Design of Intelligent on Remote Irrigation Control System based on Cloud Database

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Abstract. Aiming at the problems of low artificial efficiency, poor irrigation precision and unequal resource distribution in large-scale shed planting, a design scheme of remote irrigation control system based on cloud database is proposed. As a communication means between greenhouse and monitoring station, LoRa realizes the wireless interaction between sensor layer, actuator layer and network layer. Establish human-computer interaction interface between mobile devices and PCs, namely WeChat small program, to realize the parameterized regulation and management of greenhouses. Establish a cloud database to store relevant data and form a chart for big data research and manual reference. The experimental results show that the designed intelligent irrigation system is simple to install, has no cable constraints, high practicability, strong real-time performance and flexible control mode, and is suitable for medium and large-scale shed planting.

1. Introduction
China's per capita water resource occupancy is at a low level in the world, among which agricultural irrigation water consumption accounts for more than 60% of the total water consumption, but the effective utilization rate of irrigation water resources is less than 50%, which is a big gap with developed countries [1]. Traditional greenhouses take up a large proportion in agricultural production, and there are many problems in artificial irrigation methods currently used: it is impossible to monitor soil moisture in real time, most of them are through irrigation, and water resources are seriously wasted. There are old irrigation facilities, wiring clutter and low precision irrigation. Because the planting area is large, the manual management method is inefficient and high cost. The original wireless technology is unstable and the maintenance cost of equipment is high. These problems seriously restrict the large-scale production of modern agriculture, so the development of intelligent irrigation system is the key way to promote the sustainable development of China's agriculture [2].

With the rapid development of Internet of Things technology, many emerging technologies such as big data and cloud storage are increasingly applied in agriculture [3]. In recent years, the application of wireless and network technologies in intelligent irrigation systems has gradually solved a series of problems existing in traditional intelligent control systems, such as complex networking, short transmission distance, vulnerable signal interference and high cost [4-6].

This paper proposes an intelligent greenhouse remote irrigation control system based on cloud database. Wireless spread spectrum technology LoRa is the means of local networking, and then uses LoRaWAN gateway protocol to build the information interaction framework between local and network server. A three-stage node is set up to realize the fusion of sensor and communication module, which solves the problem of information transmission affected by complex terrain and vast region in
the planting area. And then, the system optimizes power supply circuit, reduces equipment power consumption, and realizes wireless data acquisition and control. This system builds database storage unit with the help of cloud server to accurately monitor irrigation water consumption and record big data. In addition, web pages and WeChat clients are used to build human-computer interaction pages between mobile devices and PCs.

2. The system structure
The intelligent greenhouse remote irrigation control system based on cloud database consists of four parts, namely application layer, network layer, communication layer and equipment layer. The overall framework structure of the system is shown in Figure 1:

![Figure 1. System overall structure design](image)

In the application layer, the man-machine interaction interface of the mainstream mobile phone system is developed based on the WeChat client, which is conducive to improving the daily use experience of operators. Then, due to the establishment of a cloud database, the system will automatically record the irrigation water amount, sensor data and system operation log of the current effective irrigation time. In the communication layer, LoRa is characterized by low packet loss rate, long transmission distance and easy node networking in short-distance wireless transmission, which can overcome topographic obstacles. It has obvious advantages in large scale and geographically distributed planting areas. The system fuses LoRa module circuit with MCU controllers, optimizes sampling and communication frequency to reduce energy consumption, and realizes the construction of "cable-free" system in the true sense.

3. Network communication architecture design
LoRaWAN is a set of communication protocol and system architecture based on LoRa long-distance communication network design. It is a network communication solution for data acquisition and information interaction of large Internet of Things platform. In particular, it can optimize the low-power and battery-powered sensors to ensure the balance between network delay and battery life of different terminal nodes. At present, the construction process of the network architecture is convenient and reliable, which is widely used in smart city, shipping management, new office and other scenarios.

The intelligent irrigation remote control system designed in this paper, with the help of the popular third-party cloud server, simplifies the construction process and reduces the high maintenance cost of the server. By configuring LoRaWan gateway and server to establish network communication, data interaction between the physical layer and the network layer can be realized. The network architecture is shown in Figure 2 below:

![Figure 2. Schematic diagram of network communication architecture](image)
3.1. LoRa physical node networking

Traditional wireless transmission methods have their own advantages and disadvantages, so there are obvious differences between application scenarios and applicable methods. In the field of agricultural intelligent wireless control, Zigbee wireless communication used to be all the fashion. However, with the expansion of planting area, its transmission distance and anti-interference ability have been greatly reduced, and the complexity of local networking has also been correspondingly improved, so this technology cannot meet the actual demand. Common wireless communication technologies also include WiFi, Bluetooth, GPRS, etc., among which GPRS is not universal due to the high cost of setting up and the great influence of base station location [7]. Table 1 lists the comparison of the effects of four commonly used wireless networking:

| Method of evaluation | Wireless technology | Power consumption (receiving/sending) | Transmission distance | Applicable characteristics |
|----------------------|---------------------|--------------------------------------|-----------------------|----------------------------|
|                      | WiFi                | 70mA/350mA                           | 100m~700m             | Indoors, fast speed        |
|                      | Zigbee              | 26mA/35mA                            | 30m~150m              | Short distance, easy to be disturbed |
|                      | Bluetooth4.0        | 2mA/19mA                             | 10m~100m              | Low price, slow rate       |
|                      | LoRa                | 10mA/120mA                           | 3km~30km              | Long distance, anti-interference |

Known from the analysis of the data in table 1, LoRa technology with node passthrough ability, low power consumption, strong anti-jamming ability and other characteristics are widely used in remote areas of long distance communication scheme. Compared with other wireless technology, LoRa local network scheme is more suitable for large-scale farming fields, especially in remote signal interference, large area and surrounded by mountains, the planting area.

The system adopts star point topology network distribution layout. According to the actual situation, LoRa nodes are divided into three levels. The first level serves as the total node, with a small number of layout, and it plays the role of information scheduling. The secondary node serves as the relay node and compensates the signal for the region with serious packet loss and large span. The three-stage nodes are integrated with sensors and actuators in a greenhouse. In order to ensure accurate irrigation and overall management of all greenhouses, the communication protocols of physical nodes at each level should be unified in format but with obvious individual identification, and the communication protocols of cross-level physical nodes should be different from those of the same level, so as to ensure efficient and stable communication of physical networking.

3.2. Cloud server and database design

In order to show irrigation water consumption, irrigation schedule and historical irrigation records more intuitively, the system set up a database in the cloud server to realize the functions of data storage, retrieval and view. Based on this function, users can quantify their own irrigation indicators and accumulate production experience. Researchers can carry out corresponding studies with the help of the irrigation amount of water in a period, so as to realize accurate control of the irrigation situation in a certain area and establish corresponding expert system [8]. The cloud server database setup process is shown in Figure 3:
Application layer data handler

| Connection | Recordset | Command |
|------------|-----------|---------|
| ADO        |           |         |
| OLE DB     |           |         |
| MySQL provider for OLE DB | | |
| RDS for MySQL | Remote data Service | |
| MySQL database | | |

Figure 3. Cloud server database construction process

The cloud database can completely retain historical data [9-11], which is convenient for users to retrieve data records anytime and anywhere. Compared with the traditional intelligent irrigation system, the application of cloud database in the irrigation system will no longer limit the working place and working time of operators, and it has a more stable control flow, so as to realize the recording and backup of monitoring data all day long.

3.3. Software interface and architecture design

The client is divided into mobile terminal and web terminal, and its data comes from the cloud server. It is mainly divided into three parts: adding irrigation task, data parameter display and historical data display. The software interface of the mobile terminal relies on the WeChat client. At present, it can support the real-time creation of monitoring irrigation tasks by multiple terminals, the allocation of irrigation usage time item by item or multiple items, and the retrieval of irrigation history records, sensor parameters and other functions. Its interface is shown in Figure 4 below:

Figure 4. Schematic diagram of the client interface

Users can choose manual mode and automatic mode in the operation interface according to the actual situation, and users can also add field devices through code scanning, which is convenient for
diversified scene requirements. When the set value exceeds the range, the device side will have the corresponding prompt message. By viewing the historical data, the users can retrieve the data graph of the specific date. If positioning hardware is added at the device end, the distribution of the specific device end on the map can also be viewed. This function is being improved at present. In addition, WeChat terminal users can achieve multi-user control at the same time through security verification, and operation records of different users will also be synchronized to the operation log of the server, facilitating master-slave decentralized management.

4. Device layer hardware circuit design

Hardware circuit design mainly includes sensor, LoRa chip, master control chip and peripheral circuit design. In addition, considering the waterproof design, the hardware circuit needs to use epoxy resin for waterproof treatment [12]. Under the premise of performance guarantee, this design adopts the domestic mature chip, the chip model is STC15, its price is low, and the operation is stable, so it is suitable for the use of a large number of terminal equipment. LoRa chip SX1278 of Semtech company is used for wireless communication function. The sensor end adopts the combination of amplifying circuit and module. The overall circuit design framework is shown in Figure 5 below:

![Figure 5. Circuit structure design framework](image)

In order to facilitate debugging, a serial port interface is reserved in the circuit to facilitate the user to set the sampling frequency and obtain the fixed ID number of the device through instructions. Battery pack and solar energy are used in the device end to ensure the battery life of no cable. In the mission-free state, the master chip will turn on the low-power mode -- sleep mode, and periodically wait to wake up, so as to ensure the balance between performance and low power. The above design provides a guarantee for the modular construction of the system.

5. The system test

The system was tested on the spot in Shandong Weifang Gaomi City Chunhuaqiushi Agriculture Co., LTD., mainly to test the stability and functionality of the system, including the effective node number and packet loss rate of LoRa networking, the accuracy of cloud data flow interaction, the reliability of communication system and the actual effect of remote irrigation.

During the test, 30 sets of LoRa three-stage nodes were used, including 30 sensor terminals and 30 actuator control terminals. The equipment terminals are arranged in 30 greenhouses with relatively dispersed positions, and each of the 10 sensors is used as a group area. The test time is 24 hours, and the total coverage area of the effective test area is more than 40hm². The results of networking test and data are shown in Table 2:

| Equipment terminals serial number | Number of effective nodes | Packet loss rate/% | Control delay time/s |
|----------------------------------|---------------------------|--------------------|---------------------|

Table 2. LoRa networking test and data recording results
The intelligent remote irrigation system is designed in this paper, and the reliability of its communication is a very important index. During the test, the disconnected times of communication within the 24-hour test period were counted, and the recorded data were shown in Table 3:

| Sensors and actuators serial number | Period of time | Sensors 1-10 | Sensors 11-20 | Sensors 21-30 | Actuators 1-10 | Actuators 11-20 | Actuators 21-30 |
|------------------------------------|---------------|-------------|---------------|---------------|---------------|---------------|---------------|
| 00:00-04:00                        | 0             | 0           | 0             | 0             | 0             | 0             | 0             |
| 04:00-08:00                        | 0             | 0           | 0             | 1             | 0             | 0             | 0             |
| 08:00-12:00                        | 0             | 0           | 0             | 0             | 0             | 0             | 0             |
| 12:00-16:00                        | 0             | 0           | 0             | 0             | 0             | 0             | 0             |
| 16:00-20:00                        | 0             | 0           | 0             | 0             | 0             | 0             | 0             |
| 20:00-24:00                        | 0             | 0           | 0             | 0             | 0             | 0             | 0             |

As can be seen from the test data in Table 2 and Table 3, the field communication equipment of this system has good operation results, low packet loss rate and small delay, and the number of communication drops is less than or equal to 1, and the communication reliability of the system is good.

6. Conclusion
1) The remote irrigation control system based on cloud database proposed in this paper takes LoRa as a means of communication and uses the wireless interaction between sensor layer, actuator layer and network layer to solve the cable obstacle and terrain limitation.
2) The application layer has stable and reliable functions, which can realize complete monitoring, recording and control functions. Through the investigation of operators, the new control interface is more intuitive and convenient, easy to use and simple operation process, with high practicability and user experience.
3) The records of the cloud database are accurate, and the historical records can be checked at any time. The communication of this system is reliable, it can freely increase or decrease the number of nodes to adapt to the different scale of agricultural planting area, at the same time, it has the characteristics of low cost.

Above, the designed intelligent remote irrigation control system has broad application prospects and popularization significance, and can play an important role in the sustainable development of agriculture.

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