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E-Nose using Genetic Algorithm

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ABSTRACT: *Electronic nose is an instrument which is use for automatic detection and classification of odors and gases. An electronic nose is generally composed of a chemical sensing system (array of sensors). This system is used for automatic identification of volatile chemicals for environmental, medical applications, commercial industries, including the agricultural, biomedical, cosmetics, food, manufacturing, military, pharmaceutical, regulatory applications and various scientific research fields. This paper is about development of e-nose using genetic algorithm, comparison of traditional e-nose system and intelligent e-nose system.*

Keywords *- Artificial intelligence, e-nose, Genetic algorithm.*

I. INTRODUCTION

The E-Nose System present in this research is based on the comparison of different approaches. It compares two results to get the output from sensor with traditional approach and with using artificial intelligence that is with genetic algorithm. The input taken by sensor which is in the form of analog signal get converted in digital form with the help of analog to digital converter present in the microcontroller which used in the system. Then apply Genetic Algorithm to get optimized output from the population of input and then that optimized output get compare with the standard results of sensors. Compares the output with traditional approach. People have invented many advanced technologies to make the life easier and more colorful. They have the air conditioner to adjust the temperature of their house, they have the car to walk, they have the telephone to talk with families and friends, they have the refrigerator to keep food fresh, they have the microwave and the oven to cook food easily, and they have computer and Internet to relax and have fun, etc. It seems that there are no worries in their lives. However, just because of the fast developed technologies, their lives become more dangerous. More technologies may bring their health more harm. Now the number of people who got the cancers increases greatly, some people may use the technologies negatively to harm the others, like the invention of poisonous gas or dangerous bomb. Therefore, the biggest concern for people now is about their health and security. Now they need another advanced technology to help them detect the danger, whether the bacteria or other poisonous element around them. The solution for this problem should be the electronic nose which can be applied to the health and security field to ease people's concern.Although our product is called electronic nose, it does not look like our human being's nose, but it functions similar to our nose[1].

II. SYSTEM DESCRIPTIONS

2.1. SYSTEM STRUCTURE

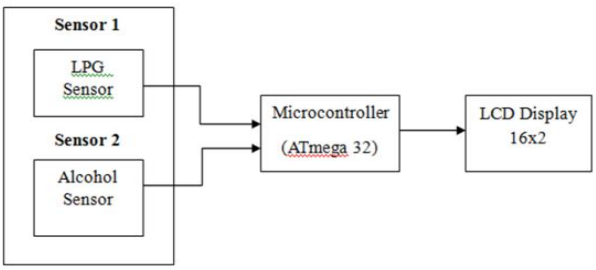

Figure 1. E-nose block diagram

Above Fig. 1 shows the basic block diagram of the system in those two sensors is shown sensor 1 is a LPG sensor and sensor 2 is the Alcohol sensor. When sensor senses the molecules of LPG and Alcohol in environment it produces analog output. That analog output then converted in digital form by using ADC present in the microcontroller. How it will convert is explain in the following explanation. After that by applying GA we will find final output and will show on the LCD.

2.2 Conventional Approach for E-nose

In traditional Electronic Nose, An electronic nose is an instrument, which discriminates odours by analyzing partially selective gas sensor array data with pattern recognition methods [3]. In previous approach where sensor technology used the pattern recognition system just like the figure print analysis, take one solution compare with database and on the basis of database sample it generate the output. Another approach is using Artificial Intelligence, in this approach the system take its own decision on the basis of previous experience just like human being do. In this system we are using GA to give intelligence to the system. GA are probabilistic (stochastic) and not deterministic. It is adaptive and able to deal with highly nonlinear models and noisy data and. It can rapidly check the solution set. GA does not need gradient information or smooth functions to estimates the solutions. In practical purposes they appear to work best in combination to optimize the parameters. GA starts with an initial random population and allocates population of possible solutions to the regions of the search space. How GA is work we will discussed in the following section.

2.3 Working Principle of Genetic Algorithm

GA was first developed by John Holland and is mainly used in search and optimization process and also an effective technique for machine learning applications. GA is called 'blind' because they have no knowledge of the problem. It based on the scheme of natural selection. They can be parameterized in such a way for solving optimization problems that is based on natural selection. In nature, GA attempts to copy the natural principle by coding the possible alternative solution of a problem, which features similar to chromosome. In general, chromosomes are any point that is applied to the fitness function. Fitness function is an objective function we want to minimize. Each chromosome is assigned a 'fitness score' according to how good a solution to the problem it provides. Chromosomes consist of a string of gene. The genes can be bits, integers, or any data structure. The chromosome is also called individual and structure. All possible solution to a given problem can be represented as population. In other words, a population is an array of individuals. In every iteration the genetic algorithm performs a series of computations on the current population to produce a new population. Each successive population is called a new generation. Since the different individual has to be evaluated and compared again to each other, the concept of fitness is introduced. The fitness value is the value of a particular solution.

2.3.1 Genetic Algorithm Operator [4]

The operation of GAs begins with a population of random strings representing design or decision variables. The population is then operated by three main operators reproduction, crossover and mutation to create a new population of points. GAs can be viewed as trying to maximize the fitness function, by evaluating several solution vectors. The purpose of these operators is to create new solution vectors by selection, combination or alteration of the current solution vectors that have shown to be good temporary solutions. The new population is further evaluated and tested till termination. If the termination criterion is not met, the population is iteratively operated by the above three operators and evaluated. This procedure is continued until the termination criterion is met. One cycle of these operations and the subsequent evaluation procedure is known as a generation in GAs terminology. The operators are described in the following steps.

1) Reproduction
2) Crossover
3) Mutation

1) Reproduction

Reproduction (or selection) is an operator that makes more copies of better strings in a new population. Reproduction is usually the first operator applied on a population. Thus, in reproduction operation the process of natural selection causes those individuals that encode successful structures to produce copies more frequently. To sustain the generation of a new population, the reproduction of the individuals in the current population is necessary. For better individuals, these should be from the fittest individuals of the previous population.

2) Crossover

A crossover operator is used to recombine two strings to get a better string. In crossover operation, recombination process creates different individuals in the successive generations by combining material from two individuals of the previous generation. In the crossover operator, new strings are created by exchanging information among strings of the mating pool. The two strings participating in the crossover operation are known as parent strings and the resulting strings are known as children strings. A crossover operator is mainly responsible for the search of new strings even though mutation operator is also used for this purpose sparingly. Many crossover operators exist in the GA literature. One site crossover and two site crossover are the most

common ones adopted. A one site crossover operator is performed by randomly choosing a crossing site along the string and by exchanging all bits on the right side of the crossing site as shown in Fig. 2

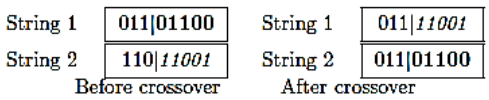

Figure. 2. One site crossover operation

In one site crossover, a crossover site is selected randomly (shown as vertical lines). The portion rights of the selected site of these two strings are exchanged to form a new pair of strings. The new strings are thus a combination of the old strings. Two site crossovers is a variation of the one site crossover, except that two crossover sites are chosen and the bits between the sites are exchanged as shown in Fig. 3. One site crossover is more suitable when string length is small while two site crossovers are suitable for large strings. Hence the present work adopts a two site crossover. The underlying objective of crossover is to exchange information between strings to get a string that is possibly better than the parents.

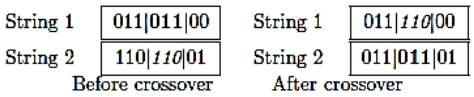

Figure.3 Two site crossover operation

3) Mutation

Mutation adds new information in a random way to the genetic search process and ultimately helps to avoid getting trapped at local optima. It is an operator that introduces diversity in the population whenever the population tends to become homogeneous due to repeated use of reproduction and crossover operators. Mutation may cause the chromosomes of individuals to be different from those of their parent individuals.

Mutation in a way is the process of randomly disturbing genetic information. They operate at the bit level, when the bits are being copied from the current string to the new string, there is probability that each bit may become mutated. This probability is usually a quite small value, called as mutation probability pm. A coin toss mechanism is employed; if random number between zero and one is less than the mutation probability, then the bit is inverted, so that zero becomes one and one becomes zero. For example, the following population having four eight bit strings may be considered:

01101011
00111101
00010110
01111100.

It can be noticed that all four strings have a 0 in the left most bit position. If the true optimum solution requires 1 in that position, then neither reproduction nor crossover operator described above will be able to create 1 in that position. The inclusion of mutation introduces probability pm of turning 0 into 1. These three operators are simple and straightforward. The reproduction operator selects good strings and the crossover operator recombines good sub-strings from good strings together, hopefully, to create a better sub-string. The mutation operator alters a string locally expecting a better string.

2.4 Flow Chart of Working Principle

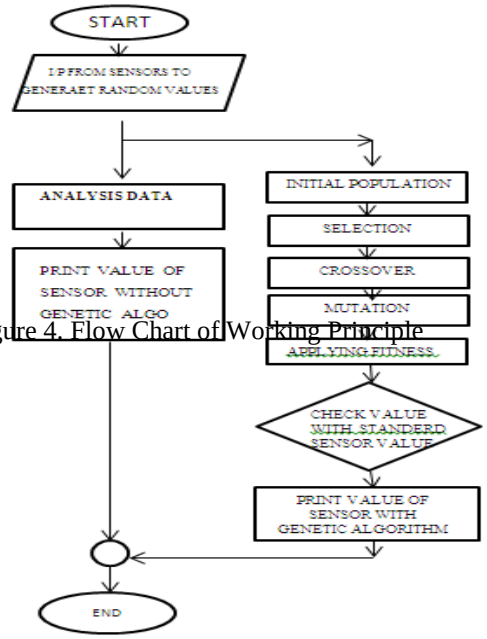

Figure 4. Flow Chart of Working Principle

III. RESULTS AND DISCUSSION

3.1 Deriving Gas concentration from Output Voltage

1) LPG Sensor

Here is a the equation which convert analog output to PPM gas concentration
PPM = Analog Voltage in mV x 2
Example: Gas sensor voltage is giving output as
2500mV (2.5V) So the gas concentration in PPM = 2500x2 = 5000 PPM
Base on above equation some standard results are as follows:

PPM	200	300	500	1000	2000	3000	5000
Voltage (mV)	100	150	250	500	1000	1500	2500

Table 1. Standard result of LPG Sensors

2) Alcohol Sensor

Here is a the equation which convert analog output to mg/L gas concentration
mg/L = Analog Voltage in mV x 0.002
Example: Gas sensor voltage is giving output as
2500mV (2.5V) So the gas concentration in mg/L = 2500x0.002 = 5 mg/L.
Base on above equation some standard results are as follows:

mg/L	0.2	0.3	0.5	1	2	3	5
Voltage (mV)	100	150	250	500	1000	1500	2500

Table 2. Standard result of Alcohol Sensors

Following Fig. 5 is showing the experimental setup and different components used in the experiment

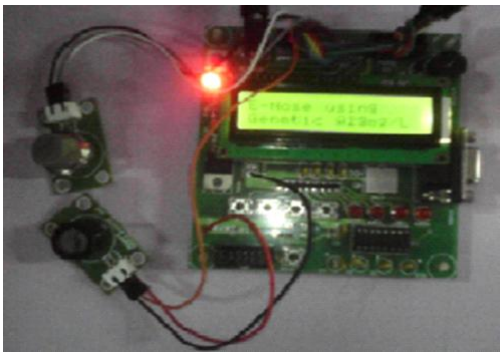

Figure. 5 Experimental Set up

3.2 Graphical Representation

3.2.1 LPG Sensor

	w/o GA (PPM)	With GA (PPM)
Sample 1	300	360
Sample 2	1000	1011
Sample 3	2000	2023
Sample 4	3000	3036

Table 4. Values obtained by LPG sensor at different samples

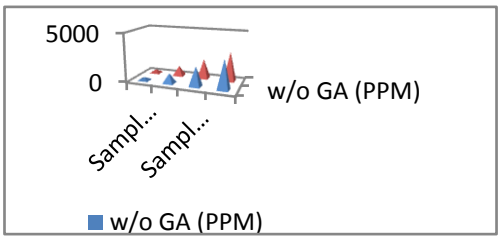

Figure. 6 Graphical representation of LPG sensor

3.2.2 Alcohol Sensor

	W/o GA (Mg/L)	With GA (Mg/L)
Sample 1	1.21	1.3
Sample 2	1.23	1.35
Sample 3	3.23	3.35

Table 5 Values obtained by Alcohol sensor at different samples

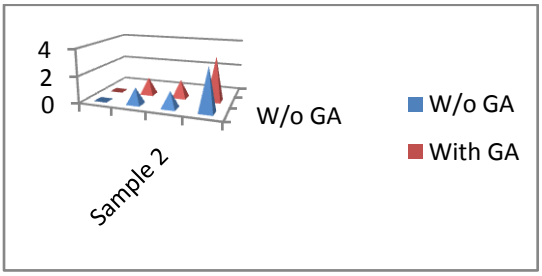

Figure. 7 Graphical representation of Alcohol sensor

IV. CONCLUSION

The experiment Development of E-Nose is about to find out the part per million molecules of LPG and Mg/L Alcohol molecules present in the atmosphere. For that the system is using two approaches, one is tradition approach in that the value get by sensor is directly display another one in that the Artificial intelligence is applied by using Genetic Algorithm on obtained values, and after observation it is conclude that the output obtained by applying genetic algorithm is more optimized than the traditional approach with respect to the standard values of sensors output. And the E-nose is working successfully.

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