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# Design of Gas Detection System Software Based on Sensors

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## ABSTRACT

The rapid development of modern industry and the improvement of human living standards have made the living environment of human beings worse and worse, and various harmful substances have seriously endangered human health. A novel porphyrin chemical sensor was used as a gas sensor to design a gas detection system based on porphyrin chemical sensor. The gas was identified by detecting the color change information generated before and after the reaction between the sensitive substance in the porphyrin chemical sensor and the target gas.Realize monitoring of the detection process and various detection parameters, control of image signal processing and analysis process, and management of detection data. There is still a certain gap between the actual output gas concentration value and the actual concentration value. For ammonia concentration with a concentration greater than 100ppm, the recognition accuracy is higher, and the overall average error is less than 10%.

**Keywords:** Sensor; Gas Detection; Software Design.

## 1.0 Instruction

In the industrial production process, there are many areas that involve toxic gases. Countries, industries, and enterprises have deployed various types of monitoring equipment and instruments from various aspects, which plays an important role in protecting the safety of workers working in the area. , but fixed wired monitoring equipment is still the mainstream today[1].

Gas detection systems are used in a wide range of applications, from defense engineering to home life. At this stage, most gas concentration detection devices in the domestic market can only detect a single gas, some can detect a plurality of gases, but it still has defects such as low sensitivity and single function. This paper proposes a new monitoring system from the other hand based on wireless sensor network technology, which is a toxic gas monitoring system based on wireless sensor network. The system fully considers the particularity of toxic gas region and the characteristics of wireless sensor network. The monitoring network built by wireless sensor network technology has the convenience of network, security, accuracy and remote control[2]. The innovation of the article is based on the gas detection system of porphyrin chemical sensor, which uses the mechanism of metal porphyrin molecule to react with gas to produce color change. The detection system uses chemical sensor image as detection signal.

## 2.0 Journals Reviewed

Li Z found that there are many methods for gas quantitative detection. Spectrophotometry, rapid measurement tube method, ion chromatography detection method, gas sensor detection method, etc. are

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currently mature methods, among which gas sensor detection method is widely used[3]. Zhu C pointed out that the principle of the gas sensor detection method is to directly measure with a gas sensor, and use the selectivity and sensitivity of the gas sensor to determine the type and content of the gas.

The detection method is low in cost, easy to operate, and the detection process is convenient and quick, it is suitable for on-site real-time monitoring of gas and gradually becomes a widely used gas detection scheme. However, due to the poor selectivity of the gas sensor unit of a single sensor to the detection object, the detection of complex malodorous gas is poor[4]. Wang C designed an electronic nose that detects tea leaves, tea and tea bottoms to distinguish the quality of tea[5]. China Agricultural University uses electronic nose to establish an electronic nose fingerprint of white wine, and develops the idea of a nose that can be used for liquor identification. Similarly, Yuan X is also using the electronic nose to establish a scent fingerprint of Chinese herbal medicines, hoping to identify Chinese medicine through the electronic nose. However, the domestic electronic nose technology is still in the experimental stage, and it is necessary to invest more in the market like foreign countries. More research and experimentation is needed[6].

## 3.0 Experimental Method

### 3.1 Principle of porphyrin chemical sensor array

Both metal porphyrin and olfactory receptors contain metal ions. The recognition of odor molecules bymetal porphyrin depends on the bonding between metal ions and odor molecules. When the odor is contacted with the metal porphyrin, the absorption spectrum of the metal porphyrin changes, and the surface exhibits a change in color.Since the bonding size and tension of different odor molecules and metal ions are different, the color change of the metal porphyrin surface after contact is also different. The color change of the metal porphyrin can uniquely characterize the characteristic information of the odor, called the color "fingerprint" information[7].

### 3.2 Detection and analysis system design

#### 3.2.1 Development platform and development environment

The detection and analysis system development platform adopts Windows XP operating system, and the development environment adopts Visual C++ development environment. Visual C++ has strong ability of underlying hardware. At the same time, Visual C++ is an integrated development environment closely connected with Win32. Visual C++ development system can be used to develop a variety of applications. From the underlying software to the upper-level user-oriented software, Visual C++ can be used for development[8].

#### 3.2.2 Software system design

According to the software system function analysis, the software system design mainly includes three module design, signal acquisition module design, signal analysis module design and data management library module design, using ActiveX control(communication control MSCOMM programming) to realize serial communication. With ActiveX controls, the program is very simple to implement, clear in structure, and simple to develop. The system uses ACCESS to establish a database, and establishes a database management interface in the system to manage the database[9].

### 3.3 Image acquisition application

The system uses VFW software development tools to program video playback and image acquisition. VFW is a software package for digital video that Microsoft introduced in 1992.A key idea of VFW is that it does not require dedicated hardware for playback. It enables the programmer to flexibly implement digital video signal acquisition by sending messages or setting attributes, and storing them in a file or processing the video buffer. Only 27 to capture the card to support the VFW standard can be programmed using the API provided. Therefore, application compatibility and portability developed by VFW are better [10].

**3.4 Sensor image signal pretreatment**

During the shooting process, due to the offset of the chip placement and image deformation, the dot matrix is unevenly arranged. The image rotation can correct the physical position of the image, so that the dot matrix can be arranged neatly in the image. The original image captured by the camera is 24 bits.color image[11], the system converts the acquired color image into a grayscale image, which can greatly improve the subsequent image processing speed. There are generally three methods for grayscale processing:

① Maximum method: Make the value of R, G, B equal to the maximum of the three, namely:
R=G=B=MAX(R,G,B)
②Average method: Let the values of R, G, and B be the average of the three, namely:
R=G=B=(R+G+B)/3
③Weighted average method: Give R, G, B different weights, so that the values of R, G, B are weighted average, that is: R=G=B=(WRR+WGG+WBB)/3R=G=B=$(W_R R+W_G G+W_B B)/3$
In it, WR, WG, and WB are the weights of R, G, and B, respectively.

**3.5 Response feature quantification**

A 6×6 porphyrin chemical sensor response characteristic is represented by 108 components (R, G, B components of 36 sensitive points: 36×3), and each component has a value range of 0-255, so theoretically a sensor array can have a resolution of 256108. However, due to the inevitable error in the system, it is actually not 256 pixel levels that are effectively discernible. Experiments have shown that a color component is discernible in resolutions of 10 orders of magnitude. In order to improve the efficiency of network identification, the response characteristics are first quantified.

Three kinds of gases (acetone, toluene, ammonia gas) were selected for gas qualitative identification. Experiments were carried out using a 3-layer BP neural network. The number of input layer nodes was 108 (sensor characteristic quantity), and the number of output layer nodes was 3 (3 types gas), the error value is set to be 0.001. A total of 30 samples were selected from the gas fingerprint database for training the network, 10 for each gas, with a concentration ranging from 10 to 200 ppm. Another 6 samples were selected for testing.

**4.0 Experimental Result**

**4.1 Feature extraction results and analysis**

The purpose of feature extraction is to provide reliable and efficient analytical data for data analysis. The extraction process is mainly based on experimental data and various mathematical statistical methods to select effective features for extraction[12]. In the system, the color change information generated by the sensitive point after the sensor reacts with the target gas characterizes the gas property and it is the characteristic information of the sensor image. For a feature, the criteria for judging have the following four aspects: z Distinguish ability: for images belonging to different types, their characteristics should have significant differences; z Reliability : For similar images, the eigenvalues should be closer; z Independence: The selected features are not related to each other; z Small quantity : The complexity of the image recognition system increases rapidly as the number of features increases. In particular, the number of image samples used to train the classifier and test results increases exponentially with increasing number of features.In this paper, the pixel mean value of each sensitive point in the sensor array is extracted as the feature information. The color information of the sensitive point is independent feature information, and the color feature information is represented by the pixel mean value, which greatly reduces the feature information redundancy and improves the subsequent feature recognition efficiency.

**Table 1: Response Feature Coding Table**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **1** | 3,4,4 | 0,2,1 | 3,2,1 | 3,0,0 | 3,0,1 | 1,3,2 |
| **2** | 3,22,38 | 4,1,1 | 1,2,1 | 3,39,48 | 1,3,4 | 1,1,3 |
| **3** | 1,2,0 | 1,2,0 | 2,0,0 | 1,2,3 | 21,69,38 | 1,1,1 |
| **4** | 2,28,28 | 13,71,69 | 0,0,1 | 8,52,43 | 2,1,1 | 1,4,3 |
| **5** | 2,51,69 | 5,5,3 | 2,28,35 | 44,18,0 | 28,34,32 | 4,0,1 |
| **6** | 1,3,3 | 3,2,2 | 3,3,3 | 4,2,4 | 2,3,4 | 3,3,4 |

In this paper, the characteristics of the system response characteristics are obtained by analyzing the response characteristics of the system : z gas selection specificity, not all sensitive points in the sensor will respond to all gases, but a certain sensitive substance corresponds to a gas response characteristic with concentration, the color of the sensitive point changes with the concentration.

**Table 2: Feature Quantification Table**

| Quantification Level | Original Pixel Level (Pixel Value) |
|---|---|
| 1 | 0-25 |
| 2 | 25-50 |
| 3 | 50-75 |
| 4 | 75-100 |
| 5 | 100-125 |
| 6 | 125-150 |
| 7 | 150-175 |
| 8 | 175-200 |
| 9 | 200-225 |
| 10 | 225-255 |

### 4.2 Gas qualitative recognition result

It can be seen from the experimental results that the network converges faster in qualitative training, and the accuracy of qualitative analysis of gas is very high which is very close to the ideal output.

**Table 2: Qualitative Analysis Output**

| Sequence | Network Output Value | Expected Value | Gas |
|---|---|---|---|
| 1 | 0.0039 0.0078 0.9930 | 0 0 1 | acetone |
| 2 | 0.0116 0.0069 1.0011 | 0 0 1 | acetone |
| 3 | 0.0163 1.0091 0.0050 | 0 1 0 | toluene |
| 4 | 0.0093 0.9860 0.0045 | 0 1 0 | toluene |
| 5 | 1.0294 0.0027 0.0638 | 1 0 0 | ammonia |
| 6 | 1.0086 0.0053 0.0095 | 1 0 0 | ammonia |

### 4.3 Gas quantitative identification

According to the principle that the metal porphyrin reacts with organic gas to produce color change, a novel gas detection system is constructed. The system identifies the gas by converting the characteristic information of the gas into the porphyrin sensor image information. This paper builds a complete detection software system application platform for the gas detection system, which integrates signal acquisition, signal processing analysis and data management. Through the analysis of the system image signal, a set of automatic feature extraction method is designed, and the neural network is used to realize the accurate identification of the characteristic signal, which realizes the automation and intelligence of the detection system.

**Table 3: Quantitative Analysis Output**

| Sequence | Sample Gas | Identification Output | Output Error |
|---|---|---|---|
| 1 | 10ppm | 12.58ppm | 25.8% |
| 2 | 150ppm | 55.7ppm | 11.4% |
| 3 | 105ppm | 106.32ppm | 6.32% |
| 4 | 150ppm | 148.78ppm | 0.81% |
| 5 | 200ppm | 212.53ppm | 6.27% |

There are certain errors in quantitative identification. The paper summarizes several factors that affect the quantitative analysis results of the network as follows: ①The repeat ability of the sensor itself. ②Experimental conditions, such as unstable gas distribution, unstable image signal acquisition. ③Signal pre-processing is good or bad. ④The number of training samples. Condition 1 is the factor that has the greatest impact on the recognition result, and the small number of training samples also affects the accuracy of the recognition. Therefore, to improve the accuracy of gas quantitative identification, it is necessary to improve all aspects of the system.

The image signal processing algorithm in this paper needs to be improved.The focus of image signal processing in this paper is the automatic identification of sensitive points. However, the automatic recognition algorithm for sensitive points is realized by mesh division and region segmentation. The premise of mesh segmentation is that the sensitive points are arranged evenly in the array and in the image. During the detection process, due to the incorrect placement of the sensor, the distribution of sensitive points may be uneven or severely tilted, and meshing may not be performed correctly in this case. As an application software, all factors should be considered, so the system corrects the image in image preprocessing, but such correction is still manual, which affects the efficiency of signal processing and analysis. Therefore, subsequent research should automatically correct the image.

## 5.0 Conclusion

In many fields, the identification of gases still relies primarily on the smell of humans or animals to distinguish, identify or evaluate. However, both humans and dogs have their subjectivity, which affects the success rate and accuracy of their identification, and continuous real-time monitoring of flammable, explosive, and toxic gases cannot be done by humans or animals. Therefore, an accurate and effective gas detection system is designed to monitor the industrial or domestic environment in real time. Through the host computer, the staff can discover hidden dangers in a timely manner, reduce the occurrence of accidents, and ensure the safety of personnel life and have significant economic and social benefits. The new gas detection system develops a software application platform, which realizes functions of signal acquisition, signal processing analysis and data management. It has the advantages of convenient operation and stable operation, it has achieved the expected results. The automation of the detection process is realized. In the feature signal recognition by the neural network, the recognition rate of the gas has a high recognition rate, but the quantitative recognition rate of the gas is not accurate, and more samples are needed for training to improve the gas recognition rate. At the same time, in order to improve the recognition rate, it is necessary to improve various parts of the system.

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