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Research on Online Monitoring System of Crop Growth Environment

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Abstract: The growth of traditional crops relies mainly on fertilization, variety improvement and mechanized planting to increase production. Crop yield and fruit quality of crops are difficult to guarantee in the face of declining soil fertility and deteriorating environment. The direction of modern crop development is to develop a smart crop model, and to achieve efficient management and sustainable development of crops through precise sensing technology and in-depth intelligent technology. Smart agriculture based on Internet of Things and data mining has obvious effects on improving traditional crop planting patterns, and is an ideal model for efficient management of crops. The Internet of Things monitoring system combines a variety of wireless sensors, robots and drones to collect real-time growth data of crops in a timely manner, enabling visualization and online monitoring and management of crop growth environments. Therefore, this study is aimed at the problem of inaccurate collection of growth environment parameters of crops in greenhouses during the growth process of crops, and designed a greenhouse greenhouse intelligent monitoring system based on Internet of Things. This study used Internet network to realize human-computer communication interaction, and monitored the soil temperature and humidity, air temperature and humidity, and CO_2 concentration in the greenhouse to complete the monitoring of the on-site crop growth environment. It was also accurate irrigation of crops to achieve precise collection of labour, environmental parameters for crop growth, and remote control of irrigation equipment. The experimental results of the system showed that the system is stable and has good robustness and can achieve the expected design goals.

1. Introduction

In recent years, with the rapid development of science and technology, it has been unable to meet the requirements of modern agricultural development by relying solely on artificial traditional rice field monitoring methods. Timely, accurate and multi-dimensional access to crop growth environment information is conducive to sustainable crop production, ensuring national food security, increasing food production and increasing farmers' income. Data mining can analyse the data collected by the Internet of Things monitoring system, and discover the changes in the agricultural environment hidden in a large number of agricultural data to achieve intelligent analysis and intelligent decision-making [1]. The main applications of agricultural big data are management of production process data, ecological environment data and agricultural equipment monitoring and remote control data. Through the establishment of an intelligent data platform, intelligent analysis, intelligent decision-making and intelligent control of agricultural production processes are realized.

At present, many agricultural experts and scholars have closely combined the actual needs of agricultural production and have done a lot of research on the monitoring of crop growth environment. The integration of modern science and technology such as sensing technology, remote sensing technology and robotics with agriculture has enabled the development of crop growth environment monitoring technology to be further developed in depth and breadth, and has achieved many results [2]. This provides effective information for agricultural scientific research and production management. *Kim, H. J* adopted GIS, cloud computing and mobile Internet technologies to realize the farmland remote sensing information service and field monitoring cloud platform based on the integration of Web and mobile, which is beneficial to the remote sensing information service of agricultural conditions to multiple terminals. Intelligent pattern transformation [3]; *Khan, R* carried out remote sensing monitoring research on the growth of crops in the Songnen Plain, and developed a monitoring system based on MODIS (Moderate-Resolution Imaging Spectroradiometer to realize the monitoring and management of the distribution and growth of crops in the study area [4]; *Sreekantha, D. K.* collected crop images through a drone equipped with a digital camera, and uses visible light vegetation index to obtain crop information, which realized the detection and localization of crop images [5].

However, the sensor-based agricultural harvesting technology based on the Internet of Things has a small operating range, low equipment utilization, and poor information collection flexibility. Moreover, due to the complexity of the monitoring object and the environmental conditions, it is easy to cause abnormal signal signals, resulting in incompatible or even contradictory data collected; Therefore, this study was aimed at the problem of crops in the process of growing greenhouses, the demand for labor in greenhouse greenhouses, and the inaccurate collection of crop growth environment parameters [6]. The intelligent greenhouse monitoring system for crops based on Internet of Things is designed. This study used Internet network to realize human-computer communication interaction, complete the monitoring of on-site crop growth environment to achieve accurate collection of labor, crop growth environment parameters, remote control of irrigation equipment. It is hoped that this study can provide a theoretical basis for exploring the most popular on-line monitoring technology for crop growth environment.

2. Design and Implementation of on-Line Monitoring System for Crop Growth Environment

The system collected the real-time growth environment information of the crop according to the wireless sensor, and simultaneously photographed the growth of the crop by the camera, and dynamically displayed it in the form of a chart or an image. This can show the real-time growth of crops compared with normal crops, showing whether the pests and diseases are serious, to provide early warning of the disasters and to give corresponding countermeasures. The soil temperature and humidity, air temperature and humidity, and CO_2 concentration in the greenhouse were monitored online to complete the monitoring of the on-site crop growth environment [7]. According to the soil water content, rainfall, irrigation water source and irrigation method of different plots, the optimal irrigation time and water volume of the crop are obtained, and the corresponding irrigation strategy is also given.

2.1 Overall Design of the System

Considering the low cost of greenhouse cultivation and the stability of data transmission, the system used *Lo Ra* wireless technology for data transmission. The system was mainly divided into three parts, namely, the sensing layer, the network layer, and the application layer. The network architecture adopted a star topology, and the data in the database was stored hierarchically, which could effectively reduce database query overhead and ensure system performance [8]. The overall structure of the system is shown in Figure 1.

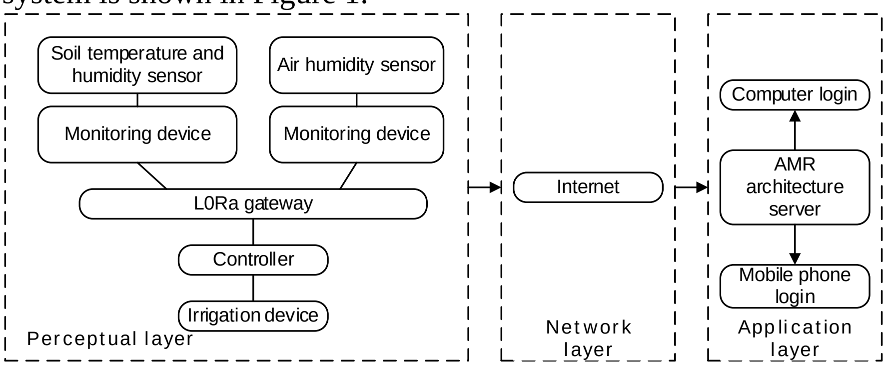

Figure 1 Overall Structure of the Online Monitoring System for Crop Growth Environment in This Study

The main functions and components of each part of the system are shown in Table 1.

Table 1 The Main Functions and Components of Each Part of the System

Sections	Composition	Features
Perceptual layer	CO_2 sensor, air temperature and humidity sensor, soil temperature and humidity sensor, light sensor and surveillance camera, and irrigation device	LoRa wireless technology is used to collect environmental parameters in greenhouses online, and online growth status of crops can be monitored online.
Network layer	GPRS, Internet	Send the collected crop parameters to the ARM server
Application layer	MySQL database, agricultural expert library, ARM server, system terminal	Compare, analyse and screen the collection data of the crop's growing environment with the agricultural expert database, and select the irrigation decision
Client	Client	To realize the monitoring of the greenhouse environment, the user sends control commands through the control interface to realize the operation of the controller.

The functions of the lower computer system of the crop growth environment online monitoring system should be as follows: Firstly, the system detects the temperature, humidity, carbon dioxide concentration and light intensity of the greenhouse; Secondly, the system has a number of actuators, such as intelligent sprinklers; Finally, the system can periodically transmit the collected parameters to the server, and notify the server of the abnormal information in time.

2.2 System Hardware Design

2.2.1 Sensor Node Design

The structure of the sensor node design mainly includes LoRa wireless acquisition module, power module, CO_2 sensor, illumination sensor, soil temperature and humidity sensor, air temperature and humidity sensor. The LoRa wireless acquisition module in this study uses the AT89S52 ultra-low power wireless chip, and its frequency range can be extended from 0MHz to 600MHz. This frequency range ensures the reliability and stability of data transmission. Each sensor node is equipped with a set of sensors. In order to reduce the number of sensors in the greenhouse, the system uses the three-in-one sensor to detect the temperature, humidity and light intensity of the greenhouse. The LoRa transmission in this research system uses a star network structure. Each node can send data to the central point at the same time, and each node can randomly send data without time limit. When affected by the external environment and the transmission channel is congested, the node can adopt auto-frequency modulation and rate adaptation technology. This greatly reduces the outstanding probability that many nodes generate data at the same time.

2.2.2 Control Node Design

The controller is mainly composed of SMT32 single chip microcomputer, LoRa wireless module, voltage regulator module, relay module and power module. The sensor transmits the collected greenhouse data to the server and makes a decision after comparing it with the agricultural expert knowledge base. It is transmitted to the microcontroller through the LoRa wireless module, so that the control valve and the pump are turned on and off through the relay and solid state relay under the board for automatic control.

2.2.3 Design of Gateway Nodes

The gateway node is the key of the intelligent monitoring system. The data collected by the sensor node is mainly sent to the server through the gateway node. At the same time, the control command sent by the monitoring terminal is sent to the control node through the gateway to complete the irrigation. In this system, the gateway node selects the GPRS module, and completes the task of sending data to the server, which can realize long-distance communication.

2.3 System Software Design

The sub-nodes of the on-line monitoring system for crop growth environment are mainly used to collect and control information such as temperature and humidity in the greenhouse. The microprocessor at the child node processes the information and sends the data to the master node. At the same time, the microprocessor at the child node also controls the related equipment to change the environmental parameters such as temperature and humidity in the greenhouse according to the information returned by the master node. If the user is in the greenhouse, the relevant parameters of the greenhouse can also be used to change the environmental parameters such as temperature and humidity in the greenhouse.

2.3.1 Program Flow of System Software

The program flow of the system software is as follows: The microprocessor at the child node first initializes the program to determine if there is an interrupt request. If there is, the program will form a breakpoint at the place where it is being executed, execute the interrupt, and open communication with the host. If the host sends a request to transmit data, the opportunity to send the collected temperature and humidity data in the greenhouse to the host; If the slave receives a heating command sent by the client to the host and then sent by the host to the slave, the heater is turned on from the opportunity to heat it to a specified temperature, and the heater is turned off after reaching the specified temperature; If the slave receives an instruction to increase the humidity, the pump is turned on and the drip irrigation is started. When the specified humidity is reached, the pump is turned off to stop drip irrigation. When the interrupt processing is completed, the program will return to the breakpoint again to execute the program that was not completed.

2.3.2 Software Design of Online Monitoring System

In order for the client to communicate with the monitoring terminal, the server IP address needs to be set. Farmers can access the IP address of the server through the Internet network and GPRS mobile data, thus monitoring the greenhouse. In the main interface, you can view crop growth trends, crop history data, planting technical guidance, pump control, water and fertilizer ratio and other functions in real time. This allows remote manipulation of crop irrigation and fertilization in greenhouses (Figure 2).

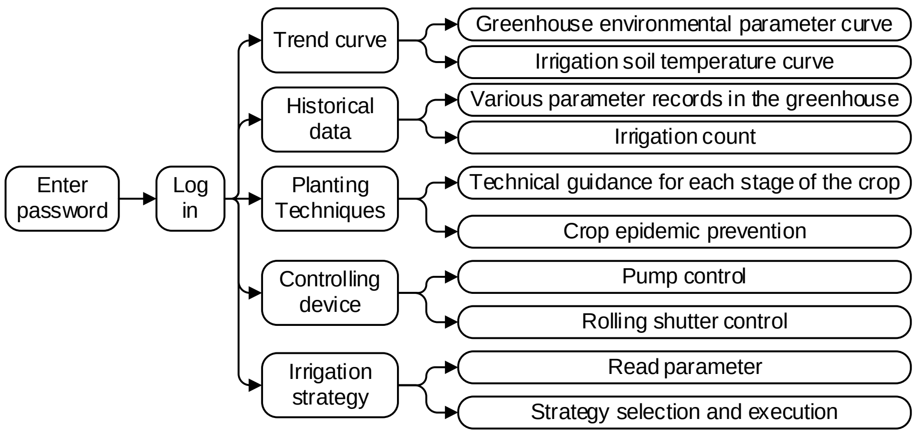

Figure 2 Control Interface Architecture Diagram of the Online Monitoring System

2.3.3 Control Program for System Abnormal Parameters

When an abnormal parameter occurs, it is necessary to notify the lower computer to control accordingly. Taking humidity as an example, when the humidity information sent by the node is less than the set lower humidity limit, the server needs to send a humidity adjustment command to the node subsystem to properly irrigate the vegetables. When the humidity is greater than the set range, the humidity is reduced by increasing the air flow. When the humidity reaches the set range, the irrigation of the vegetables is stopped immediately.

3. Practical Application of on-Line Monitoring System for Crop Growth Environment

The system is applied to the actual greenhouse for testing. The content of the test mainly includes system stability test and sensor acquisition accuracy test.

3.1 System Stability Test

Based on the analysis of the parameters uploaded to the server environment, this study analyzes the trend curve formed by the uploaded data to verify the stability of the greenhouse monitoring system. Table 2 is the data of soil temperature and humidity, air temperature and humidity, and CO_2 concentration in the greenhouse detected by sensor node No. 1 within the greenhouse within 24 hours. This data can prove that the node data transmission is normal, and it is enough to prove that the monitoring system works stably.

Table 2 Data of Soil Temperature and Humidity, Air Temperature, and Co_2 Concentration in a Greenhouse Detected by a Sensor Node within 24 Hours

Time	Light intensity	Soil relative humidity	Soil temperature	Air relative humidity	Air temperature	CO_2 concentration
09:00	1350 LuX	38.1%RH	20.4℃	46.1%RH	25.1℃	2.4%
12:10	1167 LuX	39.9%RH	20.9℃	45.8%RH	26.0℃	2.6%
16:00	1547 LuX	38.6%RH	20.1℃	46.2%RH	24.6℃	1.9%
20:00	1634 LuX	39.8%RH	20.8℃	40.9%RH	24.1℃	2.1%
24:00	1460 LuX	40.2%RH	20.3℃	45.4%RH	24.7℃	2.4%

3.2 Accuracy Verification of the System's Sensor Acquisition Data

Five sensor nodes are selected to collect the air temperature and soil moisture of a certain moment, and the accuracy of the sensor collection is checked by comparing with the manually collected data. The results are shown in Table 3.

Table 3 Precision Comparison Data of Air Temperature and Soil Moisture Collected by Five Sensor Nodes at a Certain Moment

Node number	Air temperature comparison			Soil relative humidity comparison		
	Detection value	Actual value	Error%	Detection value	Actual value	Error%
1	25.1℃	25.3℃	0.79	46.5℃	45.9℃	1.31%
2	24.9℃	24.3℃	2.47%	42.7℃	43.1℃	0.93%
3	24.6℃	25.1℃	1.99%	44.9℃	46.2℃	2.81%
4	26.1℃	25.5℃	2.35%	47.2℃	46.8℃	0.85%
5	25.6℃	25.9℃	1.16%	46.1℃	47.1℃	2.12%

It can be seen from Table 3 that the sensor acquisition accuracy of the monitoring system is very different from the actual value and meets the requirements of the design requirements. The study design can transmit about 1900 sets of data within 24 hours. That is to say, each node alternately transmits 16 sets of data every minute, and works continuously for two hours. The used traffic is about 500kB, the correct rate of transmitted data is 99%, and it is not transmitted distance and weather during transmission. The impact of the situation.

The design uses a lithium battery to support all nodes for 48 hours of continuous operation. At the same time, the results of this research experiment also show that in the middle of 24 hours, the temperature in the air gradually rises or gradually decreases, and the fluctuation range is relatively small; The humidity in the air also has a tendency to rise or fall, but the fluctuation is relatively large; The soil moisture is basically unchanged, and its fluctuation is not large. Since the detection probe of the soil moisture sensor is buried underground, it is less affected by weather factors, and the temperature and humidity sensor is suspended on the branch, which is greatly affected by the external environment. Therefore, the fluctuation of temperature and humidity is relatively large. Therefore, the design can monitor the change of the growth environment of crops in real time, and can timely process the sudden changes of the environment, the system is stable and reliable, and the price is low.

4. Conclusion

For future agricultural development and modern agricultural construction, agricultural decision-makers and operators should combine technologies such as Internet of Things, big data and cloud services, and artificial intelligence to achieve remote monitoring and real-time processing of agricultural conditions and disasters. This is to promote the realization of agricultural production, agricultural product quality, farmers' income and other expected goals. An online monitoring system based on the growing environment of crops is an organic combination of microcomputers, including soil moisture collection, temperature and humidity collection in the air, remote monitoring center software system. This study designed the hardware and software of the data acquisition module for crop growth environment. This study realized real-time measurement of data and historical data query and storage functions. Through this system, we can monitor the environmental parameters affecting crops anytime and anywhere, and realize the sharing of agricultural information resources. This has laid an important technical foundation for further research and exploration of the Internet of Things in the field of agricultural environmental monitoring.

Acknowledgements

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