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E-nose: The Food Spoilage Detector

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Abstract—*In this article, we propose a method for detecting and clearing food spoilage issues by observing the variation in electrical properties in sensors is recorded by computing system of E-nose with the help of microcontrollerATmega16A. Electronicnose (E-nose) system that employs an array of gas detectors each tailored to respond differently to a range of odours has been presented. On introduction of any gaseous compound, the sensors respond by giving a particular fingerprint that is analysed in signal transduction process. Food spoilage detection system consists of gas sensor units, microcontroller, memory unit, control unit, display unit and alarm unit. A variety of different mechanisms operates gas sensing cells. Each gas sensor unit is further divided into array of gas sensors and these arrays produce electrical signals which are directly proportional to the amount of gases. The data collected from electronic-nose (E-nose) devices is used to identify specific type of information about chemical nature of samples under investigation using fingerprint profiles of gaseous mixtures containing volatile organic compounds released from the food.*

1. INTRODUCTION

Microbial spoilage is a major problem in bakery products since it can induce nutritional losses, off-flavours, and formationof mycotoxins or potentially allergenic spores we have to store food (like fruits, vegetables etc.) in cold storage for future use. If suitable environment (proper temperature, humidity etc.) is not maintained in the storage area, after some time due to growth of micro-organisms, chemical reactions and various other factors, food get spoiled. Due to the presence of enzymes in food and growth of bacteria, some chemical changes occur in food. Due to these chemical changes, some gases produce like Carbon dioxide (CO2), Ammonia (NH3), Methane (CH4), Hydrogen sulphide (H2S). As the time passes, the decomposition goes ahead and the concentration of these gases increases in the storage environment. By using different gas sensors, detection of concentration of these gases in air can be done. By monitoring the concentration of these gases, we can estimate the quality of food kept in store. This detector detects the amount of some specific gases present in the air of storage area in which food is stored and alarms us about the changes in the ratios of these gases. This work introduces a novel approach towards identifying specific gaseous mixture of volatile chemical compounds rather than individual chemical compound present in a sample of mixtures.

2. LITERATURE REVIEW

As time passes during the storage of food, due to the chemical reactions involving enzymes and activities of micro-organisms, deterioration of food starts. Some gases are produced during the phenomena of food deterioration.[1] Thus ratio of gases present in air changes. Using gas sensor arrays monitoring of these gases can be done. [2][3] Different types of gas sensor arrays are available for the measurement of quantity and analysis of these gases. [4][5] By monitoring the changes in the amount of these gases suitable patterns are obtained. By studying these patterns we can detect the phenomena of food spoilage. [6] Different types of microcontrollers can be used for the monitoring and calculation purpose. These microcontrollers can be programmed to control required devices and trigger alarm.

3. PROPOSED ARCHITECTURE FOR FOOD SPOILAGE DETECTION SYSTEM

Detection of food spoilage phenomena should be quick and reliable. Recent studies using electronic noses (gas sensors based electronic systems) have shown this type of technology very effective in detecting spoilage in several food products. Analysis time is normally of the order of a few seconds making this type of technology ideal for the detection of food spoilage. Where e-noses use robust mass spectrometry technology that is unaffected by moisture in the sample, ambient humidity or ambient temperature fluctuations, this system also possess these qualities along with a wide range of applications related to food storage.

Spoilage is the process in which microorganism, bacteria and various enzymes under the favourable conditions of moisture and temperature, performs chemical reactions with the food and finally deteriorates it.

4. INTRODUCTION TO E-NOSE

E-nose can be defined as arrays of sensors able to generate electrical signals in response to volatile organic compounds present in gaseous sample. They can also determine various characteristics properties of the odour. Data obtained from e-nose devices provides specific information about the chemical nature of the sample using the aroma of gaseous mixture

containing volatile organic compounds. An E-nose device identifies specific gaseous mixtures includingorganic or inorganic chemicals rather than Identifying individual chemical compounds.

5. NEED OF E-NOSE

Electronic nose is comparatively cheaper than human sniffers. Detection of hazardous gases is not possible with a human sniffer. It can also determine various properties of the odour generated by sample. The non-invasive analysis of gaseous mixtures provides a means for identifying the presence of enzymes in food and growth of bacteria due to which chemical changes occur that leads to the formation of gases like carbon dioxide (CO_2), ammonia (NH_3), methane (CH_4), hydrogen sulphide (H_2S). E-nose analyses provide useful qualitative information about the physiochemical characteristic without the need for time consuming analyses to identify all chemical components in sample mixtures

6. WORKING PRINCIPLE OF E-NOSE

An electronic nose consists of three major parts:

Sample delivery system

Generates headspace of a sample i.e. object under consideration and then Injects this headspace of that particular object into the detection system.

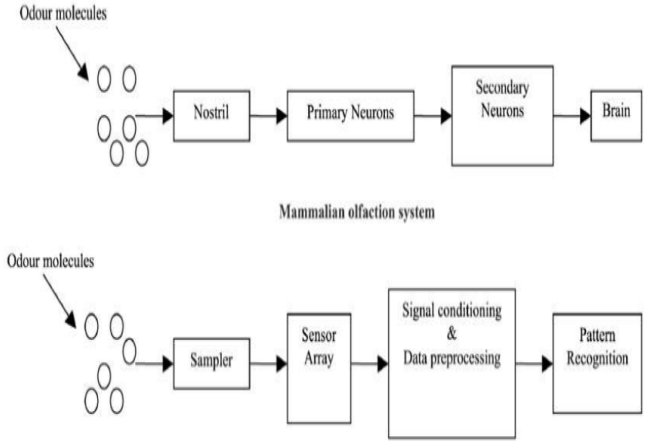

Fig. 1: comparison between working of human nose and E-nose

Detection system

It is the reactive part of the system, consisting of a sensor cell. Adsorption of volatile compounds on the surface of sensor causes a physical change in the sensor, due to which they experience a change in electrical properties. A specific response is recorded by the electronic interface which transforms the signal into a digital value.

Computing system

Recorded data are computed based on statistical models. Which comprises of different data acquisition models e.g. fuzzy logic that Works to combine the responses of the sensors.

7. SENSOR TECHNOLOGY USED IN E-NOSE

The sensor array forms the primary step in the detection or identification of an odorant. The most commonly used sensors in the electronic nose comprises of:

- Piezoelectric sensors
- MOSFET sensors
- Optical sensors

Piezoelectric sensors

Adsorption of gas onto the surface of the polymer leads to change in mass on the sensor surface. This in turn produces a change in the resonant frequency of the crystal. This change in frequency is proportional to the concentration of the test material.

MOSFET sensors:

A volatile organic compound produces a reaction in the sensing layer (gate).This causes the physical property of the gate to change. Thereby the threshold voltage is changed and thus the channel conductivity takes place and the sensor becomes active.

8. FOOD SPOILAGE DETECTION SYSTEM

The block diagram below in Fig. 2 shows food spoilage detection system. This block diagram comprise of gas sensor units, microcontroller, memory unit, control unit, display units and alarm units etc.

Each gas sensor unit contains array of gas sensors particularly used to detect different gases. These arrays of gas sensors unit will produce the electrical signals that are directly proportional to the amount of gases present around the sensor.

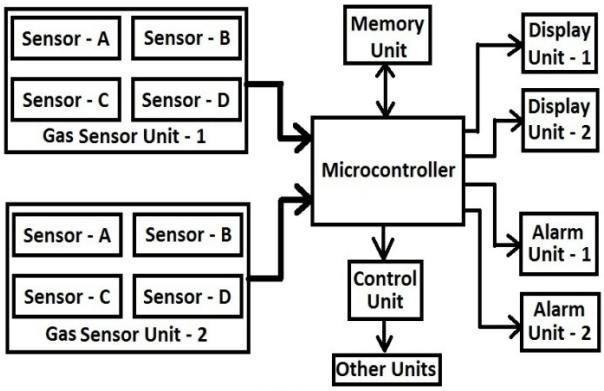

Fig. 2: Block diagram of Food Spoilage Detection System.

Microcontroller receives these signals from the analog to digital converter output and performs calculations based on the programs that have been written into its internal memory. Then it generates results in ppmv (parts per million by volume). For the specific amount of any gas, microcontroller generates different signals and sends them to different units. These results can be stored in memory units for future reference also.

Microcontroller also displays the amount of different gases on different display devices situated on different locations (inside store room, outside store room and at other remote locations). It will trigger some alarms at different locations if amount of one or more gases exceeds its critical limits.

We have different gas sensors to sense the gases produced during the decomposition of food in any open-to-air container. Theses sensors produce electrical signals proportional to the concentration of gases. These electrical signals are in analog form and need to be converted in digital form using analog to digital converters. These digital signals are given to microcontroller for processing. The microcontroller processes these signals according to the program feed in it and produces corresponding output signals. Now these signals are given to the audio amplifier and the display drivers. Audio amplifier drives the speaker or buzzer which produces the sound according to this signal to alert us as an alarm. The display driver can drive different types of display devices. These display devices can be either of numerical display type (like 7 segment display, 14 segment display or any type of LCDs) or any type of bar graph displays. Numerical displays will display concentration of gases in PPM (Parts per million) and the bar graph display will display the level of concentration of gases. After getting the alarm, remaining and other side by food products can be rescued before spoilage.

Gas sensor unit

This unit may have different gas sensors or modules one or more than one according to our needs. Different gases can be measured such as Methane, Carbon dioxide, Hydrogen, Ammonia and Sulfur dioxide with different sensors or modules available. Here methane (CH4) is preferred among these gases as it mostly represents the phenomena of food spoilage. We have used MQ-4 gas sensor for methane. Here are two mostly used sensors available in market, TGS 2611 and MQ-4. Both are semiconductor based sensors, consume very low power and have high sensitivity to methane (CH4) gas. These sensors are having very compact size and along with that are easily available in the market at very low cost. In fact, TGS2611-E00 uses filter material in its structure, which makes the sensor's working to be unaffected from interference gases such as alcohol.

Micro-controller

A micro-controller is a microcomputeron a singleintegrated circuitcontaining a micro-processor, different types of memories, counters, converters and programmableinput/outputperipherals. Program memory remains temporarily available within the chip in the form ofRAM, NOR flashorOTP ROM in small amount. Micro-controllers are suitable for these types of embedded applications. We can choose a micro-controller according to our requirement of type of sensors or modules' output, display and alarm units inputs, type of communication port used etc. We have used Atmel's ATmega16A micro-controller.

Micro-controllers having low-power consumption are preferable here. If large number of sensors is required to set, micro-controller should be fast enough to process this huge amount of data in real time and having memory space capable of storing it. Micro-controller should be rich in variety of instructions set to provide ease in required programming. It should have enough I/O lines to communicate with all sensors and output units. Some micro-controller is available with inbuilt analog to digital converters attached to its I/O pins and it is required in case of analog sensors and output units. Software and IDEs provided by the manufacturers of micro-controller should be updated with latest technology available.

Memory unit

Memory unit is required for storing data and for calculations purpose. Output devices display the result that received in the form of electrical signals from microcontroller. Memory unit associated with the microcontroller is more preferable because of its compactness.[8] Memory unit should be compatible and accessible with that particular type of microcontroller.[3]The data from the microcontroller can be easily stored in the memory unit directly memory unit used here can be RAM/ROM/PROM/EPROM/EEPROM as per our requirement.

Display unit

A display device is an output device that is used for presentation of information in visual form. When the information is supplied to display in the form of electrical signal, the display is called an electronic display. Display unit may be of CRT, LED or LCD type. We have used a 16X2 LCD display for monitoring the whole system. Aliquid crystal display (LCD) is aflat on a module along with electronic circuits including integrated circuits. This type of display uses the light modulating properties ofliquid crystals. Liquid crystals do not emit light directly. [1]LCD used here have 16 pins for communication with micro-controller and can display text (like letters, digits etc.) in British language. It has 2 line display where each line is capable of displaying 16 characters. LCD is preferable for its low power consumption feature.

Alarm unit

An alarm device or system of alarm devices gives an audible, visual or other form of alarm signal about a problem or condition. Alarm devices may produce audio; visual or both type or signals. Alarm devices can be fitted at desired (local or

remote) locations. Number of these devices depends upon our needs. We can assign separate alarm unit for each sensor or module. In our prototype, we used a piezoelectric buzzer for audio alarm with satisfactory results.

Control and other units

Thecontrol units used here to control different types of external and large equipment like fans, coolers spraying devices etc. It is commanded directly by micro-controller according to the programming. It controls different units by providing switching signals and required amount of power to them for their proper operation. Most external devices are managed by the CU.

9. CONCLUSION

An experimental measuring system basedon a micro-controller (with methane gas sensor) has been developed and tested. We have a system capable of detecting the change in the amount of different gases due to the phenomena of food spoilage. This system monitors and displays the amount of different gases present in air of store room in real time. It can also store this data in its memory for future use. This system can alert us with the help of audio-visual alarms located at different locations in early stages about food deterioration happening in any part of the store room. Thus we can take suitable actions to prevent further deterioration of neighboured food placed in different containers in store room.

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