

Chapter 4

Noise and Repeatability of Odorant Gas Sensors in an E–Nose

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ABSTRACT

The impact of the characteristics of the sensors used for electronic nose (e-nose) systems on the repeatability of the measurements is considered. The noise performance of the different types of sensors available for e-nose utilization is first examined. Following the theoretical background, the probability density functions and power spectra of noise from real sensors are presented. The impact of sensor imperfections including noise on repeatability forms the basis of the remainder of the chapter. The impact of the sensors themselves, the effect of data pre-processing methods, and the feature extraction algorithm on the repeatability are considered.

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INTRODUCTION

An electronic nose (e-nose) is composed of a gas sensor array and corresponding signal processing and pattern recognition algorithms. It is capable of mimicking the olfaction system of humans and mammals, and recognizing odorant gases. E-noses are more and more widely used in environmental monitoring, food production, and medicine such as odor evaluation (Xu *et al.*, 2008; Pearce, 2003; Gardner & Bartlett, 1999; Schiffman, Bennett, & Raymer, 2001). The response of all sensors in an e-nose together constitutes a unique profile that gives the “fingerprint” of odor. The gas sensors of an e-nose have several salient features. The sensors in the array interfere with each other and different sensor types are used, some of which have large heating current and power dissipation. Some of the sensors require amplifiers with an extremely high input impedance (e.g. higher than $10^{11} \Omega$) that makes them susceptible to interference. Sensors may have large dynamic currents that produce electromagnetic disturbance to the output of other sensors in the same array. Limitations of the gas sensors include sensitivity to temperature and humidity, with shifting baselines with time and high noise levels at the sensor outputs. The accuracy and repeatability of gas sensor response is heavily affected by the above factors.

NOISE FEATURES IN THE ODORANT GAS SENSORS

The noise from the sensor array comprising of several odorant gas sensors may result in inaccurate cluster analysis of the tested material (Goodner, Dreher & Rouseff, 2001). In our experiments, it is observed that the noise of gas sensors cannot be ignored. In the worst case, the noise magnitude may be some 20% of the signal magnitude of particular sensors. This section considers the noise features of several typical gas sensors used in the e-nose developed in our research laboratory (shown in Figure 1), including their probability distribution functions (*pdfs*) and power spectrum estimation, which are essential in noise cancellation (Wang & Zhang, 2002; Biswal, DeYoe, & Hyde, 1996; Friedrichs, 1995) and odor analysis by noise power spectrum (Solis, *et al.*, 2001).

Typical Gas Sensors and Their Noise

Resistive Gas Sensors

The resistive gas sensors we studied are of MOS (Metal-Oxide Semiconductor) such as tin dioxide. Figure 2 shows a typical sensor circuit and its interface diagram. Pins 2 and 5 are connected to the heater of the sensor, and the resistance between Pins

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