Characterizing Odors Using Electronic Nose Sensors

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Abstract

The goal of this project is to understand the responses of electronic nose sensors when exposed to specific food odors. To achieve this, we built an experimental setup consisting of an array of three chemical sensors, their corresponding signal conditioning circuitry, and a data acquisition device. For acquiring and processing the data measurements, we implemented a graphical user interface (GUI) in Labview. We calibrated the signal conditioning circuit in air to improve the selectivity of the sensor array when exposed to food odors. We tested our experimental setup on a small set of foods and built a training dataset of the array responses for future use in automatic classification of odors.

Background

Electronic sensing technology is a developing field of study that has greatly advanced over the last decade. Currently, most research focuses on classifying odors within a limited odor set. Also of interest is detecting and distinguishing specific odors and the particular compounds within each odor. There has been some use of electronic noses in building safety and quality control.

Applications

The designed GUI and experimental setup can be used as a starting point for future research exploring chemical array signal processing applications, such as specific compound detection, chemical source localization, and medical diagnosis.

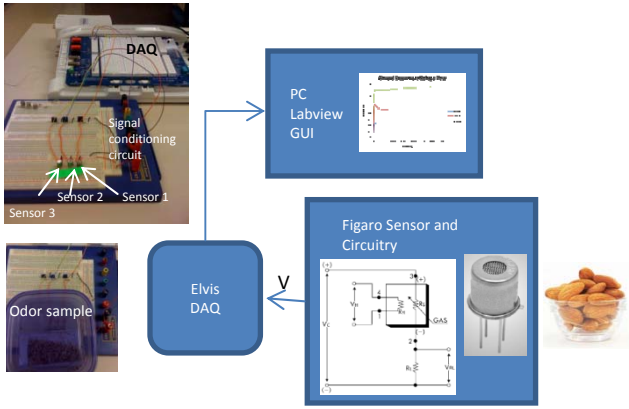
Sensors

Three different chemical sensors manufactured by Figaro are used. The sensing element is composed of a metal oxide semiconductor layer on an alumina substrate of a sensing chip with an integrated heater. When there is a detectable gas/odor, the conductivity of the sensor changes depending on its concentration.

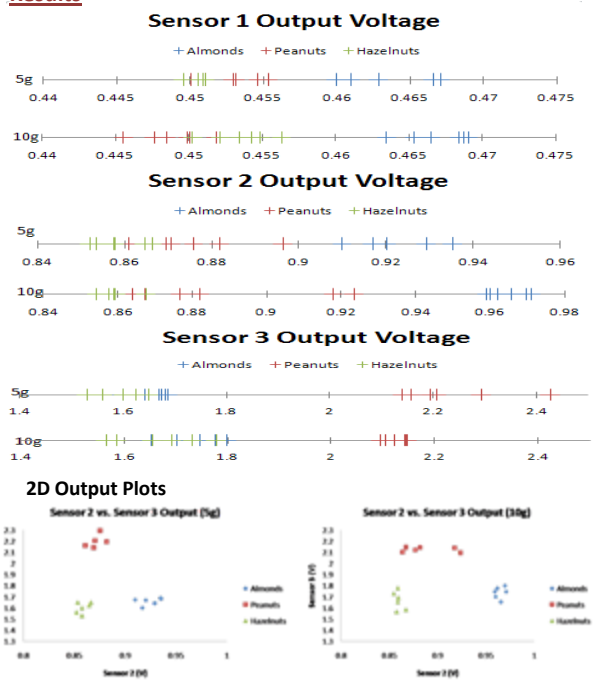
	Model #	Sensitive to:
Sensor 1	TGS 2610	LP gas, propane, butane
Sensor 2	TGS 2620	Vapor of organic solvents, other volatile vapors
Sensor 3	TGS 2602	Odorous gases, volatile organic compounds

Experimental Setup

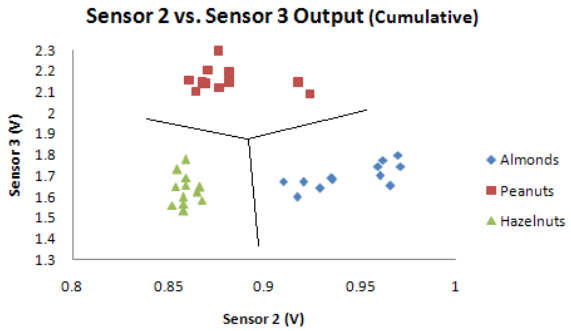
The samples used were crushed almonds, peanuts and hazelnuts. We chose nuts because of their availability and ease of storage, and to gain insight on allergen detection. Each sample was a fixed mass of either 5 grams or 10 grams. The sensors were placed in a sealed container and exposed to the nuts. The voltage change in the sensors was measured and recorded. Each experimental run was 300 seconds long, to allow the voltage to level off. Between runs the sensors were allowed to rest for 300 seconds so that initial sensor temperature remained constant.



Results



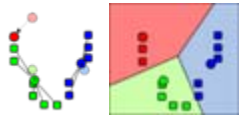
2D Output Plots



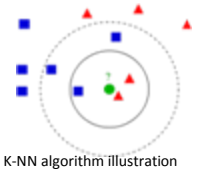
Analysis

Maximum voltage levels for each odor obtained under each sensor are plotted in 1D and 2D to determine whether clustering occurs.

K-means and K-nearest neighbor machine learning methods will be used to classify data points. K-means is used for unsupervised clustering; it clusters data by minimizing overlap between the clusters. K-nearest neighbor (K-NN) is a supervised technique for classification. This means that training data is given and the algorithm generalizes from the training examples to the whole population. K-NN classifies data points based on how physically far an observation is from all reference points.



K-means algorithm illustration



K-NN algorithm illustration

Discussion

The scatter plot above shows that the sensors are sensitive to specific types of odors. All three nuts are in distinct regions. Sensor 2 is useful for differentiating almonds from hazelnuts and sensor 3 is useful for differentiating peanuts from the other nuts. In combination, the two sensors allow reliable classification of all 3 nut types. This data will be used as a reference when we later classify data using K-means and K-NN. The 1D plots for 5g and 10g show that when the concentration is higher, some sensors show more consistency from trial to trial. The greater concentration does not necessarily show higher overall voltage levels.

References

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•http://en.wikipedia.org/wiki/K-means clustering (10/21/09)
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•Kotsiantis , S.B. (2007). Supervised Machine Learning: A Review of Classification Techniques.
Informatica 31 249-268