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Design of E-Nose for Allergic Determinations using SNN for SOC Implementation

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Abstract— Recognizing there is still a long journey ahead until a truly artificial nose is designed to refine and enhance current detection capabilities by integrating an interferent filter and a gas chromatograph to eliminate interference effects. Gas sensors used in electronic noses are based on broad selectivity profiles that mimicks the responses of olfactory receptors in the biological olfactory system. The basic building blocks of a generic electronic-nose systems include sample delivery, sensor chamber, signal transduction and acquisition, data pre-processing, feature extraction and feature classification. In conventional systems, the processing module is a personal computer separated from the remaining parts of the system. In this context, our work involves sensors connected to ADC system which converts received analog signals from sensors to digital signals. These digital signals then sent to CPU in which Signal processing is done. The output results from CPU send to digital display system to show the results.

Index Terms— Electronic nose, gases, LPC2148, sensing system.

1 Introduction

Olfaction is not only essential to human beings but has recently also become of interest to industry. An electronic nose is an instrument which comprises an array of electronic chemical sensors with partial specificity and an appropriate pattern recognition system, capable of recognizing simple or complex odors [7]. It is based on the fact that flavour, odour and volatile compounds are recognized through the sense of smell. The ability to reliably measure and quantify factors such as impurities, taints and adulteration are the reasons why industries favour electronic nose in ensuring product quality consistency. It also holds many advantages over other methods which includes; (1) rapid, real-time detection of volatiles; (2) lower costs; and (3) automation.

In a portable E-Nose system, learning and classification algorithms play important roles. Since system operation time is usually limited by the sensor responding time rather than data recognition [1], [5], the calculation speed of the algorithm is not a vital concern, but power consumption is substantially more critical.

The biological system is highly energy efficient, and our inspiration from it can help us to design a low- power classification algorithm. Furthermore, the E-Nose will be composed of hundreds of thousands of sensors in the future. To contend with the problem of such high dimensions, a biologically plausible algorithm is more sufficient. To make the artificial system as reliable as a biological system, many researchers have investigated how biological systems work, and have constructed a similar system using artificial neurons operating with action potentials and other bio-inspired characteristics to perform learning and classification tasks [7].

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These neural networks are called spiking neural networks (SNN). Implementing an SNN by Very Large Scale Integration Technology may reduce the power and silicon area of the chip [1]. For greater mobility and longer battery usage time, the power and the size of an E-Nose are crucial concerns. The aim of this work is to develop and implement an E-nose system for SOC. The remainder of this paper is structured as follows: Section 2 gives the literature survey. Section 3 introduces the proposed method and implementation of the circuit blocks. Section 4 presents the results and discussion. Section 5 offers the conclusions and future work.

2 Literature Survey

Hung-Yi Hsieh and Kea-Tiong Tang proposed SNN based E-Nose system to classify odor. This paper describes the design, simulation, fabrication, and test of an SNN chip implemented in 0.18 μm complimentary metal-oxide-semiconductor (CMOS) technology [1]. The SNN takes advantage of subthreshold oscillation and onset-latency representation to reduce power consumption and chip area, providing a more distinct output for each odor input. The proposed SNN chip is suitable for future integration in an E-Nose system-on-chip. John J. Wade and Heather M. Sayers proposed "SWAT", a Spiking Neural Network Training Algorithm for Classification Problems [5]. This paper presented a training algorithm specific to SNN topology which classifies data represented by spike trains. SWAT demonstrates good generalization and noise immunity. Results also show that SWAT can classify complex datasets. Iman Morsi proposed E-Nose system with artificial intelligent techniques for gases identification. Electronic nose is the intelligent design to identify food flavors, cosmetics and different gas odors, depending on sensors. The continuous developing of these sensors permit advanced control of air quality, as well as, high sensitivity to chemical odors. Accordingly, a group of scientists have worked on developing the properties of sensors, while others have modified ways of manufacturing ultra low-cost design sensors. In the design of an electronic nose, sampling, filtering and sensors module,

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signal transducers, data preprocessing, feature extraction and feature classification are applied. Fengchun Tian and Simon X. Yang proposed the detailed description on circuit and noise analysis of odarant gas sensors in an E-Nose. Electronic noses (e-noses) are more and more widely used in environmental monitoring, food production and medicine such as odour evaluation. The response of all sensors in the e-nose together constitutes a unique profile that gives the "fingerprint" of odor. The noises from the sensor array comprised by several odorant gas sensors may result in inaccurate cluster analysis of the tested material. In our experiments, it is observed that the noise of gas sensors cannot be ignored. In the worst case, the noise magnitude could become up to 20% of the signal magnitude of some sensors.

3 Proposed Method and Its Implementation

The proposed method is carried out with following objectives.

1. Odor will target on GAS sensor arrays
2. SENSOR OUTPUT is converted into digital before processing
3. Digital output of ADC(Analog to Digital Converter) is given to CPU for signal processing
4. In CPU(Central Processing Unit), signals are analyzed and classified
5. Output is display in the LCD (Liquid Crystal Display) display.

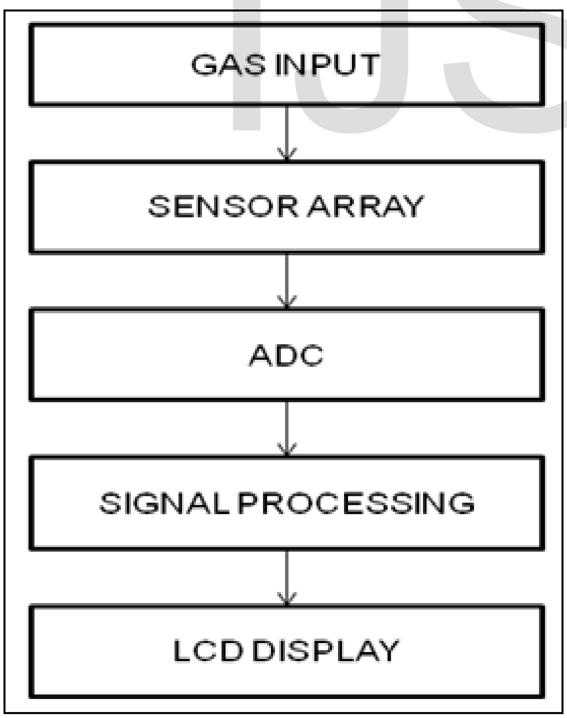

Fig.1 Architecture of E-Nose

The major components include an electrochemical type carbon monoxide (CO), ethane (C_2H_6) and methane (CH_4) gas sensors that senses the presence of gas in the air.The sensor output is given to the ADC unit used for converting analog signals into digital, to linearize the values and to display the gas concentration in terms of PPM. Then the values are fed to the MCU for the signal processing. Also the classification and coding mechanisms are coded into MCU so that this setup serves the purpose of warning the user so as to protect smelling from gases.The various modules of this method are described below:

3.1 Gas Sensing Element

The constant DC voltage obtained from the power supply enables the sensor. The sensor consists of sensing element (CO, CH_4, C_2H_6 gas senor) and a transmitter. The sensor consists of two electrodes and a filter that lets in only the corresponding gases. When the particular gas passes into the chamber, it constitutes a current flow between electrodes and the amount of current is proportional to the number of particular gas ions.
MQ-series gas sensors are well suited to get the flavours peak individually. MQ series sensors are High Sensitivity, Simple driving Circuitry, Compact, portable and low cost.

TABLE 1
Gas Sensors Used In Electronic Nose

Sensor	Sensitive to
MQ-3	Alcohol
MQ-4	Methane
MQ-6	LPG, Propane
MQ-7	Carbon monoxide
MQ-8	Hydrogen

3.2 Signal Processing and display unit

A Microcontroller Unit consists of ADC which is used for converting the analog values into a digital value. The output from the sensor is converted into corresponding voltage using the voltage follower circuit. The voltage obtained is given to the ADC which then generates 10-Bit value. The 10-Bit value is then linearized and converted into PPM levels. This values are sent to the MCU where the signal processing will be done. The use of embedded technology provides several interesting benefits: an abstraction layer for signal acquisition and control, high level programming of the signal processing algorithms, hardware for interfacing various types of displays, etc. A small data-acquisition and relay board provides sufficient I/O to control the e-nose and acquire the signals. The ARM processor [LPC2148] is programmed using Keil uVision-4 software so as to display the classification of the input samples in the LCD display based on the threshold values. The threshold values can be varied depending upon the concentration of the

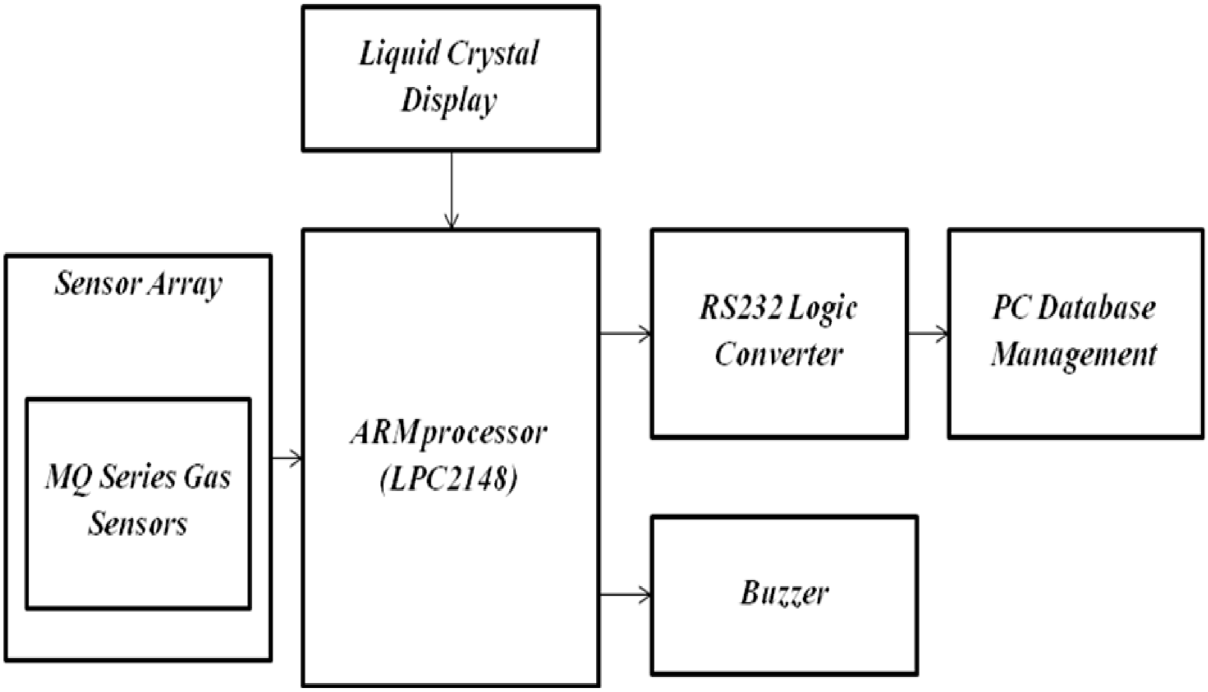

FIG.2 PROPOSED SYSTEM IN BLOCK REPRESENTATION

gases. The concentration of the gases in terms of PPM/PPB and the threshold value of the input samples will also be displayed in the LCD. The buzzer sounds used to indicate the varying concentration of the input samples.

3.3 ARM[LPC2148]

The LPC2148 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded outline support, that combine the microcontroller with embedded high- speed flash memory ranging upto 512 kB. A 128-bit wide memory interface and sole accelerator architecture enable 32-bit code execution at the highest clock rate. For critical code size applications, the another 16-bit Thumb mode reduce code by more than 30 % with minimum performance penalty Due to their tiny size and low power consumption, LPC2148 are perfect for applications where miniaturization is a key necessity, such as access control. Serial communications interfaces ranging from a USB Full-speed device, multiple UARTs, SPI to I2C-bus and on-chip SRAM up to 40 kB, build the devices very well suited for communication gateways and soft modems, protocol converters, voice recognition and low end imaging providing equally large buffer size and high processing power.

4 RESULTS AND DISSCUSSIONS

The gas samples are given to the sensors, which feeds the analog samples to the ARM processor. The samples are then preprocessed and normalized by the algorithm, and categorized to distinguish the response of Electronic Nose. The algorithm helps to measure and attain results that could be presented in simple two- dimensional plots. The main purpose of this analysis is to monitor the gas availability in the environment and its results are plotted can be seen in graph and as well their value for every time second. The measurement result is described in Fig.3.

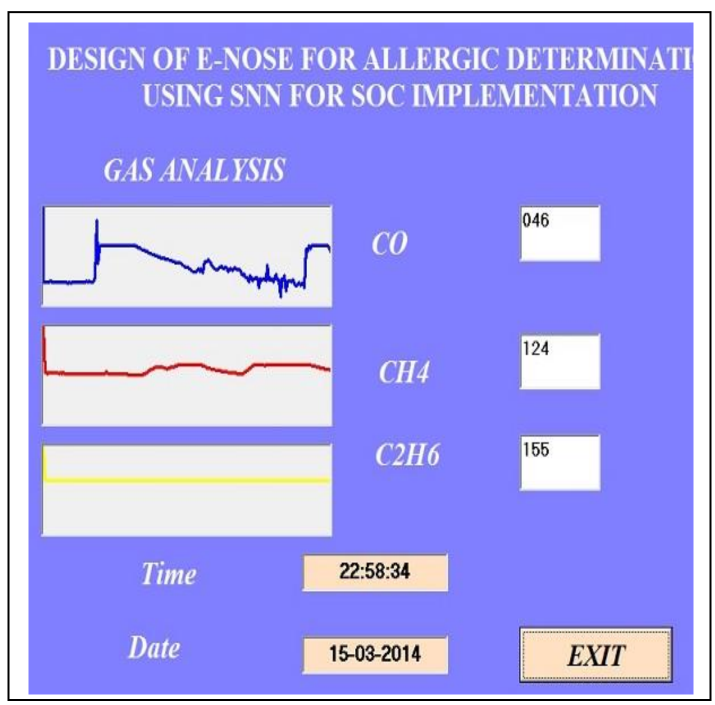

FIG.3 GAS ANALYSIS USING E-NOSE

5 Conclusion and Future Work

The proposed work involves the implementation of E-Nose system for SOC to provide high-level information to make decisions about each gas achieved by using efficient and affordable sensor. An enormous data collected allows analyzing and characterizing of different gases. The proposed system mainly used to take necessary precautions against smelling dangerous gases. This method allows better monitoring , reliability and time conserving and thus reducing the extra hardware cost and biological system efforts. The future work involves increasing the sensor array with accurarcy.

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