Development of E nose for inspection of spices

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Development of E Nose for Inspection of Spices

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ABSTRACT:
Spices play an important role in providing aroma to a food product. Unfortunately, the chemical composition of spices is very complex and can vary due to climatic and growth conditions or post-harvest treatment. Various volatile organic compounds (VOCs) are responsible for the characteristic odor and if done by a sensory panel it becomes subjective. The sense of smell is a key factor in deciding the quality of food in terms of the aroma as well as its flavor. As is well known, chemical analysis of VOC by gas or liquid chromatography is a costly and time-consuming affair. An electronic nose with gas sensor array is capable of rapidly distinguishing between gas compositions and complex fragrance of spices.

An electronic nose, with tin oxide sensor array as input and artificial neural network for has been designed and developed. LabVIEW based VI has been designed for data acquisition and analysis. The E-Nose has been successfully used for various applications like VOC identification and mixture analysis, determining freshness of bread, quality of yogurt etc.

The work is being further extended to analyze the odor of spices. Measurements are taken from the headspace of four spices namely cardamom, cinnamon, pepper and clove. The data is analyzed and a neural network trained to identify the odor. Capability of the network to estimate the quality if possible is also being investigated. The paper will detail the experiments carried out, data preprocessing and feature extraction. Preliminary results obtained have shown promising results and will be discussed.

Keywords: Volatile organic compounds, tin oxide sensor array, LabVIEW, Spices

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I. Introduction

An electronic nose (E-nose), is used to mimic the mammalian olfaction system. The researchers were using different techniques and technologies to develop the E-nose. The tin oxide gas sensors are sensitive to most of the volatile organic compounds (VOC). Only difficulty is these sensors will respond to number of VOCs. From these various VOCs one gas will have more sensitivity for one sensor. Therefore these gas sensors were normally used in array form. Different types of gas sensors will be used having different gas sensitivity. The response of this sensor array will develop different pattern for different gases.

With above hypothesis B. A. Botre etal E-nose was tested for different VOCs, freshness bread and quality of yogurt etc and currently its being extended further to analyze the spices odor.

The work is being further extended to analyze the odor of spices. Spices as parts of plants, like dried fruits, seeds, barks and roots are components of many foodstuffs. Measurements are taken from the headspace of four spices namely cardamom, cinnamon, pepper and clove.

II. System Description

Three TGS26xx type gas sensors from Figaro have been used. The Data acquisition part of work has been done by using a LabVIEW VI and DAQ card (NI PCI-6024E).

This VI has the provision of adjusting the ON-OFF time for the sensor heater, thereby controlling the sensor response.

This experiment was having static system of E-nose to sample the spices. In this experiment the data sampling was done for
Cinnamon, Clove, Cardamom and Pepper. Also air samples were taken before sampling each spice, so that the headspace for the sampling will be flushed of previous sampled spice. The block diagram for this experiment is shown below.

Fig. 1 : Block Diagram of E-nose system

The Sensors were made ON and OFF through the LabVIEW VI (120 seconds = ON time and 180 seconds = OFF time). For switching, an IC ULN2003 is used. An analog output is taken from the DAQ card output which is used as a switching signal for the gas sensors. This VI is storing the sampled data into an excel sheet.

Fig. 2 : Data acquisition VI in LabVIEW

The samples were taken in periodic nature. The sensor were kept ON for 120 seconds and made OFF for 180 seconds. The sampled data is then used for Back Propagation-Multi Layer Perceptron (BP-MLP). Before proceeding for the Neural Network (NN) training, feature extraction is required to be done. The feature extraction is done from ON time sampled data. The extracted data are normalized between zero to one before used by the NN training part. The normalized data are given to the MATLAB for implementing BP-MLP. The testing for this NN is done in MATLAB only. A MLP has an input layer of source nodes and an output layer of neurons; these two layers connect the network to the outside world. In addition to these two layers the MLP has one or more layer of hidden neurons, because these output neurons are not directly accessible. The hidden neurons extract important features contained in the input data. The training of MLP is usually accomplished by using a BP algorithm. The BP learning is an computationally efficient algorithm.

Fig. 3 : ON time sensor response for Cinnamon

Fig. 4 : ON time sensor response for Clove

Fig. 5 : ON time sensor response for Cardamom
The above figures (Fig. 2 to 5) show the sensors responses for the cinnamon, clove, cardamom and pepper. This is only ON time response for the sensors. The data samples which were taken for training and testing the NN were taken from these cycles.

III. Results and discussion

The NN training was done number of times, and after each training different results were obtained. The first training was done using single data point from every ON time cycle. Due to this the training points were limited resulting in the less percentage accuracy of NN testing. This same process was repeated for two more training and testing sessions. Even after having new data sets and more ON time cycles the NN testing improvement was not satisfactory. This scenario was changed when training was done for three data points from one ON time cycle. The testing result for this NN training was nearly 76.75% accurate. The very recent NN training was done for five data points from one ON time cycle. The testing for this NN has given 100% results. The improvement for five NNs is shown below Table 1. Average accuracy for NN1 to NN5 is 56.5%, 69.75%, 66.5%, 76.75%, and 100% respectively.

Table 1: NN results

<table>
<thead>
<tr>
<th></th>
<th>NN1 (%)</th>
<th>NN2 (%)</th>
<th>NN3 (%)</th>
<th>NN4 (%)</th>
<th>NN5 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cinnamon</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Clove</td>
<td>33</td>
<td>28</td>
<td>50</td>
<td>66</td>
<td>100</td>
</tr>
<tr>
<td>Cardamom</td>
<td>71</td>
<td>66</td>
<td>66</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Pepper</td>
<td>22</td>
<td>85</td>
<td>50</td>
<td>66</td>
<td>100</td>
</tr>
</tbody>
</table>

IV. Conclusion

The different training and testing experiments show that if more data points were used from single sample for training, the testing results will improve considerably.

V. Reference