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Design and Implementation of Toxic Gas Concentration Monitoring System for Indoor Decoration Based on Odour Sensor Technology

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With the improvement of people's material living standards, they have also put forward higher quality requirements for the living environment, but the resulting toxic gases such as formaldehyde, toluene and organic volatiles brought about by decorations are fatal to human health. To this end, this paper designs one odour sensor-based toxic gases concentration monitoring system for indoor decoration: at the front end of the system, it is equipped with an independently-developed highly sensitive formaldehyde sensor; Wi-Fi technology with high stability and long transmission distance is selected as the main information transmission method; the front-end monitoring circuit can monitor the environmental parameters such as temperature, humidity, formaldehyde concentration, and CO concentration of each unit in real time; the design of the Web interface is based on the development of SpringMVC3+Hibernate3 development software and Oracle11g database. Finally, through the test of the toxic gas concentration monitoring system for indoor decoration, it's found that it works stably in line with the design requirements.

1. Introduction

As the economy and engineering technology develop rapidly, the average living level in the world has been significantly improved. People have begun to pursue higher quality and more efficient life while satisfying basic living conditions (Saitoh et al., 1998; Ji et al., 1999; Saito et al., 1995). With the continuous expansion of the world population crisis, in the context of economic development, the average living environment and human settlement have been facing severe challenges. Due to renovation and materials factors, indoor pollutant concentrations and types have been increased to varying degrees (Shindo et al., 2001; Jin et al., 2011; Kim and Kwak, 2009), e.g., in the newly decorated home, a large amount of formaldehyde, benzene and other toxic volatile substances are harmful to the human body. In order to achieve full monitoring of indoor toxic gases and ensure the safety and living standards of residents, it is necessary to promote the indoor odour sensor technology and equipment (Alizadeh and Soltani, 2013; Guo et al., 2006; Drickamer et al., 1992). In China, the development of odour sensor generally lags behind internationally developed countries. In summary, in order to adapt to the real-time monitoring and real-time data transmission of indoor toxic gases, an odour sensor-based indoor decoration pollutant concentration monitoring system with monitoring function must be established.

2. Key technologies of system design

2.1 Odour sensor technology

The odour sensor, also known as electronic nose, is an electronic system using the response pattern of a gas sensor array to identify odours. It can continuously monitor odour status in real time at specific locations over hours, days, or even months. The electronic nose consists primarily of three functional devices: the odour sampling operator, the gas sensor array, and the signal processing system (Jia et al., 2014; Kim et al., 2012; Marjovi and Marques, 2013). The main mechanism for the electronic nose to recognize the odour is that each sensor in the array has different sensitivities to the gas being measured, e.g., gas No. 1 produces a high

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response on one certain sensor and low response to other sensors (Mao, 2018); the sensor to which No. 2 gas produces a high response is insensitive to No. 1 gas. In the final analysis, the response pattern of the entire sensor array to different gases is different. It is this difference that enables the system to recognize the odour based on the response pattern of the sensor.

2.2 Communication technology

The core component of the indoor decoration toxic gas monitoring system is the information transmission module. At present, the widely used communication technologies and systems are: the wire communication system and wireless communication system. Among them, the wireless communication system can be subdivided into Wi-Fi communication technology, ZigBee communication technology and Bluetooth technology (Bahraminejad et al., 2010; Niimura, 2012; Brown, 1981). Compared with wire communication technology, wireless communication technology has the characteristics of higher transmission efficiency, faster transmission rate, higher mobility and better cost performance. Now the wireless communication technology has been widely used in sensor systems.

3. Overall design

3.1 Requirements analysis of system

Figure 1 The system must ensure that the monitoring data can be collected and transmitted in real time, and the collected data can be quickly aggregated into the personal computer at the remote terminal. At the front of the sensor probe, a higher precision detector is used for environmental sensing. In the data transmission process, based on the Wi-Fi communication technology, the receiving device can be arbitrarily added and deleted in real time. Therefore, in the system design, the probe with higher sensitivity is installed at the front-end position, and the hardware circuit design of the upper computer, the control and design of the lower computer system, and the design of the Wi-Fi communication module are also included. The specific structure is shown in Figure 1

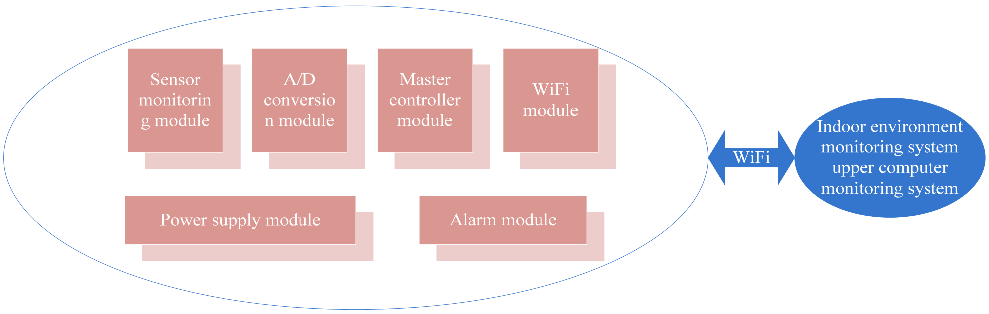

Figure 1: Structure diagram of indoor decoration concentration monitoring system

3.2 Overall structure design of System

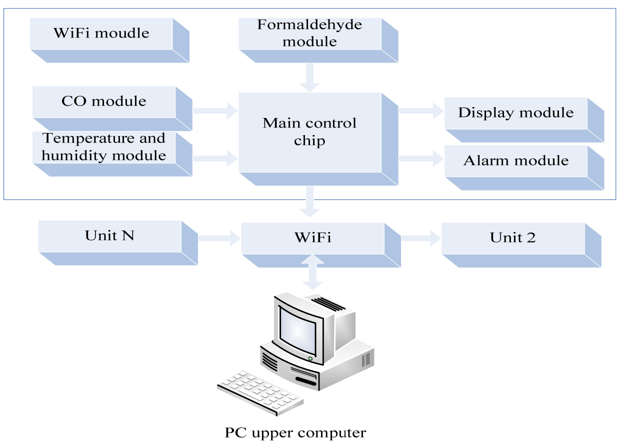

Figure 2: General structure diagram of the system

The monitoring system is generally divided into two layers, namely: the PC upper computer monitoring operation interface and the lower computer monitoring unit module. The specific structure of the system is shown in Figure 2.
The upper computer monitoring operation interface is written and developed by the relatively reliable SpringMVC3+Hibernate3 technology, and the Oracle11g database with excellent performance and high stability is selected as the relevant database. Spring Security design techniques are used in the usage rights control process. Besides, the whole process of the project is implemented by means of instant annotation, which prevents the cumbersome process in the system file configuration process. Thus, the whole process of project management is more efficient. In the lower computer design, the Wi-Fi communication technology is used to transmit the data centrally to the central server, and the specific application of the Wi-Fi communication technology is shown in Figure 3. The upper computer relies on the program control to complete the data reading, thus completing the relevant information on the remote personal computer, and monitoring the environmental parameter values of the node location in real time.

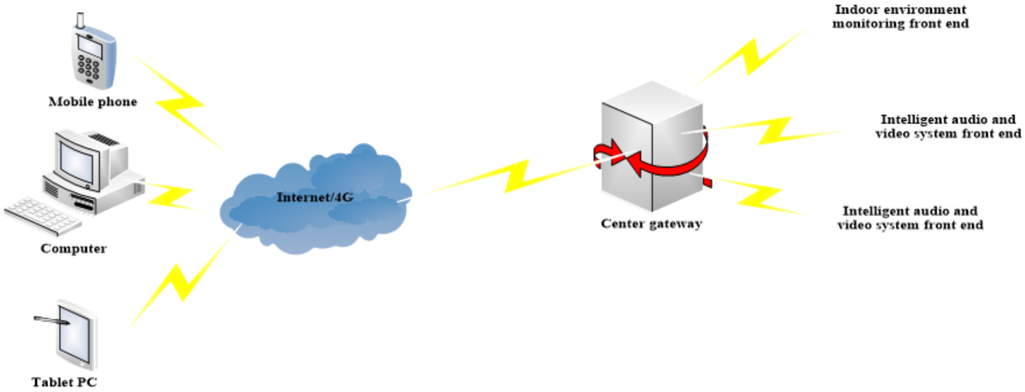

Figure 3: Topological structure of WiFi technology application

3.3 System device selection

1) Mode switching chip: ADC0832 data module switcher.
2) Front-end front sensor probe: semiconductor gas sensing array.
3) Display components: LCD1602
4) Wireless communication Wi-Fi module: ESP8266 Wi-Fi module.

4. Sensor preparation

4.1 Preparation of sensitive materials

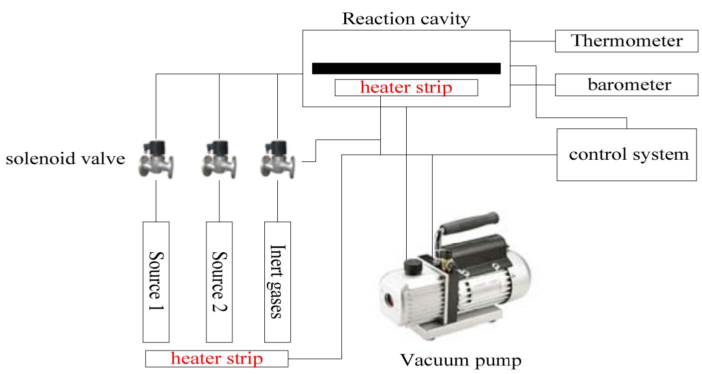

Figure 4: Flow chart of ALD atomic deposition method

In indoor pollutant monitoring system, the formaldehyde substance sensor can be used. The formaldehyde-sensitive material used in this paper can be prepared and obtained by itself. The addition of semiconductor materials can increase the sensitivity. Therefore, in this paper, different types of sensitive materials obtained by different types of methods were used as the detection sensitive substances of formaldehyde substances. The monitoring methods mainly include hydrothermal method, gel method and ALD monitoring method etc. This section focuses on the ALD method.

ALD method mainly relies on a new layer of atomic osmosis membrane and the atomic membrane state reaction of the previous layer in the deposition process. Through the above process, a single layer atomic film can be layer-by-layer plated onto the base material, wherein, in the atom deposition process the deposited single-layer atomic film can be finally attached to the bottom material. The ALD atom deposition process is shown in Figure 4.

4.2 Sensor component preparation

In the overall material monitoring system, the sensor is one of the core components. In the preparing process of sensor component, the heater-type medium-thickness film gas sensing device was selected. Among them, the preparation of the gas-sensitive component is mainly divided into the following three basic steps:

1) Place the ceramic product in a high concentration (Wang et al., 2018) ethanol solution and the beaker in an ultrasonic cleaning device.
2) The prepared sensitive material together with the deionized water is thoroughly pulverized at 4:1 ratio in an agate mortar and then turned into the viscous state.
3) The Ni-Cr composite material using the heating electrode is integrally penetrated into the ceramic pipe, the inside of the ceramic pipe and the heating wire lead are integrally welded to the rubber bearing, and then the welded gas component is mounted on the aged rubber bearing. Finally, the air sensitive components after welding are installed on the aging console.

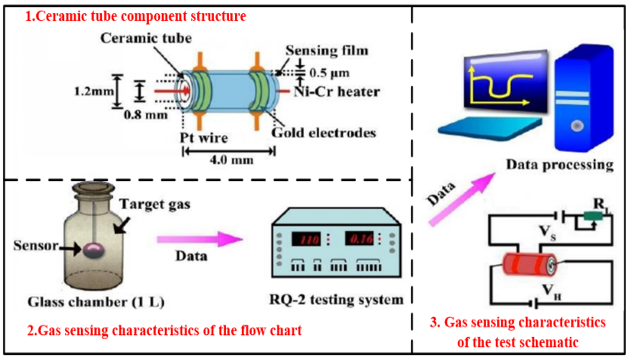

Figure 5: Process and principle of gas sensitive property monitoring platform

The gas sensitivity test technology is mainly used after the gas sensitive components are aged and tested by a self-established gas sensitivity test console. In the sensor type selection and preparation stage, for the test problem of sensor sensitive materials, the steel cylinder with a capacity of 1L and a B2912A precision test unit manufactured by KEYSIGHT were used in this design. The main work process and principle of the overall gas sensitive quality monitoring platform are shown in Figure 5.

5. System software and interface design

The indoor environmental monitoring system is mainly composed of two main parts: the lower computer monitoring system and the upper computer operating interface.

5.1 Lower computer software design

In the operating program design of the hardware and circuit components for the lower computer, the main function is to use the program writing and measurement, achieve the real-time monitoring of the lower computer, and accurately determine the various gas content in the indoor fixed environment. The software and program design process mainly involve the corresponding main control chip monitoring port, related information processing program and software development. The design process of the monitoring parameters for the lower computer is introduced in detail as follows:

1) Program initialization stage

Initialize the system and set related parameters.

2) Main control program design

The sensor module is installed at the corresponding monitoring point of the lower computer, to dynamically measure the pollutants parameters in the environment. Once the pollutants exceed the standard, the monitoring unit shall send an alarm signal. Figure 6 shows the program diagram of the monitoring system.

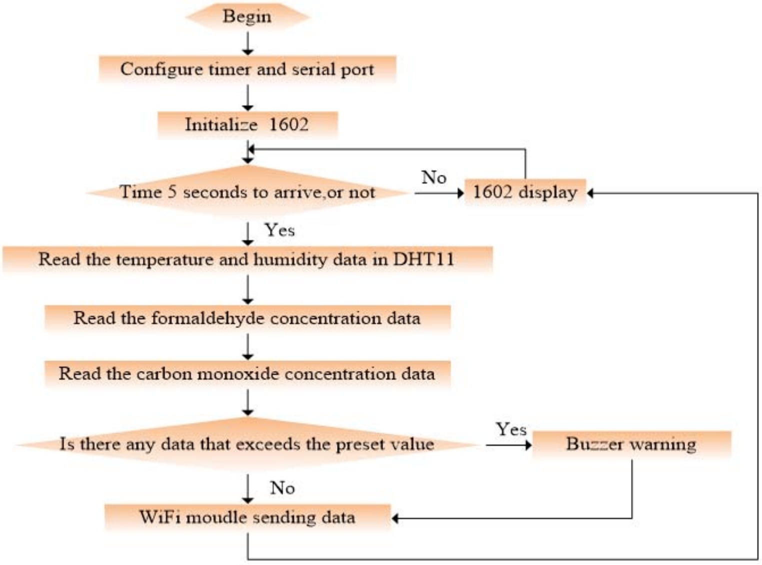

Figure 6: Monitor system program diagram

3) Measuring system design of indoor formaldehyde and carbon monoxide
The working principle of the indoor formaldehyde and carbon monoxide monitoring system is basically the same. The digital analog switching device can switch the analog signal into a digital signal and have access to it through the P4.4 on the main control chip. The main control chip converts the digital signal into the previously calibrated standard value and then makes comparison; if not exceeding the alarm value set by the system, the next step can be continued; otherwise, the monitoring system can transmit the data to the data server in real time.

5.2 Host computer monitoring interface design

The indoor gas monitoring system selects the upper computer monitoring operation interface. This operation interface can collect and transmit relevant information in time, and also transplant the system to other systems to achieve home intelligence.
Users can directly log in to the operation interface through the Internet using a personal computer, and log in to the collection system by entering the user name and password. Among them, the username and password are saved in the database. The login interface is shown in Figure 7.

Figure 7: Monitor system login interface diagram

6. Conclusions

(1) This paper designs and implements one set of odour sensor-based toxic gas concentration monitoring system for indoor decoration, which has many advantages such as high transmission precision and

excellent cost performance. The monitoring end of the system is loaded with formaldehyde odour sensor with high sensitivity and fast information transmission capability.

(2) The specific method of information transmission is based on the stability and high efficiency of information transmission. Wi-Fi technology can be used to realize long-distance transmission. For the temperature and humidity, formaldehyde concentration value and carbon monoxide concentration value etc., personal computer can be used to make remote real-time observations and determine the overall quality of the environment in the area being observed.

(3) In the circuit system of the lower computer, the corresponding software operating system and program are designed. Under the joint work of hardware and software, the real-time ambient air environment parameter monitoring of the lower computer is realized.

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