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Smart Accident Avoidance and Pollution Control System using Electronic Nose

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Abstract

The occurrence of diseases due to pollution and alcohol consumption, accidents due to gas leakage at sudden combustion points, inadequate monitoring of the automobile systems leads to need of Electronic Nose. Automobiles equipped with real-time olfaction monitoring systems, the problems about the odour detection of harmful contents can be reduced efficiently if the advanced algorithms can be implemented in the vehicles. The significant information that was necessary to monitor the automobile system, the control actions are taken to provide the safety measures dealing with the situation of the system. This paper is dedicated to the development of smart automobile accident avoidance system which is equipped with low-cost, reliable, compact and portable based on Metal-Oxide-Semiconductor (MOS) sensors and processing of signals of sensors. This paper detects the odours of alcohol, carbon dioxide, Liquefied Petroleum Gas (LPG) or smoke and combustible gases. Electronic nose system was verified and tested in real-time conditions. The specific pattern developed by each sensor in the sensor array, is compared using the look-up table generated and the implications are derived whether which is interfering gas responsible for the resulting situation and further corrective actions are taken to bring the system under control.

Keywords— *LPG, Lab VIEW, lookup table, MOS,* ***odour, perception, pattern recognition, sensor array.***

I. INTRODUCTION

Accidents of automobiles are increasing day by day due to consumption of hazardous contents like alcohol. The high alcohol consumption leads to the imbalances in the bloodstream of human leading to stimulation in the senses of brain activity. In such a condition, the person is unable to drive the vehicle properly and leading to the many hit and run accidents. Further, the sudden combustion in vehicles due to the combustible gases leads to fire accidents. Also, the increasing use of the automobiles leads to an increase in the release of the harmful gases that may even cause diseases like tuberculosis, bronchitis and asthma. Further increase in the pollution due to the gases may lead to the ozone depletion resulting in acute infections like skin burns and in extreme case causes sarcoma or skin cancers. So with a view to achieve objectives of reducing accidents due to alcohol consumption, reducing diseases due to rise in pollution and prevent gas leakage or accidents due to combustible gases a compact and portable E-nose system has been proposed that can continuously monitor and detect the odour contents of the gases leading to the disturbances in operating conditions of the system and can take corrective action when required.

An electronic nose is basically based on the idea of human bio-nose which works according to the principle of olfaction with the help of sensing by neurons. Here the raw signals are determined from the smell of mixed odours, microcontroller analogous to the human brain that processes the signals and look-up tables, neural networks or the advanced algorithm used are similar to neurons that govern the sensing using sensors and determine whether which odour is the causative agent. Research is going on to increase the sensitivity of the E-nose as that of the human nose to solve the

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problems of human sniffers or dog sniffers to prevent the disturbances in the health of living beings. So, this robotic approach of mimicking the human nose has been undertaken to increase the range of olfaction using E-sensing technique.

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This paper develops a prototype of the E-nose system using n PIC18F4520 microcontroller with odour perception technique using look-up tables. Accuracy and correctness of the system have been tested using the program in Lab-VIEW. Depending on the readings of the odour contents given by sensors the patterns are generated and compared according to the look-up table fed through the programming earlier and the resulting odour is detected. This approach doesn't ensure any significant improvement in bad air quality control but it deals with the detection of pollutant content. Lab-VIEW is the prime detector of the intensity of the odour content using signal processing.

II. LITERATURE SURVEY

Many approaches perception of odours has been developed based on the theory of olfaction and E-sensing technique. The various methods dealing with the development of different E-nose models having different objectives but the principle of working is based on Gas Chromatography and Mass Spectrometry (GC/MS) i.e. quantitative analysis of odours. There is the detection of volatile organic compounds(VOC) using the E-nose Page Layout.

Table I
Literature Survey of E-Nose

Reference No.	**Target Odours**	**Sensors**	**Technology**
[1]	Fruity Odours	Figaro Taguchi Gas sensors (TGS)	K-nearest Neighbours (KNN)
[2]	Pulmonary TB	Applied Sensors	Artificial Neural Network (ANN)
[3]	Volatile Organic Compounds (VOCs)	Figaro (TGS)	K-nearest Neighbours (KNN)
[4]	Alcohol, NH_3, H_2S, VOC	Figaro TGS	Artificial Neural Network
[5]	Co_2, No_2, VOC	MQ	Fuzzy Logic
[6]	Organic Shallot	MQ, Figaro TGS	Principal Component Analysis
[7]	Lung Cancer	Three micro hotplate metal-oxide sensors (MOS)	Neural Network
[8]	Head and neck, Colon, Bladder cancer	AS-MLV sensors; Applied Sensors GmbH	Artificial Neural Network
[9]	Vapours and liquid Components	Biomimetic Cross-reactive sensor arrays	Review paper, NA

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[10]	Volatile organic compounds (VOCs)	Nano sensors	Basic classification algorithm
[11]	Various Gases	Gas Sensor array	Type 2 Fuzzy

E-nose is developed in such a way that it can identify complex fruity odours using Figaro TGS sensor array and utilising the KNN algorithm [1]. KNN is the K-Nearest Neighbour algorithm. KNN determines the Euclidean distances between the measurement point of the sample to be classified and the points relating to the training data that identify the different olfactory classes. The unknown sample is attributed to the olfactory class to which most of the k points nearest to it. Although very simple, this method does provide satisfactory results, and some papers have reported classification accuracy values of over 90% [7].

Pulmonary Tuberculosis is the chronic multi-factorial disorder resulting from causative agent Mycobacterium Tuberculosis. The E-nose can easily detect Pulmonary TB without doing X-ray or other tests. It uses GC/MS spectrometry to detect TB. This E-nose is also called a Diag Nose which has 12 metal-oxide sensors, being four different sensor types (AS-MLC; AS-MLN; AS-MLK; AS-MLV, Applies Sensors Gmbh) in triplicate[2]. The bacterial cultures of Mycobacterium Tuberculosis are developed and the patients are asked to undergo a test of 10 min in which during first five minutes the sensors are exposed to the breath sample, taken from the sample bag, and during last five minutes, there is recovery phase in which chemicals that are adsorbed get released from the system in clean air. There are chemical adsorption and desorption taking place at sensor arrays, caused by the sample, during this 10 min in every single measurement [2].

E-nose is compared with human olfactory system and is enhanced with the KNN using TGS sensor array for detection of VOC.8051 microcontroller is used, and a pump is used to pass the odour to the sensor array from the sample. This was an efficient approach to sense the odours appropriately [3].

This system detected Ammonia (NH3), Hydrogen Sulphide (H2S), alcohol and VOC using the TGS sensors. It used ANN to pass the decision whether which is an interfering odour. This system used acoustic sensors, such as Quartz crystal microbalance (QMB); surface and bulk acoustic wave (SAW, BAW), Carbon black composite detectors (CBCD), Catalytic bead (CB), Catalytic field- effect (MOSFET), Calorimetric, Complementary metal-oxide-semiconductor (CMOS), Conducting Polymer (CP), Electrochemical (EC), Electrical porous silicon sensor (EPSS), Fluorescence, (FL), Infrared (IR), MOS, and Optical sensors [4].

Harmful industrial, as well as indoor and outdoor pollutants, are detected using this system. Carbon monoxide (CO), NO2 and VOC are detected using MQ- series sensor array. It uses fuzzy logic for bad air quality monitoring control. Fuzzy logic provides unique response patterns that are used to classify and quantify the single pollutants inside complex gas mixtures, as found in real applications [5].

The proposed E-nose system was utilized to detect the growth of shallot using odour perception using MQ-series and TGS sensor array equipped with the PCA plot to determine the separation within the shallot plots. All conditions such as the chemical fertiliser, insecticides, plant growth nutrients and bulb growth nutrients are considered [6].

Detection of lung cancer in the early stage is very much essential. Only 15% of lung cancer cases are curable if detected in the first stage. Exhaled breath analysis by electronic nose technology measures volatile organic compounds (VOC's) in exhaled breath which are associated with lung cancer. The E-nose company uses a software program called Athena. This program comprises of pre-processing, data compression and neural network to handle big data analysis. Data analysis in E-nose technology is principally based on generating prediction models which need to be validated internally and externally for eventual use in clinical practice. This paper describes the analysis of big data, captured by E-nose technology in lung cancer. This is done using generating prediction models with Athena, a data analysis program specially developed for analysing VOC data [7].

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The authors[8] compares patients head and neck squamous cell carcinoma with patients colon or bladder cancer to determine the distinctive diagnostic characteristics of the e-nose. Samples were analysed and control using an artificial neural network. They concluded that "The E-nose technique can distinguish colon cancer from bladder cancer"[8].

In this paper, biometric cross-reactive sensor arrays have been used to detect and analyse a wide variety of vapour and liquid components in applications such as food science, public health and safety, and diagnostics. It surveys various types of biomimetic cross-reactive sensor arrays (also referred to as electronic noses or tongues in the literature), their current use and future directions, and an outlook for future technological development [9].

Generally, E-nose is composed of multiple sensor arrays having specific features. This technology has a major role in identifying respiratory diseases [10].

This paper gives the comparisons of materials that can be used in gas sensors, as well as analysis of their advantages and disadvantages [11].

III. METHODOLOGY

Fig.1. describes E-nose consists of a sensor array of four sensors. MQ-2, MQ-3, MQ-6 and MQ-135 these four sensors are used to detect the CO2, alcohol, smoke and combustion respectively.

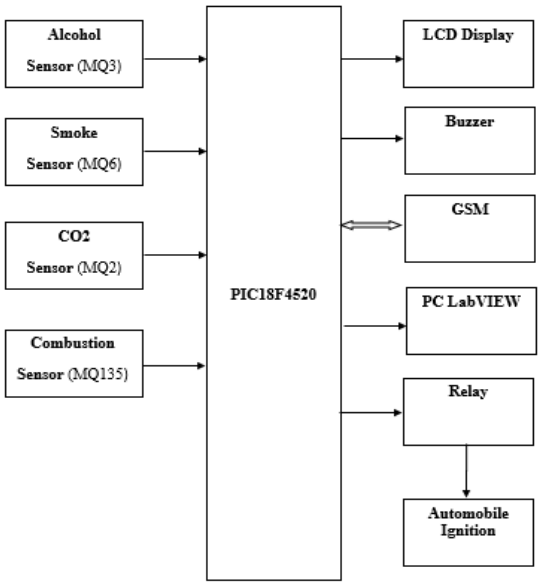

Fig. 1 Block Diagram of E-Nose Accident Avoidance System

Sensor array measures the odour content in ppm (parts per million).PIC18F4520 microcontroller controls all the components and processes the signal. This RS232 port is used to send data serially to the computer using CP2120 (RS-232 to USB) driver. It displays the data on 16x2 (32 characters) LCD display. The relay is an electromechanical coil used as a switch to trigger the circuit. GSM module (SIM 900) is used to send the SMS using AT commands and Omni-directional antenna using mobile communication which uses frequency range over 900 MHz-1800MHz. Figure 2. is a flowchart of E-nose and detailed idea about the working of the system. Sensor array senses the odour content from the sample and passes the signal to PIC18F4520.PIC18F4520 microcontroller processes the signal given by sensor array and converts analogue signal to a digital signal using 10-bit ADC. This data is sent serially over RS232 port to the computer using CP2120 driver. It displays the information on a 16x2 LCD display. The data detected by sensor array is given to Lab VIEW (Laboratory Visual Instrumentation & Engineering Workbench) through RS232 serial cable and CP2120 driver. This signal is plotted on the Lab VIEW to show the intensity. As soon as the odour content raises an above-set point of sensors that are fixed using programming the buzzer is

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ON which is an active low mode and the relay becomes OFF which is the active high mode. The relay acts as the switch which passes the decision of automobile ignition depending on the concentration of odour content and immediately texts message is being sent to the owner of an automobile using GSM module (SIM 900) for preventive measures and corrective action to be taken.

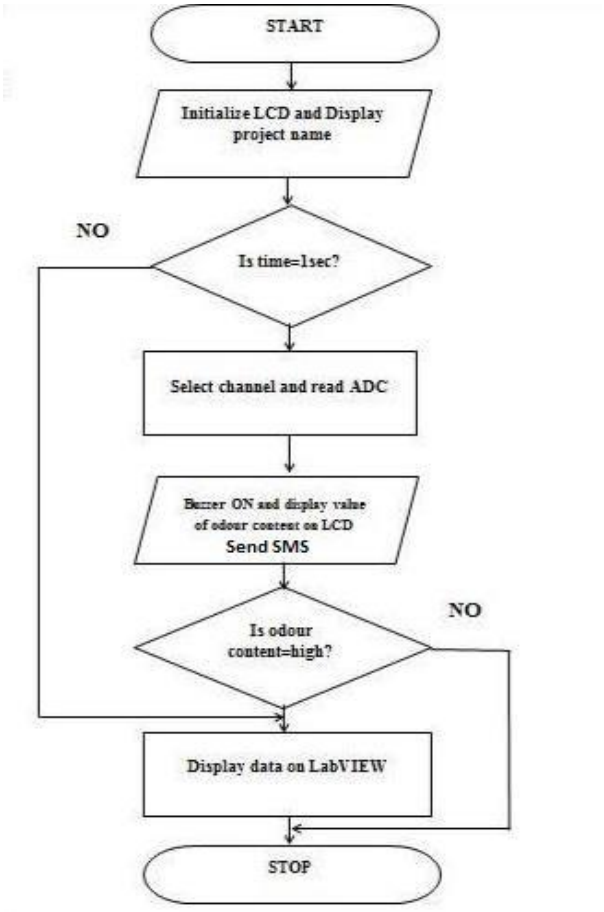

Fig. 2 Flow Chart of E-Nose Accident Avoidance System

There are 4 modes installed in the system explained below.

A. E-Nose mode(Default)

This is the default mode of the system. Setpoint for the sensors is fixed using programming in Embedded C. As soon as the odour content raises an above-set point of sensors, the buzzer is ON which is an inactive low mode and the relay becomes OFF which is an inactive high mode. The relay acts as the switch which passes the decision of automobile ignition depending on the concentration of odour content and immediately texts message is being sent to the owner of the automobile using GSM module (SIM 900) for preventive measures and corrective action to be taken.

B. Breath Analyser mode

The MQ-3 sensor is activated in this mode. If the alcohol content consumed by the driver is more than setpoint, then the buzzer is ON relay is OFF and the message is sent to the owner of the vehicle for the safety of the vehicle.

C. Pollution Analyser mode

The MQ-2 sensor is activated in this mode. If the CO_2 pollutant content released by the vehicle is higher than setpoint, then the buzzer is ON relay is OFF and the message is sent to the owner of the vehicle to inform that vehicle is polluting the environment and gives an alternative to use different

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feed or fuel, e.g. Use gasoline mix instead of petrol or diesel.

D. Combustion Analyser mode:

The MQ-135 sensor is activated in this mode. If the combustion content sensed is more than setpoint, then the buzzer is ON relay is OFF and the message is sent to the owner of the vehicle for safety of the vehicle to prevent it from fire accidents.

IV. RESULTS

The readings are taken for various VOC and odour contents are determined. Depending on these readings, a look-up table is prepared in which we get the highest text on each sensor corresponding to the respective samples used. The concept behind this look-up table is reverse engineering i.e. we are getting the readings in ppm which are values of the peak of the digitized waves with respect to analog voltages. Thus a pattern is recognized by these reading in Table II look-up table. When the unknown sample then the comparison is made according to the look-up table feed through the programming earlier, and if any approximation between these two patterns is found later, the resultant odour is detected. A funnel model is designed for a uniform distribution of odour sample to sensor array at the centre point.

TABLE II

LOOK-UP TABLE

Sensor / Sample	**MQ-6**	**MQ-3**	**MQ-2**	**MQ-135**
LPG	680	558	601	587
Alcohol	800	920	624	228
Co2	497	500	549	486
Incense Stick	500	560	677	722

There are 4 modes installed in the system:

A. E-Nose mode: In E-Nose mode is the default mode and odour is uniformly distributed about centre point and is taken by all the sensors and depending on the highest sensitivity of dedicated sensor the odour is detected. Results on LCD and LabVIEW are shown in Figure 3 & Figure 4, respectively.

Fig. 3 LCD Results of E-Nose Mode

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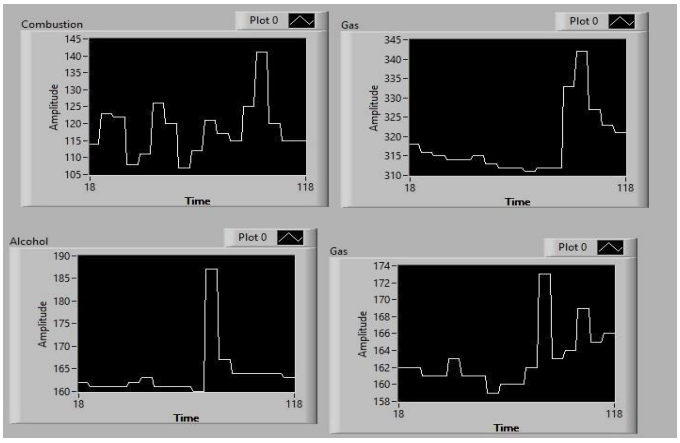

Fig. 4. Result waveforms for E-Nose Mode.

B. Breath Analyser

The MQ-3 sensor is in activated mode during this mode. The setpoint for this mode is fixed to 700 ppm. When the value of alcohol content rises above 700 ppm, high alcohol is detected. Figure 5 and Figure 6 show the results for the Breath Analyser mode as follows:

Fig.5. LCD Results for Breath Analyser Mode.

Fig. 6. GSM Results for Breath Analyser Mode.

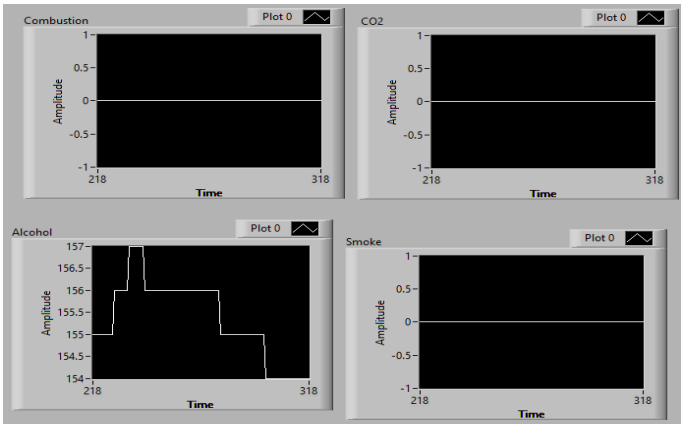

Fig.7. LabVIEW Results for Breath Analyzer Mode

C. Pollution Analyzer

The MQ-2 sensor is inactivated mode during this mode. The setpoint for this mode is fixed to 500 ppm. When the value of CO2 content rises above 500 ppm, the HIGH CO2 is detected. The results of the pollution analyser mode are shown in Figure 7 and Figure 8 as follows

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Fig.8. LCD Results for Pollution Analyser Mode.

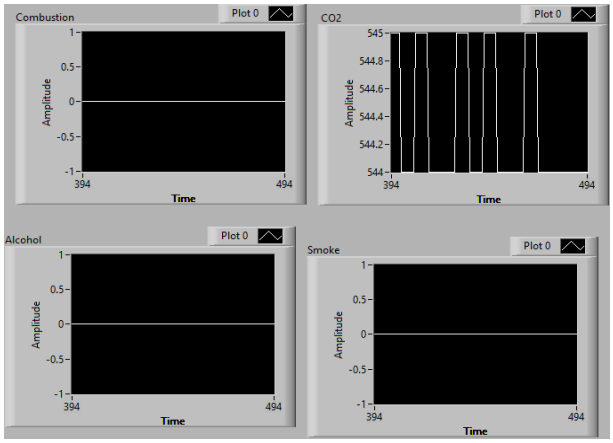

Fig.9.LabVIEW Results for Pollution Analyser Mode

D.Combustion Analyser

The MQ-135 sensor is inactivated mode during this mode. The setpoint for this mode is fixed to 400 ppm. When the value of combustion content rises above 400 ppm, HIGH COMBUSTIBLE is detected. The results of the combustion analyser mode are displayed in Figure10 & Figure11 as follows.

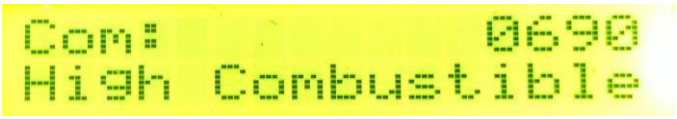

Fig.10. LCD Results for Combustion Analyzer Mode.

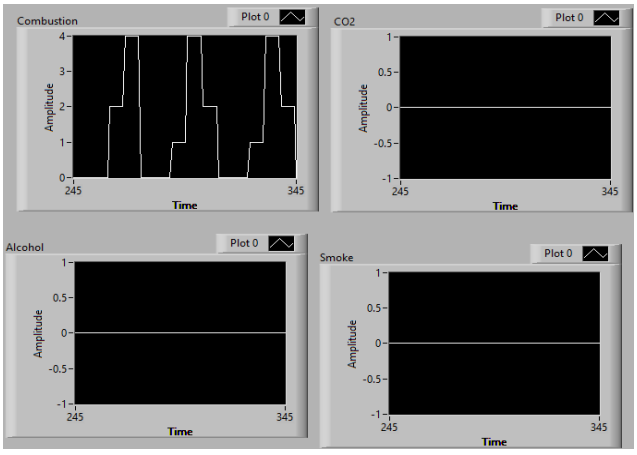

Fig.11. Lab VIEW Results for Combustion Analyser Mode

The mixing of the odours is avoided using the inverted funnel model. It ensures a uniform distribution of odours.

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V. CONCLUSION

The proposed system is designed with a real-time olfaction model that can automatically detect the mixture of the odours (alcohol, smoke, CO2) released from the various sources. This system works primarily works in the four modes E-nose mode, Breath Analyser mode and Combustion Analyser mode and Pollution Analyser mode. To achieve higher sensitivity of sensors, we have to switch on the sensors and keep it under monitoring for minimum 3 to 6 hours. Hence the three modes (air pollution control mode, breath analyser mode and combustion control mode) give high sensitivity and fast response. We have used Lab VIEW software to plot the result captured by each sensor in the respective mode. Depending upon the availability of 3 modes, we can activate the particular sensor. To avoid the mixing of the odours and to ensure uniform distribution of the odours, the inverted funnel mode is used. The performance of the system is also tested using threshold provided by lookup table II.

VI. FUTURE SCOPE

This system can be implemented with the ad-hoc network in multiple automobile monitoring system. The further system can be enhanced by adding GPS module for tracking the vehicle in the worst situation like accidents thus accident spots could be located, and addition of ECG electrodes or sensors can monitor the injured driver of the vehicle.

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