Electronic Nose: A Non-Destructive method based Fruit Ripeness Determination

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Abstract

Electronic nose or an artificial nose mimics the behaviour of human nose i.e., can be used to interpret flavour or odour of many food items. The aim of this paper is to develop an electronic nose that can be used as non-destructive instrument to measure the fruit maturity considering Ethylene as the key component. The fruit chosen for the study is tomato. The major application of this study would be to insert the E-Nose at the fruit boxes to monitor continuously the concentration of ethylene to detect the fruit ripeness during shipment.

Keywords: *Electronic Nose, Ethylene gas sensor, Non-Destructive method.*

I. Introduction.

One of the main concerns of the food industry is the systematic determination of fruit ripeness under-harvest and post-harvest conditions, because variability in ripeness is perceived by consumers as a lack of quality. Most of the traditional methods that have been used to asses fruit ripeness are destructive and thus cannot be so readily applied. Some of these methods [1] rely on:

- Fruit firmness - uses penetrometer or an impact force
- Colorimetry - uses some fruit cultivars
- Measuring the level of chemical species - uses pH values, titratable acidity and soluble solid contents

In this paper, we have introduced a new method of determining the fruit ripeness using ethylene gas vapour emitted by the fruit during its various ripening stages. Although the human nose is often more sensitive to odour than an electronic nose, this new technology provides a lot of advantages. E-Nose attempts to do same as the human olfactory sensor which transmits the signals (odour) to the brain which then interprets what it is with few sensors and a processing element. The other industries which use this E-nose are environment monitoring, tobacco industry, medical diagnostics and so on.

II. Related work.

There are numerous approaches followed to assess the quality of the fruits using E-Nose. In this paper we have made a comparative study of various assessment techniques. The rest of the section is organized as follows: section A deals with review based on sensors and section B deals with review based on analysis.

A. Review based on sensors.

The artificial sensors which consists of an array of gas sensors with different selectivity pattern [2] mimics partially the human sensory sensory system. The Smart Sensor Networks [3] which has its potential applications ranging from vineyards to equipment maintainance. Here Bluetooth is proposed as possible communication standard and also have performed case studies in the deployment of the smart sensor in the wine industry and the chill chain(issues for the manufactures of frozen foods like meat and poultry). The different sensor types, its principle of operation, fabrication methods, sensitivity ranges, advantages and disadvantages of metal oxide sensors, quartz crystal microbalance, surface acoustic wave and MOSFET sensors in [4]. The quality of the apples have been assessed by using three different sensors [5] in which the first sensor namely NIR is capable of performing the local measurements on one physical property of the fruit(sugar content) and the second one namely MV is capable of performing global measurements on other physical properties of the fruit (colour, shape, size and aroma)and EN, the third sensor combines the measurement of other sensors to improve the accuracy of quality assessment. E-Nose system for the characterization and classification of honey from different geographical regions [6] have employed the use of an array of 10 MOSFET sensors and 12 MOS sensors which were capable of generating a pattern of volatile compounds present in the honey samples. The sensor responses were evaluvated in both statistical and neural network methods.

B. Review based on analysis.

The combined use of E-Nose and E-tongue [7] to test the performance of potato chips and potato creams classification problem and they have used Radial Basis Function (RBF) Neural Nett algorithm to obtain better results. A real time shell monitoring [8] of black tea during fermentation process have used Time-delay neural network (TDNN) architecture for small peak prediction on time series data obtained from electronic nose. The ripeness of apple using simple E-Nose [9] and the classification has been done using neural networks (fuzzy ARTMAP, LVQ and MLP) to classify the samples into three states of ripeness with 100% accuracy. Out of the these three methods, fuzzy ARTMAP was found to be the best classifier in the presence of Gaussian Noise.

III. Implementation.

The major components include an electrochemical type Ethylene (C_2H_4) gas sensor that senses the presence of ethylene gas in the air. The sensor output is given to the Microcontroller unit used for converting analog signals into digital, to linearize the values and to display the ethylene gas concentration in terms of PPM. Also classification and coding mechanisms are coded into MCU so that this setup serves the purpose of warning the user a large concentration of ethylene in ripening room to avoid spoilage.

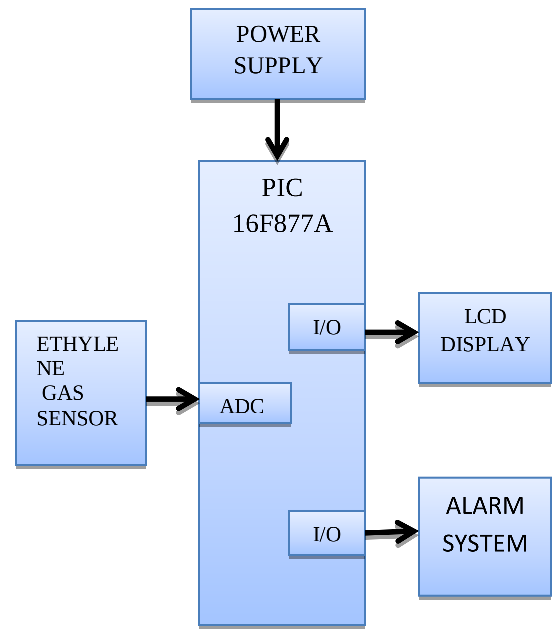

Fig.1 Block diagram of E-Nose using PIC16F877A

The various modules of this system are described below:

- Sensing Element

The constant DC voltage obtained from the power supply enables the sensor. The sensor consists of sensing element (Ethylene gas sensor) and a transmitter. The sensor consists of two electrodes and a filter that lets in only ethylene. When ethylene ion passes into the chamber, it constitutes a current flow between electrodes and the amount of current is proportional to the number of ethylene ions. This current gives rise to voltage. The 4-20 mA transmitter converts the voltage output into current in the range of 4-20 mA. In standard specifications of transmitter, the 4mA corresponds to the zero level and the 20mA corresponds to the highest level.

- Processing and display unit

A MCU is used for converting the analog values from sensor into a digital value, an ADC peripheral inside the microcontroller is used for this purpose. The output from the sensor is converted into corresponding voltage using the following circuit:

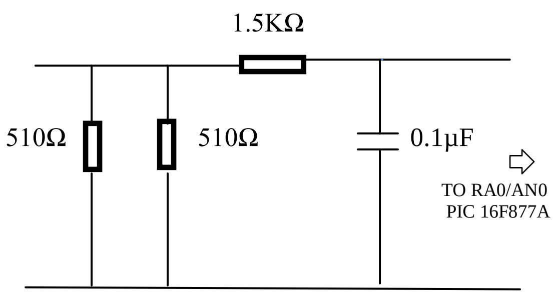

Fig.2 Conversion of current to voltage

The voltage in the range of 1.02mA-5.1mA is given to ADC which then generates 10-Bit value corresponding to the input voltage. The 10-bit value is then linearized and converted into PPM levels.

The PIC16F877A is programmed using MPLAB software such the classification of the input samples can be displayed in the LCD based on the threshold values which can be varied depending upon the ethylene concentration of the input samples. To facilitate this, two switches are employed which helps in varying the threshold manually. The LCD is programmed in such a way that varying ethylene concentrations of the sample will be displayed in terms of PPM and the threshold value for the input sample will also be displayed. The various buzzer sounds indicates the varying ripening levels of the input sample.

IV. Results & Discussion.

This system provides the strategies to stabilize the supply of tomato as it consists of numerous problems while exporting and importing. Using ethylene gas sensor along with microcontroller the ethylene concentration of the tomatoes are effectively determined than the previously available techniques and accordingly the ripening stages are classified as over-ripe, Ripe and un-ripe. The proposed non-destructive system using Ethylene gas sensor can be used for any kind of fruits since all the fruits emit ethylene while they ripe. Also has >90% accuracy and compactness.

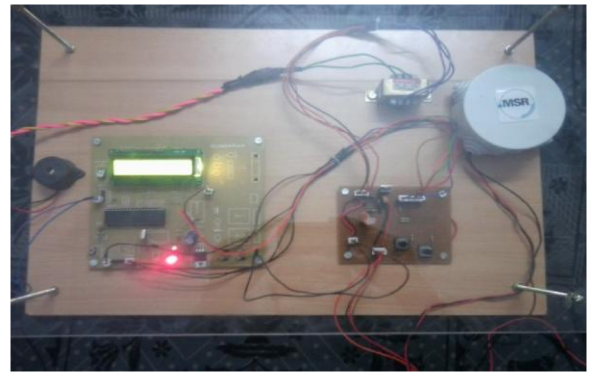

Fig.3 Prototype model of the proposed system using Ethylene gas sensor.

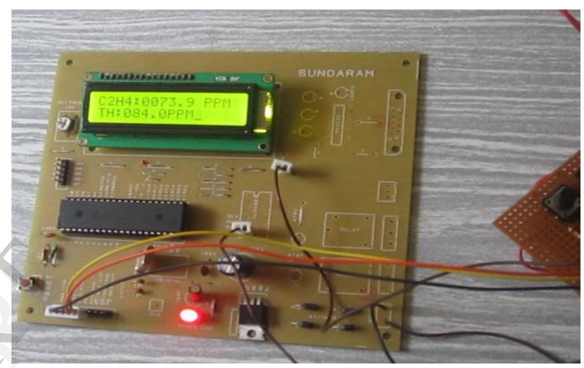

Fig.4 Output with PPM values on the LCD display.

V. Conclusion.

The concentration of ethylene varies at the different stages of fruit ripening and it has to be controlled at the minimum because it also stimulates ripening which leads to over-ripe and get soiled. Thus, we provided an effective and successful solution to this problem using an E-Nose consisting of Ethylene gas sensor and PIC Microcontroller so as to maintain the level of ethylene which retards spoilage, reduces loss in shipping environment.

VI. References.

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