

# Study on Application of Medical Diagnosis by Electronic Nose

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**Abstract:** In recent years, with the in-depth research of electronic nose technology, the bionic olfactory system has been widely applied in the medical field. This article elaborated basic components, working principle, recent achievements of electronic nose in the modern medical application. And it proposed a new mode about combination of the electronic nose technology with the dialectical thinking of traditional Chinese medicine (TCM).

**Key Words:** Electronic nose, body odor, western medicine, traditional Chinese medicine, olfactory examination

“Electronic nose”, which is to imitate human olfactory system, is a system of intelligent electronic instrument designed and developed to be highly cross-sensitive to gas. In 1964, Wilkens and Hatman used gas of the oxidation — reduction reaction on the upper electrode to the olfactory process of electronic simulation, which is the first report of electronic nose. The concept of gas classification using intelligent chemical sensor array was first proposed by Professor Persaud and Professor Dodd from the University of Warwick in 1982 [1]. In 1987, in the Eighth European Conference on Chemical Sensing Research Organization at the University of Warwick in Britain, the concept of pattern recognition was first proposed by Gardner’s gas sensing team of the University of Warwick, which aroused widespread interest in the academic field. In 1989, on the North Atlantic Treaty Organization’s conference for the study of the chemical sensor information processing, the electronic nose was defined as follows. “The electronic nose is composed of multiple properties of overlapping gas sensor and appropriate pattern classification methods. It is capable of identifying single and complex odor [2].” Subsequently, the First International Academic Conference on Electronic Nose was held in Iceland in 1990. The research of electronic nose technology has been developing rapidly.

At present, the electronic nose technology has become one of the hottest research directions globally. The electronic nose has been widely used in the food industry, environmental monitoring, security, public security and military, pharmaceutical industry and medical industry.

## 1 Basic structure and working principle of electronic nose

Electronic nose is mainly composed of three parts, which are the scent sampler, gas sensor array and signal processing system. The signal processing system comprises a signal pretreatment system and a pattern recognition system.

The working principle of electronic nose is as follows. Odor molecules are input to the electronic nose by the scent sampler, and adsorbed by a plurality of gas sensor array, and converted into an electrical signal. Then, the generated electrical signal is input to the pretreatment system for pre processing, filter, exchange and feature extraction. Further processing is conducted by the pretreated signal pattern recognition system to complete the gas signal qualitative and quantitative identification and to make odor identification.

### 1.1 Scent sampler

The main function of a scent sampler is to absorb gas by a vacuum pump to a sealed chamber composed of a sensor array.

### 1.2 Gas sensor array

Key part of the electronic nose is the gas sensor array. It is an implementation from the gas molecules to detected electrical signals into the hub. It is composed of the gas sensing element which has broader spectral response characteristics, larger cross sensitivity and different sensitivity of different gas. In the work, when the gas sensor contact with gas molecules, it produces a certain response and the response mode. This response mode is recorded and transmitted to the signal processing system to be analyzed. At the same time, it compares with a large number of gas molecule signals which have been stored in the repository in order to identify and determine the gas category.

An odor is sensed by multiple sensors to constitute the

sensor array to the odor of response spectrum. Each scent has its characteristic response spectrum (i.e., odor's "fingerprint" map). Therefore, according to the characteristics of response spectrum, different odors can be distinguished. At the same time, it also can measure a variety of the cross sensitivity of the gas by the sensor array through appropriate analysis methods to achieve the analysis and identification of mixed gas.

### 1.3 Signal preprocessing subsystem

The preprocessing system of electronic nose is to filter, exchange and extract the feature for output signals of the sensor array. And feature extraction is the most important part. A reasonable data and the way of expression are selected for pattern recognition. Currently, the most commonly used feature extraction methods are relative method, finite difference method, the normalization method and logarithmic method [3].

### 1.4 Pattern recognition subsystem

Pattern recognition subsystem is to further process for the pretreated signal, including data processing, intelligent interpretation analyzer and repository. The relationship between many trained gases and the signals is deposited into the repository of the pattern recognition system. So, the gas signal can be compared with to complete gas recognition. Currently, the commonly used pattern recognition methods are the statistical pattern recognition techniques (including local minimum variance, linear classification, least-squares method, discriminant analysis, principal component analysis and so on), artificial neural network (ANN) technology and evolutionary neural network (ENN) technology [4]. Among them, the main development trend of electronic nose is the application of pattern recognition based on ANN method for a variety of gas content and its detection and identification.

## 2 Relation of body odor and disease

Body odor is human biological information [5]. The odor of human body is composed of hundreds of gaseous compounds according to the determination of biologists. Among them, 149 kinds of chemical substances are from the respiratory organ discharges, 250 kinds contained in the gastrointestinal gases, 299 kinds from the urine, 196 kinds from the feces, 151 kinds from sweat, and 271 kinds contained on the surface of the skin [6]. The odor of human body is closely related to one's health. Normal healthy person does not radiate abnormal odor. But when the body is in a disease state, the body will emit special abnormal odor through the mucosa of the skin, respiratory secretions, or gastrointestinal secretions and excretions. These abnormal odors are likely to be the special sign of some diseases. For example, patients with type 2 diabetes often emit the smell of pyruvic acid; the respiratory gases of patients with typhoid fever

often contains baked bread smell; scent of beer is always found in lymph nodes patients; pus-like odor is often found in the exhalation of patients with pulmonary ulcer or bronchiectasis with infection. At present, detection of scent has been applied in the clinical diagnosis of less than 40 kinds of diseases in the medical field both at home and abroad [7]. Therefore, detecting abnormal odor is a good method in the early diagnosis of disease.

One of the important methods to a clinical condition data acquisition is the olfactory examination of diagnostic methods (referred to as smelling) in traditional Chinese medicine (TCM). The syndrome of a disease can be diagnosed through the olfactory examination. For example, sputum with fishy-smell was recorded as an important diagnosis in dicator of pulmonary abscess in the *Essentials from the Golden Cabinet* by Dr. Zhang Zhongjing. In general, the sour flavor rancid filthy gas indicates excess heat; the mild or slightly fishy smell indicates deficiency-cold. Therefore, the olfactory examination has significant importance in the TCM syndrome diagnosis.

## 3 Application of electronic nose in modern medicine

Conventional collection measure of odor information is conducted by the physician's olfaction. However, the detection of these special odors by physicians is easily to be influenced due to subjective recognition, fatigueness, or psychological repellence. And some special abnormal odor is beyond the range of human olfactory perception. Therefore, the traditional olfactory diagnosis in clinical application has not received its due attention. The introduction of the electronic nose technology of medicine is to overcome the traditional shortcomings of olfactory diagnosis, and promote the development of olfactory diagnosis. As a noninvasive, rapid diagnostic technology, the research and application of electronic nose technology in the clinical diagnosis are mainly relate to the detection of the pulmonary diseases, microbial infections, type 2 diabetes and urinary system diseases.

### 3.1 Detection of pulmonary diseases

The incidence of lung cancer has increased year by year. The bronchoscopy and biopsy, as gold standard for the diagnosis of lung cancer, are mainly applied in the middle-late stages of lung cancer. However, the early diagnosis of lung cancer is the key point to reduce lung cancer mortality rate. According to both domestic and international researches, although no obvious organic pathological changes of patient can be detected in the early stage of lung cancer, there are characteristics of volatile organic compounds (VOC) contained in the exhaled gas of the patient. Therefore, the detection of odor molecules can be used as a specific indicator in the diagnosis of lung cancer in the early stage. It has also caught a lot of attentions.

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