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Design and Realization of Indoor Air Odor Control System Based on STM32 Single Chip Microcomputer

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With the design and realization of indoor air odor control system as research objective and based on the brief introduction to a detection control system at home and abroad and its development trend, this study introduces sensor technology to the main indoor air odor (formaldehyde and ammonia gas) and air temperature and humidity which seriously threaten people's health. On the basis of a brief analysis of the overall structure of the indoor air odor control system and the detailed design of the system's lower electro-mechanical circuit and system software, this study sets up an indoor air odor control system with PC as platform and STM32 single chip microcomputer as core. The test of the system shows that the system can realize real-time monitoring of indoor air odor, temperature and humidity, and can get the overall quality level of indoor environment, with certain feasibility and practical value.

1. Introduction

With rapid development of economy, people's living quality is continuously improved, and people's requirements for indoor environment and beauty are gradually raised. The use of a large number of new house decoration materials and furniture makes indoor air pollution more serious. Among them, the common indoor air odor is mainly from formaldehyde and ammonia gas, including other benzene series and TVOC toxic and harmful gases (Conti-Ramsden et al., 2012). These gases are mainly derived from the materials used for interior decoration, interior furniture and building walls (Ramirez et al., 2016). Although most people think that frequent ventilation can exhaust the peculiar smell of indoor air and prevent from threatening their health, the concentration of various harmful gases can be restored to that in pre-ventilation after the doors and windows are closed for a few hours since the pollution sources still exist, especially the widespread use of air conditioners, resulting in the reduction of window ventilation time. The sharp increase in the concentration of various harmful gases greatly increases the harm to human health (Wang et al., 2011).
As early as in the end of the 20th century, foreign countries began to detect indoor abnormal odors, but it is necessary to take samples in the site and send them back to the laboratory for detection, which not only requires a long waiting time, but also has a high cost (Yu and Lin, 2015). With the progress of science and technology, this situation has been improved. At present, a sensor array for detecting indoor air odor and temperature and humidity has been installed in many foreign buildings, which can carry out real-time control of various elements (Salamone et al., 2017). The development and maturity of PC technology promote the wide use of the popular real-time detection and control system, but the effect is not optimistic since China is still in the initial stage of indoor air odor detection, keeping a big gap with foreign countries (Olaijua et al., 2018). The main development direction of indoor air odor control system is the fusion of computer and sensor technology, the fusion of sensor data and algorithm, the miniaturization of detection and control system, and the friendly human-computer interaction interface (Zhou and Chuang, 1994).
In the light of the above analysis and based on the research of relevant indoor air quality detection and control system at home and abroad, this study introduces single chip microcomputer technology and sensor technology with PC computer as the platform and designs a control system with STM32 single chip microcomputer as the core, which can detect indoor air odor (mainly for formaldehyde and ammonia), temperature and humidity in real time. The test results show that the system can realize real-time detection and control of indoor air quality, achieve the desired design goal, and have high accuracy and stability.

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2. Overall Structure of Indoor Air Odor Control System

2.1 Selection of sensors

Sensor (Yan et al., 2017) is the most important part of gas detection. It functions as a converter to convert the concentration of the detected gas into a corresponding voltage or current. At present, there are many kinds of sensors used for gas detection in the market, which are divided according to the principle (Mei and Xia, 2017) into semiconductor gas sensors, solid electrolyte gas sensors, contact combustion gas sensors, electrochemical and photochemical gas sensors, etc., each of which has advantages and disadvantages, and all of which should have stability, sensitivity, selectivity, corrosion resistance and economic practicality. After comprehensive comparison, an electrochemical sensor is selected thanks to its simple operation, higher stability and accuracy, lower price and wider detection range.
At present, the new digital sensor (Holmberg and Chen, 2003) is widely popular in the market because of its advantages of direct digital signal output, high reliability and precision, and strong anti-interference. Therefore, this study selects DHT21 digital temperature and humidity sensor, which belongs to compound temperature and humidity sensor. It mainly depends on its internal resistance-type probe and NTC temperature sensing probe to detect the surrounding environment. It has the advantages of high stability and reliability.

2.2 Overall structure of indoor air odor control system

Figure 1 shows an overall structure of an indoor air odor control system (Yongsu et al., 2010) determined by function, which comprises a single chip microcomputer, a upper computer and a sensor as main components. The single chip microcomputer sends the gas information detected and converted by the sensor into humidity temperature to the upper computer (PC) through RS-485. The upper computer is responsible for data fusion, analysis and display. When the data value is poor or very poor, the lower computer sends out red flashing light alarm, and at the same time, the system will automatically open the ventilator for ventilation; when the data is very poor, the system will also open the sound and light alarm circuit, remind people to take necessary measures.

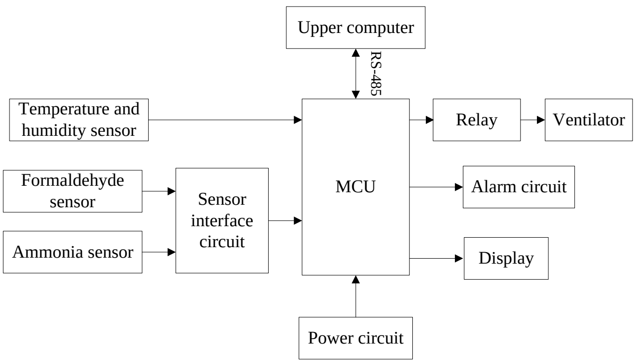

Figure 1: System block diagram

3. Design and Realization of Indoor Air Odor Control System Based on STM32 Single Chip Microcomputer

3.1 Design of the hardware circuit of the system lower computer

The quality of the lower computer of the system is directly related to whether the system can operate safely and stably. Therefore, the basic principle of its design is strong anti-interference ability, economic rationality, safety and reliability.

3.1.1 Controller selection

Single- chip microcomputer (Janssen et al., 1982) is called "computer on circuit board", which combines CPU, memory and other IO interfaces with large-scale integrated circuit technology. With the gradual development of electronic and computer technology, single chip microcomputer has developed from the first 4 bits to 32 bits now. Table 1 shows the performance comparison of single chip computers with different memories (Lay-Ekuakille et al., 2014). As the core part of the system, the single chip microcomputer can provide a continuous flow of power for other systems. According to the functions of this system, this study selects the cost-effective STM32 as the main control unit.

Table 1: Comparison of performance of different memory microcontrollers

MCU	Price	Interface	Anti-interference	Speed of execution	Development	Typical representative
8-bit	low	rarely	very poor	slow	simple	MSC-51
16-bit	low	less	poor	slower	simple	ATmega16
32-bit	lower	many	strong	fast	simpler	STM32

3.1.2 Design of the hardware circuit of the system lower computer

The hardware circuit of the system lower computer includes (Cho, 2012) the circuit design of gas sensor, temperature and humidity sensor, control and alarm, and power supply. Because the space is limited, this study only takes the circuit design of the alarm device in the lower computer as an example. Figure 2 is a circuit diagram of an alarm device, which sends out commands to the light emitting diode and the buzzer through a single chip microcomputer to realize an alarm mode of sound and light combination. Figure 3 shows the front and back sides of the designed 3D diagram of the lower computer.

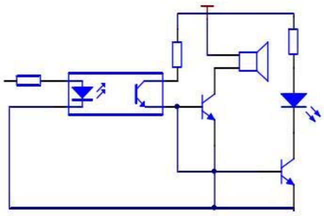

Figure 2: Alarm circuit

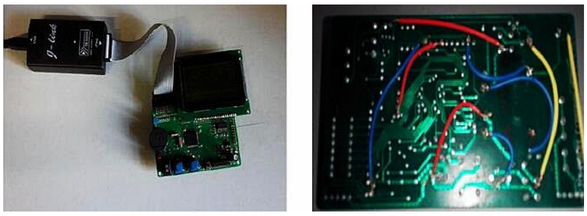

Figure 3: Lower computer 3D diagram

3.2 System software design

3.2.1 System lower computer software design

In order to make the detection, display, communication and control as a whole, this study adopts the modular design concept, carries on the detailed design of the system initialization, the communication, the clock and the liquid crystal display program (Zhou et al., 1993), making it more convenient to call and debug the subprogram. Figure 4 is a flow chart of data acquisition and transmission. The lower computer sends the processed data to the upper computer through RS-485 for further processing.

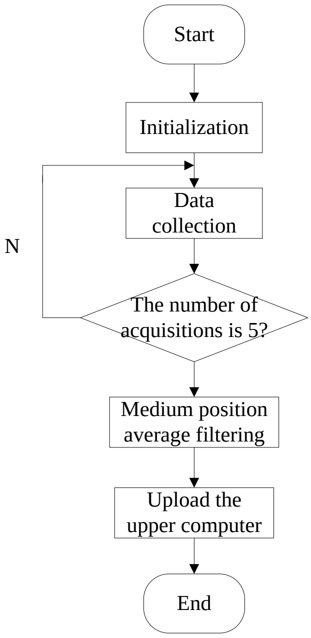

Figure 4: Data collection and sending flow chart

Table 2 shows the protocol header code for the two-byte string defined herein for the purpose of facilitating data transmission.

Table 2: Code table

01	Represents the formaldehyde concentration detected
02	Representative ammonia concentration detected
03	Represents the detected humidity
04	Represents the detected temperature
00	Return

3.2.2 Upper computer interface design

The monitoring interface can command and supervise the operation of the system. It is an important part of the upper computer system. It can not only display the data transmitted from the lower computer system but also control the lower computer system. By comparing the advantages and disadvantages of various upper computers on the market, this study finally selects Visual Basic 6.0 visual development software to develop the upper computer of the system. Figure 5 shows the login interface of the indoor air odor control system. In order to ensure safe operation, the user needs to input the correct user name and password before logging in.

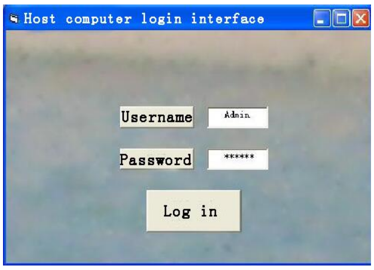

Figure 5: Login interface of the indoor air odor control system

3.3 System test

After the system programming is finished, the HEX file generated from the conversion is downloaded into STM32 by using J-Link emulator, and then the HEX file is converted into machine code which can be recognized by the machine. The key to success of the air odor control system is the connection of the upper and lower computers, and the serial port is the link of the connection. Figure 6 shows the flow chart of the serial port connection.

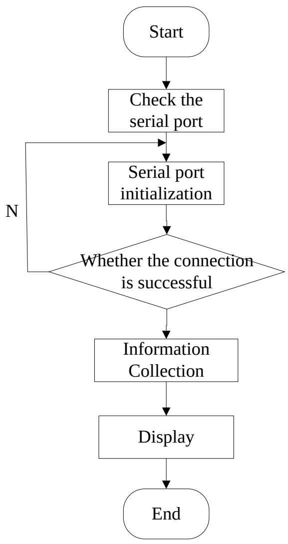

Figure 6: Serial port connection flow chart

After the serial port connection is successful, the system is tested. The lower computer displays the test result on the 12864 display and uploads it to the upper computer. Figures 7 and 8 show the test results displayed on the monitoring interface of the lower computer and the upper computer respectively.

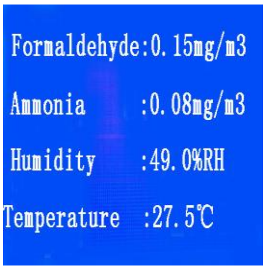

Figure 7: Lower machine test results

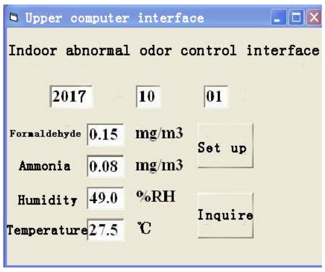

Figure 8: PC test results

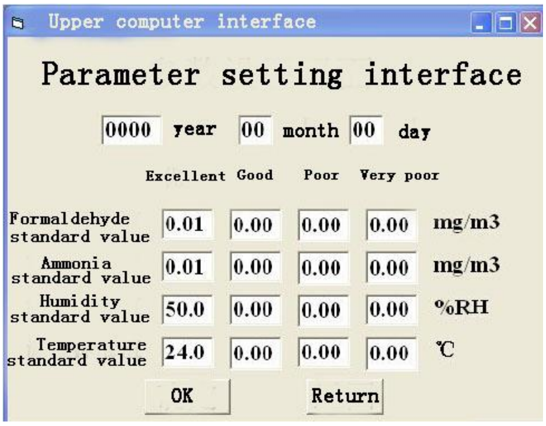

Figure 9: Parameter setting interface

It can be seen that the upper computer and the lower computer display the same result, indicating that the connection is successful. Because the different changes of indoor air and environment season have different effects on indoor environment, users can also set the indoor alarm reference standard value by clicking the setting button. Figure 9 shows the parameter setting interface. Users can also inquire the previous indoor air quality through the query key.

4. Conclusions

Under the background that indoor air pollution is serious and indoor air quality is gradually drawing more attention, this study focuses on the design and realization of indoor air odor detection system on the basis of relevant references at home and abroad. The specific research results are as follows:

(1) With the simple analysis of the present situation of indoor air pollution, this study determines the design target of the system for controlling ammonia formaldehyde and indoor temperature and humidity.

(2) After determining the electrochemical, this study designs temperature and humidity sensor and controller required by the system, the overall structure of the system.

Based on the design of hardware circuit and software of the system, this study selects Visual Basic 6.0 visual development software to design the monitoring interface of the upper computer of the system, and tests the system is tested, with the test results showing that the system achieves the expected design target and having certain application value.

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