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Research Article

Study on the Intelligent Control System of Subtropical Fruits and Vegetables Greenhouse Based on Wireless Sensor Network

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Abstract: In this study, a set of intelligent management system for fruits and vegetables greenhouses adapted to subtropical environment was set up based on wireless sensor network. The study results showed that this system could realize real time intervention on greenhouse temperature, humidity and illumination according to the database the sensor network collected. The development of his system realized implementation of refined cultivation of vegetables and fruits and could provide safeguard to realize ecological agriculture.

Keywords: Fruits and vegetables greenhouse, intelligent control system, wireless sensor network

INTRODUCTION

In subtropical areas, fruits and vegetables require a lot to growth environment. The temperature, moisture, illumination and concentration of CO2 in greenhouse influence the growth of fruits and vegetables with different degree. It is a very complex job to well manage the fruits and vegetables greenhouse. Farmers not only need to own some planting technologies but also need to know the environmental situation of the greenhouse at any time (Chunyou, 2014). When planting out-of-season vegetables, farmers need to look after the greenhouse all the day (Wang *et al*., 2006). Therefore, superabundant manpower resources are consumed, which causes low profit of planting fruits and vegetables in greenhouse (Lifeng and Bingmei, 2013). At present, it is the urgent demand of farmers to achieve increase of harvest and profit of the greenhouse on the basis of reduction of investment and manpower. Wireless intelligent sensor network has the abilities of labeling (Yang *et al*., 2010), perception and intelligent treatment and it mutually connects other devices with the help of communication technology. The purpose of this sensor is to offer intelligent service.

Scientific research and production practice indicate that the yield of fruits and vegetables greenhouse is directly influenced by environmental factor (Montero *et al.*, 2009). It is significant to apply intelligent wireless monitoring control system to greenhouse. Intelligence means using kinds of sensor to monitor and automatically control the temperature, moisture, illumination and concentration of CO2 in greenhouse and building an environment which is suitable for the growth of fruits and vegetables to increase the yield. Most of intelligent systems need to be equipped with communication cable whose cost is high. So intelligent system cannot meet the requirements of most of farmers. Following the deep agricultural research, it is a hot issue to develop environmental information collection system which is in mobile environment. The communication mode of GSM and GPRS has incomparable superiority of cost-performance ratio in distributed data collection system. GPRS is a wireless grouping exchanging technology based on GSM system. It offers terminal-to-terminal wide-area wireless IP connection and has many obvious superiorities to well meet system's requirements of data collection and real-time transmission (Hou and Gao, 2010). Therefore, we use wireless communication technology based on GPRS, aim at the actual production situation of agricultural greenhouse and design an environmental factor monitoring system for intelligent fruits and vegetables greenhouse (Park and Park, 2011). This system has high reliability, strong extendibility and convenient operability. It can be made and installed according to area characters and requirements of customers. Therefore, the application and popularization prospect is very wide.

MATERIALS AND METHODS

The selection of temperature and moisture sensor: The traditional sensors have the following characters:

- They output analogue signals; however, microprocessor can only process digital signals. So the output signals must be operated with A/D conversion. In order to operate A/D conversion, pre-amplifier, sampling holder, A/D converter and other devices must be installed. And signals are interfered easily.

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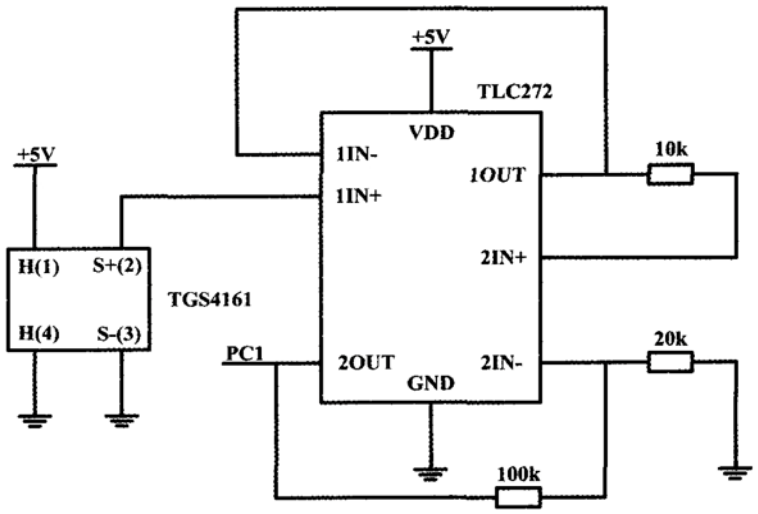

Fig. 1: Circuit connection of TGS4161 sensor

- The long-term stability is weak; they can be influenced by external conditions easily. Error is large after working for long time owing to aging and drifting; in addition, their precision can be greatly influenced by the precision and stability of power resource. In order to guarantee precision, the requirement to power source is strict and cost is increased.
- Consistency is weak. The channels (such as detecting circuit) of analogue circuit are not consistent. Batch production is difficult to be achieved; curve fitting and calibration must be operated.
- In order to calibrate curve, users need to equip with calibration equipments which are complicated and expensive and datum, which adds to working difficulty and cost.

SHT-11 single-chip integrated sensor is developed by Sensirion. It has two-line digital output with full-scale calibration and it can simultaneously measure moisture, temperature and dew point (Soto-Zarazua *et al*., 2011). It doesn't need peripheral components and it directly outputs the digital signal of relative moisture, temperature and dew point after the digital signal is calibrated. That can effectively make up for the deficiency of the traditional temperature and moisture sensor.

The interior of SHT-11 sensor is integrated with temperature-sensitive component, moisture-sensitive component, amplifier, A/D converter, calibration data storage, digital bus connector and voltage stabilization circuit. As for temperature sensor and moisture sensor, their silicon chips adjoin each other tightly; they can accurately measure dew point and will not introduce error owing to the temperature difference of them. This sensor directly converts the analogue signal to be digital signal by A/D conversion and outputs the digital signal which has been calibrated, which can effectively decrease the interference in analogue transmission. That can make good consistency and stability of performance indexes of the sensor. In addition, the cost is low and it can be conveniently used. The chip of SHT-11 temperature and moisture sensor can be seen in Fig. 2.

The selection of carbon-dioxide concentration information sensor: The information detection of carbon dioxide applies TGS4161 carbon dioxide sensor, which is a solid electrochemistry gas-sensitivity component. It has characters of small size, long lifetime, low cost and low power dissipation. The detection range is 350~10000×10-6; working voltage is 5V. When TGS4161 carbon dioxide sensor detects the concentration of carbon dioxide, the time in which the interior electrochemistry reaction reaches its balance is about 12 h. The voltage between positive electrode and passive electrode relates to temperature; the temperature needs to be compensated; the response time of the sensor is about 1.5 min.

The circuit connection of carbon dioxide sensor can be seen in Fig. 1. In signal modulation circuit, a high-impedance amplifier TLC272 carrying bias current is added. Then the sensor transmits the obtained information by PC1 port to Single-Chip Microcomputer (SCM) to operate A/D conversion. The SCM needs to make corresponding calculation and conversion to the collected signal, which will be helpful to achieve accurate detection of real value of carbon dioxide concentration.

The working method of wireless-transmission intelligent control system: Perceiving nodes need to perceive and transmit environmental information. Its software design includes three parts which are the

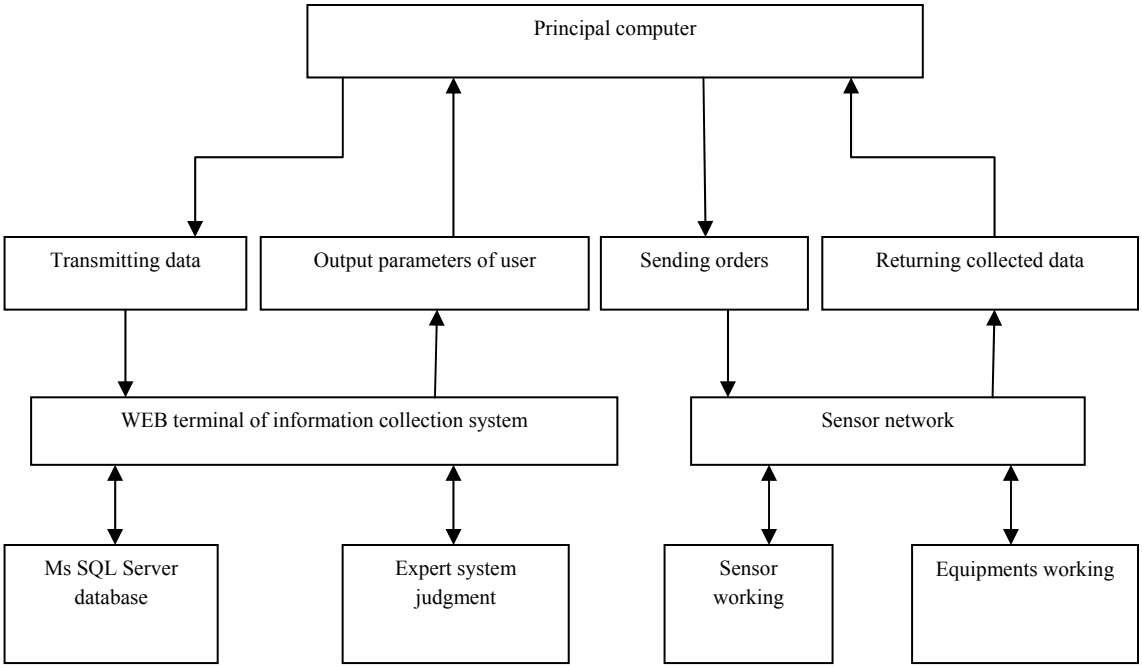

Fig. 2: Data processing flow diagram of functional design of principal computer software system

initialization of SCM modules, data collection of sensor and data processing and transmission. The program in initialization of SCM modules needs settings of pin function, register state, clock frequency and working parameters of functional modules. Data collection of sensor will finish the collection of environmental information; it can read the analogue quantity of carbon dioxide concentration and digital quantity of temperature and moisture. In addition, the program is added with timing function, limit-value alarm function and interruption, which will guarantee stable, reliable and safe data collection. Data processing and transmission transmits the collected data information to transmission nodes by wireless transmission module. The transmission nodes will make corresponding compensation and conversion to the collected data information. At last, the data information can be sent to principal computer by GPRS. The information of perceiving layer communicates with principal computer by GPRS, which will achieve wireless remote transmission of data. The receiving and processing of principal computer data is completed by a series of matching software which is running in WEB server of monitoring center. The module mainly includes data receiving, data storage and data management and diagnosis analysis based on WEB. Some parts of the program are developed based on the. net platform of Microsoft company and they are programmed using C# language; in addition, they are combined with database Ms SQL Server to manage data. The irrigation system and illumination system of the greenhouse can be adjusted through remote control, which will achieve intelligent optimization of illumination conditions, ventilation conditions and irrigation system. Figure 2 is the data processing flow diagram of functional design of principal computer software system.

RESULTS AND DISCUSSION

Experimental unit of grass-root agricultural vegetables greenhouse is selected to make site test. Temperature and moisture sensor and illumination sensor are used in experimental process. Illumination sensor is an integrated portable structure, which can be directly connected to the system to use. Through the test, the system can achieve the following functions:

- It can collect data from temperature and moisture sensor and illumination sensor.
- It can achieve multi-nodes transmission by wireless transmission module GPRS.
- It can send data wirelessly by wireless transmission module GPRS.
- It can adjust illumination and control irrigation system through software remotely.

CONCLUSION

Greenhouse is an epitome of food science modernization. It is an integrated system which includes structure, electromechanical equipments, biology and environment. It can not be influenced by location and climate and it can effectively improve agricultural ecology and production conditions. It plays an important role in scientific development and reasonable utilization of agricultural resources, the promotion of yield rate of

lands, improvement of labor production rate and promotion of social economic benefits. The detection of greenhouse signal is the key of automatic greenhouse control. The vegetables & fruits greenhouse monitoring system based on GPRS module uses distributed collection structure. Every SCM only completes limited data collection and processing task. That requires a little to the hardware circuit of SCM. Low-end hardware can be used to constitute high-performance system. In addition, when a data collection node malfunctions, other nodes will not be influenced. The SCM can collect the temperature, moisture and illumination intensity from temperature and moisture sensor and illumination sensor. And SCM will operate real-time wireless data transmission to the collected data by GPRS module with SIM card. Then the data can be sent to monitoring terminal for manager to know the environmental situation of the greenhouse in real time. The system's performance is promoted; at the same time, performance-cost ratio and the accuracy of transmitted information are emphasized. This system is a promotion of the traditional monitoring system of agricultural environmental factors, which is beneficial to the rapid and high-efficiency development of agriculture. Therefore, this system has wide marketing application prospect.

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