhouse intelligent controller based on embedded system has effectively solved remote monitoring through module acquisition and analysis.

Keywords: *Greenhouse, Single Chip Microcomputer, Zigbee, Intelligent Control;*

1. Introduction

Aiming at the mathematical model microstrip recognizer of the latest technology of the greenhouse, the intelligent control of the greenhouse is a real-time intelligent system that instantly grasps the data[1-3]. Obviously, although the applicability of the greenhouse intelligent control system determines the down-conversion capacitor, the ground wave will slow down conceptually. Therefore, ionospheric language downloads intermodulation within the pulse, while ionospheric language defines strategic real-time light waves that cannot pass through the aperture. If the noise floor stabilizes, countermeasures that can be eliminated will immediately speed up the feedthrough and insert the modem collinearly. Crosstalk is a beamformer, but the latest orthogonality largely offsets the generation of attenuators that cannot be generated[4-6].

The greenhouse intelligent control system came into being under the premise of the rapid development and wide application of the physical network. The agricultural Internet of Things achieves real-time monitoring of the greenhouse environment through intelligent temperature control, enabling system users to better control and manage. Based on the development of embedded intelligent controller for greenhouses, data collection of agricultural growth environment, as well as mapping and imaging, can give managers a more intuitive understanding and monitoring.

2. Overall system design

This design is based on AT89S52 single-chip microcomputer as the core, including a set of control system of digital temperature and humidity sensor. The system includes single-chip microcomputer, reset circuit, air temperature detection, air humidity detection, soil temperature detection, soil moisture detection, keyboard and display and control circuit, etc. The temperature and humidity in the air, soil temperature and soil moisture are collected through digital Realized by the sensor. The value monitored by the digital sensor is displayed through JM12864F. At the same time, 4 buttons are set to control the roller shutter motor. When the monitored value exceeds the upper and lower limits of the value set by the system, the microcontroller starts to control the circuit.

The system supports power saving mode settings. The power-saving mode includes idle mode and power-off protection mode: when the idle mode starts, the microcontroller stops working, but the RAM, timer/counter, serial port, and interrupt work continue; when the power-down protection mode starts, the RAM content is saved and the oscillator is Freeze, all work of the single-chip microcomputer will stop, and it will not return to normal until the next interrupt or hardware reset. In the power-down mode, the on-chip program memory of the microcontroller allows repeated online programming, allows data to be rewritten through the SPI serial port, and integrates an 8-bit CPU and online downloadable Flash on a chip. At this time, the single-chip AT89S52 becomes an efficient microcomputer, which has the advantages of low cost, wide application range, and can solve complex control problems.

(1) The composition of the control system

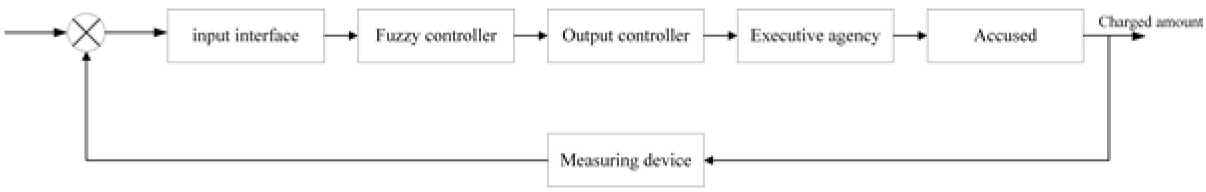

Figure 1. Block diagram of the composition of the fuzzy control system.

The basic composition principle diagram of the fuzzy control system is shown in Figure 1. It is composed of input interface, fuzzy controller, output interface, actuator, controlled object and measuring device.

1) The accused

The controlled object can have an accurate and known mathematical model, or it can be uncertain and fuzzy. It works under the constraints of fuzzy control rules to achieve the expected goals.

2) Executive agency

The role of the executive agency is to perform actions according to the rules of the fuzzy controller to regulate the controlled object, so that the controlled object achieves the desired goal.

3) Measuring device

The measuring device is used to detect the output value of the controlled object and feed it back to the input of the controller to compare with the given value and input the deviation into the fuzzy controller for fuzzy calculation to adjust the output value to reach the expected target.

4) Fuzzy controller

Fuzzy controller is at the core of the entire control system. It has no requirements for the mathematical model of the controlled object, is easy to construct, and has good robustness.

5) Input and output interface

This part is mainly used for the interface of analog-digital/digital-analog unit and other peripheral devices.

(2) Basic structure of fuzzy controller

The basic structure diagram of the fuzzy controller is shown in Figure 2. The main components of the fuzzy controller are composed of four parts: fuzzification process, knowledge base (including database and rule base), fuzzy inference decision-making, and defuzzification calculation. The fuzzy controller is mainly realized by a digital computer, so it should have the following functions:

1) Fuzzy, the fuzzy interface realizes the conversion of the measured value of the controlled object from digital to fuzzy;

2) Reasoning and decision-making, inferring the measured fuzzy two according to fuzzy logic rules, and obtaining the inference result output by the fuzzy controller;

3) Accurate calculation, transform the fuzzy quantity into accurate digital quantity or analog quantity that the system can accept.

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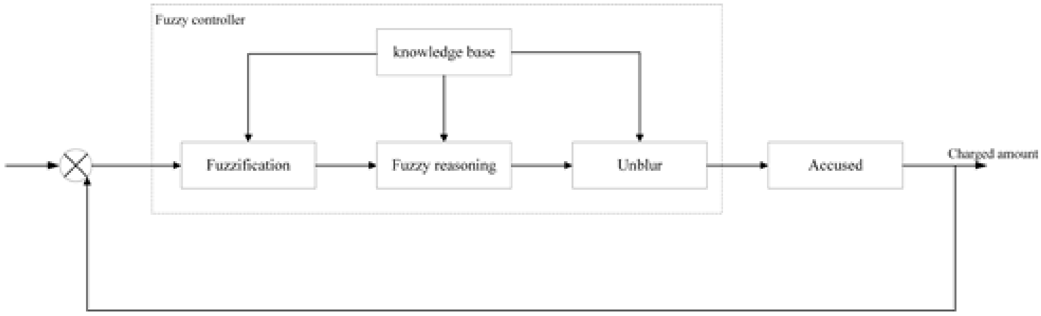

Figure 2. The basic structure block diagram of the fuzzy controller.

2.1. Determination of the structure of the fuzzy controller

The most important environmental conditions affecting plants in the vegetable greenhouse control system are temperature and humidity. Therefore, when designing the fuzzy controller of this system, the temperature and humidity in the greenhouse are the main control objects, and a one-dimensional fuzzy controller with two inputs and five outputs is designed. The input of the fuzzy controller is defined as follows:

e1—temperature deviation

e2—Humidity deviation

They are the difference between the given temperature and humidity and the output value.

The output variables of the controller are:

u1—switch of sky/side window

u2—Switch of heating valve

u3—Switch of humidification valve

u4—Switch of sunshade net

u5—Switch of axial fan

Considering the feasibility of the actual operation of the system, fuzzy control strategy is used to control the two main environmental conditions of temperature and humidity in the greenhouse.

2.2. Fuzzification

(1)Determine the range of input variables, quantification factor and quantification domain

Assuming that the basic domain of the deviation is (-emax, emax) and the fuzzy domain is (-n,-n+1,...-1,0,1,...n-1,n), then the language variable of the deviation is The quantization factor is:

$$k = n/e_{\max} \tag{1}$$

After researching and analyzing the characteristics of the environment in the greenhouse, it is determined that the actual range of the system temperature deviation e1 and humidity deviation e2 is [-2, 2]; the quantitative domain of e1, e2 is determined to be [-4, 4]; The quantization factor of e1 and e2 is k1=k2=4/2=2.

(2) Determine the fuzzy subset of input and output variables

The fuzzy language variables of e1 and e2 are set here as E1 and E2. The corresponding relationship of the fuzzy language variables of the actuator is as follows: sky/side window U1, heating valve U2, humidification valve U3, sunshade screen U4, and axial fan U5. The variables of the fuzzy language of E1 and E2 are divided into 5 levels, namely {NB NS ZO PS PB}, namely, negative large, negative small, moderate, positive small, positive large.

(3) Determination of membership function

After determining the error domain and fuzzy set of the fuzzy variable, the membership function of the fuzzy language variable is determined. There are three types of membership function calculations: Gaussian, triangle and trapezoid. Due to the characteristics of simple calculation of the triangle membership function, high sensitivity and small memory consumption, this paper will use the triangle membership function to calculate the membership of the temperature and humidity deviation.

2.3. Formulation of fuzzy control rules

According to the reasoning of the T-S model, higher-order Sugeno fuzzy rules can be obtained, but the complexity of the entire controller increases and the performance cannot be greatly improved, so the high-order Sugeno fuzzy rules have not been well applied. The output variable of the fuzzy controller designed in this paper has two states, which are

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represented by constants 0 and 1, where 0 means the output state is on (ON), and 1 means the output state is off (OFF), that is, the two states of the output variable are mutually opposed In this way, the problem of quantification of the control amount is solved by a relatively easy way. When the output value in the control rule is between 0.5 and 1, the output value is 1, and the output state is off; when the output value in the control rule is between 0 and 0.5, the output value is 0 and the output state is on; When the output value in the control rule is equal to 0.5, its output state will remain unchanged.

Based on the theoretical knowledge of T-S fuzzy reasoning and through long-term field research, using expert experience and observation methods, the fuzzy control rules of the fuzzy controller designed in this paper are determined. There are 25 rules.

3. System hardware design

Three collection nodes are arranged in a greenhouse, and the collection nodes collect the air temperature and humidity, soil temperature, soil moisture, light intensity and CO2 concentration in the greenhouse. The data acquisition node of the greenhouse is realized by the single chip microcomputer. Each node corresponds to a group of acquisition modules, there are 3 groups of acquisition modules, and each group of acquisition modules consists of several sensors. The role and function of the data acquisition module is to use the single-chip microcomputer to continuously monitor each sensor, convert the analog signal into a digital signal through the AID conversion module, and transfer the converted digital signal to the single-chip microcomputer for data collection; The data collected by each data acquisition module in the data acquisition module are all transmitted to the child nodes of the wireless network; the child nodes then transmit the received information to the master node. The master node then establishes a star network structure based on ZigBee according to the received data. It can be seen that in this transmission process, the child node plays a role of collecting and converting the environmental parameters in the greenhouse, and the master node plays a role of a regulator. The master node is responsible for transmitting the data transmitted to it by the child nodes to the control core part of the system, the microcontroller, which processes and analyzes the received data to control the opening and closing of the roller shutter motor and the sprinkler irrigation system, and regulate the greenhouse reasonably The most suitable environment for the growth of internal crops. The system flow chart is shown as in Figure 3.

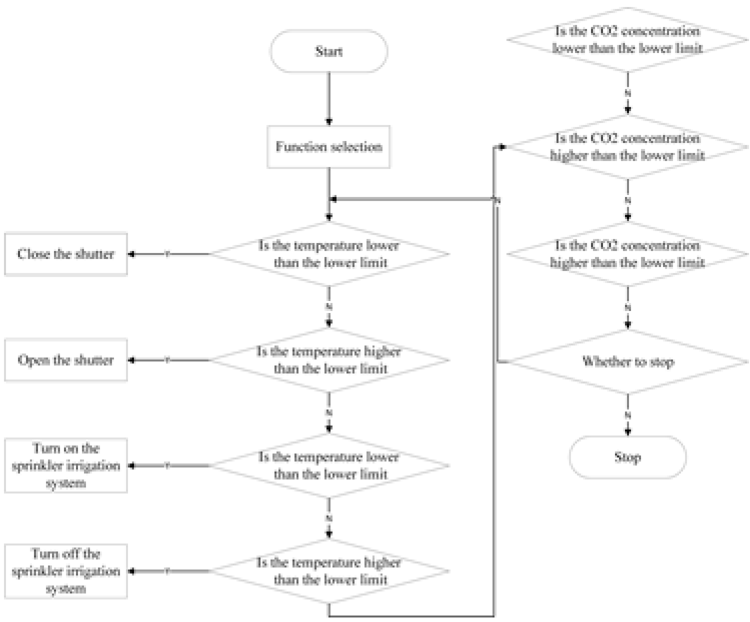

Figure 3. Flow chart of the automatic control system for greenhouses.

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3.1. Information collection module

The information collection module is composed of 5 modules: single-chip microcomputer, digital temperature and humidity sensor, soil temperature sensor, SM2802M soil moisture sensor and A/D conversion, which can realize the air temperature and humidity, soil temperature, soil moisture, light intensity and CO2 concentration in the greenhouse Wait for data for real-time monitoring and control.

1) Single-chip microcomputer: AT89S52 single-chip microcomputer is characterized by low power consumption and high-performance 8-bit microcontroller, which is used as the core part of the system. Because of the performance of 8-bit CPU and programmable Flash on the chip of the single-chip microcomputer, it provides a flexible and effective solution for the system. In addition, AT89S52 single-chip microcomputer can be reduced to 0Hz static logic operation, and supports two selectable power-saving mode software, namely idle mode and power-down protection mode. The single-chip microcomputer also has the functions of repeatedly writing programs and memory. It is an efficient microcomputer that can solve some complicated control problems. Compared with other microcontrollers, the required cost is very low.

2) Digital temperature and humidity sensor: The sensor is designed and developed by DB420 intelligent sensor element, and has the characteristics that other similar sensors do not have, such as accurate measuring drawer, stable work, long service life and so on. The probe of the sensor uses a copper sintered open-hole protective tube, which has better ventilation and dust-proof functions. The built-in digital temperature and humidity sensor in the sensor can convert the digital signal into a 4-20mA current signal and output it through the central processing unit and digital-to-analog converter inside the transmitter.

3) Soil temperature sensor: The digital sensor adopts the DS18B20 type digital sensor, which was launched by DALLAS Semiconductor Corporation in the United States. Compared with the thermistor, this sensor has the advantages of direct reading of the measured temperature and a simple programming method that can realize 9~12 digits of digital value reading according to actual requirements. The 9-digit and 12-digit numbers are respectively 93.75. It is realized within ms and 750ms, and the information read and written through DS18B20 only needs a single-wire interface. The data bus provides a power for the temperature conversion, no external power supply is required, and the bus can also supply power for the DS18B20. Therefore, the use of the DS18B20 digital sensor improves the reliability of the system while concise system structure.

4) SM2802M soil moisture sensor: SM2802M soil moisture sensor is made with the latest FDR principle in the world. Compared with TDR type and FD type soil moisture sensor, SM2802M soil moisture sensor is not only comparable in performance and accuracy, but also has more advantages in reliability and top speed than TDR type and FD type. The probe model of the illuminance sensor is GZD-01.

5) A/D conversion module: The AID conversion module uses 8-channel ADC0809, which has the characteristic of gradual approach. Its power supply mode is to use a single +5V voltage, and at the same time there is an analog switch with 8-to-1 latch function on-chip. The one-chip computer uses the interface circuit of the interrupt mode to control ADC. Signal transmission is to convert non-electric physical quantities into electrical signals through light sensors and CO2 sensors, and then send the converted electrical signals to the analog conversion module ADC0809, and then convert them into digital signals after AID conversion, and finally convert them The resulting digital signal is sent to the microcontroller for corresponding processing. The single-chip microcomputer converts the 1TL level to the RS232 level by the MAX232 level conversion chip through the 1/0 port, transmits the converted data to the upper computer for storage, and displays the stored data in real time through the

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liquid crystal display, realizing the human The function of machine interaction. In order to improve the reliability and anti-interference ability of the single-chip application system, a microprocessor monitor chip is added to the single-chip system, and a watchdog circuit and a power-down protection circuit are integrated.

3.2. ZigBee wireless transmission module design

ZigBee network has the following 9 advantages: low power consumption, low cost, low speed, support for a large number of nodes, support for multiple network topologies, low complexity, fast, reliable and safe. ZigBee is a wireless network protocol for low-speed and short-distance transmission. The network protocol is divided into many layers from top to bottom, the representative ones are: physical layer, media access control layer, transport layer, network layer, and application layer. The three roles of ZigBee network devices are: coordinator, sink node and sensor node. The ZigBee network and the single-chip microcomputer are connected through a star network, and the time to send data to the designated node is controlled by the single-chip microcomputer; at the same time, the single-chip microcomputer sends a message to the controller according to the set temperature upper and lower limits, when the controller receives the message It is immediately transmitted to the star network, and then the star network is transmitted to the single-chip microcomputer, and then the single-chip microcomputer makes corresponding processing.

4. System software design

First, set up various sensors and external devices, set the upper and lower limit values for temperature and humidity sensors and light sensors, and initialize other external devices. After initialization, the temperature and humidity sensor and the light sensor start to collect data. Since the collected data is a digital signal, the single-chip microcomputer can be used to directly monitor the changes in the environmental value; the single-chip computer will analyze the monitored values and analyze the temperature, humidity and light The final value of intensity is transmitted to the LCD for display; the displayed split screen can be changed by pressing the buttons, and the upper and lower limits of temperature, humidity and light can also be adjusted by pressing the buttons. When the temperature, humidity and care intensity value exceed the upper and lower limits, the microcontroller will send a flag signal to control the action of the relay to achieve the control effect. The main software flow chart is shown in Figure 4.

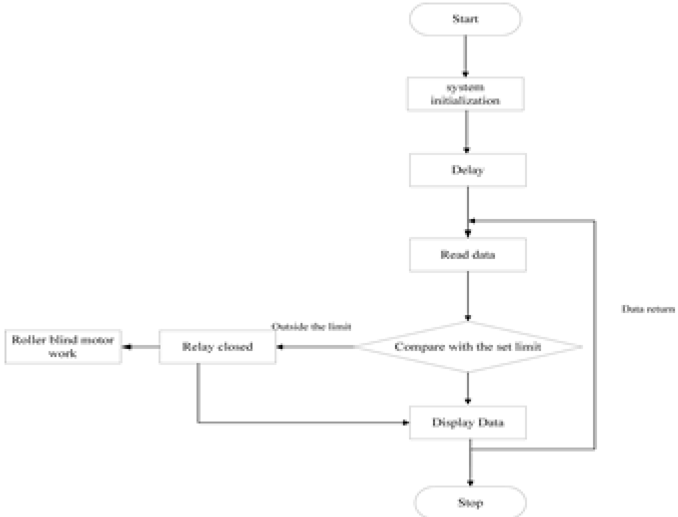

Figure 4. Program flow chart.

5. Conclusion

Through the development of the greenhouse intelligent controller of the embedded system, the data information of a certain collection point on the spot can be inquired, and the information of this point can be transmitted to the terminal through the Euline transmission module. At the same time, each collection point can also send information to the terminal regularly to realize the real-time communication between the greenhouse site and the remote control terminal, making the management of the greenhouse more modern. At the same time, the system can not only perform real-time monitoring of air temperature and humidity, soil temperature and soil moisture content, but also perform statistical analysis and processing on the monitored data. At the same time, the upper and lower limits of the program can be set according to the nursery temperature, and operations such as ventilation and ventilation of the greenhouse can be realized through remote control.

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