An Agricultural Habitat Information Acquisition and Remote Intelligent Decision System Based on the Internet of Things

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Abstract. On the basis of the information perception technology and mobile interconnection technology, through the technology of Agriculture Internet of Things, the multi-sensor system integration is realized, and the collaborative sensing of habitat information come true in crop production. This paper designs architecture of hardware and software for the system. By wireless multi-hop and seamless connection technologies of "triple net integration", common interfaces and scanning technologies of multi-sensor standard signal transform are used to achieve the multi-parameter information acquisition of crop during its growth. Wireless monitoring nodes of the Agriculture Internet of Things are distributed in each measurement point of the farmland, and they are responsible for information collection, pretreatment, and wireless transmission of eight parameters data, including the environment temperature, environment temperature, Light intensity, Carbon dioxide content, soil temperature, soil humidity, soil pH, soil salt. The data processing and service system execute remote data storage and on-line information release. The intelligent decision support system achieve real-time warning of abnormal parameters. Experiments show that the architecture of the system is reasonable, and the system has good accuracy, stability and reliability, in line with the practical application of grassroots agricultural field.

Keywords: the Internet of Things· Intelligent Decision· Agriculture Habitat Information· Information Acquisition· Zig Bee· ARM

1 Introduction

In recent years, Chinese scholars have launched a broad and in-depth study for farmland environment monitoring. These studies mainly rely on 3S (GIS, RS, GPS) technology in a large range, and take the way of artificial ground survey in a small range. Surely these studies have made a lot of valuable research results. However, from the practical application, the farmland environmental information monitoring

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system that based on 3S technology has some questions of data imprecise, poor real-time and poor efficiency [1].At present the network technology and wireless communication technology have been rapid development. Especially the development and maturity of ZigBee and GPRS / CDMA technology made up for the lack of abovementioned research, and to provide an effective way for improving China's agricultural information monitoring system. Currently the data transmission technology which based on ZigBee and GPRS / CDMA has a number of typical applications in some related areas. However through integrating long-distance data collection with agricultural expert system for field data collection, processing data and sending messages to provide timely service to farmers, the related researches still needs to strengthen [2]. This paper has developed a wireless information monitoring field and timely service system which based on ZigBee and 4G technology, which can uniformly monitor and manage the environmental parameters (including environmental temperature and humidity, soil temperature and humidity, light, rainfall, soil pH) that distributed in farmland through the ZigBee wireless network, while can use the SMS to release production guidance information to the farmers at any time [3].

2 Design of Architecture of the System

The entire monitoring and service system consists of a monitoring host, a ZigBee network and an expert system. The ZigBee network consists of a ZigBee gateway node and a number of ZigBee sub-nodes that connect multiple external sensors. They form a wireless monitoring network. The ZigBee network sub-nodes collect the environmental parameters in the agricultural area through various sensors [4]. The collected data of environmental parameters are sent to the gateway node according to the ZigBee protocol through the wireless communication module of the terminal node. The gateway node will real-timely send the received information back to the server knowledge base system through the serial port, and give timely guidance according to the expert knowledge [5]. The whole system architecture is shown in Figure 1.

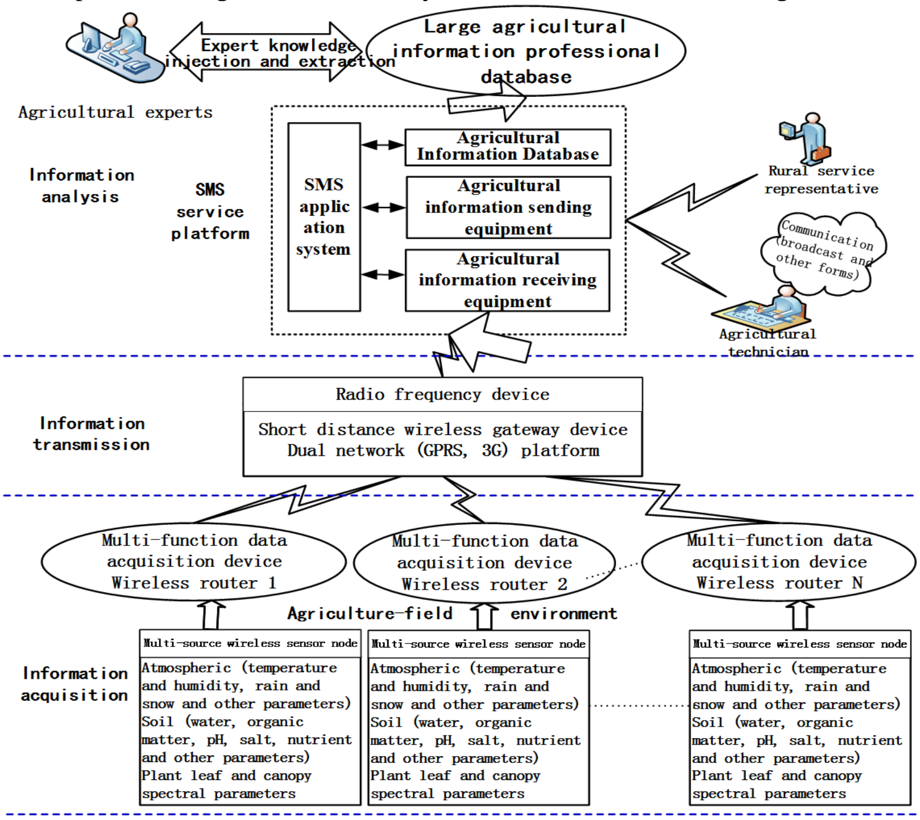

Fig. 1. The system architecture

3 Design and Implementation of System Function

3.1 Design of Hardware Structure of Sub-node

The sub-node hardware structure of Lower position machine is designed for multiple modular, and its structure is shown in Figure 2. It mainly consists of the sensor module, data processing module, ZigBee communication module and power supply module [6].

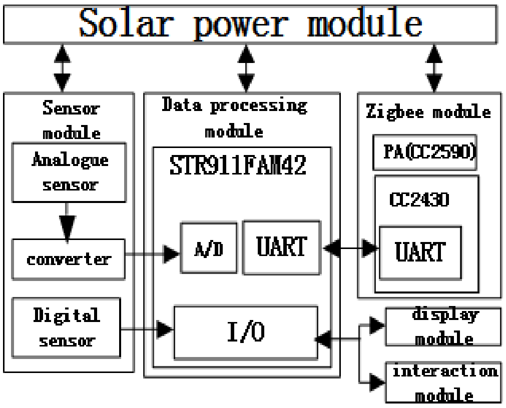

Fig. 2. Hardware structure of a sub-node

The data processing module is mainly composed of integrated A/D converter and the microprocessor that has a certain storage capacity. It is responsible for node network transaction management, data conversion and control of power supply of the external equipment. It combined the display module with keyboard module to achieve on-site data display and parameters setting [3]. The data acquisition module is composed of various sensors (environmental temperature and humidity, soil temperature and humidity, rainfall, light, soil pH and soil salinity). It is responsible for the quick and accurate collection of environmental information in the field. The wireless communication module is responsible for the data transmission and instruction transceiver among gateway nodes. The power management module is responsible for providing all of sub-nodes with the power in the entire network [7].

This paper selected a 32-bit low-power ARM11 microprocessor STR911FAM42 that the ST company developed as the core of data processing module. For other common low-end microcontrollers, it has richer resources and low power consumption, and can provide some processing capacity for future system function expansion [8]. In addition to the normal operating mode, it has also different levels of low-power operation mode, and is very suitable for low-energy farmland information monitoring applications in the field [9].

3.2 Design of Software Structure of Sub-node

The sub-node of lower position machine mainly realized the functions of sensor information acquisition, field data display and working parameter setting and ZigBee network communication. The AT commands are used to realize the communication between the data processing module and the ZigBee wireless communication module, which simplifies the communication process and ensures the versatility of the ZigBee wireless module. In order to reduce power consumption, here the following measures are taken: 1) When the sub-node is idle, the microprocessor is in sleep mode, when the RTC alarm and external interrupt come, it is in wake mode; 2) when the microprocessor acquires sensor data, through the I / O port The mouth control electronics relay is closed to supply power to the sensor, and the electronic relay is disconnected at other times [10]. The program flow of sub-node is shown in Figure 3.

Compared with the assembly language, the C language is easy to develop, readable, good maintenance and other good characteristics, so the software program of sub-node is written in C language. In order to ensure the accuracy of the sensor data, using 4Bytes to represent the data, in line with IEEE 754 floating point definition. The sub-node sends the data to the gateway node in the following format, where the leading byte includes the packet sequence number, the node ID, etc. The extended byte is used to extend the additional sensor data and the frame check bit [11].

Table 1. The sub-node sends the data to the gateway node.

Leading	Sensor 1#	...	Sensor 10#	Extended bytes
4 Bytes	4 Bytes	...	4 Bytes	4 Bytes

In the mountain farmland environment, due to changes in terrain, the wireless signal is easy to be interfered, resulting in data packet loss and error. Therefore, the sub-node software can reduce the data packet loss and bit error rate by increasing the number of data transmission and frame checking. At the same time, the software filtering technology is adopted to improve the accuracy of data acquisition [12].

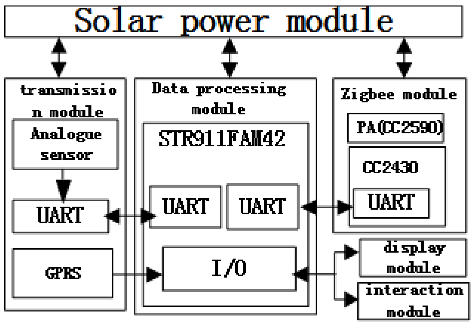

Fig. 3. Hardware structure of a gateway node

3.3 Design of hardware structure of gateway node

The hardware structure of gateway node of the lower position machine realized modular design, the structure is shown in Figure 3, mainly consisting of remote data transmission module, data processing module, ZigBee communication module and power supply module [13].

The data processing module is still using STR911FAM42 as the core unit, and responsible for the node network transaction management, data processing and control of external equipment such as power supply, and combined with the display module and keyboard module to achieve node information display and work parameter settings. The remote transmission terminal is responsible for the remote information Transmission, and collecting farmland environmental information quickly and accurately[14]. The ZigBee communication module is responsible for data transmission and instructions transceiver among sub-nodes. The power management module is responsible for providing energy to the entire gateway node [15].

3.4 Design of Gateway Node Software Structure

The software design of gateway node of the lower position machine mainly includes the network communication program that based on ZigBee protocol, the node information display, the information storage and forwarding program. The flow of main program is: the gateway node stores and integrates the data received from the sub-nodes, and encapsulates the data into the data frame according to the corresponding working parameters and the agreed code. Then they are sent to the industrial host through serial port 0, and keeps inquiring serial status until all the data is finished sending [16]. And then it is ready to receive the next packet. The gateway node main program flow is shown in Figure 4.

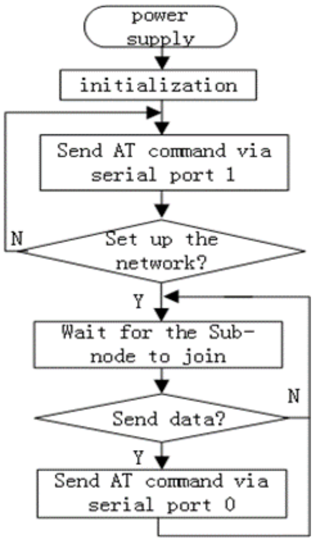

Fig. 4. Gateway node flow

4 Intelligent decision support application system

Taking intelligent information processing as the core technology, the expert knowledge is integrated into the network service center to build a knowledge base. Through the technologies of multi-point automatic acquisition of the field farmland environmental data, wireless transmission based on public band, virtual online expert analysis and decision-making, and integration of remote real-time sensing data, the rapid diagnosis of farmland information and remote monitoring is realized. It actively push early warning and forecasting information. The real-time data collected by the system terminal are carried out data fusion and mining through the intelligent information processing module. Further the knowledge base system is integrated into the relevant pest forecast and fertilization decision-making module [17]. The decision-making results are submitted to the SMS service platform, and the real-time information is sent to the users. Through the GSM Modem (CM310) module and RS-485 computer communication interface, these are submitted to the WEB service system for network publishing [18]. At the same time, we use the methods of model calculation, knowledge reasoning and qualitative and quantitative ways to realize the comprehensive reasoning and decision based on production rules. Finally the real-time early warning information and intelligent decision-making of crops is achieved according to real-time data and processed data and rule base [19]. As shown in Figure 5 and Figure 6 below.

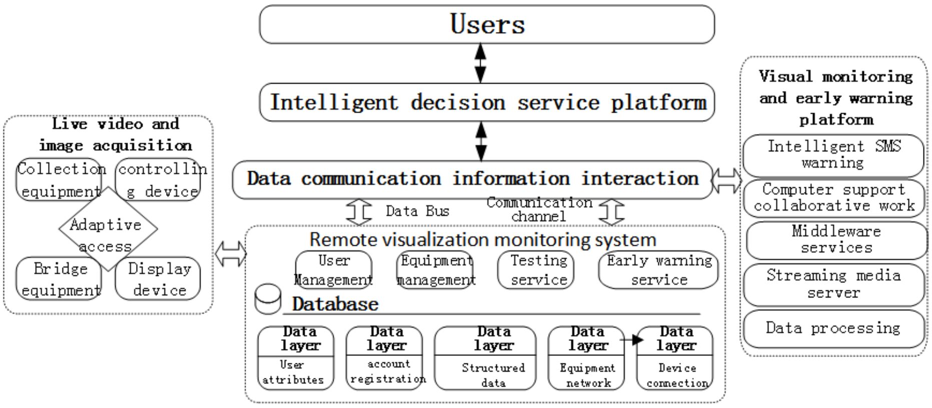

Fig. 5. Intelligent decision support service system structure

Fig. 6. Display interface of Intelligent decision support service system

5 System Experiment and Analysis

In order to test the stability and reliability of the system, the environment temperature and humidity sensor, soil temperature and humidity sensor, light sensor and other sensors are connected with the terminal ZigBee node that installed in the field farmland monitoring point. the terminal nodes collect these sensing data, after the data are each finished to send, it will automatically enter the sleep mode, and recovery wake mode after receiving the acquisition command, and fulfill re-acquisition of data, continuous monitoring for a month. The gateway node displays the received data and uploads the received data, then transmitted to industrial control host through the serial port. The system display interface is shown in Figure 7 below. The data curve is drawn as shown in Figure 8.

Fig. 7. Display interface of The Entire System

Fig. 8. Analysis of Trends of Crop Habitat Information

The experimental data show the terminal nodes have send the 24 groups data of the environmental temperature and humidity, soil temperature and humidity, light intensity and other sensors in a month of monitoring, and the gateway node has received all of sensing data in real time. The loss rate of data packet is zero, and the collected data are accurate and reliable. At the same time in application demonstration of the system, this paper also carried out testing wireless transmission distance of the data, the current system can achieve barrier-free network transmission distance of 800m, point-to-point communication distance of about 2.5km. Relatively the transmission distance of a common ZigBee transceiver module is 200m. So the communication distance of our designed system is increased by about 10 times. So our system has achieved the desired effect.

The above experimental results show that the wireless sensor network based on ZigBee and ARM11 technology has good stability and reliability, and can provide real-time reliable and accurate on-line monitoring services for habitat parameters acquisition and precision agricultural production.

6 Conclusion

This paper briefly introduced the basic principle of the farmland information monitoring system based on ZigBee and ARM11 technology, as well as the development process of the system's hardware and software. The stability and reliability of the system is verified. The ZigBee and ARM11 technologies are applied to field farmland information transmission, and has greatly improved the reliability and real-time of the system [20]. The expansion and maintenance of the node is also very easy. It help improve the economic management of precision agricultural production [21].

Although the system needs to further improve in anti-interference, anti-fading, energy saving and network topology, the system's integration of a variety of wireless communication technologies is very good learning for the existing 3S-based economic farmland information monitoring system. With the growth of demand for economic farmland products, China's agricultural production needs to be further developed on the existing basis [22]. Future agricultural production requirements will strengthen integrated of a variety of information technologies. The advantages of integrated multi-system are played for the efficient management farmland production and providing accurate scientific basis [23].

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