Design of Mobile Environment Monitoring and Analysis System Based on GPRS

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Abstract. This paper aims to solve the problems such as limited range, poor mobility, poor signal, and failure of real-time transmission analysis of the previous environmental monitoring system. To do so, a new mobile environment monitoring and analysis system based on GPRS was designed comprehensively, using mobile GPRS technology, real-time server and intelligent analysis and push. By relying on the characteristics of wide range of cellular transmission and strong signal, problems such as poor mobility signal of previous systems can be solved.

1. Introduction

As the rapid growth of society and economy, environmental issues have become more and more crucial concerns for our daily lives [1, 2]. The average concentration of PM2.5 in FoShan was 54 micrograms per cubic meter in 2017, which reflected a pretty harsh environmental problem in FoShan. Given that, how to monitor the information of our environment as well as inform the public to take protective measures have become an important social issue. The mobile environment monitoring and analysis system can fulfil such needs by collecting data and precisely sending back the analyzing data to the users’ smart phones or their computer. It can also provide citizens with personalized services and effective advice to protect their health.

This system is different from the traditional environmental monitoring equipment which devices are huge and inconvenient. The devices that this system used to receive data is designed as a small box and its sensors we put inside are able to collect the gas content from environment. What’s more, this system was designed in module, which it can be modified by adding and deleting different types of sensors in order to apply in other fields, such as food monitoring, medicine detecting, warehouse securing, etc.. According to that, it has a huge application space in urban environmental protection, resident health, furniture, enterprises and other fields.

2. System Design

2.1. System Design Scheme

GPRS data acquisition and transmission module was the most basic component of the system, which was used to transmit the collected data to the server in real time through wireless network [3]. The whole system contained sensor module, GPRS module and power module. The power module used light and convenient lithium battery, which showed its mobility and ensures that the module could collect and upload data stably. And the further information of the system structure was illustrated as follows. Firstly, the hardware part needed to power up AM2302 temperature and humidity sensor, PM2.5 sensor and STM32ZET6 microcontroller and GPRSUSR-7S3. Secondly, the...
AM2302 temperature and humidity sensor, PM2.5 sensor and STM32ZET6 were connected through the serial port USART1, and the environmental data measured by the sensor was sent to the STM32ZET6 microcontroller. Thirdly, STM32ZET6 would be connected with GPRSUSR-7S3 through a serial port. The data obtained from the sensor was encapsulated by a single chip, and then sent to USR-7S3 through a serial port. Fourthly, the GPRSUSR-7S3 module would send the data that received from the MCU directly to the cloud platform server through GPRS/GSM network, and the data would be saved in real-time into the MYSQL database. Finally, the software part of this system, which owned the analytical function, would be able to read the MYSQL database, and then presented the processed information to users through PC web page or the application over WeChat. The system adopted intelligent data-push function to determine pollution level according to current data and display them to users.

2.2. System Structure Design
The system structure was showed in figure 1.

2.3. Hardware System Implementation

2.3.1 Processor module-STM32ZET6. The processor module covered with A/D converter and memory, and was responsible for data storing and processing [4]. As for the whole system, the data would be collected by the sensor module, and transmitted to the GPRS module through the serial port. STM32F103ZET6, using cotex-m3 nuclear chip, 144P pin, standard 20P socket, external crystal oscillator 8M of JTAG interface, clock crystal oscillator 32768Hz, MAX232 conversion circuit, was suitable for external serial port line, and with clock backup battery, it was able to keep the clock and important information from losing power.

2.3.2 Temperature and humidity sensor module - AM2302, PM2.5 sensor module - GP2Y1010AU0F. The calibration coefficients of the AM2302 sensor was stored in the OTP memory in the form of coding programs. These calibration coefficients were called by the internal sensor during the processing of detection signals. The sensor consisted of a capacity humidity sensor and an NTC temperature sensor and was connected to a high-performance 8-bit MCU. Therefore, this product had excellent quality, fast response, strong anti-interference ability and high cost performance. Single-wire serial interface made the system integration easier, faster, with lower volume and power consumption. The GP2Y1010AU0F sensor contained an infrared light-emitting diode and a photo transistor, which was arranged diagonally to allow it to detect the reflected light of dust in the air. The sensor had an extremely low current consumption and outputted an analog voltage proportional to the measured concentration, with a sensitivity of 0.5v /0.1mg/m³.

2.3.3 Transmission module - GPRSUSR-7S3. USR-7S3 was a GPRS DTU device, which was a terminal device used for information transmission through GPRS global communication network to convert IP data to serial data or serial data to IP data. It adopted with TCP/IP protocol and provided a lot of caching that supported AT instruction. It also owned a standard TTL data interface to access transparent transmission of data.

2.3.4 Display module – TFTLCD. TFTLCD was a thin film transistor liquid crystal display. It owned the characterizations of good brightness, high contrast, strong layering and bright color. TFTLCD included LCD_CS to deal with LCD chip selection signal, LCD_WR to deal with
LCD processing write signal, LCD_RD to deal with LCD reading signal. Also, it had DB, a 16-bit bidirectional data line, to communicate with STM32’s I/O ports. And LCD_RS could process hard reset LCD signal, which made it a command/data sign for the system. In addition, there were also BL_CTR, the one that was able to process backlight control signal, and T_MISO/T_MOSI/T_PEN/T_CS/T_CLK, which processed touch screen interface signal.

2.4. Programming

This program was coded with C language and was developed under the situation of embedded and integrated environment of MDK5. The software of the embedded system was divided into several functional modules, and the main program had made the complete system worked by calling each function at proper time. While entering the main program, firstly, the program would run the initializing function, and then initialize the LCD, AM2302, GP2Y1010AU0F and ADC. Then entered an infinite loop of polling state. During the loop, STM32 would first send the sensor data to the serial port USART1. The GPRS module USR-7S3 would then read the sensor data from the serial port USART1. What’s more, the LCD was connected with the external by a 16-bit data line and communicated with STM32 through I/O. Furthermore, GPRS was able to transfer the data in the serial port directly to the socket script on Cloud server and saved the data to MySQL database. Finally, the data on the database would be read and displayed by the WeChat applet to monitor the environment data in real time. Fig.2 shows the core chart of the whole process.

2.4.1 Network connection process with GPRS module. In general, GPRS initiated TCP communication requests to the server through the server's IP address, port number and other parameters [5]. After receiving a response from the server, the GPRS module considered the handshake with the server was successful, so that it might maintain this communication connection. To be specific, there were three steps for users to access GPRS business: First of all, attaching the GPRS network. Secondly, activating the PDP (Packet Data Protocol). And finally, establishing the TCP/UDP links [6, 7]. An attached network of GPRS meant that the users first performed GPRS access and informed the network of its existence, which was the registration location and users’ information to SGSN. Then a logical link between MS and SGSN that allowed the user to send the data would be established. Once the GPRS network was done, the module was in the READY mode and ready to activate the PDP [8]. Furthermore, users should continue sending and receiving GPRS data in order to activate the packet data address that required to initiate the PDP process. This allowed MS to be recognized by the corresponding GGSN, thus enabling communication with external data networks. After the two steps above, the final step is to log in the GPRS network, with the TCP/IP link established, users could send and receive data with the server.
2.4.2 Main Program Code.
#include "delay.h"
#include "key.h"
#include "sys.h"
#include "lcd.h"
#include "usart.h"
#include "dht11.h"
#include "adc.h"

int main(void)
{
    u8 temperature;
    u8 humidity;
    u8 pm;
    int i;
    delay_init();  //Initialize the delay function
    NVIC_PriorityGroupConfig(NVIC_PriorityGroup_2); //Set interrupt priority to group 2-bit preemption
    priority and 2-bit response priority
    uart_init(115200);   //Initializing Serial port 1 to 115200
    LCD_Init();  //Initializing LCD
    POINT_COLOR=RED;   //Set the font to red
    LCD_ShowString(30,70,200,16,16,"DHT11 TEST");
    LCD_ShowString(30,90,200,16,16,"PM2.5 Test!");
    LCD_ShowString(30,150,200,16,16,"Temp:  C");
    LCD_ShowString(30,170,200,16,16,"Humi:  %");
    LCD_ShowString(30,190,200,16,16,"pm:  μg/m3");
    POINT_COLOR=BLUE;  //Set the font to blue
    DHT11_Init();   //Initializing DHT11
    Adc_Init();  //Initializing ADC
    while(1)
    {
        DHT11_Read_Data(&temperature,&humidity);  //read the data of temperature and humidity
        pm=Get_GP2Y_Average(20);  //Take the average of 20 times
        LCD_ShowNum(30+40,150,temperature,2,16); //Display temperature
        LCD_ShowNum(30+40,170,humidity,2,16); //Display humidity
        LCD_ShowNum(30+40,190,pm,2,16); //Display PM2.5
        printf("\n temperature = %d humidity = %d\n", temperature, humidity);
        printf("\n the value of PM2.5 is %d\n", pm);
        for(i=0;i<40;i++)
        {
            delay_ms(250);
        }
    }
}

3. Data Analysis
Here it would be a few simple examples with the data we collected from Foshan that would help to verify the practicability of the system. The following data acquisition was from Dali town, Nanhai district, Foshan city, including three days of 2000 groups of information. The data were obtained through the temperature sensor, humidity sensor and PM2.5 monitoring sensor. The Fig. 3 shows the top 20 sets of data, and the TIME was processed through Python in order to facilitate subsequent analysis, which the units and tens of the digits mean the Hour and the digits after the decimal point mean the Minute (example: 15.16 means 15:16). Fig. 3, Fig. 4, Fig.5 and Fig. 6 below respectively show the time distribution, temperature, humidity and PM2.5 distribution after fitting. And Fig. 7 shows the Line Chart about all those information [9].

According to all those figures above, we may come to a simple conclusion that besides some of floating/wrong data above (like the data about 15:30 may seem to be a wrong data), the floating frequency of PM2.5 was basically consistent with temperature, humidity and time. While in the early morning and late evening, PM2.5 seemed to be a little bit lower and would reach its top in the afternoon (about 15:00 to 16:30). Meanwhile, the humidity might show the same regulation as PM2.5, but less floating rate. It also seemed that humidity and temperature had little impact on PM2.5 fluctuation [10].

In addition, based on the value range of the air pollution index set by Chinese government (Level 1: 0~50, Level 2: 51~100, Level 3: 101~200, Level 4: 201~300, Level 5: 300+), it would be easy to confirm that Foshan’s air quality index was between Level 2 and Level 3, which was actually at the average of Chinese national air quality. Fortunately, the Foshan government has been implementing a series of measures to improve the environment.

| NUM | TMP | HUMI | PM2.5 | TIME |
|-----|-----|------|-------|------|
| 0   | 28  | 76   | 153   | 15.16|
| 1   | 28  | 70   | 149   | 15.17|
| 2   | 28  | 68   | 153   | 15.17|
| 3   | 28  | 68   | 151   | 15.17|
| 4   | 28  | 68   | 152   | 15.22|
| 5   | 28  | 69   | 153   | 15.17|
| 6   | 28  | 69   | 150   | 15.23|
| 7   | 28  | 69   | 150   | 15.24|
| 8   | 28  | 69   | 152   | 15.24|
| 9   | 28  | 69   | 153   | 15.24|
| 10  | 27  | 68   | 157   | 15.25|
| 11  | 27  | 68   | 154   | 15.25|
| 12  | 27  | 68   | 152   | 15.26|
| 13  | 27  | 68   | 150   | 15.26|
| 14  | 27  | 68   | 157   | 15.17|
| 15  | 27  | 68   | 155   | 15.27|
| 16  | 27  | 69   | 151   | 15.17|
| 17  | 27  | 69   | 149   | 15.28|
| 18  | 27  | 69   | 153   | 15.29|
| 19  | 27  | 69   | 154   | 15.29|

Fig. 3. Time histogram

Table 1 top 20 sets of the data
4. Conclusion
In this paper, a new mobile environment monitoring and analysis system based on GPRS was designed by using mobile GPRS technology, real-time server and intelligent analysis. Relying on the wide range of cellular transmission and strong signal, this system could quickly collect and upload data. More importantly, by using Python to analyse the collecting data and form up diagrams, it would be convenient for many of us to get a better sense of our surroundings.

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