Research on Integrated Management System of Water and Fertilizer Based on Internet of Things

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Abstract. This paper designs and implements a management system of agricultural water and fertilizer integration based on Internet of Things (IOT). The design of the management system, which solves the problems of energy consumption, accuracy, stability and expansibility, is mainly composed of modules with monitoring management, water and fertilizer control, data management and remote control, while realizing greening, intellectualization, networking and digitization. The system takes SK-S7G2 microcontroller as the core to build a bidirectional data channel between the client and temperature sensor, humidity sensor and light intensity sensor by using 4-G wireless network and Ethernet communication modes. Then, the sensor parameters are sent to the client and the control instructions of the client are received to realize the remote real-time control of the motor, fan and other equipment. the production environment data collected by SK-S7G2 are transferred into the database of cloud server to construct an agricultural database of real parameters of crop growth environment. Finally, the feasibility and validity of the management system have been verified by the real environmental test, which proves that the design of the management system proposed in this paper is an effective solution of the intelligent agricultural water and fertilizer irrigation system with the characteristics of energy saving, high efficiency, accuracy and scalability.

Keywords: Internet of Things · Water and fertilizer integration · SK-S7G2

1 Introduction

Please note that the first paragraph of a section or subsection is not indented. The first paragraphs that follows a table, figure, equation etc. does not have an indent, either. China has been a big agricultural country since ancient times, agricultural technology has been inherited for thousands of years. Farmers have also occupied the vast majority of China's population so that Chinese government pay close attention to the issue

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concerning agriculture, the country and the farmers [1, 2]. At present, there is still a certain gap between China and developed countries in agricultural level and agricultural technology [3]. Although a series of advanced technologies have been introduced and learned in recent decades, there is still much room for improvement [4], some new demands have been put forward:

Greenization: The large and long-term use of chemical fertilizers and pesticides has resulted in land salinization and environmental pollution.

Precision: The selection and use of chemical fertilizers are not precise enough, so it causes serious consequences in crops and humans.

Digitalization: The popularization of digitalization and networking of agricultural technology in China is poor, so it is not conducive to the management and analysis of agricultural data.

Internet of Things, which based on the Internet, collects information, identifies intelligently and manages decision-making by using radio frequency identification (RFID) and other sensing devices. The development of IOT technology can effectively solve the drawbacks of traditional agriculture, and provide technical support for the Greenization, precision and Digitalization of agriculture [5, 6].

This paper focuses on the design of the management system of agricultural water and fertilizer integration based on the IOT technology. The latest SK-S7G2 is used to control the relevant equipment and devices in real time and make irrigation plans. Sensors are used to detect the environment, and data are transmitted to users through 4G module for real-time monitoring of agricultural growth environment. Peristaltic pump is never used in agriculture as one of the industrial metering pump, now it is used as a liquid transfer device to solve problems of lack of pressure and Incorrect feeding of water and fertilizers in the device of fertilizer and water integration.

The stepless regulation of 0–100% can be achieved by improving the metering pump. Meanwhile, the flow can be controlled manually or by frequency regulation, remote control and computer automatic control can be realized.

Finally, the production environment data collected by SK-S7G2 are transferred into the database of cloud server to construct an agricultural database of real parameters of crop growth environment, and to achieve better agricultural production management through intelligent analysis of agricultural data.

2 Overall Design

The overall design for management system of the water and fertilizer integration based on IOT is shown in Fig. 1. The core part of the system is the microcontroller SK-S7G2, which is based on ARM Cortex-M4 processor, and it's clock speed reaches 240 MHz, all needs for development of the management system is to be Completed. Water pump and fertilizer pump is equipped for agricultural irrigation in the system, Temperature sensor, humidity sensor, light intensity sensor, PH/EC sensor and solenoid valve are also installed, and Sensing data and solenoid valve status are transmitted to S7G2 microcontroller through bus. The design mainly includes the following four modules.

2.1 Monitoring Management

In this paper, SK-S7G2 microcontroller is used to acquire environmental indicators, including air temperature, air humidity, soil humidity and light intensity, by installing various kinds sensors for agricultural production environment. All kinds of sensor data are transmitted to SK-S7G2 by CAN bus, and then these detected data are transmitted to the user's mobile device through UDP protocol for real-time monitoring by using the connected 4G module. Meanwhile, the real-time working state of every device is also transmitted to the client through this method. In addition to displaying the environmental data of farmland, the client sends commands to SK-S7G2 controller connected with 4G module through UDP protocol, which realizes the control of fan and fertilizer pump. In this process, the microcontroller judges whether the client command is valid by logical analysis. If it is reasonable, the microcontroller executes the command, otherwise the operation will not be carried out.

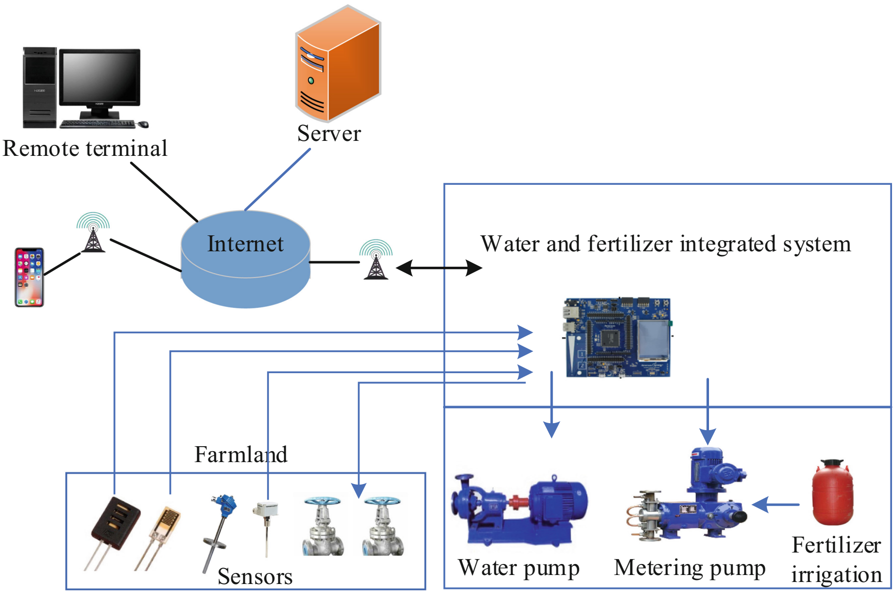

Fig. 1. The overall design of water and fertilizer integrated system.

2.2 Water and Fertilizer Control

In terms of water and fertilizer supply and control, peristaltic metering pump, which is characterized by stable pressure, precise fertilizer feeding, and the ability to transport corrosive liquids) is the main equipment. Water and fertilizer is fed into the pump as a similar peristaltic way by pipeline pressure, then be together into the mixing pipe through the different ports, and be transported to drip irrigation pipes on the farmland for irrigation by the solenoid valve. Filters will be installed in the reservoir to filter various substances such as sediment, so that The drip irrigation pipes won't clog up. Moreover, PH and EC value detectors can be installed in the pipes to detect the water and fertility quality for the import and export, which will further improve the accuracy of irrigation.

2.3 Data Management

In this paper, crop data collection is carried out in the process of farmland planting and management, and a pertinent database is constructed. The data of crop growth status are recorded in the database, which is conducive to further improving the cultivation mode of the crop. It is also convenient for scientific researchers to use the real data when they are engaged in agricultural research.

2.4 Remote Control

The control software queries the historical data from the cloud server through HTTP protocol for remote control, and sends the query instructions to the cloud server through POST method; The client sends the control commands to the cloud server through UDP protocol, and the cloud server transmits the control commands to SK-S7G2 which is equipped with 4G module by UDP protocol to controls the related equipment. Then, the communication between devices is to express their identity by sending heartbeat packets to the cloud server. The cloud server takes out the IP and port of the device and designs a list of device addresses, so that the program can be better maintained.

3 Program Testing

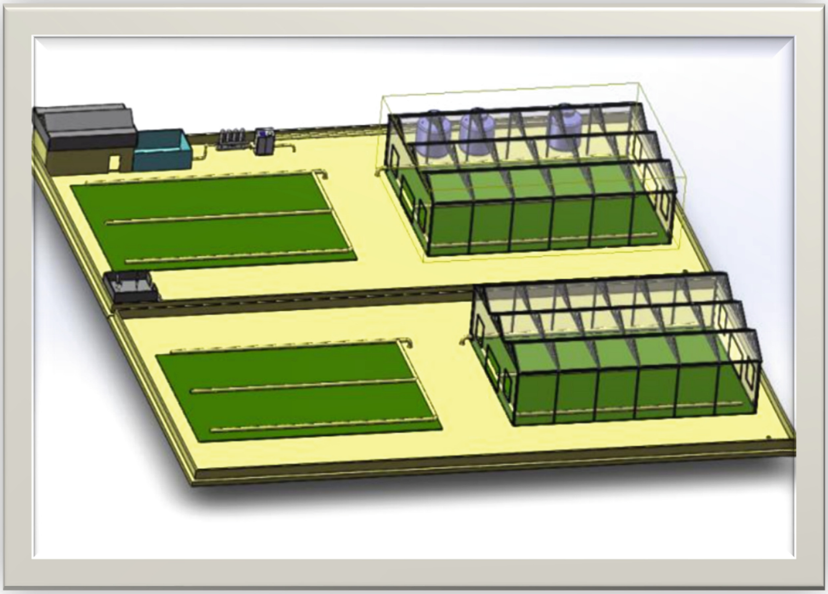

Fig. 2. The simulation diagram of the testing system.

The simulation diagram of the testing system is given in Fig. 2. Water and fertilizer integration is the main part of the testing system, which consists of metering pump, liquid savings box, mixing pipe, transmission pipe, solenoid valve, drip irrigation pipe

Table 1. The main part of the testing system.

Number	Component name	Parameter
1	Fertilizer mixing pipeline	2 lines
2	Water source pipeline	1 line
3	Metering pumps	3
4	Simulated greenhouse and field	Two pieces each (four pieces in total)
5	Solenoid valves for controlling irrigation switch	4
6	Sensors	Temperature, humidity and illumination
7	Ventilator	1
8	4G Internet Module	1
9	Transport pipelines	Some

and so on. See Table 1 for details. A reducer (small wheels drives large wheels) is used in the metering pump to ensure sufficient and stable power in irrigation, and to facilitate the realization of precision control.

Figure 3 shows the hardware devices connected to SK-S7G2 and the communication protocols used to connect the devices.

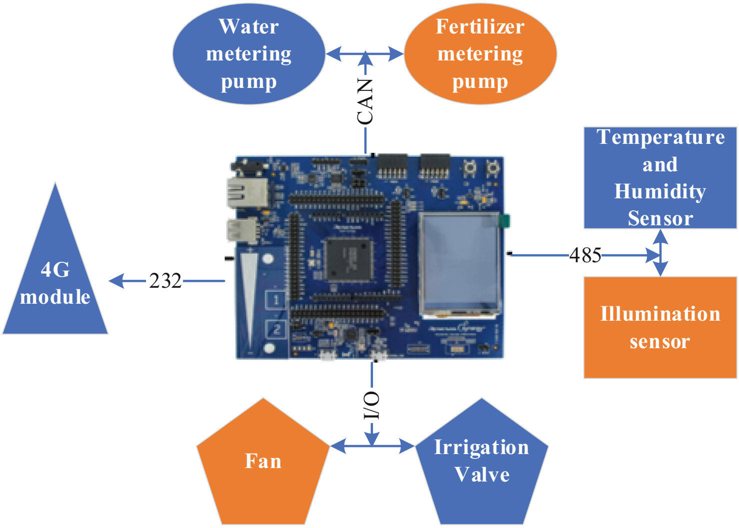

Fig. 3. Hardware system diagram.

Figure 4 shows the flow chart of the software:

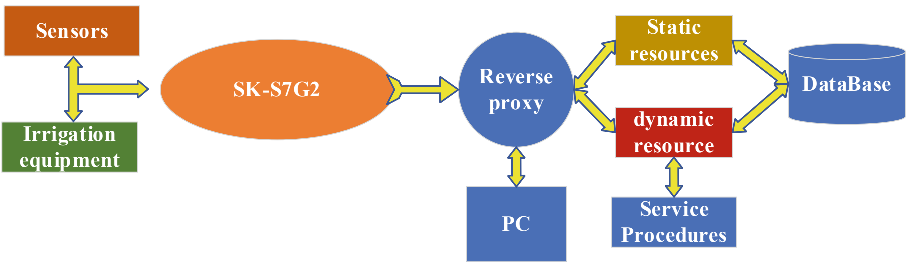

Fig. 4. Software flow chart.

After the equipment is assembled, we expect to test it according to the following scheme (Table 2):

Table 2. Test results of the water and fertilizer integration system.

Number	Test scheme	Test result
1	Observing whether SK-S7G2 can accept and display the measured data of farmland environmental sensor	Correct
2	Observing S7G2 data sent to client by changing the environment around sensor	Correct
3	Observing the historical data recorded in the database on the client	Correct
4	Control the fan and irrigation equipment by sending control commands from the client	Correct
5	Establishing expected control through irrigation planning	Correct
6	Control the speed regulation and working time of metering pump	Correct
7	Mix and transport inhaled water and fertilizer	Correct
8	Automatic cleaning function before irrigation based on S7G2	Correct
9	Getting relevant information on the web interface	Correct
10	Observing the consistency of data at the receiving and sending of the cloud server	Correct

The sensor delay is in a reasonable range when testing, and the packet loss rate of control command is low, so that the real-time control is effective. The client can acquire the real time status of farmland production environment and equipment. After setting irrigation plan, the control operation can be realized. The historical environmental data received by SK-S7G2 can also be acquired, which is conducive to the query of data.

4 Conclusion

By investigation, it is found that traditional irrigation methods are still used in many areas of our country which not only takes up too much labor, but also has low popularization of digitalization, precision and mechanization. Many problems have been found in agricultural irrigation equipment on the market, such as the water and fertilizer integration. In order to save the cost of equipment, people always use the one of low precision and mechanical. This will not only lead to excessive use of water and fertilizer in the process of fertilization and irrigation, resulting in waste of resources and environmental pollution, but also significantly reduce production efficiency, leading to increased crop costs. In order to solve this key problem, more advanced technology and modern equipment are used in the water and fertilizer integration management system, and more rational allocation and installation are carried out, giving full play to the role of each part, so as to achieve the maximum overall efficiency of the system.

Water and fertilizer integration system is based on Internet of Things technology. Firstly, the latest SK-S7G2 is used to control the equipment and devices in real time. Sensors are used to detect the environment for real-time monitoring of agricultural growth environment. Then, Peristaltic pump is never used in agriculture as one of the industrial metering pump, now it has been used as a liquid transfer device to solve problems of lack of pressure and Incorrect feeding of water and fertilizers in the device of fertilizer and water integration. In this paper, the management system of water and fertilizer integration has achieved precision and networking by design and innovation, mainly due to the stepless regulation of 0–100%. The flow can be controlled manually or by frequency regulation, and that the remote control and computer automatic control can be realized, which has the characteristics of intuitive and clear, smooth operation, no noise, small volume and convenient maintenance. Finally, the production environment data collected by SK-S7G2 are summarized into the cloud server database in order to build a database of crop growth environment requirements in order to realize the management and follow-up analysis of agricultural data.

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