An Intelligent Warning to Smokers by e-Nose

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Abstract— E-nose is a self-controlled Smoke Detector developed using arduino microcontroller and sensors. It is capable of sensing the smell in the ambiance via gas sensors and programmed to alert the smokers giving red signal with buzzer. Smoke Detection algorithm facilitates the intelligent warning to the cigarette smokers. Now-a-days, smokers' count is increasing with a high speed raising health and moral issues to the people especially in case of passive smoking at public places. Today 'No Smoking' rules are only written, but to make these rules being followed this work would be a milestone. To implement e-Nose, a cigarette smoke detector with Red/Green LED and buzzer using arduino uno board R3 is developed. MQ-2 gas sensor is used to detect cigarette smoke and combination of buzzer and LEDs is used to warn smokers. This work demonstrates the development of e-Nose and evaluation of the performance of developed product. In nut-shell, this e-Nose which is cigarette smoke detector is designed to achieve high degree of awareness among public and to reduce the smokers' count especially at public places.

Index Terms— **Mobile Robot, Gas sensor, Arduino, Smoke detection, Microcontroller, buzzer, LED.**

I. Introduction

The smokers count is increasing rapidly in almost all age-groups, posing a big threat to the health. It is pathetic when public areas are considered in this regard. In our current life style, e-Nose can become a good tool to abide smokers to the specific smoking rules. It will surely enhance the awareness in society about the increasing threat to health because of smoking. A survey [1] suggests that more than 25% adults are involved in smoking habits. It encompasses active and passive both types of smoking. An active smoking is an activity when a person smokes, also called first hand smoke. A passive smoking is an act when a person inhales the smoke being released by a smoker, also called secondhand smoke. Both active and passive smoking are hazardous to health. It causes coronary heart disease fatal or nonfatal [2,3]. Smoking habit directly imposes genital diseases, pulmonary and respiratory diseases, cancers, cardiac diseases [4].

Lack of awareness among people is root to the increasing smokers' count at public places. Poor law enforcement from the authorities is also a big cause. All leading to the non-guilty of smokers smoking in areas surrounded by others. The major objectives of the entire work being presented here is to warn to such smokers with buzzer and signaling red to their act, when e-Nose senses cigarette smoke by using a MQ-2 gas sensor. Microcontroller Arduino board is used for this purpose. The development of e-Nose to alert the smokers with buzzer and red alert as cigarette smoke is detected can be used at any target place to sense cigarette smoke by measuring CO particles in environment. Software & Hardware set-up allows generating the warning with red signal and buzzer sound at any destined location. This paper is comprised of six sections where Section-I is discussing the major objective of this work with the goal and scope. Section II brings light to the related work carried out in this direction with literature review. Section III describes the design of e-Nose and brings a light on the major components of e-Nose. Section IV explains the overall set-up for this experimentation and emulation of e-Nose. Section V depicts the results and discussions. Section VI concludes the entire work with future.

II. Related work

The hazards of smoking and the continuous increase in smokers' count [1] motivate researchers to contribute in smoke detection field. They found out multiple ideas and implemented to minimize the smokers' count at public places. Multiple devices are developed to detect cigarette smoke like wireless smoke alarm, wireless smoke detection system and prediction of the frequency of activation of smoke detector for house fire through computational fluid dynamics modeling. All these techniques are basically of two types, one is vision based technique and another one is sensor based detection. Celik et. al. [5], Dedeoglu et. al. [6] utilized video frames and image-processing to detect smoke. Smoke detection using cameras covered in multiple projects. Krstinic et. al. [7] exploited histograms from images to detect smoke. Liu et. al. [8] implemented pattern recognition algorithms on the images captured using cameras to smoke detection. Toreyin et. al. [9] proposed wavelet based detection from the video clips. The problem with vision based techniques is high expense and somewhat inappropriateness of installation of surveillance cameras. Smoke detection using sensors is relatively easy to deploy and less expensive too.[10]. Wang et. al. [11] combined vision-based algorithm with sensors to give real time accurate results. In comparison to the various technologies already implemented, e-Nose is more effective, less expensive and easy to install. With e-Nose, gas sensor can detect smoke without actually viewing the smoker that is totally without any breach to the privacy of smokers.

III. Design of E-Nose

The work is dedicated to develop e-Nose that is basically an Arduino Smoke Detector which can sense the environment for detecting smoke and produces output voltage. If the level of concentration of smoke particles in the premises reaches a certain threshold indicating some tobacco smoke activity, buzzer sounds and RED LED turns on. If not so the case is, then GREEN LED is on signaling absence of smoke activity.

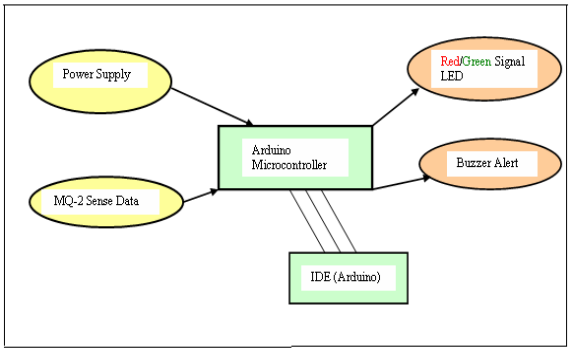

Fig. 1. Design of e-Nose

The core element in the design of e-Nose is the Arduino board as shown in figure 1. Inputs (Power supply and Sensor MQ-2) and the outputs(LEDs, Buzzer) are connected to the Arduino. Sensor senses the ambiance and on the basis of concentration level of smoke particles generates the output voltage. This output voltage is fed to the Arduino board. As the sensor MQ2 detects the ppm of smoke parcticles, it supplies corresponding analogue value to arduino. The concentration value determines the voltage. Arduino converts this analogue value of voltage (range 0-5 V) into corresponding digital 10 digit value (range 0-1023). Arduino program controls the LEDs and buzzer. If the computed digital value is greater than the threshold then Red LED is ON with buzzer sound. Otherwise, Green LED is turned up and no buzzer is triggered.

First up, Hardware components are to be assembled to develop the e-Nose. Components are shown in figure 2.

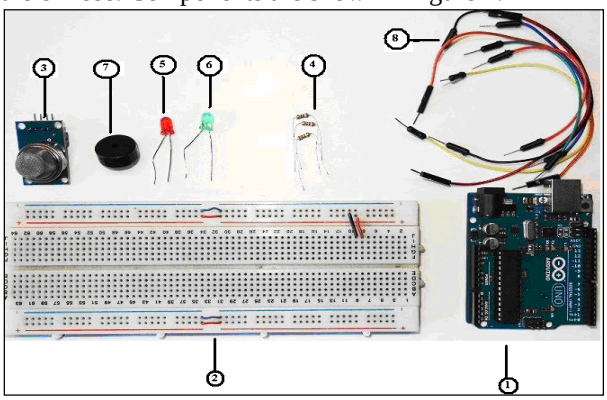

Fig. 2. Components of e-Nose

1. *Arduino UNO & Genuino UNO (Qty:1) [12]*
2. Breadboard *(Qty:1)[13]*
3. MQ-2 Smoke Detection Sensor *(Qty:1)[14,15]*
4. Male/Female Jumper pair *(Qty:1)*
5. 5 mm LED-RED *(Qty:1)[16]*
6. 5 mm LED-GREEN *(Qty:1)[17]*
7. Buzzer *(Qty:1)*
8. Resistor 221 ohm *(Qty:3)[18]*

Arduino UNO & Genuino UNO

It is an open source 8-bit ATmega328 microcontroller with 32KB Flash Memory and 2KB RAM. Figure 3 and Table 1 give complete description about Arduino [12].

Fig. 3. Arduino board [12]

TABLE I
ARDUINO BOARD SPECIFICATIONS [12]

Specification	Description
Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Breadboard

A white solderless breadboard with 2 buses [13] shown in figure 4. all specifications are tabulated under Table 2.

TABLE II
Breadboard Specifications [13]

Pitch: 2.54mm
Rated: 36V/2A
Dimensions:84x53.3x8.3mm
400 tie points with four independent common bus lines
Interlocked for larger projects
Square holes
ABS plastic material and phosphor bronze nickel plated spring clips
Accepts a variety of wire sizes (20-29 AWG)
Completely reusable and no harmful to person and environment

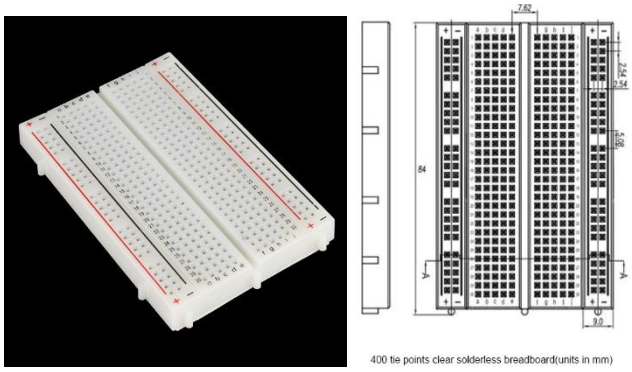

Fig.. 4 Bread board [12]

MQ-2 Smoke Detection Sensor

It is smoke sensitive including SnO_2 and flammable gases like methane, butane, smoke, alcohol etc. Table 3 depicts all specifications of MQ-2. It is supplied with potentiometer to obtain accurate results shown in figure 5.

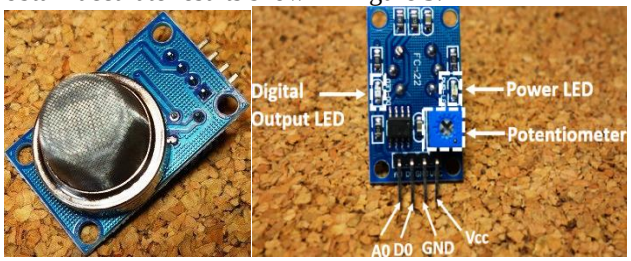

Fig 5 Smoke Sensor MQ-2 [15]

Principle to Work

The working principle of MQ-2 sensor lies in, ohm's law: Voltage= Current X Resistance

Higher the concentration of smoke sensed by MQ-2, resistance increases. More increase in resistance, the output voltage increases shown in figure 6.

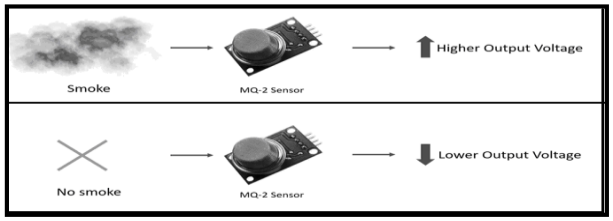

Fig. 6 Gas sensor working principle [14]

TABLE III
MQ-2 Specifications [15]

Model No.			MQ-2
Sensor Type			Semiconductor
Standard Encapsulation			Bakelite (Black Bakelite)
Detection Gas			Combustible gas and smoke
Concentration			300-10000ppm (Combustible gas)
Circuit	Loop Voltage	V_c	≤24V DC
	Heater Voltage	V_H	5.0V±0.2V ACorDC
	Load Resistance	R_L	Adjustable
Character	Heater Resistance	R_H	31Ω±3Ω（Room Tem.）
	Heater consumption	P_H	≤900mW
	Sensing Resistance	R_s	2KΩ-20KΩ(in 2000ppm C_3H_8)
	Sensitivity	S	Rs(in air)/Rs(1000ppm isobutane)≥5
	Slope	α	≤0.6($R_{5000ppm}$/$R_{3000ppm}$ CH_4)
Condition	Tem. Humidity		20℃±2℃； 65%±5%RH
	Standard test circuit		Vc:5.0V±0.1V； V_H: 5.0V±0.1V
	Preheat time		Over 48 hours

MQ-2 is major source of input to the microcontroller. Figure 7 shows the connection with arduino.

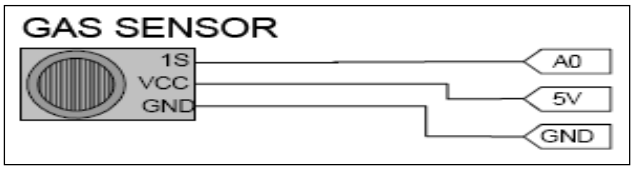

Fig. 7 The Gas Sensor Connection to Arduino Pins.

5 mm LED-RED

The Super Bright Red source color devices shown in figure 8, are made with Gallium Aluminum Arsenide Red Light Emitting Diode. It is controlled by arduino to signal the presence of smoking activity. Table 4 depicts all parameters for Red LED.

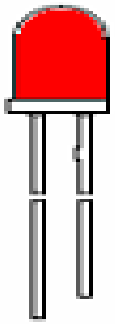

Fig.8 Red LED [16]

Features [16]

- LOW POWER CONSUMPTION.
- POPULAR T-1 3/4 DIAMETER PACKAGE.
- GENERAL PURPOSE LEADS.

- RELIABLE AND RUGGED.
- LONG LIFE - SOLID STATE RELIABILITY.
- AVAILABLE ON TAPE AND REEL.
- RoHS COMPLIANT.

TABLE IV
Red LED Specifications [16]

Parameter	Super Bright Red	Units
Power dissipation	75	mW
DC Forward Current	30	mA
Peak Forward Current [1]	155	mA
Reverse Voltage	5	V
Operating/Storage Temperature	-40°C To +85°C	
Lead Solder Temperature [2]	260°C For 3 Seconds	
Lead Solder Temperature [3]	260°C For 5 Seconds	

5 mm LED-GREEN

The Super Bright Green source color devices shown in figure 9, are made with Gallium Phosphide Green Light Emitting Diode. Arduino controls this led to signal the absence of smoking activity. Table 5 depicts all parameters for Green LED.

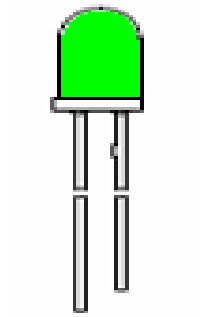

Fig. 9 Green LED [17]

Features[17]

- LOW POWER CONSUMPTION.
- POPULAR T-1 3/4 DIAMETER PACKAGE.
- GENERAL PURPOSE LEADS.
- RELIABLE AND RUGGED.
- LONG LIFE - SOLID STATE RELIABILITY.
- AVAILABLE ON TAPE AND REEL.
- RoHS COMPLIANT.

TABLE V
Green LED Specifications [17]

Parameter	Super Bright Green	Units
Power dissipation	62.5	mW
DC Forward Current	25	mA
Peak Forward Current [1]	140	mA
Reverse Voltage	5	V
Operating/Storage Temperature	-40°C To +85°C	
Lead Solder Temperature [2]	260°C For 3 Seconds	
Lead Solder Temperature [3]	260°C For 5 Seconds	

Buzzer

It is 5 Volt , Breadboard friendly Buzzer as shown in Figure 10. It is a piezoelectric element which is used as an audio signaling device.

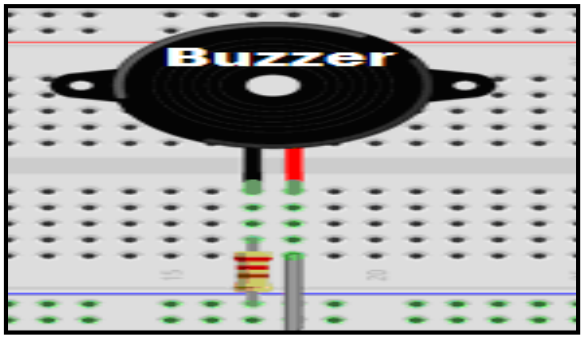

Fig. 10 Buzzer

IV. Experiment and Emulation Set-up

E-Nose is composed of all eight components mentioned in section III. The experimental Set-up involves Assembling of all these components to create e-Nose. The emulation involves devising an algorithm for arduino via IDE to control entire e-Nose.

A. Assembling e-Nose

The Components assembly for e-Nose is shown in figure 11. It clearly shows the pin-connection with the location of MQ-2 sensor mounted on Breadboard with LEDs and buzzer. E-nose is operated by battery power supply. Entire functionality is controlled by arduino and its IDE. The performance of e-Nose is tested for the dectection of cigarette smoke.

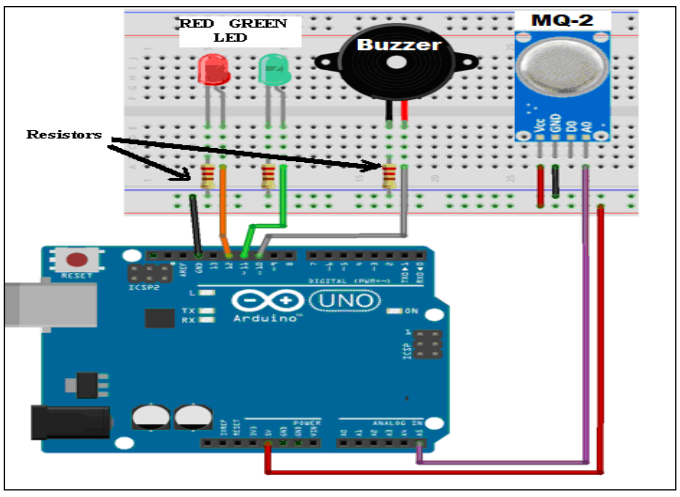

Fig. 11 Components assembling for e-Nose

B. Algorithm

Algorithm_1 is the algorithm shown in figure 12 for e-Nose as it controls the e-nose via arduino IDE. It begins with global definitions, assigning the pins to the sensors and initializing threshold value. Next, at line 6 actual initializations are carried out like mode of sensors and baud rate on serial transmission channel. Then the actual heartbeat is at line 12. Here, it reads sensor readings, writes it to screen and on the basis of these

readings, it responds via the LEDs and buzzer. If the reading is greater than the threshold then, RED SIGNAL with BUZZER ALERT is output via RED_LED as ON, GREEN_LED as OFF and BUZZER_TONE. Otherwise, NO ALERT via RED_LED as OFF, GREEN_LED as ON and NO_BUZZER_TONE. Entire Path flow is traced in flow diagram shown in figure 13.

Algorithm_1 : Algorithm for E-Nose

```
begin Algorithm_1;
Step :1. Make Global Definitions for variables and digital interfaces-pin positions for sensors
1. int smokeThreshold = 400;
2. int redLEDsignal = 12;
3. int greenLEDsignal = 11;
4. int buzzer_Warning = 10;
5. int smoke_Read = A5;
Step :2. Do Initialization: Assign mode for sensors and set baud-rate to the serial transmission
6. void setup()
   begin setup;
7.    pinMode(redLEDsignal, OUTPUT);
8.    pinMode(greenLEDsignal, OUTPUT);
9.    pinMode(buzzer_Warning, OUTPUT);
10.   pinMode(smoke_Read, INPUT);
11.   Serial.begin(9600);
   end setup;
Step :3. Define body of loop
12. void loop()
   begin loop;
13.   int analog_smoke = analogRead(smoke_Read);
14.   Serial.print("Pin A0: ");
15.   Serial.println(analog_smoke);
16.   if (analog_smoke > smokeThreshold)
      begin if;
17.       digitalWrite(redLEDsignal, HIGH);
18.       digitalWrite(greenLEDsignal, LOW);
19.       tone(buzzer_Warning, 1000, 200);
      end if;
20.   else
      begin else;
21.       digitalWrite(redLEDsignal, LOW);
22.       digitalWrite(greenLEDsignal, HIGH);
23.       noTone(buzzer_Warning);
      end else;
24.   delay(100);
   end loop;
end Algorithm_1;
```

Algorithm 1 : Algorithm for E-Nose

```
begin Algorithm_1;

Step :1. Make Global Definitions for variables and digital
interfaces-pin positions for sensors

1. int smokeThreshold = 400;
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rate to the serial transmission

6. void setup()
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7.    pinMode(redLEDsignal, OUTPUT);
8.    pinMode(greenLEDsignal, OUTPUT);
9.    pinMode(buzzer_Warning, OUTPUT);
10.   pinMode(smoke_Read, INPUT);
11.   Serial.begin(9600);
   end setup;

Step :3. Define body of loop

12. void loop()
   begin loop;
13.   int analog_smoke = analogRead(smoke_Read);
14.   Serial.print("Pin A0: ");
15.   Serial.println(analog_smoke);
16.   if (analog_smoke > smokeThreshold)
      begin if;
17.      digitalWrite(redLEDsignal, HIGH);
18.      digitalWrite(greenLEDsignal, LOW);
19.      tone(buzzer_Warning, 1000, 200);
      end if;
20.   else
      begin else;
21.      digitalWrite(redLEDsignal, LOW);
22.      digitalWrite(greenLEDsignal, HIGH);
23.      noTone(buzzer_Warning);
      end else;
24.   delay(100);
   end loop;

end Algorithm_1;
```

Fig. 12 Algorithm for e-Nose (Steps for working)

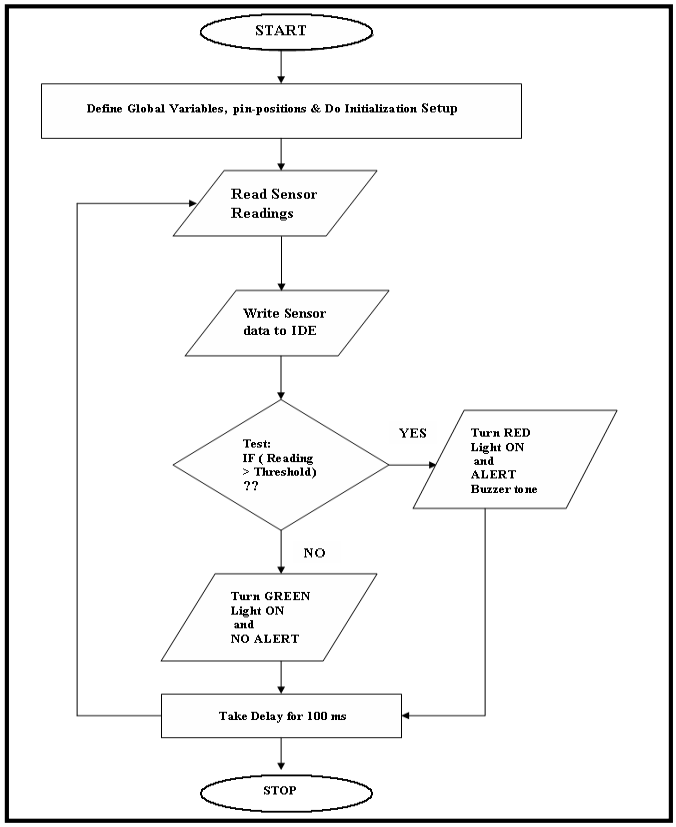

Fig. 13 Work-Flow Diagram for e-Nose

V. Testing Results

The functionality of e-Nose is tested by bringing cigarette & lighter into the scene as in figure 14. Table 6 contains sample readings noted during experiment. Test conducted in three phases. Test_Phase 1: At initial time instant, Green Led illuminates with no buzzer indicating absence of smoking act displayed in figure 15. Test_Phase 2: The burning cigarette brought to the e-nose. It detects the smoke and alerts the smoker/tester with RED signaling and generates warning with buzzer tone. At this phase, indicating presence of smoking act in figure 16. Test_Phase 3: at later time instant, the smoke dissipates with time, then it signals GREEN with no buzzer indicating absence of smoking act as in figure 17. Overall performance is shown in figure 18. It is working with 96.5% accuracy.

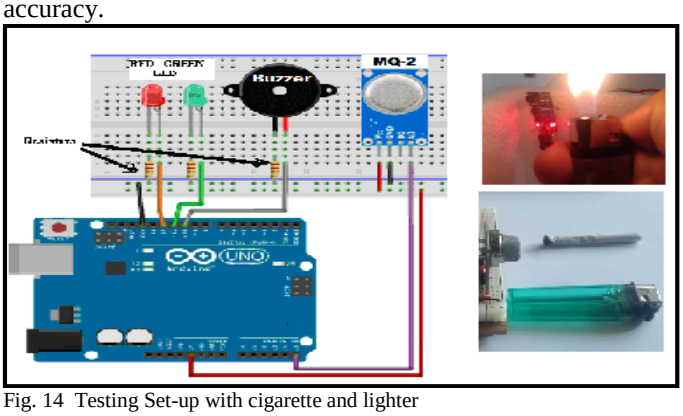

Fig. 14 Testing Set-up with cigarette and lighter

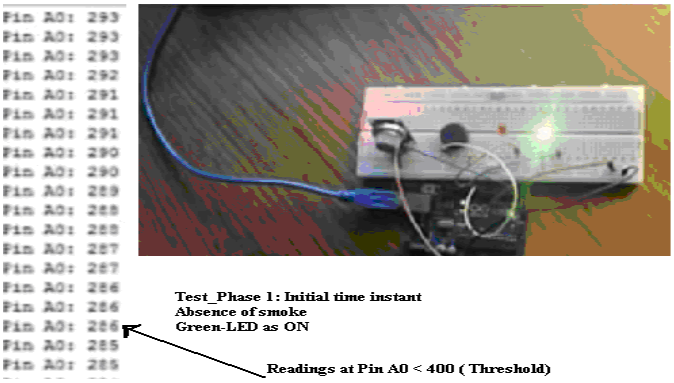

Fig. 15Test_Phase 1: NO Smoke with GREEN LED

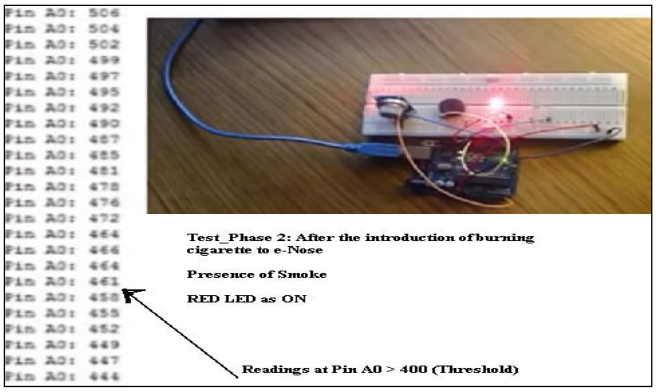

Fig. 16 Test_Phase 2: Smoke ALERT with RED LED

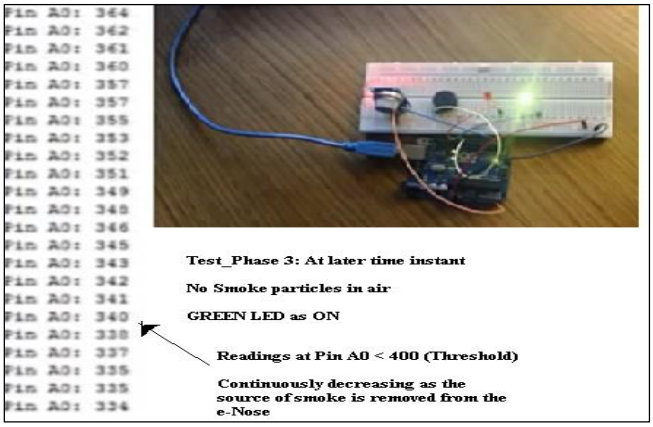

Fig. 17 Test_Phase 3: NO Smoke with GREEN LED

TABLE VI
e-Nose Experimental Results

e-Nose Experimental Results		
Pin A0 :	**Time Instant (mSec.)**	**Sensor Readings**
Pin A0 :	0	286
Pin A0 :	100	285
Pin A0 :	200	285
... .		
Pin A0 :	1200	300
Pin A0 :	1300	355
Pin A0 :	1400	402
Pin A0 :	1500	407
Pin A0 :	1600	430
... .		
Pin A0 :	2100	520
Pin A0 :	2200	524
Pin A0 :	2300	526
Pin A0 :	2400	527
Pin A0 :	2500	526
Pin A0 :	2600	526
Pin A0 :	2700	526
Pin A0 :	2800	525
Pin A0 :	2900	521
Pin A0 :	3000	514
Pin A0 :	3100	512
Pin A0 :	3200	510
Pin A0 :	3300	504
Pin A0 :	3400	502
... .		
Pin A0 :	4200	466
Pin A0 :	4300	461
Pin A0 :	4400	455
Pin A0 :	4500	452
Pin A0 :	4600	449
Pin A0 :	4700	447
Pin A0 :	4800	448
... .		
Pin A0 :	5100	426
Pin A0 :	5200	403
Pin A0 :	5300	400
Pin A0 :	5400	399
Pin A0 :	5500	385
Pin A0 :	5600	382

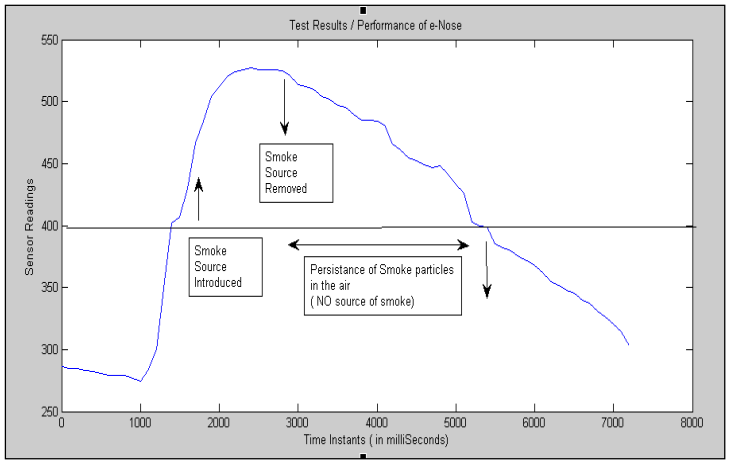

Fig. 18 .Performance plot of e-Nose

VI. Conclusion

In the view of increasing hazards of smoking, e-Nose is essential at public places. This work successfully designed and implemented e-Nose smoke detector with MQ-2 sensor, LEDs and buzzer. Sensor readings correspond to the smoke particle intensity in the air. E-nose fully designed and tested. It performs with more than 96% accuracy. In conclusion, e-Nose is a smart warning to the smokers especially at public places. It gives a buzzer alert with red signal to the smoker which is somewhat affecting his consciences. Rather, forcing a smoker to follow smoking rules verbally, it is a smart and intelligent style of warning. Further, it raises the awareness level among common people. It is effective, less expensive and easy to install. Authorities can implement the e-Nose idea at public places to make people aware about the health hazards caused by smoking. This model can further be enhanced with multiple sensors and machine learning algorithms.

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[15] Datasheet MQ-2 Semiconductor Sensor for Smoke, 2-4.
[16] Datasheet, LED, WP7113SRD/D, Super Bright Red, 1-6.
[17] Datasheet, LED, WP7113SGC, Super Bright Green, 1-6.
[18] Datasheet, Resistors, MFR Series, 1-3.