Design and Research of Crop Physiological Parameters Detection System Based on WSN

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Keywords: Crop physiological parameters, CC2530 ZigBee, CDMA DTU, LabView.

Abstract. It is of great significance to obtain the physiological information of stem and fruit diameter, chlorophyll content and plant stem flow of crops to guide the fertilization and irrigation of agriculture. Aiming at problems of insufficient method of real time detection on plant physiological parameters in traditional agriculture, a new type of crop of physiological parameters detection system based on wireless sensor network (WSN) is designed. The data acquisition of the system uses the IAR platform to build the ZigBee wireless sensor network, and the wireless sensor nodes are designed based on the CC2530 chip for acquisition and transmission the physiological parameters of the plant. The remote transmission of the system uses the ARM9-based CDMA DTU module to send the data through the CDMA2000 and the Internet network to the remote detection center. The detection center can collect the data and query the historical data in real time by the upper computer software written by LabView and SQL Service. The data indicators to determine the analysis. The experimental results show that the system has high accuracy and stable data transmission to meet the design requirements.

Introduction

The core idea of precision agriculture is to obtain planting through advanced measuring means. The internal and external information of the material is used to guide the process of irrigation and fertilization [1]. In view of the continuous expansion of the scale of modern agriculture and the continuous improvement of production requirements, and the traditional agricultural physiological system monitoring from real-time and accuracy and other aspects have been unable to meet the requirements of modern production in the context of a new WSN-based design scheme of monitoring system for crop physiological parameters. The design of the data acquisition side based on CC2530 chip ZigBee wireless network module, due to ZigBee transmission distance is limited [2], so the use of ZigBee and long-range wireless transmission combined. Long-range wireless data transmission in agriculture has a variety of ways, most of the current mobile GPRS [3] or GSM short message transmission [4], but these transmission speed is likely to cause data delay or even data packet loss. Because code division multiple access (CDMA) technology has higher transmission speed and efficiency than GSM and GPRS [5], this paper designs a CDMA DTU module based on ARM9 for long-distance data transmission.[5], the design is used based on ARM9 CDMA DTU module for long-distance data transmission. The system is based on the sensor selection of the conditioning circuit, and the corresponding algorithm is optimized to improve the accuracy of the sensor. The WSN-based crop physiological parameter detection system designed in this paper has high accuracy and stable data transmission, which can meet the needs of modern agricultural production, and has very good practicality and popularization and application value.

The Overall Design of the System

The detection system consists of data acquisition terminal, embedded gateway remote sender and detection management center. The overall structure of the system frame is shown in Figure 1.

Firstly, the sensor sends the collected plant physiological parameter information to the coordinator node in the gateway through the ZigBee protocol. The coordinator sends the data through the RS232
serial port to the ARM6-based CDMA DTU embedded module. The CDMA DTU module processes the data through CDMA2000 Network, and Internet networks send data to a web server built by PC. The advantage of being sent to the server is that the data is easy to store and easy to query. Finally, the detection center can also be based on LabView prepared by the host computer software based on known data to analyze the physiological growth of plants, and designed a set of transpiration rate and chlorophyll content and other parameters of the automatic alarm interface, which can be more accurate determine and control the growth of plants and economic indicators.

![Figure 1. System structure diagram.](image)

The Overall Design of the System

Data Acquisition Node Hardware Design

The data collection node group is responsible for collecting the physiological parameters (stem and fruit diameter, chlorophyll content, plant stem flow, etc.) of the plant and wirelessly collecting the collected data. The wireless transceiver chip chooses TI's CC2530 as the transceiver module of ZigBee network. The CC2530 is a true system-on-a-chip solution (SoC) for ZigBee networks, including a high-performance 2.4GHz RF transceiver with a high-performance, low-power enhanced 8051 core and an 8-channel 12-bit A/D Converter [6]. CC2530 has the advantages of higher sensitivity, lower power consumption and longer communication distance than the conventional CC2430 chips [7]. Therefore, it meets the requirements of high performance, low cost and low power consumption of wireless sensor and network.

![Figure 2. Hardware block diagram of sensor node.](image)

In this design, The LVDT plant stem sensor is used to measure the diameter of the stem. The chlorophyll content is measured based on the transmission type living body chlorophyll sensor. The plant stem flow measurement is based on the heat balance sensor. The output of these sensors are...
analog signals. The output signal conditioning circuit can be directly connected with the CC2530 chip. Data acquisition node hardware design shown in Figure 2.

**Embedded Gateway Hardware Design**

The embedded gateway is mainly responsible for processing and storing the received data and realizing the conversion between the ZigBee protocol and the TCP/IP protocol to send the data to the remote detection system. The embedded gateway is mainly composed of coordinator and AM9-based CDMA DTU module. The CDMA DTU module includes AM9 microprocessor and DTU sending module. The design of CDMA DTU selection CDMA2000 communication module, the module uses AM9 high-performance industrial-grade embedded processor, power supply range (DC 5V-32V), data transmission speed, the system is stable and reliable. The core hardware structure shown in Figure 3.

![Diagram](image)

Figure 3. Block diagram of embedded hardware.

Before using the CDMA DTU, we need to make two preparations. Firstly, because this design uses dynamic IP link Internet network and Web server, we need to apply for domain name, after applying for domain name resolution service, we can automatically establish communication through domain name. Before accessing the CDMA network, it is necessary to apply for SIM card from the telecommunication company. SIM card can provide link Internet network service for the CDMA DTU. Secondly, it is necessary to set parameters with terminal software or AT command before use, so as to determine the mode of data transmission into the network.

The practical application environment of plant physiological detection system is very complex, and the power supply is difficult to guarantee. Therefore, 3.6 V lithium battery is used in this design. However, the sensor module and CC2530 module in plant physiological detection system need different power supply. Therefore, this design uses DC-DC chip NCP500SN33G to obtain a stable 3.3V, which is suitable for SOC working voltage. TPS61040 is used to bootstrap 3.6V to 12V voltage suitable for all kinds of sensors. The circuit diagrams are shown in Figure 4, Figure 5, respectively.

![Diagram](image)

Figure 4. NCP500SN33G switching circuit.

![Diagram](image)

Figure 5. TPS61040 switching circuit.
System Software Design

Data Acquisition Node Software Design

The collection sensor node is mainly responsible for collecting the physiological information of the plant and sending the data to the embedded gateway. The design uses the IAR integrated development environment from the bottom up to build ZigBee network. In order to save power, the sensor nodes are generally in low power mode, until the host computer command received after the corresponding test data uploaded to the gateway. In order to improve efficiency, the host computer can be set up after a period of time after the sensor to send upload data command. In addition, a median average filtering algorithm is used to eliminate random interference within individual sensor systems [8], improving the measurement accuracy of the sensor. Sensor node work flow chart is shown in Figure 6.

Embedded Gateway Software Design

Embedded gateway software design is built on the linux-red hat linux operating system, the operating system with multi-task operation process, support a wide range of hardware, modular procedures, open source code and many other advantages are widely used [9-10]. Use the IAR integrated development environment to establish a network connection for the embedded gateway and remote detection management center. The embedded gateway flow chart is shown in Figure 7.

PC Software Design

The system uses the LabVIEW platform to write the host computer software, according to the design requirements, the software is divided into data display module, data analysis module, data storage three modules. The data display module mainly displays the received data and the analyzed result on the front panel of the host computer. The data analysis module selects the appropriate analysis and the processing method according to the different parameters of the plant to be detected. The system analysis module achieves the following functions. When the measured data are within the normal
range Indicator lights show green, indicating that plants grow normally. When a certain parameter exceeds or falls below the normal range, the corresponding indicator shows red alarm. Data storage module mainly stores data in the database. Because LabVIEW can not directly access the database, it uses SQL language to complete the access to the database. The software structure diagram of the host computer is shown in Figure 8.

![Figure 8. Structure diagram of remote monitoring software.](image)

**Experimental Results and Analysis**

In order to verify the performance of the system, four tomatoes were selected as the test objects in the greenhouse environment of 29 degrees Celsius. Four tomatoes were evenly distributed in the 250 × 250 test area, and the coordinator was placed in the central area of the greenhouse. Thus the star network structure can be formed. The physiological parameters such as stem flow, chlorophyll content and fruit diameter were collected at the same time and sent to the upper computer display interface. The collection interval was 2 hours, and the total detection time was 72 hours. The total detection time was 72 hours. The experiments show that the system can normally complete the functions of collecting, transmitting and displaying physiological parameters of tomatoes.

**Summary**

This paper designs and implements a remote crop physiological parameters detection system based on WSN. The system adopts modular structure and combined with embedded and ZigBee technology to realize the dynamic acquisition, wireless transmission and remote real-time monitoring of the physiological parameters of crops. The experiments show that the system has superior performance and stable data transmission. It has good application value in precision agricultural production.

**Acknowledgement**

This research was financially supported by Scientific Research Significant Projects of Universities and Colleges in Jiangsu Province (No16KJA460003).

**References**


