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Design and Analysis of IOT-Based Soil Information Monitoring System for Intelligent Agricultural Greenhouses

Chengmao Zhang[1,*], Zengshuo Liu[1], Yao Wang[2], Lifu Ma[3]

[1] *School of Mechanical and Vehicular Engineering, Linyi University, Linyi, Shandong, 276005, China*

[2] *School of Automation and Electrical Engineering, Linyi University, Linyi, Shandong, 276005, China*

[3] *Personnel Department, Linyi Central Hospital, Linyi, Shandong, 276400, China*

[*] *Corresponding author*

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Abstract: Intelligent agricultural greenhouses based on the Internet of Things will be the main force in the future development of agriculture, and there will inevitably be more advanced technologies applied to them. Soil information monitoring system is the combination of Internet of Things technology into traditional agriculture, through the mobile platform, a reasonable choice of soil sensors and network data cloud platform for the application, monitoring and reasonable regulation of the shed soil. It makes traditional agriculture more "intelligent" and provides an effective tool for fine agricultural spatial and temporal variability and decision making for irrigation and moisture application research.

1. Introduction

Today's Internet of Things technology is developing rapidly, and while this technology is affecting the way humans produce and live, it is also changing the way agriculture is produced and developing rapidly in the agricultural sector. Smart agriculture is further applied to reality on this basis. It improves the yield of crops, saves human and material resources and will contribute significantly to agricultural development, so smart agriculture will be a necessary trend for agricultural development. Agricultural greenhouses need to have more advanced technology applied to them, and traditional agriculture needs to be made more "intelligent" [1,2].

The IoT-based intelligent agricultural greenhouse is a combination of advanced intelligent greenhouse control system, information collection system, central control system, human-computer interaction system and cloud platform system to design and realise a set of intelligent agricultural greenhouse system applied in agricultural greenhouses, whose various system structure links are shown in Figure 1. On the basis of the intelligent agricultural greenhouse system, it is divided into three steps, which are: data collection (collecting information on the external environment for crop growth, controlling external devices and transmitting the data to the server in a timely manner), and intelligent control (based on the collected information about the crop growth environment and status in the greenhouse greenhouse, control the equipment to adjust the crop growth external environment status), and cloud platform analysis (through AIh and big data analysis, the crop growth environment is precisely regulated).

The data collection step includes the information collection system; the intelligent control step includes the greenhouse control system, the central control system and the greenhouse operating system; the cloud platform analysis step includes the cloud platform system. Each system can achieve intelligent perception of the agricultural production environment, intelligent early warning, intelligent decision-making, intelligent analysis, and expert online guidance, providing agricultural production, visual management, intelligent decision-making, and ensuring safe and high crop yields.

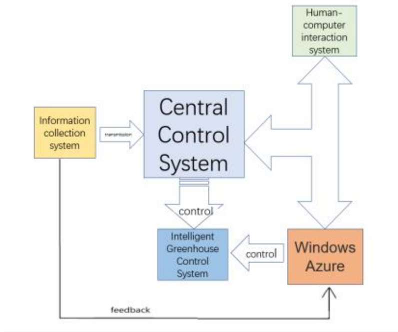

Figure 1: Structural links between systems

The design is based on an information collection system and a cloud platform system, which consists of sensor hardware such as soil EC sensors, soil pH sensors, soil moisture sensors, soil temperature sensors and software such as a cloud-based network data platform, which is an important part of the data collection step. The development and design of this system enables us to take timely, scientific and effective measures to improve soil conditions, for which the key issue to be addressed is the configuration of the software in the cloud platform system [3]. How to select the software and what software to choose to meet the design requirements and save costs is particularly important.

2. Overall System Solution Design

2.1. Basic Purpose of the System

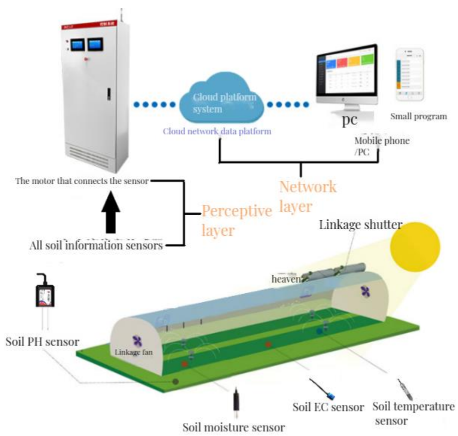

Figure 2: Schematic diagram of the monitoring system

The soil information sensor in the intelligent agricultural greenhouse soil monitoring system is used as the sensing layer, which is combined with the cloud-based network data platform as the network layer. It realizes the automatic control of soil moisture of the greenhouse, realizes the automatic adjustment of environmental factors for crop growth on mobile phone/PC and other purposes, manipulates and changes the external environmental factors for crop growth [4]. As shown in Figure 2.

2.2. System Structure Scheme

The soil monitoring system consists of two parts, the sensing layer and the network layer. The system structure diagram, as shown in Figure 3.

The sensing layer mainly includes hardware such as each sensor of the soil. The sensing layer is similar to the human sensory organs in relation to the Internet of Things, and is mainly used to collect information and sense changes in the surrounding environment. The sensing layer collects and obtains the refined information of soil environment in real time through multiple soil sensor hardware distributed in the farmland, and interchanges the information with the cloud network data platform through Internet communication.

The network layer mainly includes software such as the cloud-based network data platform. It is a cloud platform system that can realize application functions and data visualization. The information acquired by the soil sensors is processed by the DTU module, analyzed and stored and uploaded to the cloud platform service system through Wi-Fi network, and the corresponding management strategy is formulated to communicate with the motors to control the motors to operate the corresponding equipment to start and thus adjust the soil conditions, while the abnormal information is automatically alarmed. The network layer is mainly responsible for database storage, information processing and control instructions for the collected data, providing users with analysis and decision basis. Managers can store environmental data and soil data in real time via mobile phone/PC and retrieve historical data as needed.

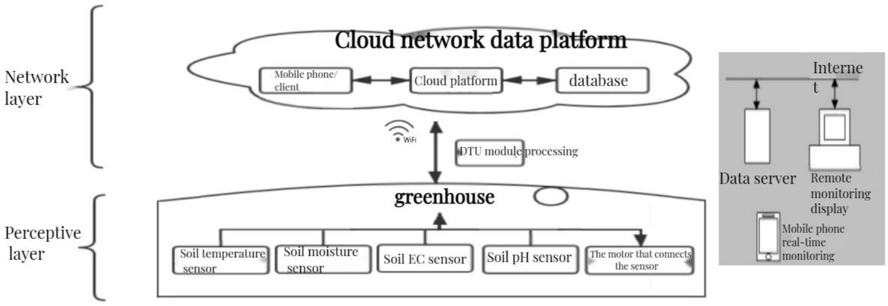

Figure 3: Monitoring system structure

3. Soil Information Sensor Hardware Configuration

Soil information sensors are an essential and important part of soil information monitoring systems [5]. They are important components for sensing external soil information through the application of measured factors and their conversion into electrical quantities that meet certain criteria. Depending on the different needs, the choice of soil information sensors is based on their cost and the type of data to be measured. The following soil sensors are configured according to the system scheme:

(1) The soil moisture sensor was selected from the product developed by Henan Deshen Agricultural Technology Development Company, as shown in Figure 4. It is a high precision and sensitive soil moisture measuring instrument. The sensor uses the electromagnetic pulse principle to

measure the apparent dielectric constant of the soil to obtain the true soil moisture content, which is fast and accurate, stable and reliable, and unaffected by chemical fertilisers and metal ions in the soil. Soil moisture sensor technical parameters, its data parameters are shown in Table 1 [6,7].

Table 1: Soil moisture sensor technical parameters

Measuring range	0~100%RH, Resolution :0.1%, Accuracy: ±3%
Power supply method	DC 5V, DC 12V, DC 24V
Output form	Current:4~20mA, Voltage:0~5V, RS485
Instrument wire length	Standard: 10m
Load resistance	Voltage type: RL≥1K, current type: RL≤250Ω
Operating temperature	-50℃~80℃, relative humidity: 0~100%
Product weight	Probe 220 g, with transmitter 570 g, product power consumption: 310mW

Figure 4: Soil moisture sensor

(2) The soil temperature sensor is selected from the product developed by Henan Deshen Agricultural Technology Development Company. The sensor uses a high precision thermistor as the sensing component, which has the characteristics of high measurement accuracy and good stability. The signal transmitter adopts advanced circuit integration module, which can convert the temperature into corresponding voltage or current signal according to different needs of users. The instrument is compact, easy to install and portable, with reliable performance; it uses proprietary circuitry, good linearity, strong load capacity, long transmission distance and strong anti-interference capability. Its shape is shown in Figure 5, and its data parameters, as shown in Table 2.

(3) The soil pH sensor (transmitter) was selected from the RS-PH-*-TR-1 model designed by Shandong Renke Measurement and Control Technology Co. Its shape is shown in Figure 6, and its data parameters, as shown in Table 3. It is a good solution to the shortcomings of traditional soil pH which needs to be equipped with professional display instruments, cumbersome calibration, difficult integration, high power consumption, expensive and difficult to carry. It truly realises online real-time monitoring of soil pH; the probe insertion design ensures accurate measurement and reliable performance; low threshold, few steps, fast measurement, no reagents required, unlimited testing times; high measurement accuracy, up to ±0.3PH accuracy, fast response time, good interchangeability; the electrode is made of specially treated alloy material, which can withstand strong external impact and is not easily damaged.

Table 2: Soil temperature sensor technical parameters

Measuring range	-50~100℃,-20~50℃,accuracy:±0.5℃
Power supply method	DC 2.5V, DC 5V, DC 12V, DC 24V
Output form	Current: 4~20mA, Voltage: 0~5V, RS485
Instrument wire length	Standard: 10 meters
Load resistance	Current output impedance ≤ 300Ω, voltage output impedance ≥ 1KΩ
Operating temperature	Temperature -50 ℃ ~ 80 ℃, humidity ≤ 100% RH
Product weight	Probe 145 g, with collector 550 g, product power consumption: 0.5mW

Figure 5: Soil temperature sensor

(3) The soil pH sensor (transmitter) was selected from the RS-PH-*-TR-1 model designed by Shandong Renke Measurement and Control Technology Co. Its shape is shown in Figure 6, and its data parameters, as shown in Table 3. It is a good solution to the shortcomings of traditional soil pH which needs to be equipped with professional display instruments, cumbersome calibration, difficult integration, high power consumption, expensive and difficult to carry. It truly realises online real-time monitoring of soil pH; the probe insertion design ensures accurate measurement and reliable performance; low threshold, few steps, fast measurement, no reagents required, unlimited testing times; high measurement accuracy, up to ±0.3PH accuracy, fast response time, good interchangeability; the electrode is made of specially treated alloy material, which can withstand strong external impact and is not easily damaged.

Table 3: Soil PH sensor technical parameters

DC power supply (default)	DC 5-30V
Maximum power consumption	485 type: 0.5W (24V DC power supply)
Range	Analog type: 0.4W (12V DC powered)
Resolution	3-9 PH
Operating temperature	0.1
Long-term stability	-20℃~60℃
Response time	≤5%/year
Stabilization time	≤10S
Output Signal	≤5min

Figure 6: Soil pH sensor

(4) The soil EC sensor was selected from a product developed by Henan Deshen Agricultural Technology Development Company, as shown in Figure 7. This product can be used to quickly measure various minerals essential to the soil, such as potassium, phosphorus and ammonia, and display them in real time on the display and store the data in the internal chip of the speedometer. After measurement the data from the logger can be downloaded to a computer via the supplied software for easy research or storage. The instrument consists of a handheld instrument salt sensor, UBS data cable and portable carrying case. The product can be used to quickly measure various minerals necessary for soil, such as potassium, phosphorus, ammonia, etc. Soil EC sensor sensor range 0-8000mg/L; measurement accuracy ±50mg/L; working environment temperature and humidity: -20℃~80℃, 5%RH~95%RH.

Figure 7: Soil EC sensor

4. Cloud Network Data Platform Software Configuration

The cloud network data platform is the key link in the design and analysis of the soil monitoring system, and is also the station that integrates data integration, data analysis, data integration, data distribution, and data warning [8]. The sensing layer realizes information interaction with the cloud data platform through Internet communication (Wi-Fi), including data information upload for system data saving, analysis, statistics, remote viewing, remote control, etc. Users can connect directly to the cloud platform via mobile phone/PC for more accurate management of agricultural greenhouses.

This design is configured according to the system solution with the Kizhi Cloud IoT platform, which has the advantages of easy to use, flexible and stable, rich functions, various solutions, controllable cost, high versatility, neutral and open, safe and reliable, etc. The platform can provide developers with self-service development tools for IoT devices, background technical support services, remote control management of devices, data storage and analysis, third-party data integration, hardware access and other technical services. It greatly shortens the development cycle of hardware products, quickly realizes intelligence, and is more free and controllable for users. The access process of the platform is shown in Figure 8.

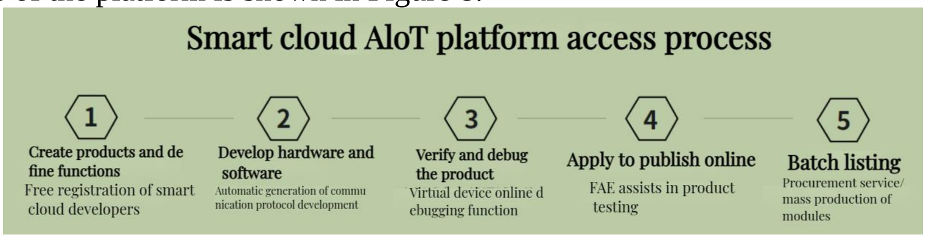

Figure 8: IoT access process of Jiji Cloud

5. Conclusions

The ever-changing science and technology has brought a brighter development prospect to agricultural greenhouses, making agricultural planting science use sensors combined with environmental information to make optimal control strategies to achieve scientific planting of agriculture. This design introduces an agricultural greenhouse soil monitoring system consisting of two parts: soil sensors and a network data platform, with a reasonable selection of multiple soil sensor devices and a cloud platform software program. This system will have a wide market space in future agricultural production.

This paper designs and analyzes the soil information monitoring system program and configuration, but the soil information monitoring system is a device designed for users who do not have sufficiently detailed signal data about the soil and is only applicable to growing those crops that have high requirements for soil conditions. Also hardware sensors are partly difficult to accomplish in determining crop growth parameters, and software configurations need technical permission and financial support.

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References

[1] Wang J. Design and implementation of intelligent agricultural greenhouse monitoring system. North University of China, 2020, 58-68.

[2] Bai Luyao. Development and implementation of intelligent agricultural system based on Internet of Things technology. Inner Mongolia University of Science & Technology, 2022, 10-19.

[3] Zhang Chenshi, Fu Kangwei et al. Design of monitoring system of greenhouse greenhouse supporting multi-platform applications for smart agriculture. Jiangsu Agricultural Sciences, 2018, 1-8.

[4] Li Xingze, Wang Fuping. Intelligent control system of agricultural greenhouse based on Internet of Things. Jiangsu Agricultural Sciences, 2018, 1-6.

[5] Yuan Xiaoping, Xu Jiang, Hou Panfeng. Intelligent agricultural monitoring system based on Internet of things. Jiangsu Agricultural Sciences, 2015, 1-4.

[6] Zhao Dongjie, Ye Kaixian, Wen Fudao, Dai Qinghong, Gao Guoli. Research on intelligent agriculture greenhouse greenhouse system. JiLin Agricultural Science and Technology University, 2021, 1-4.

[7] Cheng Shengyang, Cheng Junjing. Design of agricultural greenhouse temperature and humidity monitoring system based on Ayla IoT cloud. Intelligent agricultural greenhouse, 2017, 1-4.

[8] Ren Zhuang, Wang Jun, Kong Chao, Li Wenrui. Development of greenhouse environmental dynamic measurement and control system. Electronic Measurement Technology, 2023, 46 (01): 65-71.