Design of indoor air quality monitoring system based on wireless sensor network

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Abstract. With the development of industrial technology, China's smog weather is frequent, affecting air quality and human health. It is important to monitor indoor air quality in real time and make timely processing. This paper designs an air quality monitoring system based on ZigBee wireless sensor network. The system consists of multiple terminal modules, a coordinator module, a control module, and a monitoring center. The terminal module collects data using a variety of sensors and sends them to the monitoring center through the GPRS. Once the air quality index exceeds the set threshold, the user is promptly alerted and the corresponding air purification process is performed. The system is simple and convenient, the monitoring result is accurate, the real-time performance is high, and the application is extensive.

1. Introduction

With the rapid development of China's economy, air pollution has become more and more serious, leading to environmental governance becoming the focus of society. Environmental problems threaten human health and affect people's daily work and life to a certain extent. To control air pollution, it is first to conduct air quality monitoring and then take control measures[1]. In air pollution, PM2.5 accounts for more than half of the total airborne particulate matter, so PM2.5 becomes an important monitoring air quality index(AQI)[2]. For the monitoring of outdoor air quality, there are government departments to monitor and warn, but there is little monitoring for people's long-awaited indoors[3]. And with different time changes, the air quality has different values, users can not grasp the indoor air quality in real time. Therefore, it is necessary to design an indoor air quality monitoring system with convenient installation, accurate monitoring results and good real-time performance. Considering the advantages of high flexibility, modularity, low energy consumption and strong anti-interference ability of wireless sensor networks[4,5], an indoor air quality monitoring system based on wireless sensor network is designed.

2. Overall system design

The overall design of the system is shown in Figure 1. The system consists of several sensor modules, control modules, a coordinator module, and a user monitoring center. The sensor module mainly collects air quality data. The air quality affects not only PM2.5, but also nitrogen oxides and sulfur dioxide. Therefore, the sensor modules mainly include smog sensors, SO2 sensors and NO2 sensors. These sensors are connected to the ZigBee terminal node to form a routing node. A plurality of such routing
nodes are respectively placed on the roof of the room and the living room, so that the smog concentration of each room can be accurately measured. The ZigBee terminal node processes the collected data and sends it to the coordinator. The coordinator transmits the received node data to the user monitoring center through the GPRS module, and transmits the user's command to the control module. The control module is mainly composed of ZigBee terminal node, stepping motor, electric curtain, infrared module and air purifier. When the air quality index exceeds the standard, the smartphone will issue commands to close the curtains and open the air purifier. When the ZigBee terminal node receives the command, it controls the curtains and the air purifier. The User Monitoring Center is a monitoring software installed on the smartphone that displays and analyzes received data in real time and can send control commands remotely.

3. System hardware design

3.1. Terminal node circuit design
ZigBee terminal node and coordinator node are ZigBee nodes with CC2530 as the core. The CC2530 is a chip that supports TI's IEEE802.15.4 and ZigBee protocols in the 2.4GHz band. It contains a high-performance RF transceiver and an enhanced 8051MCU core. It also integrates a 16-bit A/D converter. Collect analog data from the sensor. The terminal node is connected to the sensor, collects air quality data, and transmits it through the RF module after processing. The block diagram of the node is shown in Figure 2. The air quality data acquisition module includes a smog sensor, an SO2 sensor, a NO2 sensor, and a temperature and humidity sensor. The smog sensor is Sharp's GP2Y1010AU0F and is also a PM2.5 sensor.
3.2. Coordinator node hardware design
The main function of the coordinator is to set up a wireless sensor network, receive the data of the terminal node and send it to the mobile phone remotely through GPRS, and forward the instructions issued by the mobile phone to the terminal control node. The GPRS module uses the MC39i from Siemens, which enables data voice transmission, short message transmission and fax functions. The MC39i can communicate with the coordinator node through the serial port, and at the same time embeds the TCP/IP protocol to facilitate Internet data transmission. The coordinator node module is shown in Figure 3, and includes an antenna module, a power supply, a clock, a display, an alarm module, and a GPRS module. The display module is used to display the air quality data in real time, and activates the alarm module when the data exceeds the set threshold.

![Diagram](image)

**Figure 2.** Terminal node circuit block diagram

**Figure 3.** Coordinator node block diagram

3.3. Control module
The control module is mainly used to control the switch of the air purifier and the curtain, and mainly includes an infrared module, a stepping motor, an air purifier and an electric curtain. The infrared module is used to control the air purifier. First, learn the air purifier remote control through the infrared learning mode, and then encode the infrared code segment of the purifier. After receiving the control air purifier command, the corresponding infrared code segment is sent to remotely control the air purifier.

4. System software design
4.1. Terminal detection node software design
Monitoring terminal node software flow chart shown in Figure 4. The terminal detection node module is divided into a sensor data acquisition module and a control module. The sensor module is mainly responsible for collecting air quality data and transmitting it to the coordinator, and the control module controls the corresponding home appliance according to the received instruction information. Each module of the system must be initialized first, and successfully join the network to communicate
data. The terminal has multiple sensor modules, which collect data of temperature and humidity sensor, PM2.5 sensor, SO2 sensor and NO2 sensor in turn. The system will judge whether the data is valid. If it is valid, the address code is read and the data is sent, otherwise the data is discarded. After the data is sent, the system can delay or sleep to reduce power consumption.

![Diagram](image)

**Figure 4.** Monitoring terminal software flow chart

4.2. **Coordinator node software design**

The coordinator node mainly has two functions. On one hand, it receives the data transmitted from the ZigBee network for unpacking, and transmits it to the remote monitoring center through the GPRS module. On the other hand, it receives the command issued by the remote user center through the GPRS module, and transmits it to the terminal node. After the coordinator initializes the system, it starts to set up the network. After the network is successfully established, it waits for the serial port to be interrupted. Because the communication between the GPRS module and the ZigBee terminal module with the coordinator main control chip are serial mode, the serial interrupt program is divided into two categories, one from the GPRS network and one from the ZigBee network. When an interrupt occurs, first determine whether the interrupt is from the GPRS module. If it is, send the command to the ZigBee network. If not, determine whether the interrupt is from the ZigBee module. If not, discard the data, otherwise, the packet is parsed and the received data is compared with the set threshold. If it is greater than the threshold, it will alarm and notify the user, otherwise it will send data to GPRS at a certain interval. Coordinator node software flow chart shown in Figure 5.
5. System test
In the test experiment, two terminal nodes and one coordinator node are selected to form a monitoring system. One terminal node is connected with SHT11, PM2.5 sensor, SO2 sensor and NO2 sensor. The other terminal node is connected to the air purifier and the electric curtain. The real-time monitoring software is installed on the mobile phone or PC. Figure 6(a) shows the real-time air quality data displayed on the display connected to the coordinator, and Figure 6(b) shows the air quality data displayed by the monitoring software. And the test results show that the system can monitor the air quality data in real time.

Figure 5. Coordinator node software flow chart

Figure 6. (a) Display result
Figure 6. (b) Monitoring Center
6. Conclusion
In this paper, the hardware design and software development of indoor air monitoring system based on wireless sensor network is completed for indoor air quality problems, which can realize real-time collection of indoor temperature and humidity, PM2.5, SO2 and NO2 concentrations. Through the monitoring software, users can keep abreast of indoor air quality information. When the air quality is very poor, people can remotely control the air purifier and electric curtains to purify the air in advance, so that people can have a good living environment when they go home. The monitoring software can be widely applied to air quality monitoring of other buildings, greenhouses, communities, etc., and has great application prospects.

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