Malodorous Gas Sensor Array System for the Olfactory Robot

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Abstract. Malodorous gas sensor array system for the olfaction robot is developed with four sensors including two semiconductor metal oxide sensors, an electrochemical sensor and a photoionization detector (PID). The system structure and experiments analysis are introduced in this paper. Result of experiments show that the steady system can keep ±0.03V fluctuation limited from 0 to 5 V after it stabilized and the maximum difference of response less than 0.02V. It means that the developed system can be satisfied for the olfaction application of robots in malodorous environment.

1. Introduction

With rapid developing of personal computer technology, robot has well advanced in vision, auditory and touch field expected olfaction. The reason of difficult to achieve olfaction robot is nonselective sense and nonlinear response of most gas sensors. Another reason is that signal of olfaction is more complex than others, in particular, more than thousands of malodorous gas can be smelled by human. According to these series of the problems, malodorous gas sensor array system of robot was developed with sensor array and pattern recognition technology to provide significance for gas tracing and concentration distributing. Not only disturbing social activities but also being harm for human, malodorous pollution defined as series kinds of distinctive gas made living conditions offensively unpleasant and harmful.

2. Malodorous gas sensor array system of olfaction of robot

The malodorous gas sensor array system includes sensor array, signal preprocessing and pattern recognition, show in Figure 1.

![Figure 1. Structure chart of robot olfactory system.](image-url)
The sensor array is composed of four sensors including semiconductor metal oxide sensors QS-01 and MS1100, electrochemical sensor 4NE-H2S and a photoionization detector (PID)[7][9]. Semiconductor metal oxide sensor has wide response to various gases with distinct reactivity to kinds of specific gas. Electrochemical sensor is a kind of detecting concentration of a series of gases as H2S. PID is used for testing the content of volatile organic compounds (VOCs)[10][11]. The detail shows in Table1.

| Type of Sensor | Reaction Principle   | Sensitivity (ppm) | Analyte                          |
|----------------|----------------------|-------------------|----------------------------------|
| QS-01          | conductivity         | 0 ~ 100           | NH3, H2, ethyl alcohol, VOCs, etc|
| MS1100         | conductivity         | 0 ~ 100           | benzene series, methyl aldehyde, etc|
| 4NE—H2S       | electric potential   | 0 ~ 100           | H2S,                             |
| PID (10.6eV)   | ionic current        | 0 ~ 10000         | VOCs                             |

The part of signal preprocessing consists of sensor signal acquisition, system control and signal modulation, shows in Figure 2. Sensor signal acquisition and system control are accomplished with C8051F020 microcontrollers from Cygnal Corp. The signal modulation is used to complete functions including amplification, smoothing, linearization, range changing, error correction, temperature compensation, etc.

Developed in LabVIEW, pattern recognition is completed the functions including communication, data calculating, information fusion and graphical user interface (GUI).

3. Experiment
Constitutional diagram and physical map of malodorous gas sensor array system are shown in Figure 3 and Figure 4. The stability and repeatability experiments are implemented in this paper.
4. Stability Experiment
The experiment operating condition is that humidity is 17%RH; atmosphere carrier gas flow speed is 800mL/min; period of preheat is 18 min. Response curve at beginning is shown in Figure 5 and response curve after system stabilized is shown in Figure 6 and Table 2 illustrates the voltage of testing atmosphere after system stabilized.
### Table 2. Results of Sensors.

| Kinds of sensor | MS1100 | QS01 | PID | NE-H$_2$S |
|-----------------|--------|------|-----|-----------|
| voltage (V)     | 2.298  | 1.236| 0.068| 0.053     |

### 5. Repeatability experiment

The experiment operating condition is that indoor temperature is 25°C; humidity is 17%RH; atmosphere carrier gas flow speed is 800mL/min; period of preheat is 18 min; concentration of sample gas – NH$_3$ is 30ppm for 1 min. Experiment repeats 3 times and every time keeps 1 min. The experiment result is shown in Table 3, and the curve is shown in Figure 7.

![Figure 7. Curve of Repeatability experiment.](image)

### Table 3. Result of Repeatability experiment. (unit: V)

| Name of sensor | 1       | 2       | 3       | Average of voltage |
|----------------|---------|---------|---------|--------------------|
|                | $V_{\text{min}}$ | $V_{\text{max}}$ | $V_{\text{min}}$ | $V_{\text{max}}$ | $(V_{\text{max}} - V_{\text{min}})$ |
| MS1100         | 2.296   | 2.817   | 2.299   | 2.823             | 2.296   | 2.808   | 0.52    |
| QS01           | 1.245   | 1.725   | 1.248   | 1.736             | 1.252   | 1.735   | 0.484   |
| PID            | 0.068   | 0.070   | 0.068   | 0.068             | 0.069   | 0.070   | 0.001   |
| NE-H$_2$S      | 0.052   | 0.055   | 0.053   | 0.055             | 0.051   | 0.053   | 0.002   |

Stability Experiment illustrates the malodorous gas sensor array system can keep base line steady without drifting after accessed atmosphere keeping a constant velocity. Repeatability experiment indicates the maximum difference of response less than 0.02V when the system keeps in a constant velocity. That means the malodorous gas sensor array system remains good stability and repeatability for detecting malodorous gas.

### 6. Conclusion

Olfaction sense of robot is significant to gas tracing and concentration distributing of mobile robot. Although olfaction of robot is more complex than vision, auditory and touch sense, the mixed gases can be detected by technology of sense array and pattern recognition. Malodorous
gas sensor array system for olfaction robot in this paper is developed with four sensors including two semiconductor metal oxide sensors, a electrochemical sensor and a photoionization detector (PID). Developed in LabVIEW, pattern recognition is completed the functions including communication, data calculating, information fusion and graphical user interface (GUI). Result of experiments show that the steady system can keep ±0.03V fluctuation it stabilized and the maximum difference of response less than 0.02V. It means that the developed system can be satisfied to olfaction of robot in malodorous environment.

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