A review on gas sensors for environment monitoring using electronic sensors for detecting pollution due to solid waste gases

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Abstract— The main aim of this research work is to detect the butane, carbon monoxide, methane, ethane, LPG and other organic gases from the solid waste and do environment monitoring. Here the set of sensors used to detect the pollutant gases from solid waste. Green and pollution free environment across the globe is very much required for the health of the nature. The different kinds of pollutions are affecting the quality of the environment around us. This review paper is mainly dealing with environment monitoring of organic gases which is a very sensitive issue in the world and is directly affecting the human health and disturbs the biological balance of earth. Here our aim is to develop a sensor array system which will detect maximum pollutant gases and which is highly responsive, accurate and low cost and low power consuming. Here we use the parallel factor analysis technic (PARAFAC) for detection of gases and compare it with the principal component analysis (PCA).

Keywords— Electronic aroma detector, E-nose device, Multi sensor array, sensors; classification; discrimination; quantification; odor concentration.

INTRODUCTION

The electronic nose is a device that detects the smell more effectively then the human sense of smell. An electronic nose consists of a mechanism for chemical detection. The electronic nose is an intelligent sensing device that uses an array of gas sensors which are overlapping selectively along with a pattern reorganization component. Now a day the electronic noses have provided external benefits to a verity of commercial industries, agriculture, biomedical, cosmetics, environmental, food, water and various scientific research fields. The electronic nose detects the hazardous or poisonous gas which is not possible to human sniffers. An electronic nose is an instrument comprising an array of electronic chemical sensors with partial specificity, and an appropriate pattern recognition system that is capable of recognizing both simple and complex odors. The smells are composed of molecules, which has a specific size and shape. Each of these molecules has a corresponding sized and shaped receptor in the human nose. When a specific receptor receives a molecule it sends a signal to the brain and brain identifies the smell associated with the particular molecule. The electronic noses work in a similar manner of human. The electronic nose uses sensors as the receptor. When a specific sensor receives the molecules, it transmits the signal to a program for processing, rather than to the brain. Electronic noses have been used in a variety of commercial agricultural-related industries, including the agricultural sectors of agronomy, biochemical processing, botany, cell culture, plant cultivar selections[1]. Pollution is the introduction of impurity into the environment that causes some change in the environment around us. Pollution can take the form of chemical substances such as solid particles, liquid droplets, or gas [2] and energy such as noise, heat, light. Air pollution comes from both natural and human-made sources. An air pollutant is a substance in the air that can have adverse effects on humans and the ecological community in the world. So there is increasing demand for detection and monitoring of greenhouse gases because of rise in polluted gases [3]. But in this paper our objective is to deal with the organic gases those are produced by the solid waste and we will concentrate on Indoor air pollution because it is major environmental risk to health [4]. So proposed system meets all the requirements for pollution monitoring. It measures and records concentration of different polluted gases such as CO, CO2, LPG. the greatest difficulties have been encountered in field applications as the most commonly-used sensors are sensitive to variations in atmospheric conditions[5,6]. The electronic nose purpose is to continuous monitoring of the material emission and validation of the correlation between the electronic nose responses and odor intensity. Quality control (QC) of the aroma characteristics of Manufactured products is of paramount importance because product consistency is essential for Maintaining consumer brand recognition and satisfaction [8].

ELECTRONIC NOSE WORKING PRINCIPLE

The electronic nose was developed in order to mimic human olfaction whose functions are non-separate mechanism, i.e. the smell or flavor is perceived as a global finger print. Essentially the instrument consists of sensor array, pattern reorganization modules, and headspace sampling, to generate signal pattern that are used for characterizing smells. One of the first studies to evaluate the possibility of using an electronic nose to identify specific environmentally-relevant compounds was carried out in 1995 by Hodgins [7]. The electronic nose consists of three major parts which are detecting system, computing system, sample delivery system.

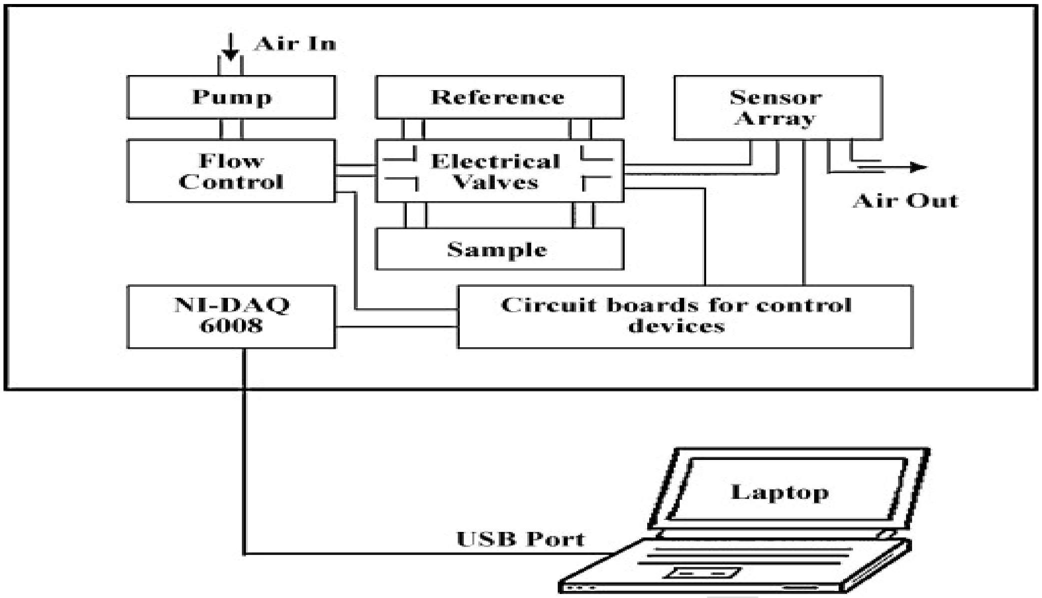

Figure.1: *Electronic nose block diagram*

METAL OXIDE SEMICONDUCTOR SENSOR

This is used for switching or amplifying electronic signals. The Working principle of MOSFET is that molecules entering into the sensor area will be charged positively or negatively which have directly effect on the electric field inside MOSFET. Sensors used in electronic noses convert gases into digital signals by using ions, molecules, atoms or fluids [9].

Metal Oxide sensors: (MOS) This sensor is based on adsorption of gas molecules to provoke change in conductivity. This conductivity change is the measure of the amount of volatile organic compounds adsorbed.

DATA ANALYSIS FOR ELECTRONIC NOSE

The digital output generated by electronic nose sensors has to be analyzed and interpreted in order to provide. There are three main types of commercially available techniques.

- Graphical analysis-
- Multivariate data analysis
- Network analysis

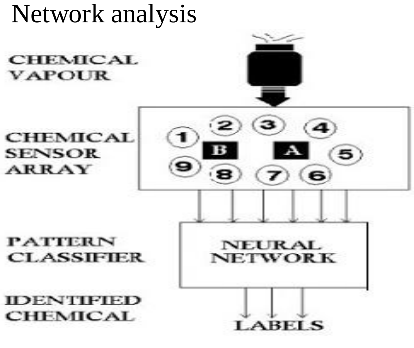

Figure.2: *Data analysis for Electronic nose*

The simplest form of a data reduction is a graphical analysis useful for comparing samples or comparing smells identification elements of unknown analysts relative to those of known sources in reference libraries. The multivariate data analysis generates a set of techniques for the analysis of data that is trained or untrained technique. The untrained techniques are used when a data base of known samples has not been built previously. In a study which used this electronic nose, classification of pears was made and the quality was determined according to their collection dates [10]. They applied regression algorithms on electronic nose data and obtained successful results [11]. Zhang also mentioned about zNose in a study that determine quality of food [12].

The PCA is a most useful when no known sample is available. The neural network is the best known and most derived analysis techniques utilized in a statistical software packages for commercially available electronic nose. The proposed electronic nose system was tested with the smells of three fruits namely, leman, banana, litchi. The smells were prepared by placing a sample of fruits in the breakers sealed with a cover. The 8051 was set in to testing or training mode. If the system is in training mode, sensor value is shown on the LCD. If the system is in testing mode, classification result of the target fruit is shown on the LCD. The sensor array gets the gas through Valve1, which is normally closed. The vacuum pump is turned on for 20 sec to pump the gas out of the sensor array.

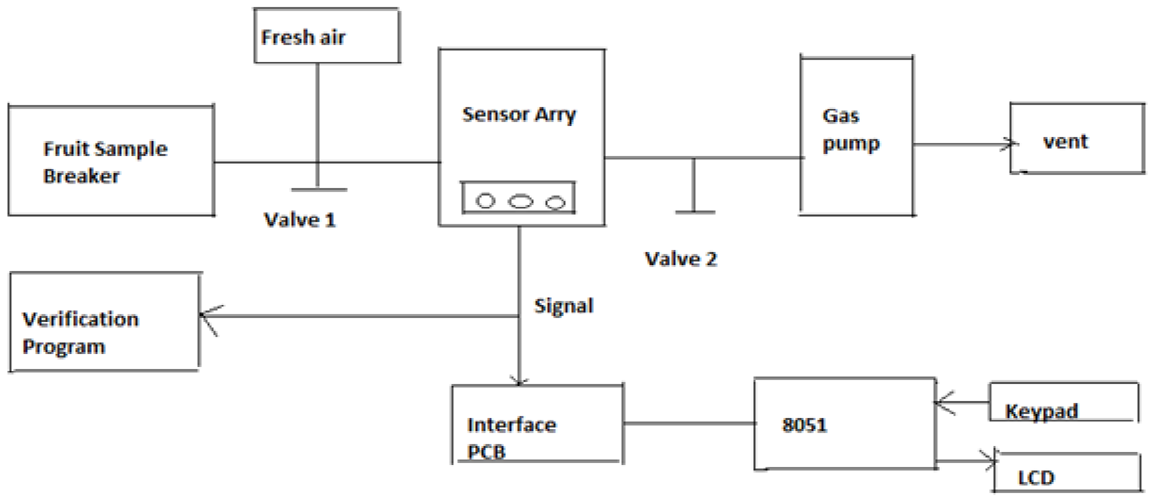

Figure. 3: *Gas testing setup for the proposed E-Nose system*

The value1 was closed and the sensor resistance was given 60 sec to reach a study state mode. The classification result of sensors characteristic value appeared on the LCD. The sensor array chamber was disconnected from the fruit sample breaker and the valve1 was opened to turn fresh air, the valve 2 was opened so that the smells were pumped out. The chamber was aired out with fresh air for two minutes.

APPLICATION OF ELECTRONIC NOSE

- Medical diagnostics and health monitoring
- Environmental monitoring
- Application in food industry
- Detection of explosive
- Space applications (NASA)
- Research and development industries
- Quality control laboratories
- The process and production department
- Detection of drug smells
- Detection of harmful bacteria

CLASSIFICATION OF SENSOR

SNO	SENSOR TYPE	GASES	POWER CONSU -MPTION	RELIA -BILITY	SENSITIVITY (CHANGE IN RATIO OF RESISTANCE RS/RO)	COMMENT
1	TGS 822	Detection of organic solvent vapors(ethanol, Methane ,co)	660mW	High stability and reliability over a long period.	Rs(Ethanol at 300ppm/air) /Rs(Ethanol at 50ppm/air)= (0.4-0.6)	It uses simple electric circuit and it has many applications like Breath alcohol detectors, Gas leak detectors/alarms, Solvent detectors for factories, dry cleaners, and semiconductor.

2	TGS2600	Iso-butane, hydrogen, Methane,co, Ethanol.	210mW	Good reliability	Rs(100 ppm of H2)/Ro(air) (0.3-0.6)	The sensor can detect hydrogen at a level of several ppm.Its application Air cleaners, Ventilation control, Air qualitymonitors
3	TGS2611	Methane	305mW	Good reliability	Rs(9000ppm)/ Ro(3000ppm) (0.54-0.66)	It is semiconductor type gas sensor which combines high sensitivity to methane gas with low power consumption and long life.
4	TGS2620	Iso-butane, co, H2,methane.	210mW	Good reliability	Rs(300ppm ethanol)/Rs (50ppm ethanol) (0.3-0.5)	High selectivity to volatile organic vapors. Solvent detectors for factories, dry cleaners, and semiconductor industries.
5	TGS825	H2S	660mW	Good reliability	Rs(H2S at 50ppm)/Rs (H2S at 10ppm) (0.30-0.45)	High sensitivity to low concentration of hydrogen sulfide.Hydrogen sulfide detectors/ Alarms.
6	TGS6810	Methane, LPG	525mW	Good reliability	(5-14)mv at 5000ppm	It has been developed for residential gas detection. And Residential LNG and LPG alarms. Detectors for LNG and LPG.
7	TGS2602	Ammonia,H2S, Hydrogen, Ethanol	280mW	Good reliability	(0.15-0.5) Rs(12ppmof EtOH)/Rs(air)	It is use to detection of air contaminants and application are Air cleaners, Ventilation control, Air quality monitors, VOC monitors, Odor monitors.
8	MICS5135	CO, Hydrocarbon	120mW	Good reliability	(1.5-2.2) Rs(at 60ppm of CO)/Rs(100 ppm of CO)	It has some important features Fast thermal response, High resistance to shocks and vibrations.
9	MICS5521	Hydrocarbon, CO	88mW	Good reliability	(1.8-3) Rs(60ppm of co)/Rs(200ppm of co)	Its features are short pre-heating time. Miniature dimension, Wide

						detection range.
10	TGS3821	Alcohol tester,H2,CO	163mW	Good reliability	(0.4-0.67) Rs(150ppm Etoh)/Rs(50ppm Etoh)	It is very high sensitive to alchol and quick response.

ODOR CLASSIFICATION

As far as the use of electronic noses for odor classification is concerned, one of the first studies that involved the use of an electronic nose in the environmental field to assign the analyzed odor samples to a specific olfactory class was reported by Nicolas et al., in 2000. After having trained the instrument with samples coming from industrial sites on different days, and with different climatic conditions, the authors have used the electronic nose in the field in order both to detect the presence of odors and to classify them, thereby using the olfactory classes identified during the training phase. Even though the instrument turned out to be able to distinguish between the different types of odors, the authors have highlighted the influence of the atmospheric conditions on the sensor responses and thus the necessity to carry out repeated training over time in order to reduce the problem of sensor drift. The study involved the use of two electronic noses, equipped with MOS sensors, which were moved at regular time intervals to six different positions inside the poultry house. The sensor response data were analyzed by PCA in order to visualize the clustering of the measurements. Principle Component Analysis (PCA)[13]. The analysis highlighted how the measures relevant to a given position inside the poultry house are located close to each other in the two-dimensional space of the PCA, thus producing data clustering depending on the sampling point. Then data were analyzed using an ANN to predict odor concentration, by discriminating samples between high, medium or low concentration levels. The obtained results are promising, as the instrument was able to predict odor concentrations that turned out to be coherent with those measured at the different sampling points. Field-recorded data is essential for achieving effective field calibration methodologies with synthetic pollution-mixture standards using sensor-fusion algorithms that are properly tuned via supervised training [14, 15].

PARALLEL FACTOR ANALYSIS (PARAFAC)

The sample component of aroma is obtained by applying PARAFAC. PARAFAC (Parallel factor analysis) is a generalization of PCA (Principle component analysis) to higher order arrays, but some of the characteristics of the method are quite different from the ordinary such as there is no rotation problem in PARAFAC, and e.g., pure spectra can be recovered from multi-way spectral data. Parallel Factor Analysis (PARAFAC)is a method to decompose multi-dimensional arrays in order to focus on the features of interest, and provides a distinct illustration of the results. We applied PARAFAC to analyze spatio-temporal patterns in the functional connectivity between neurons, as revealed in their spike trains recorded in cat primary visual cortex. During these recordings we reversibly deactivated feedback connections from higher visual areas in the pMS (posterior middle suprasylvian) cortex in order to study the impact of these top-down signals. Cross correlation was computed for every possible pair of the 16 electrodes in the electrode array. PARAFAC was then used to reveal the effects of time, stimulus, and deactivation condition on the correlation patterns. Our results show that PARAFAC is able to reliably extract changes in correlation strength for different experimental conditions and display the relevant features. Thus, PARAFAC proves to be well-suited for the use in the context of electrophysiological (action potential) recordings.

Here, we applied PARAFAC to three-dimensional arrays. A three-dimensional array can be simply viewed as a set of two-dimensional matrices of the same size. An example for a two-dimensional data array could be some measured variable, say the concentration of ozone (O_3) in the air, at different times of the day in different geographical locations. Two-way arrays of this kind are often decomposed using (bilinear) Principal Component Analysis (PCA). Imagine you are now interested in the ozone concentration not only at certain times and geographical coordinates, but also at different altitudes. The measurements now become dependent on three variables, and your array three-dimensional. PCA cannot be applied to three-dimensional structures as it is inherently bilinear. If unfolded, the array can be subjected to PCA, but loses its true three-dimensional structure. PARAFAC is able to work directly on the three-dimensional array and thus capture its true composition. An alternative to PARAFAC can be provided by the Tucker3 algorithm, which is essentially a more flexible version of PARAFAC.

RESULT AND DISCUSSION

Above we have given the different sensors and their characteristics. We have made the code for the data of sensors those are available with good qualities. The snapshot of algorithm and other graphs those have been taken from the sensors are given below. The e-nose used is this experiment contains an array of six different MOX gas sensors whose readings are recorded to obtain an odor fingerprint of the odor. These sensors are Figaro TGS-2600, TGS-2602, TGS-2611 and TGS-2620, and e2v MICS-5135 and MICS-5521. By using these sensors work we will give the graph for gas acetone and ethanol[16].

[0-20]sec: Initially the odor container was kept closed and separated from the e-nose aspiration tube for the first 20 seconds, allowing the measurement of the baseline level (sensor's response in absence of the target gas) for each sensor.

[20-30]sec: After that time, the bottle was opened and left unattended for another 10 seconds, allowing the stabilization of the gas dispersion rate.

[30-90]sec: At second 30, the e-nose aspiration was brought near the bottle, at a distance of 10cm approximately over the bottle "mouth", allowing the e-nose to smell the gas and recording its readings for 60 seconds.

[90-X]sec: Finally, the e-nose aspiration was taken away and the bottle was closed to avoid contaminating the testing room in excess. Due to the long recovery time of MOS sensors, the e-nose was left to recover its baseline level for almost 10 min before starting a new run.

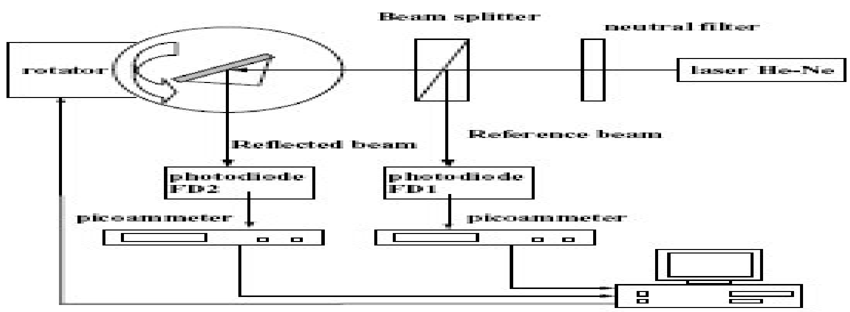

Figure.4:Gas sensing technologies Optical gas sensors

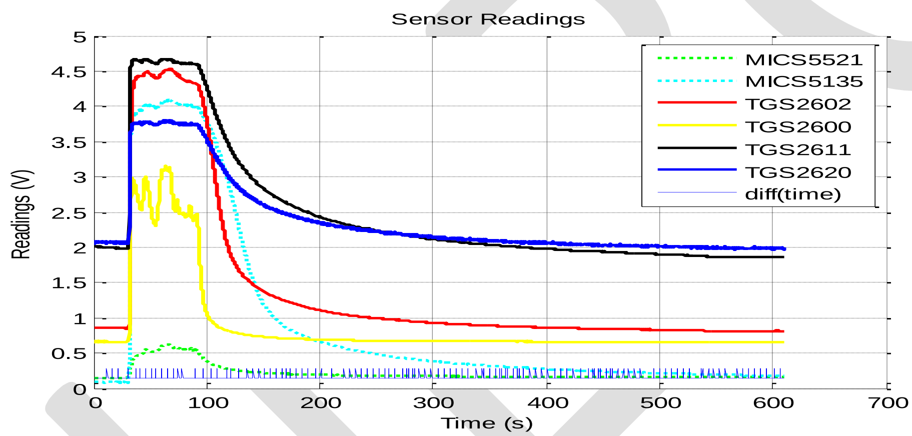

Figure.5: Different sensor graph for Acetone

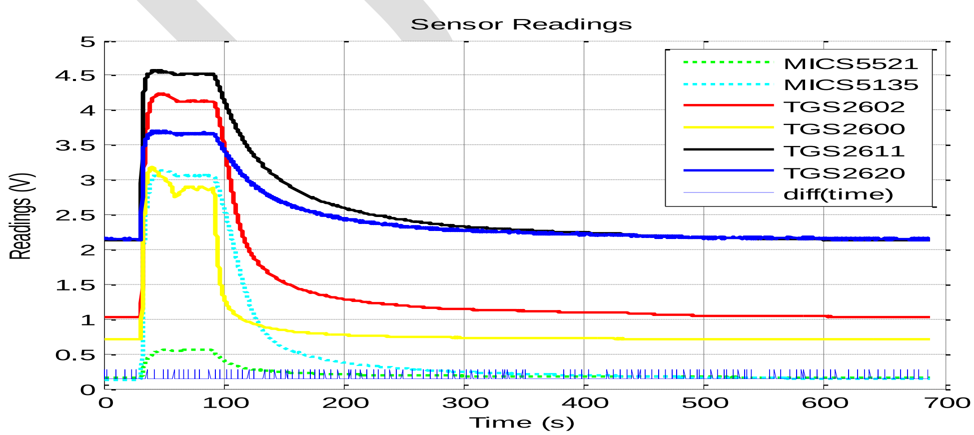

Figure.6: Different sensor graph for Ethanol

DATA STRUCTURE

The data structure of all the sensors in matlab programming.

Column 1 Time.
Column 2 Temperature (Not available)
Column 3 MICS 5521 readings.
Column 4 MICS 5135 readings.
Column 5 TGS 2602 readings.
Column 6 TGS 2600 readings.
Column 7 TGS 2611 readings.
Column 8 TGS 2620 readings.
Column 9 and following Not used

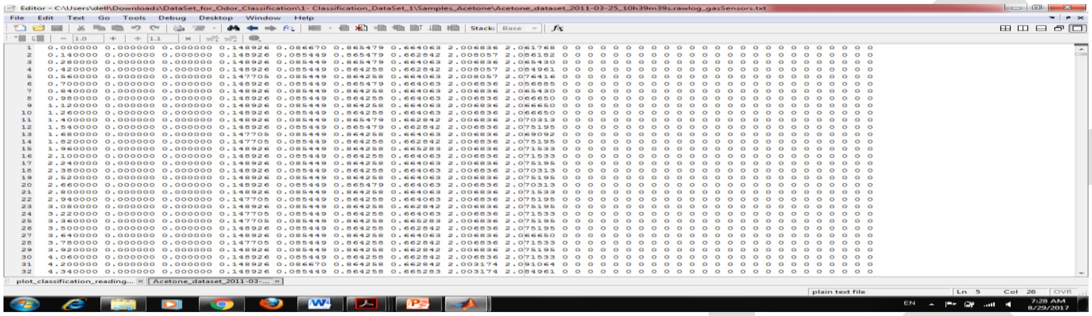

Figure.7: The data set after the programming of the sensors

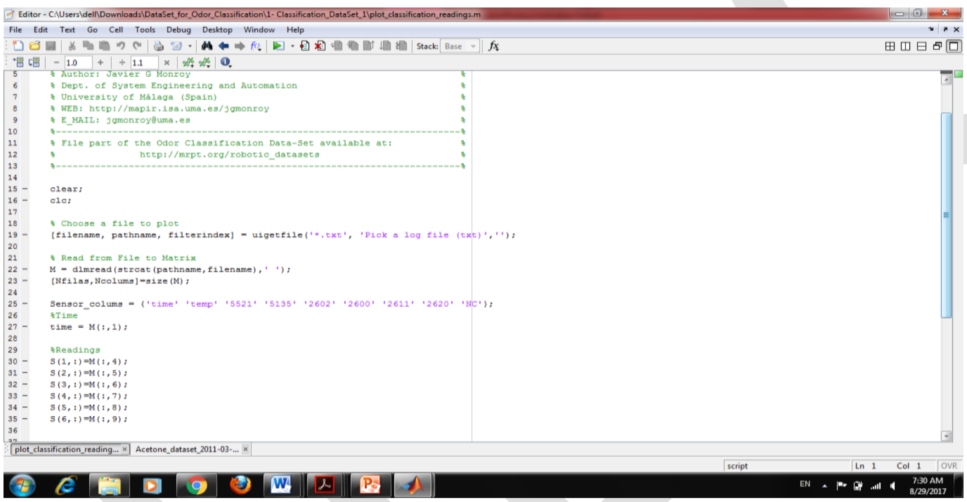

Figure.8: Programming for the sensors

FUTURE SCOPE

Future challenges regarding the use of electronic noses in the field of environmental monitoring shall presumably not be focused on the development of new sensors or data processing methods, but rather concentrate on the adjustment of the instrument for outdoor applications. In future, it would be extremely interesting to have electronic noses able to tolerate the variability that is typical of real environmental applications, as well as mobile electronic noses for field-inspection-like applications. This paper summary describes the different sensors and their uses in aroma detection. Further in future we produce these sensors in different places.

CONCLUSION

Electronic noses are an interesting and promising technology in the environmental field, both for odor impact assessment control application purposes. Once opportunely trained, electronic noses can be used successfully for both detecting and identifying odors, by attributing the analyzed air to an olfactory class corresponding to a specific odor source. With respect to other measurement methods involving the use of human assessors, instrumental analysis with electronic noses entails the great advantage of allowing the measurements to be run continuously, and at lower costs. The studies conducted in order to evaluate the possibility to use electronic noses in the environmental field have proved that said instruments are generally suitable for the different applications reported, if the instruments are specifically developed and fine-tuned. As a general rule, literature studies also discuss the critical aspects connected with the different possible uses, as well as research regarding the development of effective solutions for said problems. Regarding the sensors, several studies have highlighted the problem of stability towards temperature and humidity variations, as well as sensor response drift over time On the contrary, they require sophisticated and complex technology in order to produce accurate and reliable results. Actually, there are several extremely simple devices commercially available, which are generically defined as "electronic noses", able for instance to detect gas leaks or evaluate single gas concentrations. It is important to highlight that such simple instruments are unsuitable for environmental monitoring purposes. Here we have conclude the all data related to sensors and the graphs those are valuable for the project.

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