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Liquid Composition Identification and Characteristic Measurement Using Ultrasonic Transmission Technique via Neural Network

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ABSTRACT

This project is to determine the composition of liquids solvent by using the ultrasonic frequency signal from echoscope scan machine. The transmission technique of ultrasonic signal is focused. On the research experiment, studies on mixing of distilled water with control sodium chloride (Kitchen Salt), kitchen sugar and monosodium glutamate (MSG). The Parameters such as Fast Fourier Transform (FFT) which is the parameters are using to identify the ratio of composition of liquid solvent. The feature extraction of median, average and root mean square (RMS) from FFT is represented with different result analysis such as sensitivity, specificity, accuracy, Area under curve, kappa, F-measure and precision. The results performed more than 90% with Neural Network.

1. Introduction

Nowadays there is a lot of fake ingredients that produce by company. They produce the fake ingredient to increase the sales of the product. Before these there is several methods to detect the fake ingredient for example Fourier Transform Infrared Spectroscopy (FTIR). These methods will detect several foods in 30second. In this project ultrasonic are one of the methods are used to detect food ingredients [1-8].

One of the conventional methods to identify composition containing in solution is evaporation method. These methods try to evaporate the liquid to gas with heat in a natural system. In this system, we will be able to identify the composition presented in some solvents, for instance water. Additionally, this method is tedious and time consuming. This technique is only suitable to adopt in

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case where less than two solutes in solution. Now days there are many foods or drinks product state with fake ingredients [2].

Investigation of substance in water by using ultrasonic echoscope, this project will help in food industry to determine the substance in water. Using ultrasonic echoscope are new technologies to determine sugar and salt in water.

Ultrasonic measurement systems which consist of ultrasound echoscope and ultrasound sensors are developed for salinity and sweetness detection. Amount of sweetener and salt are determined using this proposed system. The main idea for this work is developed upon the resonance frequency of due to different substance in water, e.g., salt and sugar. The measured ultrasonic parameters are including time of flight, reflectivity, velocity of wave propagation and etc [3].

Ultrasonic are best way to investigate water substance because it has high frequency and a very short wavelength. This will make the wavelength pass through the small space. Scientists have found ways of putting this concentrated energy to use in scientific research, in industry, and in medicine. Ultrasonic also travel 100 000 times slower than electromagnetic waves, travelling time can be determined. Ultrasound wave is easier to penetrate through materials in water or liquid [9-12].

Ultrasonic are used in many applications for example an ultrasonic wave passed through a liquid makes the liquid vibrate very fast. The vibration can shake up paint to mix it thoroughly, homogenize milk by breaking up the fat particles, and the ultrasonic use for detecting the salt and sugar in food that may cause health problem such as blood pressure, kidney stone, diabetes mellitus etc.

There is different type of parameter that we can measure through the ultrasonic unit for example attenuation, acoustic and density [4]. In this ultrasonic model GAMPT can measure using reflection or transmission technique. Reflection techniques are used in this project.

2. System Overview

The weight of the sample solution is recorded using a high accuracy weighing scale. A cylinder size of 100 ml is used to calculate the solution's volume. The ingredients in the samples are distilled water, sugar, salt, and Monosodium glutamate (MSG). A crucial component is sensor displacement. Since the ultrasonic sensor is partially positioned, it cannot be removed because doing so would cause the data to alter.

The machine must be placed in a secure location where the environment won't be disturbed A-Scan is the program used to display the graph after connecting the computer to the echoscope. Figure 1 depicts an example of a jig that was used in this project to evaluate the sample.

Fig. 1. Hardware Setup

2.1 Research Flow

Figure 2 shows the flowchart of the project. This part will help to brief about the flow of project based on the flowchart. The liquid composition detection system uses the ultrasonic signal to identify the ingredients of the liquid. At the first stage all sensors will measure the reading data based on the parameter that has been set. FFT signal was taken and some feature extraction such as sensitivity, specificity, accuracy, and precision were employed. Next Neural network was employed and some performance measurement such as sensitivity, specificity, accuracy, and precision were analyzed [13-19].

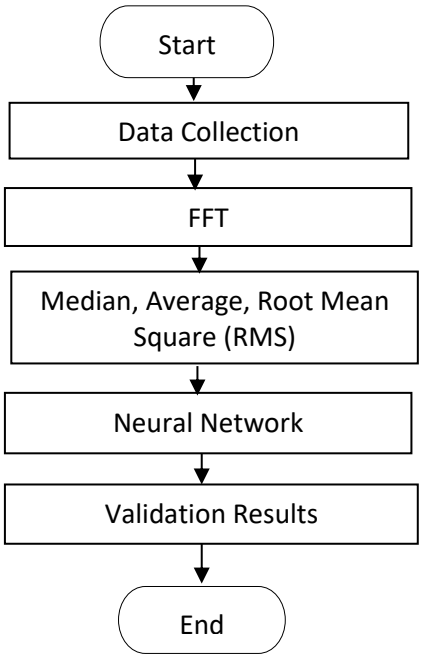

Fig. 2. Research flow of the project

2.2 Project Workflow

In data analysis used two of ml of distilled water which is 500ml and 200ml.Each sample was divided into three categories. First mix with 5 tablespoons of control sodium chloride (Kitchen Salt). with 5 tablespoons of kitchen sugar and finally a mixing of 5 tablespoons of monosodium glutamate (MSG)

2.3 Fast Fourier Transform

Echoscope GAMPT Scan Machine and 2MHz Ultrasound transducers are used to record the ultrasonic signal in transmission method. The ultrasonic signal parameter in this project is fast Fourier transform as shown in Figure 3. This parameter is used to do the several analyses using Matlab coding. As a result, fast Fourier transforms are widely used for many applications in engineering, science, and mathematics. There are many different FFT algorithms involving a wide range of mathematics, from simple complex-number arithmetic to group theory and number theory; this article gives an overview of the available techniques and some of their general properties, while the specific algorithms are described [8-12]. There are a few main components that used in FFT parameter for data analysis, there are median, average, root mean square (RMS), min power and max power.

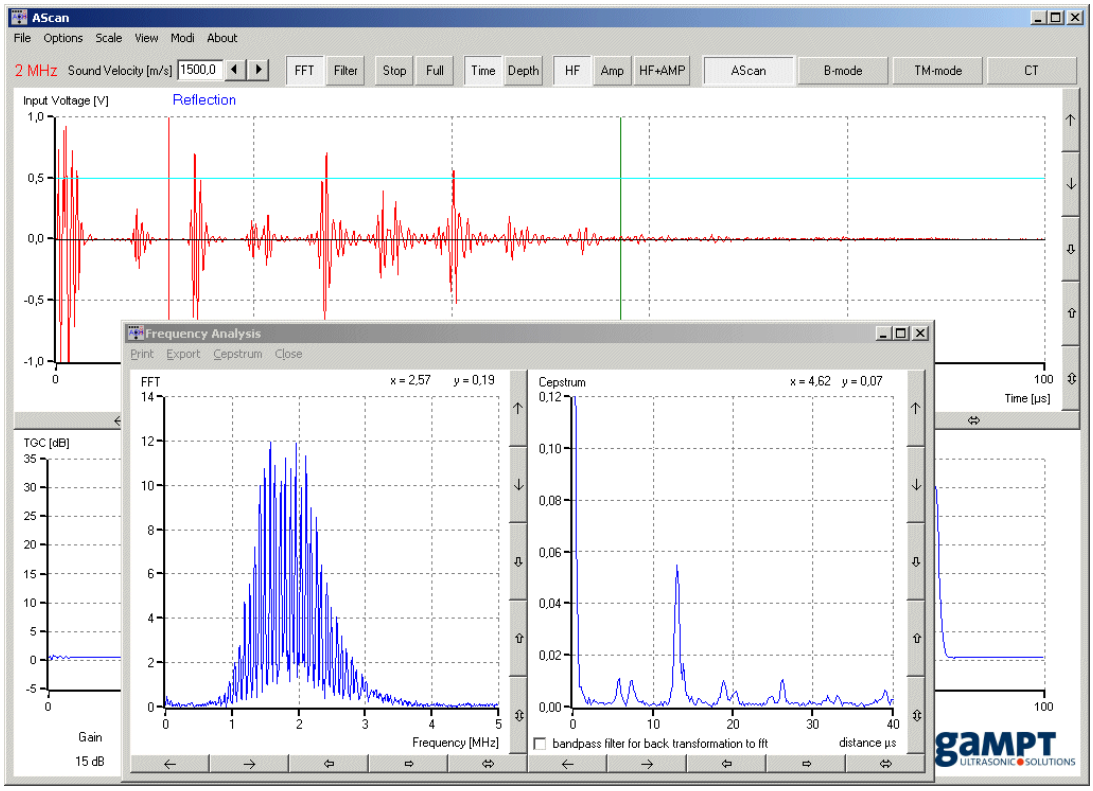

Fig. 3. The example of FFT graph

2.3.1 Mean analysis

Mean analysis is an average frequency which is calculated as the sum of the product of the ultrasonic power spectrum and the frequency divided by the total sum of the power spectrum. Mean analysis has a similar definition as several features, the central frequency (fc), centroid and the spectral center of gravity, in several studies. MNF is also called as mean power frequency and mean spectral frequency in several works. The definition of MNF is given by the Eq. (1) below:

$$MNF = \frac{\sum_{j=1}^{M,} f_j P_j}{\sum_{j=1}^{M} P_J} \tag{1}$$

Where, F, is the frequency value of ultrasonic power spectrum at the frequency bin j, Pj is the ultrasonic power spectrum at the frequency bin j, and M is the length of frequency bin.

2.3.2 Median analysis

The behaviour of mean analysis and median analysis is always similar. However, the performance of mean in each of the applications is quite different compared to the performance of median, although both features are two kinds of averages in statistics. It should be noted that means is always slightly higher than the median of the ultrasonic signal.

$$\sum_{j=1}^{MDF} P_{j=} \sum_{j=MDF}^{M} P_j = \frac{1}{2} \sum_{j=1}^{M} P_j \tag{2}$$

2.3.3 RMS analysis

The root mean square (abbreviated RMS or rms), also known as the quadratic mean, is a statistical measure of the magnitude of a varying quantity. It is especially useful when variates are positive and negative, e.g., sinusoids. In the field of electrical engineering, the effective (RMS) value of a periodic current is equal to the DC voltage that delivers the same average power to a resistor as the periodic current. The RMS value can get from the FFT graph.

These analyses are used to determine approximately value of each data sample when do the analysis. These data all are collected and normalized in a lookup table, the lookup table are shown in (3).

$$RMS = \sqrt{\frac{1}{N}\sum_{i=1}^{N} x(i)^2} \tag{3}$$

2.4 Neural Network

The development of automatic decision-making system plays an important role in this research to develop a suitable classification algorithm. Artificial neural networks as a classifier for the classification of ratio of liquid composition. In this research works confirms that only one hidden layer is required for this task after a set of experimentation. The inputs to the neural network are optimized values of three input in the first layer of the neural network mode. One hidden layer contains both 10 neurons while for the output layer, three outputs are considered. Binary sigmoidal activation function and 0.01 earning rate and 500 epochs were used within it suggest in [20].

3. Results and Discussion

From Figure 4, the best performance results will be highlighted. The maximum of Sensitivity is 71.5% gained from trial 4, the Specificity has maximum value of 83.1% from trial 8. The highest value Area under Curve (AUC) is obtained from trial 8 with 76.8 %. The best maximum of accuracy from this test is 77.5% acquired from trial 8. The maximum Kappa (k) is represented by trial 8 with 76.5%. For F-Measure, the maximum result was scored from trial 8 with 73.5%.

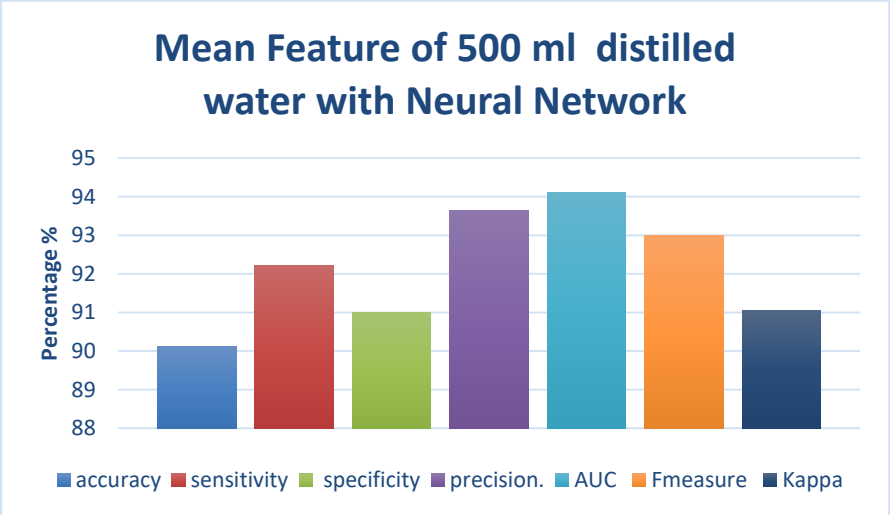

Fig. 4. Mean Feature of 500 ml distilled water with Neural Network

From Figure 5, the best performance results will be highlighted. The maximum of Sensitivity is 98.9% gained from trial 1, 5 and 7, the Specificity has maximum value of 99.7% from trial 4. The highest value Area under Curve (AUC) is obtained from trial 7 with 99.2 %. The best maximum of accuracy from this test is 99.2% acquired from trial 7. The maximum Kappa (k) is represented by trial 7 with 98.2%. For F-Measure, the maximum result was scored from trial 7 with 99.1%.

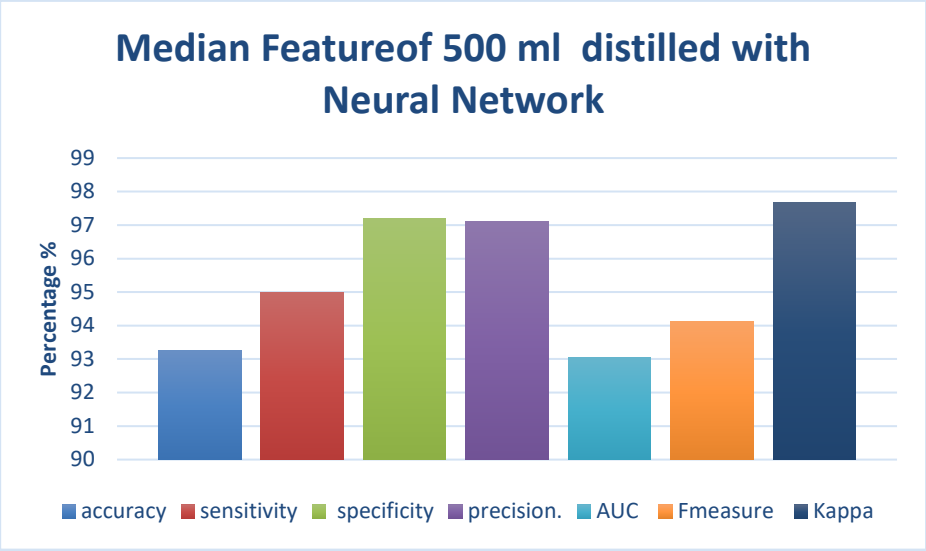

Fig. 5. Median Feature of 500 ml distilled water with Neural Network

From Figure 6, the best performance results will be highlighted. The maximum of Sensitivity is 76.9% gained from trial 8 while the Specificity has maximum value of 77.0% from trial 3. The highest value Area under Curve (AUC) is obtained from trial 3 with 75.8%. The best maximum of accuracy from this test is 76.0% acquired from trial 3. The maximum Kappa (k) is represented by trial 3 with 75.9%. For F-Measure, the maximum result was scored from trial 3 with 73.4%.

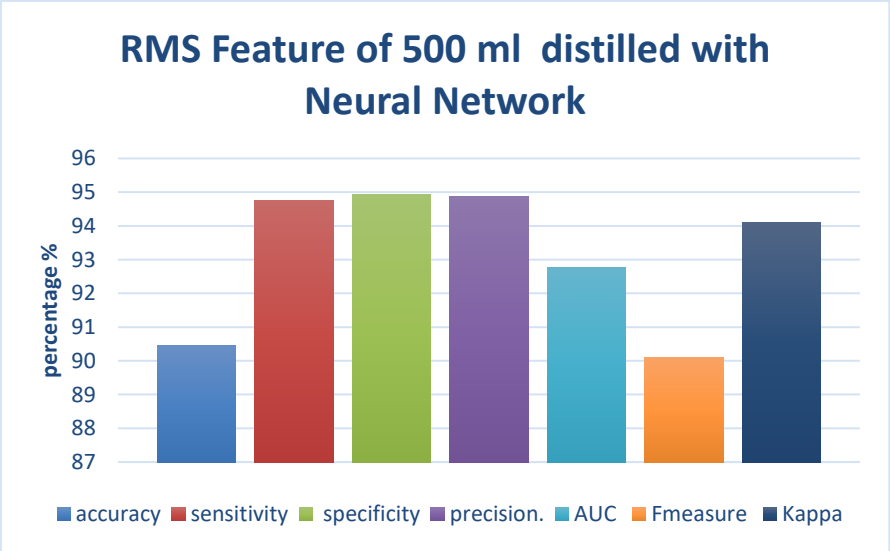

Fig. 6. RMS Feature of 500 ml distilled water with Neural Network

4. Conclusions

Ultrasonic Echoscope GAMPT unit offer food manufacturers a rapid, easy, means of verifying the identity, authenticity, and purity of the raw materials and ingredients that are used in the food industry. This transmission method classified the composition in the fluid using Fast Fourier Transform (FFT). Three main parameters such as mean, median and rms are used to get the accurate value. In this project neural networks classification method is used to analysis the data. Overall, this project can conclude that the ultrasonic transmission method can use for detecting the content of water with higher than 90% performance parameter.

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