Design of intelligent greenhouse environment monitoring system in Fanjing Mountain Area

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Abstract. With the continuous development and extensive application of high and new technologies such as computer network technology, automatic control technology and wireless communication technology, and with the rapid development of agricultural technology, especially greenhouse, soilless cultivation, irrigation, factory farming and other technologies, agricultural production has become increasingly urgent for intelligent greenhouse environment monitoring technology. Intelligent greenhouse technology is a sophisticated technology of agricultural production, which combines high-precision and advanced technology in agricultural production with computer network control technology, and is the material basis for modern agricultural technology to carry out industrial transformation. This paper mainly designs the intelligent greenhouse environment monitoring system for the Fanjing mountain area.

1. Introduction
Intelligent greenhouse (IG) technology is a significant technology to realize agricultural automation, monitoring and controlling IG, which can provide support for agricultural refinement to improve production efficiency, enhance the quality of agricultural products and reduce production cost. With the ever-changing interdisciplinary technologies such as computer technology, communication technology, network technology, automatic control technology and so on, the level of IG monitoring and controlling has been rapidly developed.

The various environmental factors in IG are concentrated by computers to control, and their monitoring sensor types are complete, such as air temperature and humidity, soil temperature and humidity inside the greenhouse, carbon dioxide concentration sensor and light intensity sensor. Based on various precision sensors, micro-controllers monitor data. In general, the all kinds of actuators inside the greenhouse can be automatically controlled, meanwhile, lots of scholars put forward many new control strategies and control algorithms to control the environment factors in IG, which makes the computer on the IG environment monitoring is no longer simple and single-factor digital control, but is established on the basis of the environment model to supervise and control, or the application of expert system to control the implementation of artificial intelligence control. Developed countries based on achieving automation IG monitoring technology are developing toward the direction of complete intelligence and networking.
2. The overall design of IG environment monitoring and control

2.1. Demand analysis
IG environment monitoring and control in the process of study, the sensors of carbon dioxide-CO$_2$ concentrations, light intensity, air temperature humidity, and soil temperature humidity, are adopted respectively to make real-time detection for environment parameters of crop growth inside the greenhouse, and data in real-time detection are transferred to child nodes. According to the control commands from the management nodes, control child nodes can control the relay switch. Management nodes are capable of collecting and processing the data uploaded by measure child nodes, can send control instructions to the control child nodes, and also can carry on the real-time display of greenhouse environment parameters. If the parameters are abnormal, it is capable of audible and visual alarm. At the scene manually control the internal actuators inside greenhouse to adjust environment parameters through the management nodes, and set the threshold of environment parameters inside greenhouse through the management nodes. Monitoring center enables real-time detection the values of environment parameters in the greenhouse, and can send control instructions down. Furthermore, the monitoring center has friendly man-machine interface, and is easy to be used.

2.2. The overall designin
According to the demand analysis, the overall structure of the IG environment monitoring and control system is designed and analyzed, and the overall framework is shown in Fig. 1. The schematic diagram of data transmission between GPRS module of management nodes and remote monitoring center is shown in red box in Fig. 1.

The working process of the whole system is divided into the following steps. First, measure child nodes realize real-time acquisition for air temperature and humidity, soil temperature and humidity, CO$_2$ concentration, and light intensity inside the greenhouse through a variety of sensors. Second, set thresholds for each parameter in the greenhouse through the key module of the management nodes. Third, measure child nodes send the collected parameters to the management nodes via RS485. Fourth, display the values of various parameters in real-time through the controlled display module of the management nodes in the greenhouse. Fifth, if the parameters are abnormal, it can be through the management nodes to sound-light alarm, and send control instructions to the control child nodes through RS485, automatically controlling actuators in the greenhouse. Sixth, the parameters processed by the management nodes are remotely sent to the monitoring center through GPRS module. Seventh, the monitoring center real-time checks each parameter values in the greenhouse through the upper machine software, and can send instructions to remotely control actuators in greenhouse. Lastly, manually and directly send commands to drive the control child nodes to control actuators through key module inside the greenhouse.
In this paper, the technology applied in the design of the IG monitoring and control system mainly includes the three critical techniques: communication technology, sensor technology, and control technology.

3. Communication techniques

Communication techniques (CTs) accurately and rapidly transfers data or information from one party to another safely through various media to achieve the communication and transmission of information. In a broad sense, the used CTs today can be divided into long distance CTs and short distance CTs. For the latter, the wired are often utilized such as RS232, RS485, and some buses, and the wireless such as Wi-Fi, Bluetooth, radio frequency identification devices (RFID), ZigBee, near-field communication (NFC), and so on. Diverse short distance CTs have their own advantages and disadvantages. According to the various applications and solutions, the most appropriate CTs can be selected. In the design of IG, the practical NFC technology includes RS232 technology and RS485 technology. The remote CTs makes the information inside greenhouse remotely transmit to the monitoring center mainly through the GPRS technology, meanwhile, the remote monitoring center can send commands to control some actuators in greenhouse so as to achieve the remote control.

3.1. GPRS technology

GPRS is called General Packet Radio Service. Compared with the traditional Global System for Mobile Communications (GSM) voice service, GPRS is a new bearer service, developed on the basis of the GSM voice system, whose aim is to provide data services in packet form based on GSM. It is the transition from GSM to 3G, commonly referred to as 2.5G. Since many technical structures in GPRS are the same as those in GSM, it is easy to provide comprehensive coverage for GPRS networks on the basis of existing mobile base station subsystems (BSS). Data transfer rate of telephone exchange is only 9.6 kbit/s in GSM, after improvement, is also up to 14.4 kbit/s or so, while that of GPRS can reach 171.2 kbps, high speed and real-time online. Therefore, the intermittent, little, or sudden data transmission can be easily solved through the GPRS CT.

3.2. Serial communication

The standards of typical serial communication include RS232 and RS485. RS232 has a short communication distance with a maximum transmission distance of about 15 meters, a low speed, and a maximum speed of 20Kbps, whose capability of common mode rejection and anti-interference performance is poor, and only point-to-point communication can be achieved, not multi-machine communication. RS232 is suitable for communication between local devices. Compared with the RS232 standard, the main features of the RS485 standard are: logic “1” of the interface level is represented by voltage difference between two lines from +2V to +6V, logic “0” from -2V to -6V, lower than RS232 and compatible with Transistor-Transistor Logic (TTL) electrical level; The highest data transmission rate is 10Mbps; The interface adopts the combination of balanced driver and difference receiver with the ability of strong anti-common-mode interference; The maximum transmission distance of interface is up to 3000 meters; Bus can connect up to 128 transceivers, and half duplex multipoint communication can be realized. Through the RS485 bus it can be simple and convenient communications, it is scalable networking and simple hardware interface, and only needs to program data format on the software, which can be achieved. Because RS485 has a strong anti-interference ability in data transmission, it's extremely common applied in some industrial control systems with poor production conditions or data acquisition and control system with high requirements for real-time stability of data.

3.2.1. The transmission circuit of RS485

This design leverages MAX485 for remote transmission. Because the protocol of RS485 bus is half duplex communication, it provides a microcontroller Input/Output (I/O) P3.2 to control MAX485 transceiver as shown in Fig. 2. When the output of P3.2 is 1, MAX485 is in sending state; when 0, in the receiving state. 7 and 8 feet are output, and are convenient to pick three rows of needles with connecting multiple terminal communication.
3.2.2. The flow chart of transmission serial port transmission in RS485 Bus. Transmission is carried out through RS485 bus, and the serial port is mainly used in the microcontroller. Therefore, the serial interface program of the microcontroller should be written, and the corresponding register should be controlled for serial transmission. Because this is designed as a remote data acquisition terminal inside the greenhouse, it only needs to send data. The flow chart is as shown in Fig. 3 (a).

![Figure 2. The interface circuit of RS485.](image1)

3.2.3. The flow chart of receiving data display in RS485. When touch is in idle state, the main controller by RS485 receives the remote the greenhouse environmental data, and the data put in the corresponding register buffer. First, judge the starting position of the data, and then estimate whether the received data is correct through the check digit, if receiving data correctly, the data is converted to the corresponding character displayed in the LCD touch screen on the corresponding position, if the received data error, re-receive until the reception is correct. The serial data reception of this system employs the method of query. The flow chart of RS485 data reception display is as shown in Fig. 3 (b).

![Figure 3. The flow chart of serial port sending and data reception display in RS485.](image2)

4. Sensor techniques
Sensors will be able to make the research object of dynamic parameters by converting into electrical signals, so it is the primary choice to test and control system. Only through sensors to obtain information
and transform it into an electrical signal that is easily transmitted and processed, can carry on better analysis and research to the information in reality. Therefore, sensors have become the window of sensing, acquiring and detecting information, which have a wide range of applications in scientific research, automated production, remote monitoring, and other fields. According to the Chinese internet of things (IOT) consortium, the existence and development of sensors has given objects senses such as touch, taste and sigh, making objects gradually become alive, which is the preliminary link of realizing automatic detection and automatic control, and the key components in the measurement and control system. In agricultural modernization and automated measurement and control, almost mainly rely on different kinds of sensors to detect and feedback environmental factors influenced on crops in agricultural environment, which keeps it in the most suitable steady state, so as to ensure the high efficiency and high quality of production.

5. Control techniques
Control techniques in IG is a class of advanced control technology to intelligent analysis and control of the acquisition of mass information. All kinds of information are stored in real time and rapidly processed through advanced information techniques to intelligent analysis and control of information, at the same time, the result of processing information can also be feedback to various actuators in IG. Intelligent control techniques carry out a series of intelligent analysis and control on the large amount of information obtained, and make IG intelligent to realize the interactive dialogue between humans and things, even among things in order to achieve the goal of effective control certain function. This technique mainly includes artificial intelligence technology, human-computer interaction theory, and intelligent analysis and control system, and other related core technologies.

6. The application of three techniques in IG

6.1. Communication techniques applied in IG
Effective transmission of data is the key to realize effective remote monitoring, although high speed and stability is ensured using wired technology of data remote transmission, it will appear particularly large engineering construction and the burden of wiring for remote monitoring sites. IG from the monitoring center generally has a far distance, so in the IG monitoring and control, cable transmission is only suitable for greenhouses internal data collection, not for remote transferring the collection of data to the monitoring center. In the research on IG monitoring and control technology, each measure child nodes test the greenhouse environment factors, and then the collect data are sent to the management nodes through RS485 in the form of 485 bus cable serial communication, as well the wired 485 serial communication bus sends control commands to the various control child nodes. Data communications between the management nodes and monitoring center, according to the particularity of the IG, choose GPRS communication technology, through comprehensive analysis, this communication technology is especially suitable for the application of IG remote data transmission. It has no specific constraints on the geographical location and size of the IG, and the efficiency of information transmission is relatively high, which can realize two-way communication, meeting the needs of this study.

6.2. Sensors techniques applied in IG
In IG, if realize real-time accurate data acquisition of greenhouse environment factor parameters, sensing techniques must be adopted. The key monitoring of environmental factors in greenhouse have air temperature and humidity, CO₂ concentration, soil temperature, soil moisture and light intensity. In the design of the system, not only consider the cost of the sensors, and try to be economical and practical, but also think about the accuracy of the sensors, expecting to achieve the precise measurement of the sensors’ data. According to the above principles, choose the sensors of CO₂, light, and air and soil temperature and humidity.
6.3. Control techniques applied in IG

The traditional control algorithms is realized based on controlled object established in mathematical models (transfer function and state equation), but internal environment system in IG has the characteristics of nonlinear, time-varying, time-delay, affected by external factors, and multivariate mixing. Meanwhile, various crops in greenhouse during different stages of growth is different on the requirements of environmental factors, so it is difficult for the intelligent IG to establish an accurate and practical mathematical model, and routine control is difficult to achieve ideal control effect in the greenhouse environment control. Fuzzy control is a kind of control strategy to control uncertain system by using human experience on the basis of building precise mathematical model of the controlled object. This strategy is suitable for the complex control system of greenhouse, which is not easy to determine the mathematical model.

At the same time, because the internal environment in IG is complex, it is difficult to rely on a control strategy and control algorithm to make the environment in the greenhouse be in the optimal growing environment for crops. This paper, on the basis of intelligent control in the greenhouse, in order to deal with all kinds of emergent situation, equips with remote control and manual control for greenhouses, and the priority of manual control is higher than the remote control, remotely controlling the actuators in the greenhouse by the monitoring center sending control instructions. If remote control does not work as expected, manually control the actuators inside the greenhouse through the button module to ensure that the greenhouse is in the most suitable environment for crop growth.

7. Conclusion

How to more accurately and more efficiently monitor and control internal environment factors in IG, as well as how to make the IG integrate higher information are the emphasis of our future research. In our future work, aiming at the characteristics of complexity, nonlinear, and strong coupling of various environmental factors of the IG environment in Fanjing mountains area, starting from the actual situation of the IG monitoring, adopt different monitoring theory and monitoring strategy to guarantee the stability, accuracy, and practicability of the IG environment monitoring system.

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