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Wireless Food Intake Recognition System

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Abstract
To maintain hydration and regularity in the dietary choices and to lead a healthier life level of food intake and proper dietary are the major concern .Necklace in the wearable form embedded with piezoelectric sensor helps in the detection of skin motion in the lower trachea during the ingestion of food and this motion produces an output voltage which produces varying frequencies which changes over time. The system with embedded sensor with a compact wireless transmitter helps to transmit the data wirelessly to phone or PC. The necklace acquires the real-time signal while swallowing after processing and analysis of acquired signals which gives the realization and classification of food types and other categories and provides a visual feedback to the user for guidance in the form of mobile phone application. An experimental result helps in characterizing the food types with high accuracy using spectrogram analysis and provides user guidance. Processing of signal is done in LABVIEW ,MATLAB.

Keywords
Piezoelectric sensor, Signal acquisition, Signal filtering, Signal Smoothening, Spectrogram analysis, Feature extraction ,LABVIEW, MATLAB

I. Introduction

Healthier style of eating is associated with reduced risk for many diseases, including several leading causes of death such as heart disease, cancer, strokes and other diabetic diseases. The development and the establishment of wireless technologies has the possibility to address our supreme goal of enabling healthier lifestyle choices and behavior modification needed to prevent obesity and obesity-related diseases.

Automatically and accurately recognizing the type of food in a non-intrusive manner without disturbance is an unaddressed challenge. Most of the current technology for patient monitoring are inaccurate and impractical due to some issues and low rates of adherence to using the technology, due to one or more shortcomings such as false detection is more.

Nowadays many monitoring systems are available such as

Glucose level monitoring system, Heart beat monitoring system, Pressure monitoring system but when one take their food regularly there won't be a need to use these kinds of monitoring systems. When the eating pattern is regular and normal the chance of getting into other kinds of diseases will get reduced.In this paper, the technique is mainly focused on a wearable food intake monitoring system which can be worn around the neck without disturbing our daily activities.

The proposed work will enable to monitor the food to monitor the regular food intake precisely from being in our workplace.The system provides a regular feedback about the food intake level and types of food by the person and the food types and other features can be received as message. LABVIEW is used to process the acquired from the Piezoelectric sensor and processing steps involved are signal filtering which is performed using Standard deviation using Sliding window technique, Signal smoothening using savitzky golay filter, Spectrogram is generated after spectrogram analysis based on time, frequency deposition an algorithm is developed. The features is extracted for each types of food intake and trained recognize the types of food intake.

Work of this paper is organized as follows. Similar works are described in section 2.Food intake recognition sensor and necklace design is described in section 3.Food intake detection method is described in section 4.Results are discussed in section 5.and concluded in section 6.

II. Related Work

Many sensors have been used in various ways to monitor food intake by detecting their swallow. E. S. Sazonov et al.[3].A piezoelectric strain gauge sensor was used to capture movement of the lower jaw during periods of quiet sitting, talking and food consumption Since the device is coupled with a strain gauge placed near the throat not practical for daily use.

How over et al.[2] introduced a method for detecting real-time information concerning bites taken during a meal. The method use an orientation sensor placed on the wrist of a user, and examine the rolling motion of the wrist in order to predict a pattern related to biting behavior. At the same time when the hand is not rotated at a determined pattern, it will not count the food bite. So, the possibility of wrong and undetection is more.

Sclabassi et al.[4] in this method it is shown that by using a video camera in wearable form to chronically record an individual's daily activities, food intake can be assessed more accurately, implementing this in day to day life is really impractical. Ottaviano et al.[5] introduce food intake monitoring system through fiber optic endoscopic examination. In which endoscope is connected to a video camera, DVD recorder, TV set. The setup will be bulky and non-wearable. Amft et al.[1] introduce food intake detection by identifying arm gestures using accelerometers and gyroscopes. Food intakes are monitored by identifying the arm gestures associated with the handling of cups, spoon and plates. However, the way of eating does not reveal the amount of food intake. At the same time possibility of false detection is high.

Makeyevet et al.[7] Swallowing sound recognition technique is proposed based on the limited receptive area neural classifier and time frequency decomposition. The proposed methodology was tested on the task of recognition of swallowing sounds no classification is performed and is limited to identifying swallows.

Suzuki et al.[8] A novel interface for sensing swallowing activities technique that is based on the duration of the swallowing action. Waveform transform analysis of audio data is performed, but the characteristic of food intake is not focused.

A piezoelectric sensor can be used as a vibration sensor which produces a voltage when subjected to physical strain is used in numerous applications. Main aim of the work is to recognize the

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food types based on the spectrogram analysis of sensed data.

III. Food Intake Recognition System

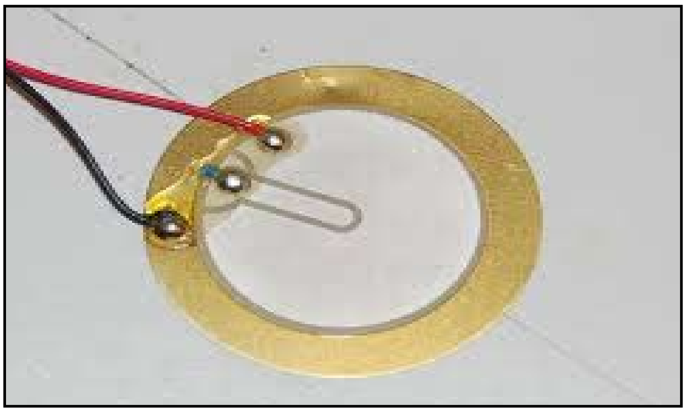
Food intake system comprise two parts hardware and software. LABVIEW is used in the processing of signals such as Noise reduction, signal filtering, signal smoothening spectrogram analysis are the preprocessing steps involved in Labview software. Feature extraction, classification and recognition of food types is performed in MATLAB software, refer[6] for wearable design of food intake recognition system. Fig(1) ,(2)shows the block diagram of food intake recognition system.

A. Piezoelectric sensor

Piezoelectric sensor is a device that uses the piezoelectric effect converting force in to an electrical charge.

Fig(3) shows the piezoelectric sensor. Piezoelectric sensors, which produce an output voltage corresponding with the mechanical stress applied to the body of the sensor. The piezoelectric sensor placed against the throat, trachea movement during swallow is represented as the output voltage of the sensor.

The signal acquired by piezoelectric sensor should be converted to a usable voltage the acquired signal is then digitized by using ADC.



Fig,1 : Piezoelectric sensor

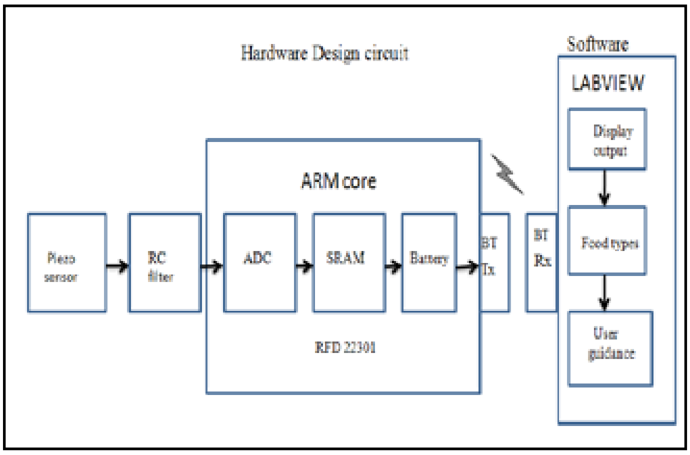


Fig. 2. : Block diagram of Hardware circuit design

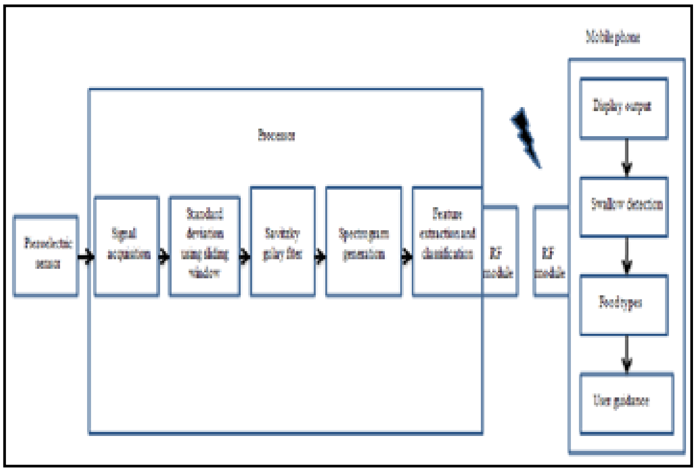


Fig 3 : Block diagram of food intake recognition system

IV. Proposed Methodology

The proposed method is implemented in LabView.It is a platform that helps to design and a system. It accelerates the productivity with graphical programming syntax that makes it simple to create, visualize, and code the systems. It is difficult to monitor the food intake in without signal processing, smoothing, and filtering, the noise cannot be differentiated from the signal. The main objective of this paper is to detect each swallow during food intake. Guidance and user feedback is given based on the detected swallow.

A. Standard Deviation using Sliding Window

Signal acquired from the piezoelectric sensor is then buffered locally until a sufficient number of samples have been acquired. Though the signal acquired from sensor is noisy it is difficult to view the clear signal .To reduce the noise content standard deviation is calculated for the acquired signal. The value is calculated for the elements that lie within the window and then the window is shifted to next element with sliding window, having window size,w.The average deviation of a signal is found by summing the deviations of all the individual samples, and then dividing by the number of samples, N.

$$\mu = \frac{1}{N-1}\sum_{i=0}^{N-1} x_i \qquad (1)$$

Subsequently, a sliding window is applied to generate a new waveform representing the standard deviation of the original data. The square root of variance gives the standard deviation.

$$\sigma^2 = \frac{1}{N-1}\sum_{I=0}^{N-1}(x_i - \mu)^2 \qquad (2)$$

The equation 2 is modified for the ease of calculating the standard deviation with sliding window.

B. Filtering and Smoothening

Savitzky Golay filter is used for data smoothing, which is based on local least-squares polynomial approximation [10].During food intake, each swallow is represented as peaks in the waveform. The savitzky golay filter reduces noise while maintaining the shape and height of waveform peaks. The polynomial is fitted to a set of input samples and then the approximation is done. The initial central point is replaced by the computed value which is equivalent to discrete convolution with a fixed impulse response. The polynomial order should be less than the frame size.

C. Spectrogram

Spectrogram often used for speech recognition. It is a visual representation of the spectrum of frequencies in a signal Creating a spectrogram using the Fast Fourier transform is a digital process. The sampled data in the time domain is broken into small data or chunks, which usually overlaps and then Fourier transformed to calculate the magnitude of the frequency spectrum. Once food intake is detected, the spectrogram is calculated around each signal.In STFT, the signal to be transformed is multiplied by the window function. The hanning window of window size 32 is used. The equation is mathematically written as,

$$STFT\{x(t)\} \equiv X(n,\omega)\sum_{t=-\infty}^{\infty} x[t]\omega[t-n]e^{-j\omega t} \qquad (3)$$

D. Feature Extraction and Classification

Using spectrogram the frequency and time changes during each food intake is monitored and the features are extracted for different types of food and samples are taken which is frequency and time are noted. Then the obtained features have to be recognized and classified this process is done in MATLAB. Solid foods have higher frequency than the liquids, this can be differentiated by the threshold value. Obtained features from LabView has to be trained and tested using neural fitting tool based on Back Propagation Algorithm in Mat lab for the food type recognition. It involves three stages training, testing and validation. Training data includes 75 percent of data and testing phase involves 25 percent of data, after validation the tested data predicts the results.

V. Results And Discussion

The real time signal acquired from piezoelectric sensor using Rfduino is received wireless in Android mobile through Rfduino test app is shown in below fig(4)

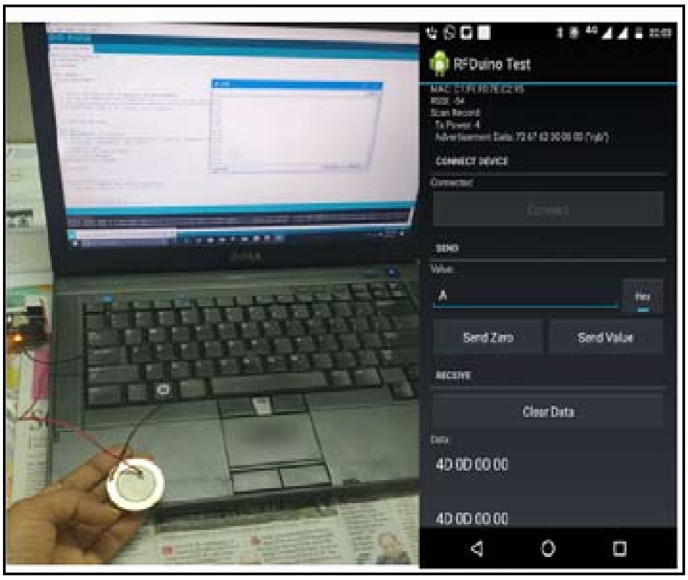


Fig. 4 : Voltage variation check by interfacing piezosensor through rfd22301

The real time signal acquired from piezoelectric sensor using Rfduino is received wirelees in Labview software is show in fig (5),(6) .

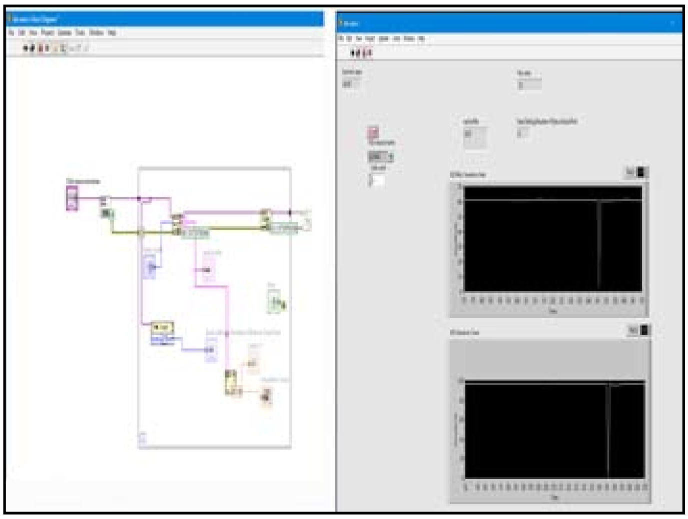


Fig. 5 : Wireless data reception from rfd22301 to labview with voltage display in frontpanel

The signal is received whenever the sensor is subjected to physical strain. In the acquired waveform more noise is observed .Signal noise should be reduced. To reduce the signal noise, the standard deviation is calculated for the acquired signal

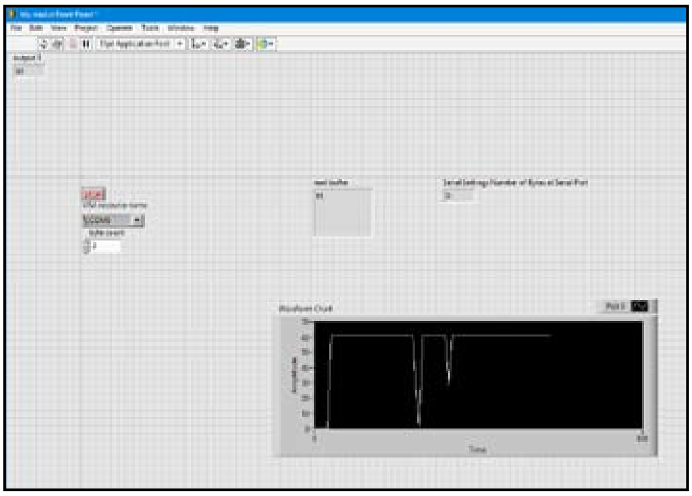


Fig. 6 : Front panel display of voltage read from rfduino

The signal is received whenever the sensor is subjected to physical strain. In the acquired waveform more noise is observed .Signal noise should be reduced. To reduce the signal noise, the standard deviation is calculated for the acquired signal. Fig (7) shows the standard deviated waveform where the standard window is calculated through sliding window.

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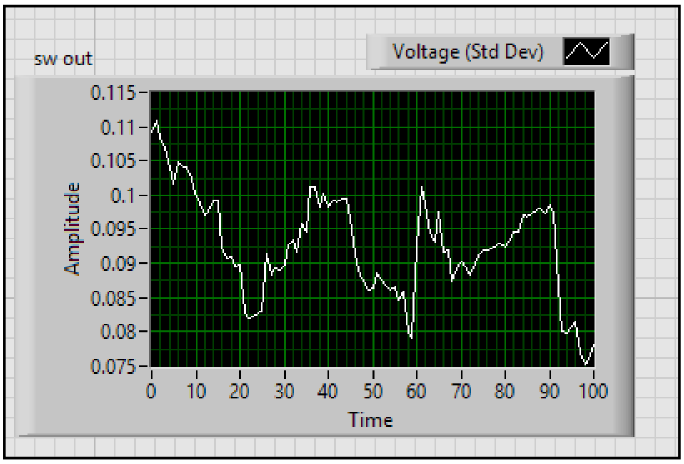

Fig. 7 : Filtered signal using sliding window

After the filtering of signal for each swallows inorder to obtain clear peaks leaving other irrelevant details signal has to be smoothened using Savitzky golay filter. Fig (8) shows the smoothened waveform.

After smoothening Spectrogram has to be generated for each swallows. For each food intake spectrogram varies based on time frequency deposition which is the visual representation of the graphical data

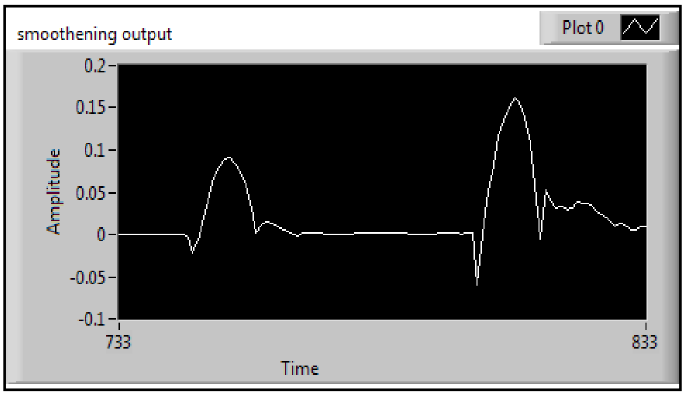

Fig. 8 : Smoothened signal using Savitzky golay filter

From the generated spectrogram features are extracted Fig (9) shows the generated spectrogram. From the resultant spectrogram frequency and amplitude for each swallows are noted and analyzed for classification.

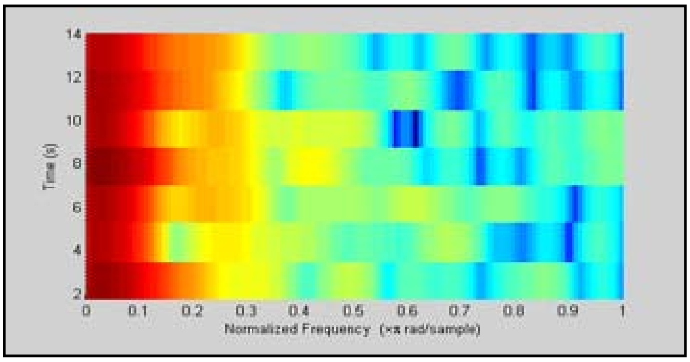

Fig. 9 : Spectrogram generation

By viewing the regression plot, the neural network fitting can be checked. The trained value should exactly fit the predicted value.

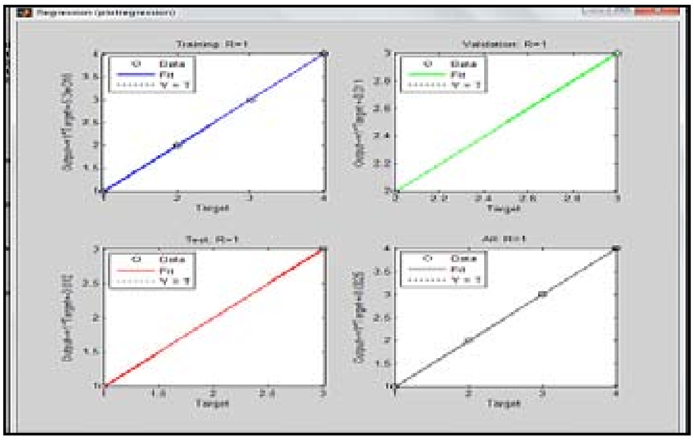

Fig. 10 : Regression Plot

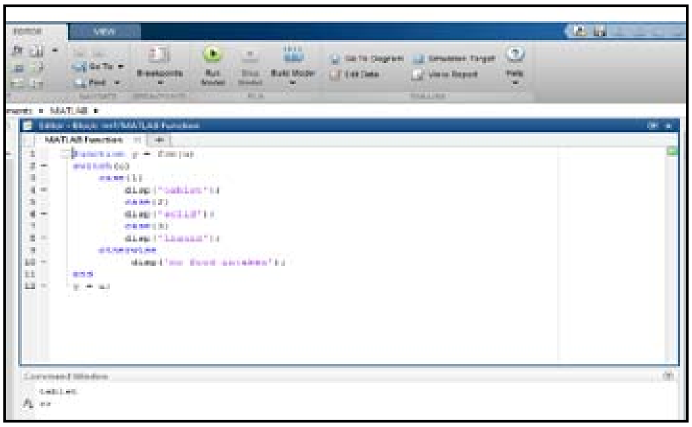

Fig.11 : Matlab Function predicting the target

After giving the input and target values for training, testing and validation with approximate number of neurons the data has to be trained and performance is noted in graph to test the accuracy and to reduce the error rate

VI. Conclusion And Future Scope

Swallow detection is analyzed based on data acquired from the piezoelectric sensor and the obtained signal is filtered, smoothened and spectrogram is generated for detected swallows,the samples of readings are taken for different classification of food and the obtained data are trained and the prediction of food type is done and the target which means the food type is displayed. In future the acquired signals feedback and user guidance is given to the mobile phone wirelessly with compact size.

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