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Liquid Identification Using e Tongue

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Abstract— Tongue is one of the most important sensory organs of our system. With the help of tongue, we are able to distinguish between the various food items which we eat or drink. The sensors on the tongue identify the tastes which are classified as bitter, sour, salty, sweet, umami (delicious). These are the parameters that help in determining and distinguishing the liquids like beer, tea, coffee, honey, milk etc. The present work describes an efficient way of identifying liquids- an electronic tongue. The electronic tongue consists of an array of sensors immersed in the liquids to identify them. The sensors generate the data in the form of electrical signals. These electrical signals are then processed. For pattern recognition, Linear Vector Quantization (LVQ) algorithm of artificial neural networks (ANN) is used.

Keywords- electronic tongue, LVQ, ANN, sensor array

I. INTRODUCTION

In today's world aroma, taste and color are considered as quality indicators for various food items. Out of these, sensory experts consider taste as the most important. A traditional way of sensory evaluation of liquids is human tongue. It is a primary organ of taste. The human tongue is equipped with taste buds and each taste bud has taste receptor cells which sense particular class of tastes. The chemicals that stimulate the taste receptor sensors are known as **'tastants'.** The human tongue detects the tastants of the liquid and with the help of taste receptor cells identifies the liquid by detecting the taste. For detecting a flavor, a series of electric pulses is transmitted to the brain where they are compared and used for identification. Based on the same analogy, electronic tongue came into picture which could identify and classify the liquids at a low cost and with more accurate results. An electronic tongue mimics the human tongue for taste identification.

An electronic tongue consists of an array of chemical sensors immersed in the liquid, signal processing unit and pattern recognition unit. An array of sensors is placed in the liquids for sensing the parameters which are used for identification. The output of the sensors is in electrical form. The data is then sent to signal processing unit. After the signal is processed it is sent to the pattern recognition unit. The results available at the output of pattern recognition unit are the detection of tastes. The taste are classified as bitter, sour, salty, sweet and umami (delicious). The umami taste is discovered recently by the Japanese and therefore it is still under research.

The remainder of the paper is organized as follows: II) Research Background. III) Proposed System IV) Simulation and Results V) Conclusion and Future Scope.

II. RESEARCH BACKGROUND

2.1 Electronic Tongue Introduction:

In the food industry, the commercial success of a product is determined by many factors, such as appearance, aroma and flavor. The growing customers' demand on food quality makes the inspection and approval of products more rigorous every day. In the tradition of taste classification of liquids, our reliance on the liquid taster's special taste ability, but working for a long time makes the human's taste buds very tired, leading to the reduction of recognition capability.

Furthermore, the use of human to have the taste evaluation was restricted in many fields, such as water environment, medical research and other correlation industry.

Considering all the above challenges, there is a need for an instrument or a device which is of low cost and very efficient when it comes to giving accurate results. There is a need for a device which can identify the taste. Based on the identification it should be able to classify the liquids. The liquids are nothing but complex chemical compounds. Hence we need a device which can analyze these complex chemicals and give required solution.

Electronic tongue is a device that mimics human to classify different taste [1]; it is made up of three parts, which are ion selected sensor array, signal processing and the algorithm of pattern recognition. For different targets, using a specific sensor array to detect the response signal which on behalf of the material characteristics, and combined with the pattern recognition algorithm, can identify the taste information of targets continuous.

2.2 Previous Work:

For wine, a custom-designed e-tongue with a hybrid sensor array consisting of voltammetric electrodes modified chemically with different electro-active substances (polymerized aqueous solution of pyrrole using six doping agents) was used to discriminate and recognize among 12 Spanish red wines based on denomination, origin, grape variety and vintage due to the cross-selectivity of the electrodes [2]. This was accomplished using PCA, PLS discriminate analysis (DA) and SIMCA analysis.

For tea, an e-tongue along with multivariate calibration (PCA-ANN) was able to determine contents of catechins and caffeine in green tea [3]. The taste system consisted of seven silicon transistor sensors with an organic coating and an Ag/AgCl reference electrode. The response intensity of each sensor was measured by the voltage difference between each coated sensor and the reference electrode. Another taste sensor system of non specific solid state potentiometric sensors along with PCA was used to differentiate between tea samples from different geographic regions and quality grades [4]. This information was compared to ten sensory attributes of tea taste and it was determined that the e-tongue could predict sensory characteristics and their relationship to tea flavor quality.

III. PROPOSED SYSTEM

The array of sensors is placed in the liquid to detect or identify different components of the liquid. Electrical signals are obtained at the sensor output which is further processed and analyzed to identify or classify the liquid. For pattern recognition Artificial Neural Network (ANN) is used. The ANN is trained to get the desired output. Information which we obtain from pattern recognition can be used which is our desired output depending on the application.

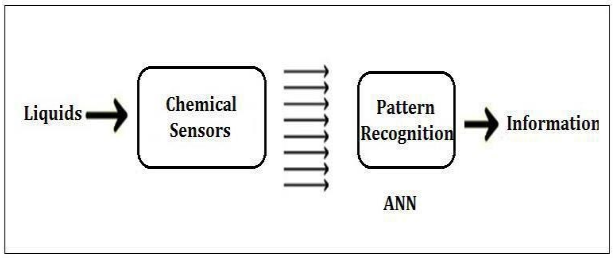

Figure 1. Proposed System

From the sensor output characteristics are extracted, combined and stored. Database is created prior with the help of response patterns for each liquid. Obtained pattern are matched with the response pattern from database. Here liquid is detected. ANN will analyze the complex data of that particular liquid and pattern is recognized.

3.1. Chemical Sensors:

In liquids various physio-chemical components are present which distinguish them from each other. Some of them which are most common and present in liquids are: pH, refractive index, lactose, ash, fat content, protein content. The chemical sensors are basically detectors whose conductance changes as soon as these chemical compounds come in contact with surface. There are wide variety of sensors available in the market like Electrochemical potentiometric, electrochemical ISFETs, Electrochemical voltametric, electrical resistive, optical, gravimetric etc [9].

3.2. Pattern Recognition:

Automatic recognition, description, classification and grouping of patterns are important problems in a variety of engineering and scientific disciplines such as artificial intelligence, medicine and remote sensing. A pattern could be a fingerprint image, human face or a speech signal, etc.

Given a pattern, its recognition or classification may consist of one of the following two tasks:

1. **Supervised classification** in which the input pattern is already identified as a member of a predefined class.
2. **Unsupervised classification** (example Clustering) in which the pattern is assigned to an unknown class.

The three best known approaches for pattern recognition are: 1. Template matching 2. Statistical classification 3. Neural network. Out of all these, artificial neural network technique has advantage of speed performance.

3.3 Artificial Neural Networks

A neural network is an information processing system. It consists of massive simple processing units with a high degree of interconnection between each unit. The processing units work cooperatively with each other and achieve massive parallel distributed processing. The design and function of neural networks simulate some functionality of biological brains neural systems. The basic unit of an artificial neural network is the neuron. Each neuron receives a number of

inputs, multiplies the inputs by individual weights, sums the weighted inputs and passes the sum through a transfer function, which can be, e.g. linear or sigmoid.
An ANN is an interconnected network of neurons. The input layer has one neuron for each of the sensor signals, while the output layer has one neuron for each of the different sample properties that should be predicted. Usually, one hidden layer with a variable number of neurons is placed between the input and output layer. [8]

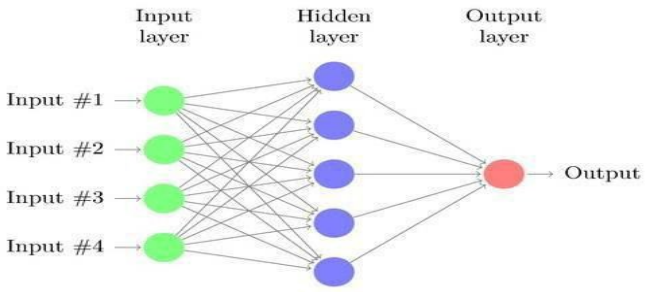

Figure 2. Artificial Neural Networks

IV.SIMULATION & RESULTS

The Matlab predefined tool for pattern recognition (nprtool) is based on a neural network characterized by:
-One hidden layer (the number of the hidden units can be chosen by the user)

- Logistic (logsig) activation functions for both hidden and output units
- Back propagation algorithm based on a scaled conjugate gradient minimization method

In order to train the neural network, we have used the LVQ (Linear vector quantization) algorithm as it is found to be very efficient for liquids. It is a supervised learning algorithm of vector quantization for labeled data.
The learning process is controlled by a cross-validation technique which consists in dividing the initial set of data into three slices:
_ Training data: the data used in the training algorithm to compute the adjustments for weights of connections
_ Validation data: when the classification error on these data starts to increase, the training process is stopped (these data are not used to compute the weight adjustments but only to decide if the network has generalization ability)
_ Test data: these data are not used in the training process but only to evaluate the quality of the classifier.
The quality of a classifier (designed to identify four classes) is usually measured by computing the confusion matrix and by representing the graph of the receiver operating characteristic curve (ROC).
Here we have taken 20 samples. These samples are divided as 5 samples of honey, 6 samples of buffalo milk, 5 samples of cow milk, and 4 samples of water. These values indicate the pH of liquids. The nntool performs the training and ROC shows quality of classifier. The samples are classified into 4 classes shown by the confusion matrix plot.

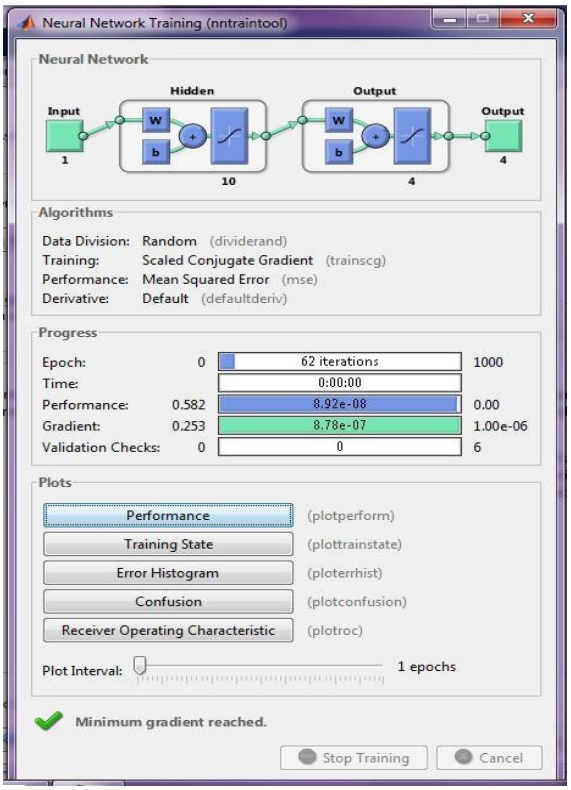

Figure 3. Training state

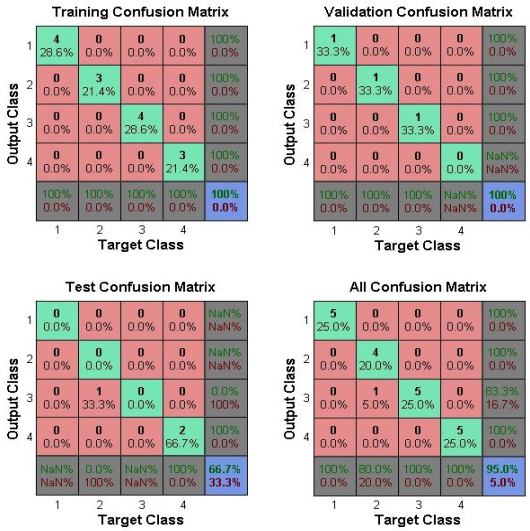

Figure 4. Confusion Matrix

V.CONCLUSION & FUTURE SCOPE

Electronic tongue serves as efficient tool for quality analysis and taste identification. The taste sensor is essentially an intelligent sensor to reproduce the taste sense, which is a complex, comprehensive sense of humans. The electronic tongue can differentiate between tastes successfully.

Artificial Neural Network is used for Pattern Recognition and data classification which improves the accuracy to identify the liquid. Due to the intelligence of the neural network the sensors need not be very accurate. More tastes can be identified with less number of sensors which also reduces the cost of sensors. The simulation results show that liquids identification can be successfully done with the help of neural networks.

In future the electronic tongue system can be improvised to search for new compositions that neutralize the bitter taste in medicines in the pharmaceutical industry, since most of the medicines have a bitter taste.

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