Study Analysis Simulation & Implementation of E-nose Technology

Ms. Sweety R. Patel[1] Prof. Satish M. Kataria[2]
[1]Department of Signal Processing and Communication [2]Department of Electronics and Communication
[1,2]Sankalchand Patel College of Engineering, Visnagar- 384315, India

Abstract— Electronics nose is an instrument which comprises an array of electronic chemical sensor with partial electrivity and an appropriate pattern recognition system, capable of recognizing simple and complex odors. In the sensor array, each sensor has its own kind of response. Certain organic compounds like butane, propane, carbon monoxide, methane are presented in house hold products which cause death to human life. Too monitor and measure these VOC's in human system gas sensor can be used .The aim of this paper is to identify the suitable pattern classification method to detect the toxic VOCs in E-NOSE Technology using appropriate hardware.

Key words: Sensor array, Toxic VOC'S identification, E-nose, K-Mean

I. INTRODUCTION

Few decade before, human nose had been used in many industries to measure the quality of food, drinks, perfumes, cosmetic as well as chemical products. Human nose was used as analytical tool in the industries. However, this sensory panel is subjective to individual perspective like mental health, fatigue and other body conditions, and it has limitation to sensing odors less gases or toxic gases. So here, In order to solve for the human nose limitations, we introduce the approach to identify the gases and their concentration level using electronics olfactory system call E-nose.

The term "Electronic Nose" was firstly describe on 1988 by Gardner and Bartlett, who defined it as "an instrument which comprises an array of electronic chemical sensors with partial specificity and appropriate pattern recognition system, capable of recognizing simple or complex odors" [1]. E-Nose is normally designed for real-time detection and discrimination of volatile analyses with partial selectivity or proper pattern recognition. . E-Nose is designed on basis of mammalian olfactory system where it is divided into three sections i.e. array of gas sensors with different selectivity patterns, a signal collecting unit and a pattern recognition software applied to a computer.

Here in Figure 1 shows a comparison between mammalian olfaction system and E-nose system. The sensor array of an E-nose has some similarities with primary neurons in the human olfaction system and is discussed in Table 1.

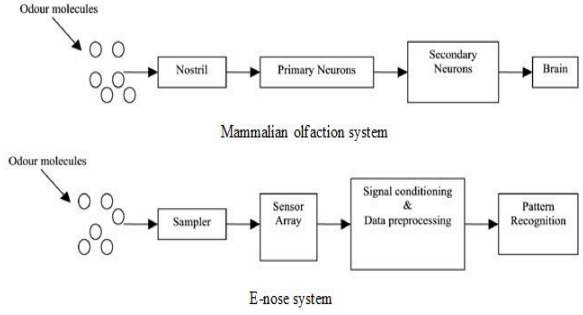


Fig. 1: Comparison between mammalian olfaction and E-nose system [2]

Mammalian olfaction system	E-nose system	Functions
Nostril	Sampler	Serves as gas detection chamber
Primary neuron	Sensor array	Sense odor and collect data
Secondary neuron	Signal conditioning & data preprocessing	Analyze and process data
Brain	Pattern recognition	Classify and identify the smell

Table 1: Function Of Each Component In Mammalian Olfaction System And E-Nose System[2]

According to the table1, In E-Nose the sensor array is made up with several sensors whose number depends on analysis to be performed. Signal conditioning & data preprocessing usually consist of an analog to digital converter and data acquisition unit to collect a data from the sensor array and its feed into a pattern recognition techniques via computer.

Normally E-nose is preferred for identification of VOCs (Volatile Organic Compound). The possible VOCs are CO, H_2S, LPG, Benzene, Toluene, Acetone, Ethyl Alcohol, Methyl Alcohol, Isopropyl Alcohol etc. VOCs are organic compounds that easily oxidized into vapor or gases. Volatile Organic Compounds (VOCs) can easily be evaporated at room temperature these chemicals are carbon based and they can easily evaporate into the air. These kinds of chemicals can enter the human body through many ways such as breathing, touching or swallowing.

There are various types of sensors that are available for this VOCs or odour identifications they can be classified like conducting polymer sensors (CP), piezoelectric–surface acoustic wave (SAW), thickness shear mode (TSM), metal oxide semiconductor (MOS), metal oxide semiconductor field effect transistor (MOSFET), electrochemical (EC).

Then the output generated by sensors are digitalized by ADC and fed to computer via. Microcontroller or other interfaces. These data are analyzed using mainly three techniques i.e.[3]

1. Graphical analysis: bar chart, profile, polar and offset polar plots.
2. Multivariate data analysis (MDA): principal component analysis (PCA), Canonical discriminate analysis (CDA), featured within (FW) and cluster analysis (CA)
3. Network analysis: Artificial Neural Network (ANN) and radial basis function (RBF)

The choice of method utilized depends on the type of available input data acquired from the sensors and the type of information that is available.

II. METHODOLOGY

This project started with the circuit design of sensors. That contains sensor array, their require circuits for given sensor, ATMEGA32 microcontroller with inbuilt ADC. The designed sensor circuit is being tested on breadboard before printing designed layout on PCB board.
Next, Data of sensors are collected in MATLAB software. Using MATLAB K-MEAN clustering algorithm is built .Then, data were classified by K-Mean clustering algorithm.

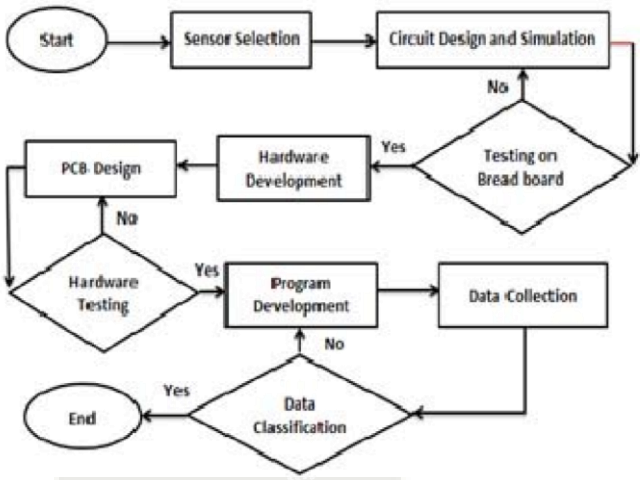


Fig. 2: Flow chart of E-nose Project [2]

A. *Sensor selection*

When compared to other electrochemical gas sensor, semiconductor gas sensors offer several advantages, including the simple principle of operation, low manufacturing costs, commercial avaibility and small size. So for that there are taking MQ2 and MQ7 gas sensors are taken for detection of LPG gas and CO gas accordingly. They are also sensitive to another toxic gases like propane, alcohol, CO etc.

B. *Data collection*

- Apply a Carbon monoxide gas or air mixture to sensor array to change the voltage level by increasing or decreasing the resistance of MQ7 sensor.
- Then apply a LPG gas which is available on house hold product to the sensor array where MQ2 sensor reacts.
- Increasing the concentration level CO from the Smoke of different material burnt.

C. *Pattern classification*

Pattern classification has mainly two types: Supervised method and unsupervised method. When we have prior information regarding the class of a subset of the data the classification scheme is called supervised classification. When nothing is known as priori the scheme is called unsupervised classification or clustering. For this E-Nose system clustering approach are considered.
Clustering is set of pattern vector classified into number of groups or classes. For making this E-Nose project K-Mean clustering algorithm are taken which is partitional clustering method.

1) *K-Mean clustering algorithm*

K-means is the simplest unsupervised learning algorithms that solve the well-known clustering problem. The procedure follows a simple and easy way to classify a given data set through a certain number of clusters (assume k clusters) fixed a priori. The main idea is to define k centroids, one for each cluster. These centroids should be placed in a cunning way because of different location causes different result. So, the better choice is to place them as much as possible far away from each other. The next step is to take each point belonging to a given data set and associate it to the nearest centroid. When no point is pending, the first step is completed and an early group age is done. At this point we need to re-calculate k new centroids as barycenter of the clusters resulting from the previous step. After we have these k new centroids, a new binding has to be done between the same data set points and the nearest new centroid. A loop has been generated. As a result of this loop we may notice that the k centroids change their location step by step until no more changes are done. In other words centroids do not move any more. Finally, this algorithm aims at minimizing an objective function.

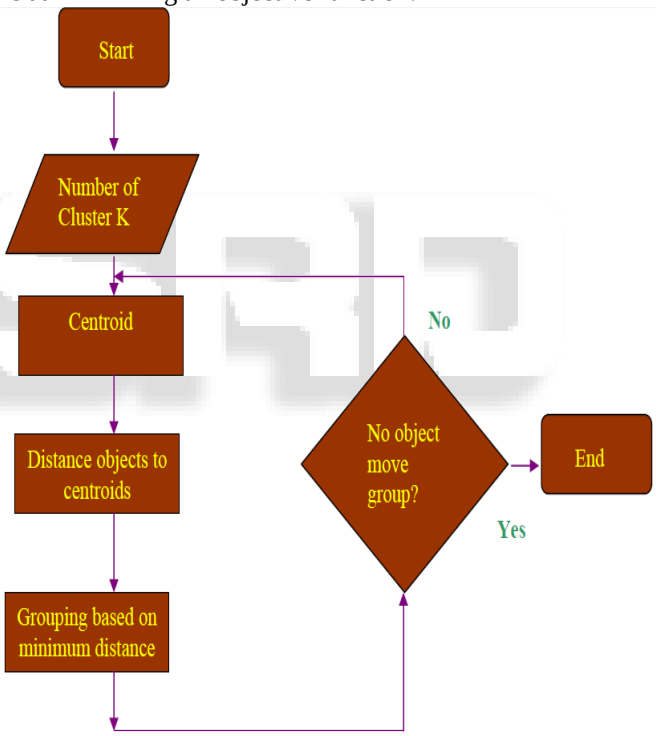


Fig. 3: Flow Chart of K-Mean Clustering algorithm

Step 1. Begin with a decision on the value of k=number of clusters.

Step 2. Put any initial partition that classifies the data into k-clusters. We may assign trained samples randomly, or systematically as the following:

- Take the first k training samples as single-element clusters.

  Assign each of the remaining (N-k) training sample to the cluster with the nearest centroid. After each assignment, recomputed the centroid of the gaining cluster.

Step 3. Take each sample in sequence and compute its distance from the centroid of each of the clusters. If

a sample is not currently in the cluster with the closest centroid, switch this sample to that cluster and update the centroid of the cluster gaining the new sample and cluster losing the sample.

Step 4. Repeat step 3 until convergence is achieved, that is until a pass through the training sample causes no new assignments.

III. HARDWARE PROTOTYPE

Designed of E-Nose consist of 2 semiconductor sensor (refer figure), ATMEGA32 microcontroller to collecting sensor analog value and 5V is supplied to the PCB board. The collecting data are taken in MATLAB as row data. Basically the performance of the system is measured by computing the percentage of correctly recognized patterns.

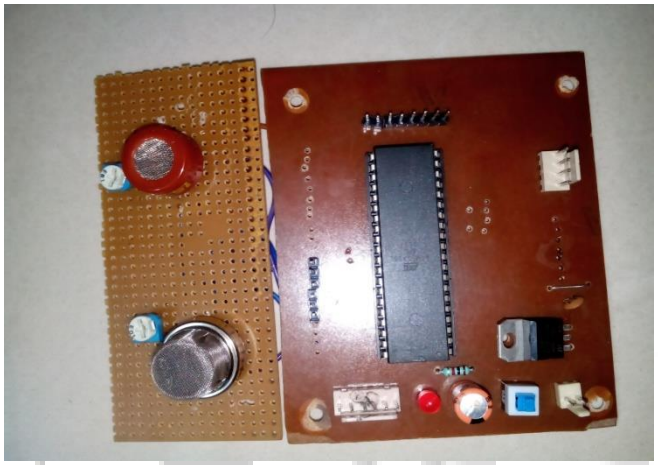
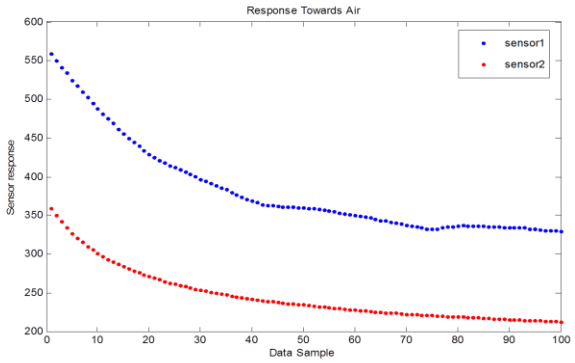


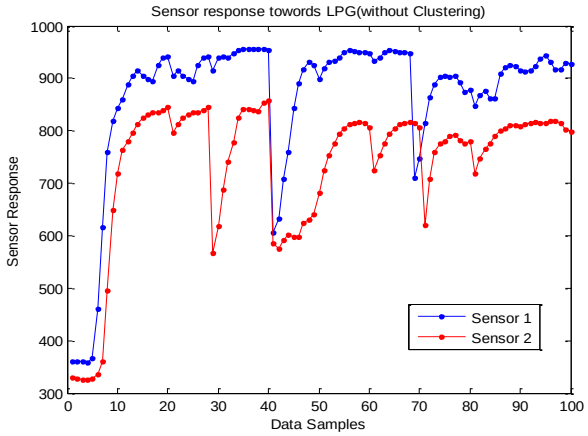
Fig. 4: Prototype of E-NOSE

IV. RESULTS

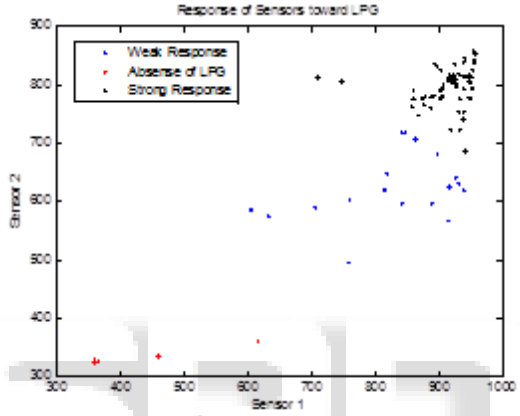
Here sensor 1 LPG gas sensor and sensor 2 is CO gas sensor. The response of the sensor when the sensor array on air is given below:



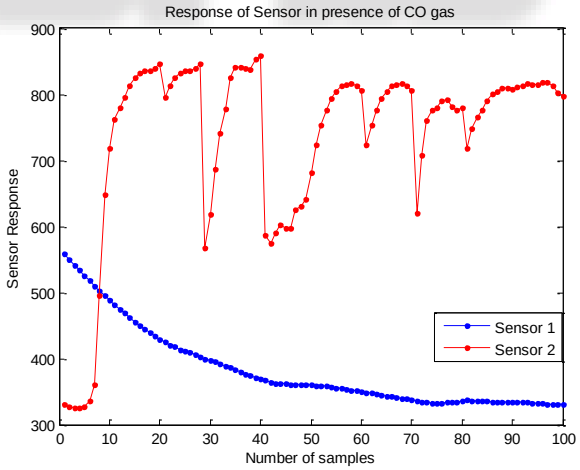
Sensor Response towards LPG without clustering where both sensor has changes its resistance value that mean both sensors are responding to LPG gas



From above figure the concentration value of LPG can not specified. So the After applying K-Mean clustering algorithm the result is:



When taken a Smoke of material the response of CO gas on both sensors are given below:



V. CONCLUSION

E-Nose is nothing but the analysis of gases presented in one or more samples. E-Nose is able to detect harmful gas on different concentration levels. Using PARC technique i.e. k-mean clustering algorithm, it can easily separate the responses towards LPG.On large scale an array of such sensor can be employed to construct an electronic nose.

VI. FUTURE WORK

Using this sensors there can be analysis a petrolllium which has number of toxic VOCs are presented. Different pattern recognition techniques are required for a comparative analysis of accuracy, sensitivity, and selectivity of an electronic nose. And for analysis of petroleum the clustering based algorithm i.e. fuzzy c mean algorithm will applied.

REFERENCES

[1] Garder j.w; Bartlett, P.N., A brief history of electronic nose.Sens. Actuat. B:Chem 1994,18,211-220.
[2] Chow Kar Kit, Azura Che Soh, Umi Kalsom Mohamad Yusof, Asnor Juraiza Ishak, Mohd Khair Hassan, Shamsul Khamis, E-Nose Herbs Recognition System based on Artificial Neural Network Technique,IEEE International Conference on Control System, Computing and Engineering, 29 Nov. - 1 Dec. 2013, Penang, Malaysia
[3] Saifur Rahman, Prof. T. Usmani, Dr.S.H.Saeed, REVIEW OF ELECTRONIC NOSE AND APPLICATIONS, IJCCR VOLUME 3 ISSUE 2 March 2013.
[4] Salaheddin Sadeghifard , Mehdi Anjomshoa, Elahe Esfandiari ,A New Embedded E-Nose System in Smoke Detection,IEEE 1st International eConference on Computer and Knowledge Engineering (ICCKE), October 13-14, 2011.
[5] Mahdi Ghasemi-Varnamkhasti, Seyed Saeid Mohtasebi, Maryam Siadat and Sundar Balasubramanian, Meat Quality Assessment by Electronic Nose (Machine Olfaction Technology), Sensors 2009, 9, 6058-6083; doi:10.3390/s90806058, www.mdpi.com/journal/sensors
[6] Jyoti Sharma, P. C. Panchariya, G. N. Purohit , Clustering Algorithm based on K-means and Fuzzy Entropy for E-nose Applications, IEEE International Conference on Advanced Electronic Systems (ICAES) - 2013.
[7] MQ Gas sensors - Arduino Playground http://playground.arduino.cc/Main/MQGasSensors
[8] Datasheet of 8-bit AVR Microcontroller with 32Kbytes In-System Programmable Flash.
[9] Datasheet of MQ 2 and MQ 7 gas sensor

