Design of air quality detection system based on bluetooth communication

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Abstract. In order to grasp the specific air quality information of the environment timely and accurately, air quality detection system was designed, which was based on the Arduino platform. This System can easily detect common atmospheric pollutants such as PM2.5, formaldehyde, CO, etc. At the same time, the data was uploaded to the mobile terminal via Bluetooth communication, and then stored in the SQLite database. It provided reliable data for later analysis of environmental conditions. When the measured data exceeded the safety threshold, a warning signal was sent to the alarm reminding module to remind the user. Experiments showed that the mean square error of the predicted value of the system was low, and accurate air pollution data can be detected in indoor and outdoor environments.

1. Introduction

With the occurrence of severe atmospheric pollution phenomena such as smog, people are paying more and more attention to atmospheric environmental pollution, hoping to be able to grasp the specific data of atmospheric pollution in the monitored living environment in time, so as to rationally arrange and carry out related activities, and reduce the harm as much as possible caused by air pollution [1]. The national environmental monitoring department publishes regional air quality in real-time, but due to the limited number of monitoring points, fixed locations, and limited monitoring data, it cannot accurately display the air quality of the user’s current location in real-time, and cannot meet the needs of ordinary users for air quality monitoring. In order to solve the above problems, an air quality detection system based on the Arduino controller is proposed, which can upload data to the mobile phone APP in real-time through Bluetooth communication to realize the monitoring of common indoor and outdoor air pollutants. The system can accurately detect and display the air quality information of the user’s current location and upload the data to the mobile terminal.

2. System function and structure

The system structure of the portable air quality detection system is shown in Figure 1, which includes the microcontroller, sensor module, LCD display module, alarm reminder module, communication module and other parts. The controller chooses the Arduino nano control platform. Arduino Nano is a
development platform based on ATmega328P. It has 14 digital IO pins and 6 analog input pins. It can virtualize multiple soft serial ports and can realize multiple analog and digital sensor Access [2]. The Arduino micro-control platform processes and analyzes the air pollutant signals collected by the air sensor in real-time, and sends the processing results to the LCD display module and mobile phone terminal for display. At the same time, the processing results are compared with the preset threshold in real-time, and the system sends a warning signal to the alarm reminding module when the threshold is preset. The system can accurately detect and display the air quality of the user's current location, and upload the data to the mobile terminal. The sensor module mainly includes PM2.5 acquisition circuit, carbon monoxide acquisition circuit, formaldehyde acquisition circuit and temperature and humidity acquisition circuit.

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

3. System development and design

3.1. PM2.5 acquisition module design
The PM2.5 acquisition module uses the GP2Y1014AU sensor. GP2Y1014AU is an optical dust monitoring sensor module developed by Sharp. Air can flow freely through the hole in the middle of the module. Infrared LEDs and phototransistors are placed at the corners of the hole. Infrared light-emitting diode sends infrared light directionally. When particles in the air block infrared rays, the infrared sends diffuse reflection; the phototransistor receives infrared, and the voltage at the signal output pin changes [3]. The PM2.5 acquisition module circuit is shown in Figure 2. The LED pin of the GP2Y1014AU sensor module is connected in series with a 150Ω resistor to limit the current supply to protect the light-emitting diode. The positive and negative poles of the light-emitting diode are connected in parallel with a 220uf capacitor to achieve a stable power supply. The LED pin is a pulse input pin and is connected to the Arduino Nano control module. The D2 pin is connected to provide an input signal for the sensor and controls the LED light inside the GP2Y1014AU sensor to turn on and off at a period of 1ms. Since the GP2Y1014AU sensor requires 5V power supply, and the maximum AD sampling voltage of the MCU is 3.3V, the signal output Vo pin needs to be divided through two resistors R23 and R24. The Vled, LED_GND, and LED-pins of the sensor control the internal LED lights. The vent in the center allows air to flow freely, and the light refracted by the dust in the air is detected to determine the content of dust. The analog voltage output from the Vo pin of the sensor in proportion to the measured dust concentration, the analog voltage output by the sensor is converted into a digital signal by AD conversion processing.

3.2. CO acquisition module design
The carbon monoxide sensor uses the ZE16-CO general-purpose gas module. ZE16-CO uses electrochemical principles to detect carbon monoxide presenting in the air. The built-in temperature sensor can perform temperature compensation and has good selectivity and stability. Through pin5 and pin6, it is connected with the soft serial port pin D10 and D11 pin of Arduino nano control module.
Based on the serial port protocol, the collected carbon monoxide data is sent to Arduino nano control module in 1s cycle.

**Figure 2.** PM2.5 acquisition circuit design

**Figure 3.** Co acquisition circuit design

### 3.3. Formaldehyde and CO2 acquisition module design

The formaldehyde acquisition module uses Adafruit's SGP30 sensor. SGP30 is a digital multi-pixel gas sensor. It uses temperature-controlled micro-heating plates and two pretreatment indoor air quality signals, which provide information on formaldehyde and carbon dioxide in the air[4]. The formaldehyde acquisition circuit diagram is shown in Figure 4. The I2C bus interface of the Arduino Nano control module is connected to the SCL pin and SDL pin of SPG30 through the drive circuit. The SCL pin and SDL pin of the SGP30 sensor transmit the digital signal to the drive circuit. The I2C bus interface of the Arduino Nano control module. Because the power supply voltage of the SGP30 sensor and the Arduino Nano are different, a drive circuit is added between the two. The data transmission is based on I2C communication, SDA is a bidirectional data line, and SCL is a clock line. The working principle is that the host sends the highest bit first to send a start signal. When the clock line state is high, the bidirectional data line changes from high to low, and then the host sends data. After the data is transmitted, the host sends a stop signal, otherwise, when the clock line is in the low state, the bidirectional data line changes from the low state to the high state.

**Figure 4.** Formaldehyde acquisition circuit design

### 3.4. The bluetooth communication module design

The Bluetooth communication module uses CC2564 chip, based on TI's seventh-generation Bluetooth core, compatible with Bluetooth 4.2 protocol with low energy consumption. The chip is equipped with temperature detection and compensation to ensure reliable RF performance within the temperature range. The multiple LDO pins of CC2564 are grounded and connected to the built-in advanced power management system to provide a reliable reference voltage regulator for internal signal processing[5]. The circuit design of Bluetooth and microcontroller is shown in Figure 5(a). CC2564 uses the standard HCI interface of the four-wire UART. Since the logic high level of the Bluetooth pin is 1.8V, which does not match the logic high level of the MCU pin. Two sn74lvc2t45 dual power bus transceivers are needed to realize the conversion of two-level signals.
The radio frequency circuit of CC2564 is shown in Figure 5(b). The BT_RF pin emits a single-ended radio frequency signal. Its physical baseband clock is generated by a low-frequency crystal oscillator through PLL phase-locked loop frequency multiplication. The internal power amplifier provides amplification for the signal. FL1 is a Bluetooth filter, and C127 is used to match the impedance of the onboard antenna. R29 and R30 are zero ohm resistors, which are used to select the onboard antenna or external antenna. The transmitting power can reach 10dBm, the receiving sensitivity is -95dbm, and it has good RF performance.

![Interface and radio frequency circuit](image)

**Figure 5. Bluetooth communication system design**

4. The design of the App

In order to facilitate the storage and processing of the data detected by the device, an APP based on the Android system is designed. The data detected by the detection device is transmitted to the mobile phone APP through Bluetooth communication in real-time. The APP stores the data in the SQLite database and synchronizes it in the active interface in real-time, which could be displayed and queried.

First, you need to declare permissions in the registration file AndroidManifest.xml: BLUETOOTH_ADMIN permission, BLUETOOTH permission, ACCESS_COARSE_LOCATION permission, which is used to start the device, connect request, and dynamically obtain location permission. The design uses the Bluetooth adapter class to get the Bluetooth adapter object and enable the Bluetooth function[6], and scans the surrounding Bluetooth, registers for broadcast, then accepts the scan results through BroadReceiver, and pairs the pre-bound Bluetooth device. At the same time, the binding address can be added to the new Bluetooth device after the pin code pairing verification. After the pairing is successful, the socket is connected to the device and the Bluetooth connection thread is opened. The connection is established based on the SPP serial communication protocol through the UUID of Bluetooth. After the connection is successful, the data transmission thread starts to receive the data sent by the hardware device and saves it to the SQLite database, design historical information query function using the ListView control, show the trend of air quality in the environment through the chart.

5. The system test and data analysis

5.1. The system test

The system adopts the embedded design method, completes the hardware test system, and develops the mobile APP based on the Android system. The air quality is collected by the microcontroller
Arduino Nano and the sensor, and the Bluetooth communication transmits the collected data to the mobile phone APP to realize display of the air quality data storage, alarm and other functions, so as to complete the real-time monitoring of the air quality and the detection of the air quality. The liquid crystal display can achieve PM2.5, carbon monoxide, formaldehyde, temperature and humidity information. The display effect of the APP is shown in Figure 6. After opening the APP, Bluetooth module detection is carried out first, then Bluetooth is searched and connected. After successful connection, the page will display the connect page. After connecting Bluetooth module successfully, the current air temperature, humidity, PM2.5, CO (carbon monoxide) and TVOC (formaldehyde) values detected by the hardware system in the current air will be received in turn. When the value is greater than the predetermined value Value, there will be a buzzer alarm and an alarm prompt dialog box will pop up on the app.

![Figure 6. App test rendering](image_url)

5.2. Test performance analysis
Select the outdoor PM2.5 detection data near the Huaita monitoring point within one day of September 23, 2019 for analysis, and calculate the average value of the monitoring data of the portable air quality monitoring system in two-hour cycles and the environmental monitoring station Huaita monitoring point. Comparison with published data, the analysis results are shown in Figure 7, The monitoring detection value of the monitoring system tends to be consistent with the published value of the monitoring point of the environmental monitoring station, and the deviation is basically kept within 5%, which can more accurately indicate the concentration of atmospheric pollutants in current location.
6. Conclusion
Real-time detection of air quality is an important issue in current air pollution monitoring. This paper has designed an air quality detection system based on Bluetooth communication. It uses a variety of low-cost air sensors to detect indoor and outdoor air quality in real-time. The data is sent to the mobile APP in real-time, which facilitates the user's query. Experimental results show that the system can accurately detect and display the air quality of the user's current location, which has certain significance for low-cost air quality detection.

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