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A Review Paper on Electronic Sensor Based System to identify undesired ingredients present in Liquid

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ABSTRACT

This paper provides a review the concept of Electronic tongue which has been used in some experiments to establish the need of fast and virtual monitoring of aqueous samples by using sensors. Electronic tongue can be used to identify or recognize specific components in a solution. In this approach, experiments are conducted using an electronic tongue to virtually monitor the quality of liquid like drinking water, milk, juice and oil. In addition, we have reviewed several improvements, implementations and extensions of the basic method and give some points. Finally, we have presented a concept that is planned for the future application of Digital signal processing and relate them to novel developments. To develop an Electronic sensor based system, we are focusing on key technologies including Sensor and membrane, interfacing, monitoring circuitry, and output driver.

Keywords: - Electronic Tongue, Sensor system, ingredients, signal processing

1. INTRODUCTION

Electronic Tongue and Electronic nose system provides more services in various fields such as environmental monitoring, food science, and point of care business. The concept of electronic tongues is more recent, and much less research has been undertaken on the development of liquid sensors and classification algorithms. A sample of water or milk has too high concentration of bacteria so to analyze bacterial growth is an important task since the bacteria can cause diseases and make the liquid unusable. But the accurate measurement of the process is time consuming.

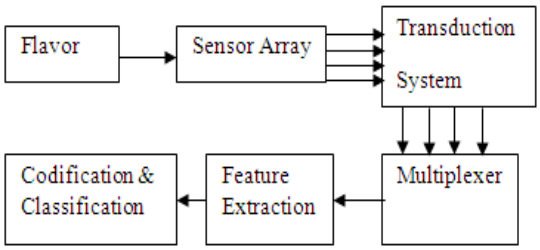

Figure 1 Block representation of Electronic Tongue.

The water may contain a broad variety spectrum of inorganic as well as organic compounds, germs etc. The measuring technique to be used has to be robust, sensitive and must be able to detect small changes in the measuring media. The adaptation of fresh water quality to the test of human is one of the challenging questions for modern society.

Virtual sensor system, tests the quality of the drinking water. The research is going with the direction to use this type of sensor system to measure the quality of liquid, for example, in [1] a four electrode conductivity probe is used and in [2] thick film based sensors are used for determining the quality of water .In [3] a lipid membranes designed sensor are used to detect pollutants in water and in [4] an optical fiber sensor system is used to detect particle concentrations in water. Multi sensor system is used as water quality instrument [5, 6] in few applications. Many available modeling approaches are able to simulate water quality using 3D mathematical model [7], artificial neural networks [8] and fuzzy probability [9].

The concept of electronic tongue [10, 11] has been developed to attract the needs of on-line monitoring of aqueous samples. Principal Component Analysis (PCA) is a mathematical transform, which is used to explain variance in exponential samples. After collecting the samples the appropriate tests were conducted using the sensor system. After

PCA analysis it is examined that there exists a clear distinction of the resulting cluster from the raw water and the purified water [12], such result would confirm the chemical change that occur in raw water.

2. DIFFERENT METHODS

The paper extended the design and characterization of shear horizontal surface acoustic wave (SH-SAW) devices for analysis of liquid samples. Smart tongue SH-SAW sensors have fabricated and tested, results were obtained on the milk freshness test and fat content [13]. Wavelet transform [14] is also used and the approximation coefficients are extracted as features and classified using minimum distance classifier. Water and milk have been tested and bacteriological growth are monitored. The water samples were stored in room temperature for 7 days, allowing the bacteria to grow. The milk was stored in room temperature to evaluate the change in quality, over the period of time to check whether the sensor system is capable to detect the originating changes. A change in the overall content is detected; this change is recorded because of the bacteriological growth. Analyzing the bacteriological growth using the wavelet transform, the combination of different sensor systems and development of a decision system using wavelet transform has been shown.

There are many indicators that specify the quality of milk, but the most commonly used is the main nutrients in milk-fat, protein and lactose content[15]. Changes in lactose contents are relatively small, while fat and protein changes dramatically. So the standards to be designed must mandatorily monitor the fat and protein content in milk for quality testing[16].

As for these two components in the detection, the traditional method is chemical analysis methods, such as the fat in milk is usually measured by Babcock method [17]. As for ultrasonic transmission in the liquid, because of the different nature of the liquid medium, liquid ultrasonic propagation in the speed and intensity level are both different. Milk consists of a solution, suspension and emulsion and complex distributed. When certain frequency ultrasonic through milk, velocity and attenuation coefficient will be significant changes. So measure of the ultrasonic attenuation coefficient and ultrasonic pulse velocity into the milk can be used to find fat and protein content. That is by measuring ultrasonic parameters to indirectly detect the quality of milk [18, 19].

Measuring instrument in this paper[20] consist of samples pool, sends and receives ultrasonic probe, ultrasonic transceiver drive circuits, signal conditioning circuits, temperature testing circuit, the multipurpose microprocessor control circuits, LCD display, the operator panel, printer interface, and PC communication interface circuit. When it is functioning, it puts the test samples to samples pool, from the trigger circuit to generate pulse excitation probes, ultrasonic transmission in the pond after receiving samples received by the probe. After receiving the ultrasonic signal timing circuit and the peak detector circuit when sound pressure measured and sound data transmission via serial communications to a PC for further data processing. After processing the velocity of sound, attenuation coefficient is measured. In order to achieve high precision testing of milk quality temperature is the key factor on the ultrasonic testing. So relationship of temperature impact and milk ultrasound parameters measurement is studied. In milk of ultrasonic parameter measurement, milk is heated. So in particular temperature range, measurement reproducibility is good and test results are stable. So the ultrasound parameters measurement method is effective to reduce the temperature impact on milk ultrasonic parameters measurement.

The paper [21] describes a multi-year project which has been sponsored by the National Science, and the Institute of Biocybernetic and Biomedical Engineering, the polish Academy of science, and the Institute of Electron Technology, Poland. Project is a electronic tongue system by using ion sensitive field effect transistors (ISFETs), extended-gate FET (EGFET) and their interfacing circuit techniques. Bridge- type constant voltage, constant current, and temperature compensation circuitries have been developed for ISFET to sense hydrogen and chloride ions for water quality monitoring applications. This result shows that ISFET and EGFET play an important role in an electronic tongue system design and its applications. The consideration of non-ideal effects on sensor interfacing circuit design has been emphasized. A new temperature compensation technique has been developed using ISFET and its accompanied depletion mode Al- gate field effect transistors. The advantages of extended –gate FET provide easy packaging and a disposable sensor head structure.

An electronic tongue made by a sensor array of ion-selective electrodes (ISE) [22] has been developed and used for the qualitative analysis of five different kinds of mineral waters. The acquired original data has been optimized by independent component analysis (ICA) and Linear Discriminant analysis (LDA), and then the learning vector quantization (LVQ) model was designed to classify different mineral waters. The application result shows that the performance of the proposed method has surpasses the traditional Self-Organizing Map (SOM) algorithm, it can improve convergence and the learning capability of the network, and give the Electronic Tongue a higher aggregate Classification rate. This circuit based on ion-selective electrodes proved to be appropriate for mineral water measurement and classification. ICA and LDA was employed to reduce the dimension of the multidimensional original signals and extract the Eigen values. LVQ applied to classification displays a excellent result, and the recognition rate is 100 %. Chemical properties and sensory analysis was successful.

Tea quality assessment is a difficult task because of the presence of innumerable compounds and their diverse contribution to tea quality A low-cost portable voltammetric electronic tongue system [23] for tea quality evaluation has been presented in this paper. The electronic tongue is based on the principle of pulse voltammetry and consists of an array of five working electrodes along with a counter and a reference electrode.
The five working electrodes are of gold, iridium, palladium, platinum, and rhodium. The voltage equivalent of the output current between the working electrode and the counter electrode generated out of the tea liquor when excited with pulse voltage between the working electrode and the reference electrode has been considered for data analysis. First, the sampled data have been compressed using discrete wavelet transform (DWT) and are then processed using principal component analysis (PCA) and linear Discriminant analysis (LDA) for visualization of underlying clusters. Finally, different pattern recognition models based on neural networks are investigated to carry out a correlation study with the tea tasters' score of five different grades of black tea samples obtained from a tea garden in India.
The electronic tongue instrument declares tea-taster-like scores for black tea liquor. Five different grades of tea were considered for the experimentation, and the PCA and LDA plots show that the electronic tongue can clearly discriminate between different grades of tea. Different waveforms for small amplitude pulse voltammetry (SAPV), Large amplitude voltammetry (LAPV), and STAIRCASE waveforms were applied through five working electrodes of noble metals, and classification has been carried out on electronic tongue data using three different topologies of neural networks. Elegant classification efficacy of the neural network models has also been demonstrated with the tenfold cross-validation method. However, the data set is collected only from one garden and does not possess wide variability.
The system, however, can be made versatile by incorporating the knowledge of tea samples from multiple gardens spread across various agro-climatic zones of India and other tea-producing countries. Nevertheless, the system described in this paper, being low cost and portable, is affordable by the tea industry and has the potential to be a useful taste-measuring instrument for day-to-day use in the black tea industry.

This paper [24] describes the development and test of a multi-sensor heterogeneous real-time water monitoring system. A multi-sensor system was deployed in the River Lee Co. Cork, Ireland to monitor water quality parameters such as pH, temperature, conductivity, turbidity and dissolved oxygen. The R. Lee comprises of a tidal water system that provides an interesting test site to monitor. The multi-sensor system set-up is described and results of the sensor deployment and the various challenges are discussed.
The paper [25] presents a new enhancement technique for infrared images. This approach combines the additive wavelet transform and the homomorphic enhancement features.

3. PROPOSED METHOD

By combining sensor systems e.g. electronic tongues together with a enhanced signal processing techniques, the classification accuracy can be increased. In the proposed research work, it is planned to develop an electronic system that can be used for identification on undesired ingredients in liquids like milk, oil, water, juices, etc.
The system hardware and software will be designed and developed and an efforts will be taken to identify the undesired material present in liquid. Research work involves use of signal processing techniques or image processing technique developments of new correlations, continuous monitoring of the liquids under test, and evaluation of properties of liquid and hence quality of liquid.

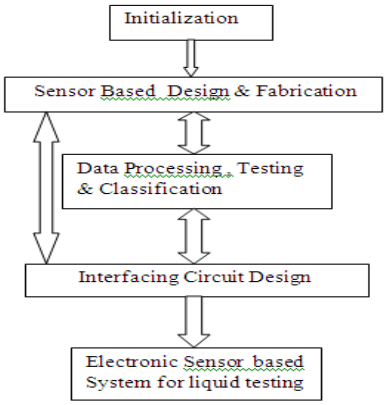

Figure 2 System Representation

The following will be the steps under taken for the research work,

- Detailed study of the concept, application and implementation of sensor networks.

- To design and develop an electronic sensor based system that can extract the information about the properties of the liquid.
- Identify and analyze the effect using different sensor based signal processing system, due to the liquid or any other ingredients present in liquid.
- PC interface will be developed for online testing and monitoring.

Evaluation results will be made available on display, displaying the quality of liquid under test.

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