Design of energy-saving greenhouse automatic irrigation system

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Abstract. In view of the urgent need of the greenhouse irrigation, a Energy-saving greenhouse automatic irrigation system is designed. The system is powered by solar energy and controlled by Single Chip Microcomputer. Multi-point humidity sensor is used to detect soil humidity. An intuitive system management platform is also provided to complete data processing. The information management software was developed for real-time monitoring and remote alarm monitoring. The experiment show that the system can realize the automatic irrigation function, when the soil humidity decreases to the lower threshold of soil humidity, the system starts to work, and when the irrigation reaches the upper threshold, the system can stop irrigation within 10min. The system is easy to operate and stable operation. It also has certain value of application. The development and use of this system can offer experience and technical support to the establishment of intelligent irrigation systems.

1. Introduction
In the process of agricultural planting, greenhouse can break through the limitation of regional, climatic and other factors, enable people eat fresh fruits and vegetables in cold winter, and increase farmers' income [1-2]. Greenhouse has been widely used in agricultural system. The soil moisture and nutrition are mainly controlled by irrigation in greenhouse environment. Scientific irrigation and reasonable regulation soil moisture are important measures to ensure high quality and yield of crops in greenhouse [3-4].

With the improvement of agricultural automation, agricultural irrigation has developed from artificial irrigation to automatic irrigation, which is used various terrain and conditions, and the effect is very good [5]. An automated irrigation system for greenhouses is proposed in Paper [6]. However, the above system can’t detect soil moisture and mainly irrigate at time intervals, which also brings a series of problems. For example, different plants have different needs for water, and soil humidity will have great impact on plant growth. The greenhouse is planted in the wilderness, and special wires must be laid to realize irrigation [7]. Therefore, based on the existing irrigation technology and the actual water demand of plant, advanced intelligent automatic control technology is applied to accurate irrigation, reduce irrigation labour and management cost [8].

Based on the above analysis, an energy-saving automatic irrigation system is proposed in the paper. The system is suitable for a variety of agricultural planting. Taking the automatic irrigation system of vegetable greenhouse as an example, the design and debugging process of the system are analyzed in detail. The system is powered by solar energy and controlled by Single Chip Microcomputer (MCU). Multi-point humidity sensor is used to detect soil humidity. An intuitive system management platform
is also provided to complete data processing. The information management software running on the system was developed for real-time monitoring and remote alarm monitoring. The test shows that the system has stable operation and simple operation, and also has certain value of application.

2. Overall system design
The system mainly includes power module, MCU module, sensor module, A/D conversion module, LCD module, key module, relay module and alarm module. The structure diagram of the system is shown in Figure 1. The system uses the sensor module to collect soil humidity, compares the collected humidity with the demand data of crops, the comparison result is used to control the relay switch, and realize the real-time automatic control of different growing crops in the greenhouse.

![Figure 1. The overall design diagram of the system.](image1)

![Figure 2. The hardware circuit of the system.](image2)
2.1. **Hardware design**  
The system uses SCM STC89C51 as the main control chip and solar panel for power supply [9]. YL-69 is selected as the soil humidity sensor, the output is analog signal, which is connected with the controller with A/D converter ADC0832. LCD module adopts LCD1602, which has small volume and low power consumption. The relay module uses RELAY-SPDT to control the solenoid valve switch, which control the irrigation of crops. The key module includes four keys, S1 reset function, S2 setting function, S3 plus function and S4 minus function, which mainly set the irrigation threshold for different crops. The alarm module uses buzzer to alarm. The hardware circuit of the system is shown in Figure 2.

![Figure 2. The hardware circuit of the system.](image)

**Figure 3.** The software circuit of the system.

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START

System initialization

Set humidity threshold

Detect soil humidity

Data processing

Test<Lower threshold?

Y

Start to alarm

Open irrigation device

Test>upper threshold?

Y

Close irrigation device

END

N

N

END
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2.2. Software design
When system is powered on, we initialize the system and set the soil humidity threshold depending on the parameters of crops. The humidity sensor measures the soil moisture, and the measurements display real-time on the monitor [10]. The controller is used to process the data. When the soil humidity reaches the lower threshold, the system starts irrigating automatically and alarm. When the soil humidity reaches the upper threshold, the system stops irrigating. The software flow diagram of system is shown in Figure 3.

3. System debugging

3.1. Simulation debugging
In the simulation, Proteus software is used for simulation debugging [11], the simulation diagram of the system is shown in Figure 4. Because there is no humidity sensor in Proteus software device library, with the working principle of humidity sensor YL-69, the simulation circuit selects adjustable resistance to replace it, and simulates the detection of humidity by adjusting the size of adjustable resistance. In the program, we set upper threshold 40% and lower threshold 20%. When the soil humidity sensor detects 11.9%, the measurement is less than the lower threshold, the relay works and the buzzer start to alarm. It is shown in Figure 5. When detection value is 50.4%, the system stops working. It is shown in Figure 6. Through debugging the system, the system can meet the design requirements.

![Figure 4. The simulation diagram of the system.](image-url)
3.2. Physical debugging

The design of the system is verified to be feasible by debugging with Proteus simulation Software and Keil development software. Because Single-Chip Microcomputer minimum system can not be debugged in Proteus simulation circuit, we first debug minimum system, then assemble components according to hardware circuit. The physical picture is shown in Figure 7.

![Figure 5. The 11.9% simulation diagram.](image1)

![Figure 6. The 50.4% simulation diagram.](image2)

![Figure 7. The physical picture.](image3)
When system is powered on, we set upper threshold 85% and lower threshold 75%. When detection value is 71.9%, the relay control solenoid valve to open, the system implements irrigation function and start to alarm. It is shown in Figure 8. When detection value is 86%, the system stops working. It is shown in Figure 9. After debugging, the functions required in the design can be realized completely.

![Figure 8](image1.png) **Figure 8.** The 71.9% physical picture.  
![Figure 9](image2.png) **Figure 9.** The 86% physical picture.

4. Conclusions
In view of the characteristics of high humidity and dynamic changes of crops in greenhouse, an energy-saving automatic irrigation system is designed. The system is powered by solar energy. The equipment has the functions of real-time monitoring, remote alarm monitoring and flexible irrigation threshold setting and so on, and provide users with intuitive system management platform and data processing. It is shown that the equipment has good stability and can meet the irrigation needs of different crops. The system is easy to operate, rapidity is able to satisfy the agriculture technical requirements. It also has certain value of application. The development and use of this system can offer experience and technical support to the establishment of intelligent irrigation systems.

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