Design of an Integrated Automatic Irrigation System for Traditional Chinese Medicine Greenhouse Planting

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Abstract. In modern agricultural production and life, the demand for automatic irrigation in traditional Chinese medicine greenhouse planting is increasing, and the traditional irrigation system often fails to the demand due to the lack of automatic control function. To solve this problem, this article designs and implements an automatic irrigation system based on Internet of Things technology. The system is based STC89C52 single-chip microcomputer, and monitors soil moisture, environmental temperature and humidity and other parameters through wireless devices. Through actual testing, the stability and of the system are verified. The results show that the system can achieve precise irrigation of crops in traditional Chinese medicine greenhouse planting under unmanned circumstances, reduce manual operation, improve irrigation, and automatically adjust irrigation strategies according to environmental changes to meet the needs of different traditional Chinese medicine plants, showing a good application prospect.

Keywords: Automatic irrigation, Internet of Things technology, microcontroller, soil moisture sensor

1 Introduction

The greenhouse plays an important role in the production of agriculture and sideline products[1]. The environment of the greenhouse has a great impact on the yield of crops, among which the temperature and humidity of the air and soil are particularly prominent. Therefore, it is very necessary to carry out multi-point detection and adjustment of the greenhouse environment[2]. present, the control of the greenhouse environment mostly focuses on temperature and adopts manual regulation[3]. In addition, the detected data cannot be automatically recorded and stored in real time, which is notducive to the analysis and optimization in the future. Based on this, this design has developed a system that can real-time multi-point detection and adjustment of the greenhouse environment This design can not only save consumption and reduce human labor, but also achieve accurate control, which is beneficial to the growth of crops and is of great significance to improve the yield of[4].

K. Bellitürk et al. (eds.), *Proceedings of the 2025 2nd International Symposium on Agricultural Engineering and Biology (ISAEB 2025)*, Advances in Biological Sciences Research 50,
https://doi.org/10.2991/978-94-6463-910-0_32

2 System Overall Scheme Design

This design takes STC89C52 as the core of the main control module, and is composed of 9 modules: the main control module the environment temperature and humidity detection module, the soil moisture detection module, the AD/DA analog-to-digital conversion module, the data display module, the water tank water level module, the relay module, and the Bluetooth module[5]. The overall structure diagram of the integrated automatic irrigation system is shown in Figure 1.

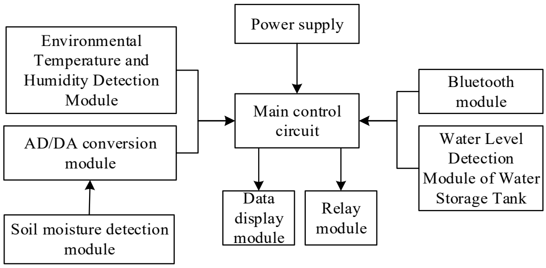

Fig. 1. Overall structure diagram of the integrated automatic irrigation system

3 System Hardware Design

3.1 Sensor Design

The system realizes multi-point detection of the environment of the traditional Chinese medicine greenhouse through multiple sensors. A waterproof temperature sensor DS18B20 used to measure the air temperature and soil temperature[6]. This sensor is the latest digital single bus device launched by DALLAS Semiconductor Company of the United States after the DS120. Although the soil moisture sensor and the air humidity sensor are different products, their output values are both voltage signals[7]. The corresponding relationship between the voltage value and humidity is known so as long as the voltage value is measured and the data is calculated and processed by the single chip microcomputer, the temperature and humidity value can be obtained[8].

3.2 Data Collection Design

This design collects data through the AD/DA analog-to-digital conversion module. The AD/DA analog-to-digital conversion module uses the PC8591 conversion chip, which communicates via the I2C bus. During communication, the microcontroller first sends a start signal and address 0x90 to the PCF8591, and then sends the register address to configure the ADC working mode and select the channel[9]. The PCF8591 converts the -bit digital signal acquisition result of the specified channel and transmits it to the microcontroller via I2C[10].

3.3 Design of Wireless Communication Device

The design uses a data display module and a Bluetooth communication module to implement the real-time display of environmental parameters and the functions of wireless data transmission, realizing human-computer interaction[11]. The data display module uses a 0.96-inch blue OLED monochrome LCD display, which is connected to the microcontroller via an2C bus interface. First, the OLED clock frequency division and contrast and other parameters are initialized to ensure normal operation; then, by setting the cursor position and offset functions, decimal value and character form of the data of the sensor parameters such as the water level of the water tank, the environmental temperature and humidity, and the soil humidity are displayed on the [12].

The Bluetooth communication module uses the commonly used HC-06 module, which is connected to the microcontroller through the serial port to realize data transmission. reading and writing the serial data buffer register SBUF and setting the overflow rate of Timer1, the configuration of serial port communication under different baud rates is realized[13]. This implements the real-time display of the real-time data of the environmental parameters collected by each sensor module on the screen through the OLED display module, and at the same time the Bluetooth communication module is used to transmit the data to the mobile phone or other terminal devices in a wireless way[14].

4 System Software Design

The software part of the system can be divided into six parts: the system initialization module, the signal acquisition module, the data storage module, the data module, the control watering module and the low power consumption sleep module[15]. The system initialization module is mainly used to initialize the LCD screen and other peripherals. The main function of signal acquisition module is to extract the soil humidity value of traditional Chinese medicine plants[16]. The data storage module completes the storage of the RS485 interface output results of the soil humidity, and the data display module can display the detected soil humidity value on the LCD screen. The control module is used to water or stop watering according to different situations of soil humidity[17]. low power consumption sleep module can achieve the function of low power consumption by entering the sleep mode of the system.

5 Practical test and Analysis

5.1 Water Tank Water Level Detection Test

This design displays the water level in the water tank through the water tank water level detection module and relay module, and controls the water pump for irrigation. water tank water level detection module uses an ultrasonic sensor to detect the water level in the water tank, and indicates the water level through three different colors of LED lights (green yellow, and red). The ultrasonic sensor sends ultrasonic pulses through the Trig pin and receives the reflected ultrasonic waves through the Echo pin, and then the distance between the water level and the sensor based on the round-trip time[18]. The water level status is displayed in real-time according to different distance ranges and the on-off of the LED lights. In this design, the height of the water tank is about 300 mm, and the detection of the water level in the water tank is shown Table 1.

Table 1. Water level detection of water tank

Measured distanc (h/mm)	LED lighting status	Water level situation	Water demand
h <50	Green, Yellow, Red	High	Not needed
50 <h<200	Yellow, Red	Medium	Not needed
h >200	Red	Low	Need

5.2 Soil Moisture Detection Test

The sampling interval was set to 6 h. After the system has been running for a period of time, the user can extract the humidity data values stored the register[19]. Table 2 shows the soil humidity values in the automatic mode of system operation for 6 days, and the test results show that the soil humidity values can be recorded 6 days of system operation when watering is carried out one day after the soil humidity is lower than 15%, and the function of autonomous learning is realized

Table 2. Automatic mode soil moisture values

Date	Time			
	04: 00	10: 00	16: 00	22: 00
May 5, 2025	26.65	25.54	25.15	23.43
May 6, 2025	23.65	23.21	21.89	19.43
May 7, 2025	17.67	16.63	15.22	14.21
May 8, 2025	27.68	26.23	25.88	24.65
May 9, 2025	22.13	21.67	20.77	18.90
May 10, 2025	17.93	16.06	15.65	14.32

6 Limitations and Prospects

This paper still has some limitations in its design. For example, when the number of monitoring sensor nodes is large, their high power consumption leads to a shorter running time; to enable remote control, it is necessary to connect each node to the network. To address these issues, further research and experiments need to be conducted with fewer monitoring sensor nodes to continuously improve system functionality. With the rapid development of artificial intelligence and machine learning technologies, environmental data analysis will enter a new intelligent era. AI and machine learning can automatically identify pollution sources, predict environmental trends, and provide precise early warnings and decision support by analyzing and mining large amounts of environmental data[20]. In addition, data fusion technology will become an important trend in future ecological and environmental monitoring. By integrating data from different monitoring devices and sources, a more comprehensive and accurate view of environmental data can be formed. The further development of environmental early warning systems will also rely on big data analysis, cloud computing, and AI technologies to achieve quick responses and warnings regarding changes in environmental quality, providing real-time and accurate environmental information to governments and the public. At the same time, the sustainability of environmental monitoring technologies will be a key consideration. The design and lifespan of monitoring equipment will be optimized to ensure long-term stable operation and reduce maintenance costs. Future environmental monitoring systems will place greater emphasis on long-term management, being able to continuously provide efficient and accurate monitoring services, supporting long-term environmental protection and ecological restoration efforts. Through sustainable monitoring methods, governments and enterprises can manage environmental resources more scientifically, formulate reasonable policy measures, and promote green and low-carbon transitions. Overall, the future of ecological and environmental monitoring technology will continuously develop towards intelligence, integration, and sustainability, providing more precise, efficient, and economical technical support for environmental protection, contributing to the improvement of the global ecological environment and sustainable development.

7 Conclusion

This design takes STC89C52 as the control core, and the parameters of temperature, humidity and soil humidity in the environment are detected soil humidity sensor and environmental temperature and humidity sensor. The detected data is transmitted to the OLED screen for display through AD/DA analog-to-digital conversion module, and the control signal waters the plant properly. At the same time, it can measure the water level of the water tank through the water tank water level detection module, and show the water level the water tank intuitively through the lighting and extinguishing of three different color LED lights. The system is designed to be simple and convenient, with high feasibility and considerable application prospects.

Acknowledgments

This work was financially supported by the Science and Technology Research Project of Jilin Provincial Department of Education (JJKH20241037CY).

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