Design of wireless monitoring system for grassland ecological environment based on Wireless Sensor Network

Bo Chang [1, a], Xinrong Zhang [2, b]

[1] Faculty of Electronic Information Engineering, Huaiyin Institute of Technology, Huai'an, Jiangsu, China

[2] Faculty of Automation, Huaiyin Institute of Technology, Huai'an, Jiangsu, China

[a] email:mmm33534@sohu.com, [b] email: nn33@163.com

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Abstract. Traditional grassland ecological monitoring data are based on manual field acquisition. Its disadvantage is that it cannot achieve continuous automatic collection, which wastes manpower and material resources, has poor real-time performance, and cannot effectively monitor grassland ecology. In view of this situation, WSN technology is introduced into the development of grassland ecological monitoring system by making use of the characteristics of ZigBee network, such as convenience, scalability and low cost. The sensor nodes are designed with CC2530 as the core control and communication device. The communication between nodes follows the ZigBee protocol, and the collected data of temperature, humidity and wind speed are processed and transmitted by multi-hop routing. It is sent to the monitoring center to accurately and timely reflect the current situation of grassland ecosystem and its evolution and change law through the management and quantitative analysis of the field data monitored. It provides important theoretical basis and technical support for the protection of grassland ecosystem. The monitoring center adopts the embedded database management mode to realize the functions of terminal node, data management and early warning, and realizes the functions of data collation, analysis, display and printing of various curves and reports. Experiments show that the system runs stably and has high data transmission accuracy. It can effectively detect the parameters of grassland ecological environment, improve the security and real-time of information transmission, and is suitable for popularization and application.

Introduction

Due to the aggravation of soil and water loss caused by the continuous deterioration of grassland ecological environment and the emergence of frequent sandstorms threatening grassland ecological security, the intensity of external disturbance in many grasslands exceeds the ability of regulation and self-repair within the system, and the ecosystem is in a damaged state. Therefore, the protection and comprehensive treatment of the grassland are of great concern to all sectors of society [1]. Grassland ecological monitoring is the premise of grassland ecological protection, so grassland ecological monitoring is of great practical significance and guidance for the restoration of grassland ecosystem [2, 3]. The traditional methods of obtaining grassland ecological monitoring data basically rely on manual field collection of images, humidity, temperature and other data, and then go back to the laboratory to analyze and summarize the data, which cannot realize continuous automatic data collection. This method not only wastes manpower and material resources, but also is poor in real-time, and cannot effectively monitor grassland ecology [4]. At the same time, the reliability cannot be guaranteed, and when measuring on a large scale, the cost is too high, the data accuracy is poor, as so on [5-7]. WSN are formed by low power network nodes through self-organization to realize information sensing, collection and monitoring tasks, and can process related data [8]. At present, many applications of WSN in agriculture have appeared [9-11], but few of them have been used in grassland ecological environment monitoring. In order to realize the visibility, dynamics and network intelligence of the monitoring system, as well as the low cost of WSN and the wide range of data acquisition, the scheme of applying wireless sensor network to

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grassland ecological environment monitoring is feasible.

In this paper, based on the sensor technology of CC2530 and the remote monitoring system of the grassland ecosystem combined with the wireless network communication technology, the self-organized WSN is adopted to collect on-site monitoring data such as temperature, humidity and wind speed of the statistical grassland. The program provides real-time data on the ecological status of the grassland for scientific research personnel engaged in the research of the grassland ecology, and provides a certain basis for the further protection and improvement of the grassland ecological environment. The characteristics of this scheme are movable nodes, easy maintenance, low networking cost, which is suitable for the automatic information monitoring system of grassland ecological environment. Through the objective analysis of the monitoring data and the summary and comparison with the historical data, the ecological situation of grassland and the law of its evolution and change are reflected in detail.

Overall Design of Monitoring System

Through investigation and analysis, the application requirements of grassland environmental monitoring system mainly include:

- Real-time acquisition, processing and fusion of ambient temperature, humidity and wind speed all day.
- Using the low power wireless communication mode to transmit the data in real time and store it in the database for query.
- The monitoring center management platform completes sensor node management, information storage, analysis and processing and curve drawing, etc.

The items of the system monitoring include monitoring temperature, humidity and wind speed. The system structure mainly include sensor node, gateway node and monitoring center. The overall structure of the system is shown in Fig.1.

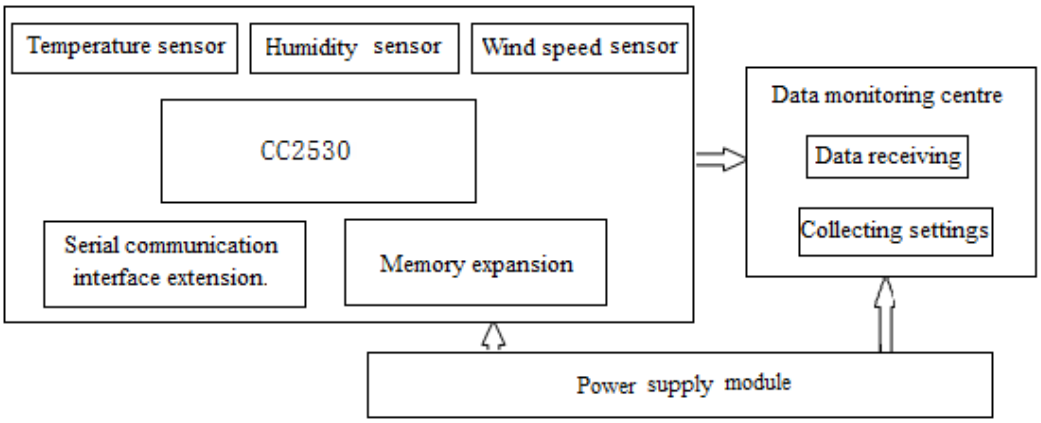

Fig.1. Structure diagram of system

The data acquisition terminal includes a temperature sensor, a humidity sensor and a wind speed sensor. The analog data from humidity and wind speed sensors are converted by ADC module of CC2530, and the temperature data are collected directly through the I/O interface module of DSP. The sensor nodes adopt the multi-hop routing strategy, which wirelessly sends the effective data to the gateway node, and then sends the information to the monitoring center for information processing. The data-monitoring center includes hardware and software, the hardware is a PC, and the software is the monitoring program of the control center. When the monitoring center needs to collect data in real time, the data acquisition terminal sends a command corresponding to the acquisition terminal, and the acquisition terminal transmits the required data acquisition to the data-monitoring center after being identified. The monitoring center performs storage, display and data distribution according to the actual needs, and provides a technical basis for controlling the related equipment.

Sensor Node Design

Sensor selection. Considering the requirements of cost saving and data accuracy, the sensor and related parameters are shown in Table 1.

Table 1 Sensors and related parameters

Sensor	Model	Measuring range	Precision	Remarks
Temperature	DS18B20	-55～125℃	0.0625℃	+5V Supply , acquisition time is ls each time
Humidity	HS1101	0~100%RH	±2%RH	Response time < 5 s, temperature coefficient = 0.04pF/℃
Wind speed	MFY-4A	0-30m/s	±0.17+0.0lFV	Voltage output 0-10 V (0-30 m/s), sampling period 6s.

The number of bits of temperature conversion results of digital sensor DS18B20 can be determined by software programming. DS18B20 has three pins, and DATA is the data line of DS18B20, which is used to transmit instructions and temperature data. Capacitive humidity sensor HS1101 is equivalent to a capacitance device, and its capacitance increases with the increase of measured air humidity. When the relative humidity is in the range of 0-100%RH, the capacitance is in the range of 162pF to 200pF, the temperature coefficient is 0.04pF/℃, and the capacitance and humidity change 0.34Pf/% RH. MFY-4A is a three-cup wind speed sensor, it can monitor the wind speed of the surrounding environment in real time, and can alarm by strong wind. When the wind speed is less than or equal to lm/s, the sensor starts.

Hardware Design of Node. Sensor nodes complete the tasks of environmental information sensing and collection, data processing and wireless communication. Considering the application requirements, as well as the factors of cost, power consumption and reliable operation, the node circuit includes the power supply module, the CC2530 micro-processing wireless transceiver module and the sensor node module.

Considering that the specific task of the gateway node is to process and send the collected information, and the storage capacity and communication ability of the gateway node are not high for the monitoring requirements of the ecological environment parameters, the CC2530 can be used for design, and the composition and the design of the sensor nodes are similar. Gateway nodes mainly complete data correction, fusion, and send to the monitoring center, but also can obtain instructions and sends the instruction to the control device after processing. The level conversion chip MAX232 and RS232 communication interface are used to convert the TTL level to the RS232 level of PC, which needs few peripheral components and follows the EIA/TIA232 communication standard, and the transmission rate is up to 220kbps.

Software Design of Sensor Node. The software of the wireless sensor node includes the system power-on self-test, data acquisition, receiving and sending, power management and other processes. After the system starts the program, the ports are configured and the corresponding functions are performed by interrupt. The primary data information transmission workflow is shown in Fig. 2.

The data information of the sensor needs to be judged by identification. If the monitoring area information is monitored, upon request, it is sent to the gateway node. After receiving, according to the requirements of the system, the gateway node sends the consent to receive the data instruction to judge whether to accept the next sensor data information. When designing node software, the functions of network

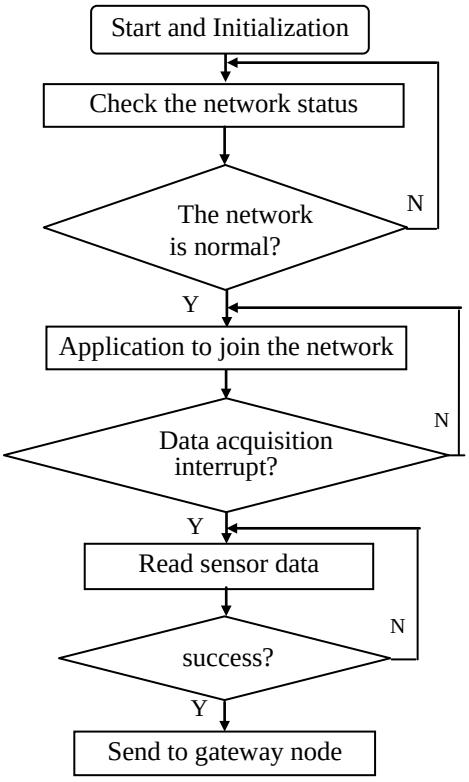

Fig.2. Software flow of the terminal node

self-assembly of each sensor node are realized by calling the API function provided by the ZigBee protocol stack.

Implementation of Data Communication

In view of the actual situation of grassland ecological environment monitoring, the network topology adopts tree structure, which has the characteristics of perfect function, wide coverage and easy realization and maintenance. There are two types of nodes: one is sensor data acquisition node, the other is network node with routing function. The sensor node is used to collect the environmental parameters and the task of the gateway node is to realize the information aggregation function of the network and send the effective data to the monitoring center computer. The function of sending and receiving information in the software of line module includes the initialization setting of CC2530 and the process of sending data and receiving and processing data through CC2530 through SPI port.

Software Design of Monitoring Center

Monitoring Center Software Function. Based on hardware composition, software design and database technology, the monitoring function of the system is developed by using C# language. In the C++ Builder integrated development environment, a new window application based on visual component (VCL) is created, called SCOMMN, all steps remain in the default state, and controls are added to the main form. The monitoring center consists of user management module, site module, data processing module and data management module. The monitoring interface design includes parameters such as ambient temperature, humidity and wind speed. After 10 times of data collection, the average value is displayed in the interface, and the collected data can be saved in text format. The buttons set in the interface are "Start collection", "Stop collection", and "data display". The system function diagram of the monitoring center is shown in Fig. 3.

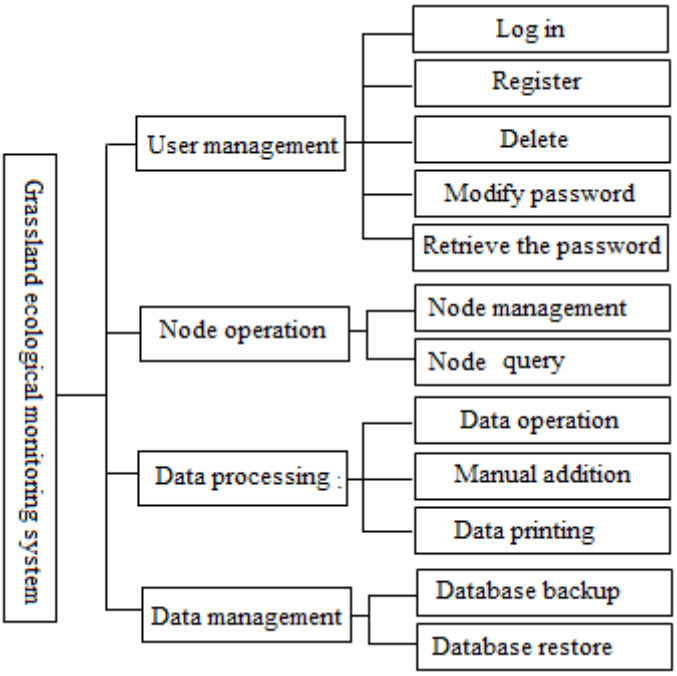

Fig.3. Software block diagram of monitoring center

Design of Node Management Software. When the monitoring terminal sensor node is added to the monitoring system, the user can go to the site management page to add the node, add a new node information table to the system database, and store the data information received from the node into the table. Users can also delete unwanted nodes from the page to remove all data information for the node from the database. The flow chart of the node management is shown in Fig. 4.

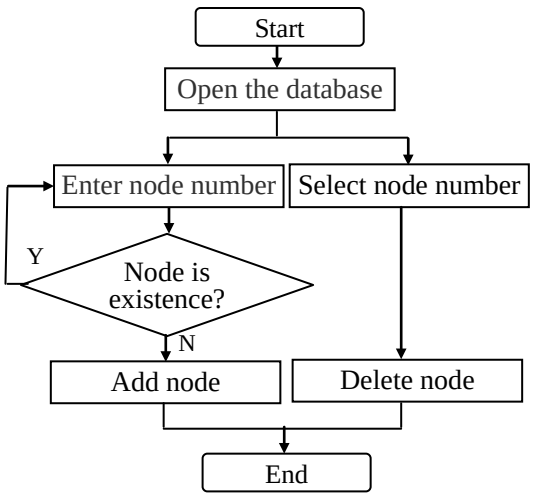

Fig.4. The flow chart of the node Management software

In this design, the fuzzy PID controller is applied to temperature control. The error and change rate of the fuzzy PID controller are taken as input language variables, while

the change of input variables and control variables in the controlled process are taken as output language variables, which is helpful to ensure the stability of the system and reduce the overshoot of the response process and weaken its oscillation phenomenon. Combining fuzzy control with PID control, using the basic principles and methods of fuzzy mathematics, the condition and operation of the rules are expressed by fuzzy variables, and these fuzzy control rules are stored in the computer knowledge base. Then, according to the actual situation of the control system, the computer uses fuzzy reasoning to realize the optimum PID parameters. Good adjustment.

System Test Analysis

After the design of the system is completed, four nodes are assembled according to the design requirements, and the experimental test antenna adopts a rubber antenna, the size of the antenna is only 8cm, the weight is about 35g, and the transmission frequency of the antenna is typically 2.4 GHz. Through field test, the straight-line transmission distance is about 45m in the absence of obstacles. Therefore, as long as the network topology is designed reasonably, the system can meet the requirements of grassland ecological environment monitoring. Select the area to be monitored for system testing in an open country. Four sensor nodes and a central node are randomly arranged, through which, the environmental data be monitored. The temperature, humidity and wind speed -the average of the four monitoring points, and their measured values are obtained as shown in Table 2.

Table 2 Statistical table of monitoring data

Monitoring data – Displayed and measured	Monitoring time								
	9:30	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30
Temperature -- Displayed (℃)	22.6	22.7	23.8	24.6	24.7	25.4	25.8	26.4	27.9
Temperature -- measured (℃)	22.5	22.6	23.7	24.5	24.8	25.3	25.6	26.3	27.8
Humidity – Displayed (%)）	68	65	62	59	57	54	51	49	48
Humidity – measured (%)）	67	63	62	58	56	54	51	48	47
Wind speed – Displayed（m/s）	12.5	13.2	9.9	9.6	9.5	9.7	10.8	11.6	11.8
Wind speed –measured（m/s）	12.4	13.2	9.8	9.7	9.5	9.6	10.6	11.4	11.7

It can be seen from the table that the data measured by the system is more accurate and distributed near the optimum value. According to the actual measurement and analysis, the maximum error of temperature is 0.2℃, the maximum error of humidity is 2%, and the maximum error of wind speed is 0.2 m/s. The curves of temperature, humidity and wind speed are shown in Fig. 5-Fig. 7, respectively.

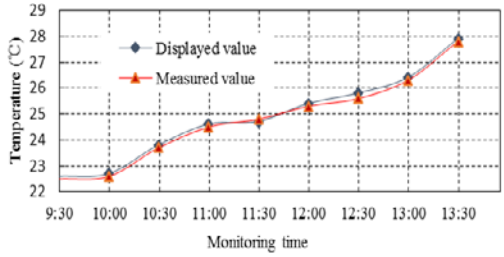

Fig.5. Curve of temperature change

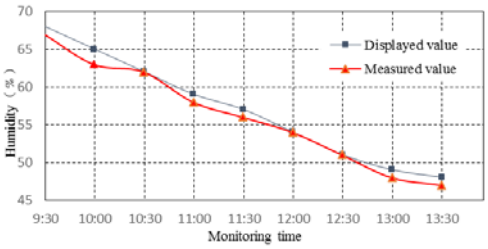

Fig.6. Curve of humidity change

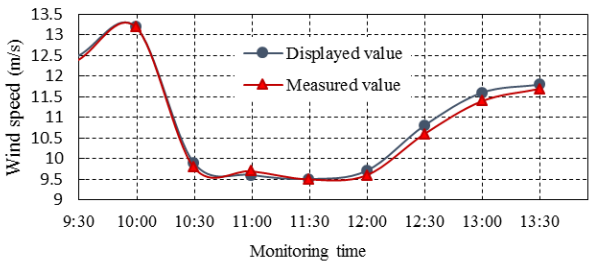

Fig.7. Curve of wind speed change

Conclusions

In this paper, a grassland ecological monitoring system based on CC2530 chip and WSN technology is studied and designed, and the functions of collecting and processing all kinds of grassland environmental information through temperature sensor, humidity sensor and wind speed sensor are realized. The monitoring terminal transmits the acquired data to the data-monitoring center through the wireless network and the gateway node, and realizes the transmission of the real-time data of the data acquisition terminal and the data-monitoring center. The network database is established in the monitoring center, so that the user can use the computer terminal to monitor the monitoring terminal information in real time. The experimental results show that the system can realize the corresponding detection function and achieve good results, and can provide reference for technological innovation in this field. Based on the design concept of low power consumption, the system can make a beneficial exploration to improve the monitoring efficiency and reduce the monitoring cost.

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