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REVIEW ON ARRHYTHMIA DETECTION USING SIGNAL PROCESSING

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ABSTRACT

An electrocardiogram (ECG) is a bioelectrical signal which records the heart's electrical activity versus time. It is an important diagnostic tool for assessing heart functions. There are number of reasons which may affect its normal working. The objective of this thesis is to implement a simulation tool on MATLAB platform to detect abnormalities in the ECG signal and classification of heart disease by extracting features from ECG signals.

Keywords: Artificial Neural Network (ANN), Discrete Wavelet Transform (DWT), Heart Disease, Arrhythmia, linear prediction coefficients (LPC) component.

I. INTRODUCTION

An electrocardiogram (ECG) is a bioelectrical signal which records the heart's electrical activity versus time which is an important diagnostic tool for evaluating heart functions. The signals that make the heart's muscle to contract come from the senatorial node, the normal pacemaker of the heart. In an ECG test, the beating heart which generates electrical impulses are recorded. This is usually shown on paper, and records any problems with the heart's rhythm.

ECG signals are non-stationary signals. Doctors can easily recognize the heart failure by manually searching thousands of heartbeats. But the several important heart cycle movements are also very small and rapid and cannot be able to catch by the human vision. It cause the level of classifying in order to detect the heart disease is not precise. So it needs an exceptional algorithm that every single event of heart signal cycle can be held correctly and characteristic of each heart disease signal must be studied to make sure the signals represent the correct disease. This characteristic needs acute evaluation to sense the suitable heart disease. In some heart diseases like arrhythmias the malfunctioning of heart occurs at random hours in a day. So an automatic diagnostic tool should be there to detect such activity and diagnose the disease. Now days doctors are preferring digital tool for diagnosis which reduces the time consumption and complexity for analysis. Also it helps monitoring of patient without frequently visiting.

Hence, the algorithms proposed must be great precision of detection and exact classifiers are desirable to obtain a effective operation and can give earlier notification to the patients. But it is very hard to choose the algorithms that can suite with all of the disease. At best an algorithm with high ranks of accuracy and reduced level of false are really needed to be accepted. In order to minimalize such limitations, a system based on the combination of two signal processing algorithms and a classification algorithm will be implemented. Signal processing algorithms will be used to extract the ECG signal characteristics based on the Discrete Wavelet Transform

(DWT) and linear prediction coefficients of the algorithm (LPC) and the classification algorithm based on the Artificial Neural Network (ANN) will be developed which will detect the disease properly.

1.1. Heart Disease

Electrocardiogram (ECG) remains the simplest non-invasive and least expensive technology for diagnosis of arrhythmia. The early detection of arrhythmia is very important for the cardiac patients. The term "arrhythmia" refers to any change from the normal sequence of electrical impulses, causing abnormal heart rhythms. Arrhythmias may be completely harmless or life-threatening. Some arrhythmias are so brief (for example, a temporary pause or premature beat) that the overall heart rate or rhythm isn't greatly affected. But if arrhythmias last longer, they may cause the heart rate to be too slow or too fast or the heart rhythm to be erratic – so the heart pumps less effectively. A fast heart rate (in adults, more than 100 beats per minute) is called tachycardia a slow heart rate (less than 60 beats per minute) is referred to as bradycardia.

1.2. Literature Survey

Hari Mohan Rai, Anurag Trivedi [1] proposed DWT based scheme to classify ECG signal data. Back Propagation Neural Network (BPNN) was used to classify the ECG data and the system performance was measured on the basis of percentage accuracy. The overall system accuracy 97.5 % was obtained with the use of BPNN classifier. K.Amtul Salam, G.Srilakshmi [2] proposed method to detect arrhythmia from ECG signal using different concepts as Discrete Wavelet Transform (DWT), Adaptive Least Mean Square (ALMS) and Support Vector Machine (SVM). An algorithm for ECG analysis of arrhythmia detection provided peak detection accuracy of 97.65%. A study of adaptive wavelet approach with discrete wavelet transform obtained better performance in feature extraction of ST segment and QRS complex detection.

Sautami Basu, YusufU. Khan [3] had made an exploratory investigation of the classification of ECG signal. DWT method was used to determine the wavelet coefficients which were associated with five features. The features were ranked by using class separability criteria. The authors have established the Shannon Entropy as one of the most suitable features for the purpose of classification. However, this feature fails to demonstrate equally well discrimination power in case of PVC type arrhythmia disease. Ridhi Saini, Namita Bindal, Puneet Bansal [4] presented a paper paper in which ten heart diseases, as well as normal, had been classified by extracting features from original ECG (electrocardiogram) signals. Sixth level wavelet transformed ECG signals and k-nearest neighbour (kNN) classifier was used to classify the diseases. Classification efficiency of 87.5% was achieved using wavelet transform and kNN classifier. P.D.Khandait, Dr. N.G. Bawane, Dr. S.S. Limaye, S.P.Khandait [5] presented paper which deals with improved ECG abnormalities recognition using Wavelet Transform techniques for feature extraction and Arrhythmia detection based on Neuro-Fuzzy approach. Wavelet-transform was used for effective feature extraction and Adaptive Neuro-Fuzzy Inference System (ANFIS) was considered for the classifier model. Testing classification accuracy of 97% was achieved. Sani Saminu, Nalan Özkurt and Ibrahim Abdullahi Karaye [6] This paper has proposed a robust ECG feature extraction technique suitable for mobile devices by extracting only 200 samples between R-R intervals as equivalent R-T interval using Pan Tompkins algorithm at preprocessing stage. The discrete wavelet transform (DWT) was used and Classification was performed using neural network back propagation algorithm because of its simplicity. the proposed method gave result with average accuracy of 98.84%.

In the literatures, many researchers have used different techniques and algorithms to develop the system. The performance of the developed system is very promising but further evaluation can be done to improve the accuracy. Our research mainly aimed to use the selected algorithm for feature extraction and classification to enhance the result of accuracy and expand the types of heart disease that can be classified.

II. DISCRETE WAVELET TRANSFORM

The ECG signal is a non-stationary signal with high frequency bursts and long quasi-stationary components. The Fourier Transform (FT) cannot be used for the analysis of such non-stationary signal because it provides only frequency information and not the time information of that frequency. The temporal information about the frequency contents of the signal is obtained by using Short Time Fourier Transform (STFT). But STFT has fixed window length. The WT has flexible time-frequency window and hence is suitable tool for the analysis of non-stationary ECG signal.

DWT theory requires two sets of related functions called scaling function and wavelet function given by

$$\emptyset(t) = \sum_{n=0}^{N-1} h[n]\sqrt{2\emptyset}\ (2t-n) \quad (1)$$

and

$$\varphi(t) = \sum_{n=0}^{N-1} g[n]\sqrt{2\emptyset}\ (2t-n) \quad (2)$$

Where $\varphi(t)$ is called scaling function, *g[n]* is an impulse response of high pass filter, and *h[n]* is an impulse response of low pass filter. Using a pair of these filters the scaling and wavelet functions can be implemented. The input signal is low pass filtered to give approximate components and high pass filtered to give detailed components of the input signal. The approximated components at each stage are further decomposed using same low-pass and high-pass filters to get the approximated and detailed components for the next stage. This type of decomposition is called dyadic decomposition, whereas decomposition of detail signal along with the approximation signal at each stage is called uniform decomposition.

III. LINEAR PREDICTION COEFFICIENTS ANALYSIS

Linear Prediction Coefficients (LPC) is well known for its simplicity and performance. It is a power tool in signal processing and can extract dominant features of speech signal. Due to the capability of precise estimation of signal parameters and fast computational speed, these coefficients are used in evaluation of electrocardiogram signal changes.

Each sample of the signal could be written as a linear equation in terms of previous inputs and outputs.

$$S(n) = \sum_{k=1}^{P} a_k\, s(n-k) + Gu(n) \quad (3)$$

The frequency effects of different parameters of the signal can be represented as:

$$H(z) = \frac{G}{1-\sum_{k=1}^{P} a_k\, z^{-k}} \quad (4)$$

Each sample of the signal can be estimated from p previous samples of it due to the linear approximation

$$\hat{S} = \sum_{k=1}^{P} a_k\, s(n-k) \quad (5)$$

A set of prediction coefficients should be found to minimize the mean square prediction error:

$$e(n) = S(n) - \hat{S}(n) = S(n) - \sum_{k=1}^{p} a_k\, s(n-k) \qquad (6)$$

The combination of LPC with WT has been proposed in this paper. Hence we apply LPC technique on each sub band signal after the wavelet decomposition which gives the combined benefits of LPC and WT.

IV. ARTIFICIAL NEURAL NETWORK

Artificial neural network is used for complex and difficult tasks. It is data mining tool used for clustering. The collection of neuron like processing units with weighted connections between the units forms the neural network.

A neural network system consists of 3 layers:

- The input layer is the feature set to be trained or classified.
- The hidden layer consists of many interconnected artificial neurons working in parallel to model the relationship between the input layer and the output layer.
- The output layer is the result obtained after running the input layer through the hidden layer.

Where each neuron in the hidden performs task which is described by the following equation:

$$a = f(wp + b) \qquad (7)$$

Where *p* is the input, *f* is the transfer function, *w* is the weight to be multiplied to the input, *b* is the bias to be added to the input and *a* is the output of the neuron the bias can be thought of as a weight, except that its value is always 1. The bias is added to the weighted input and run through the selected transfer function. If the input exceeds a certain threshold, the neuron fires, otherwise it does nothing.

V. PROPOSED SYSTEM

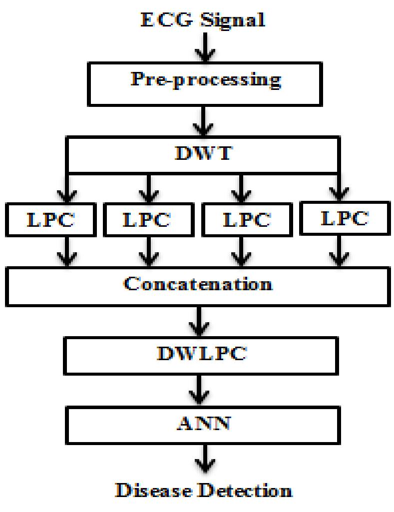

Fig. 1. Block diagram

The ECG signal database is obtained from MIT-BIH Arrhythmia Database [9]. At the first step the signal must be pre-processed and its noise must be eliminated. In this research the feature extraction method uses DWT and LPC methods to extract the R wave and consequently the QRS complex. The LPC features will be estimated from the sub band signals obtained from the DWT in the proposed technique of feature extraction. Fig.1 shows the block diagram of the proposed feature extraction system. The pre-processed and windowed speech frames

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will be DWT decomposed using Daubechies's wavelet filters. The LPC features will be estimated from the DWT coefficients in the time domain, because the time information is retained by actual wavelet coefficients. The ECG signal will be wavelet decomposed and from each of these sub bands LPC features of the *p*th order will be extracted. The LPC coefficients obtained will be concatenated to form a vector denoted as Dyadic Wavelet Decomposed LPC (DWLPC). This is given to the ANN.

VI. SIMULATION RESULTS

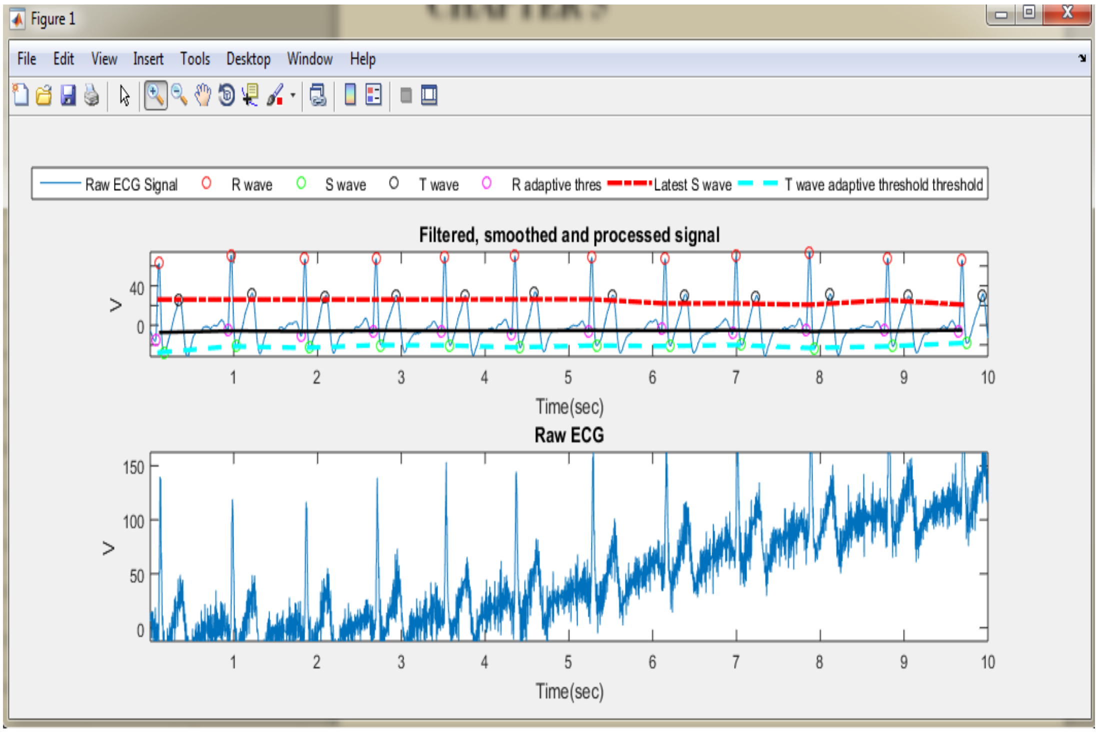

Fig. 2. Raw ECG Signal and Preprocessed ECG

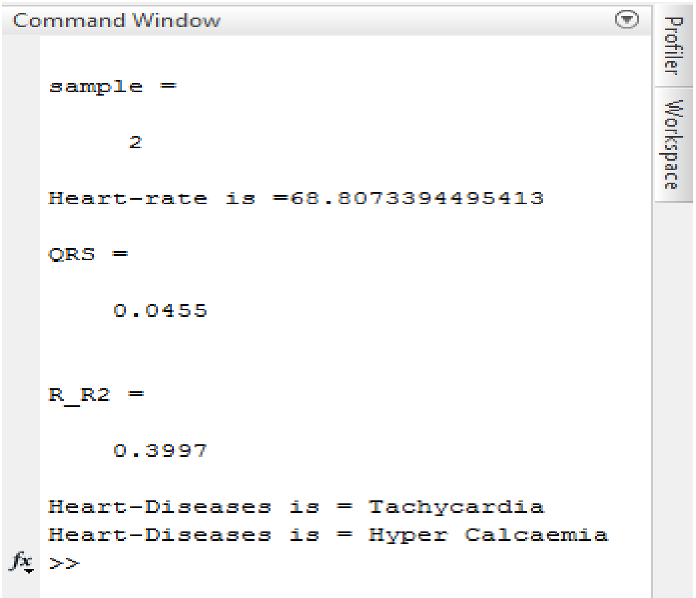

Fig. 3. Detected Diseases

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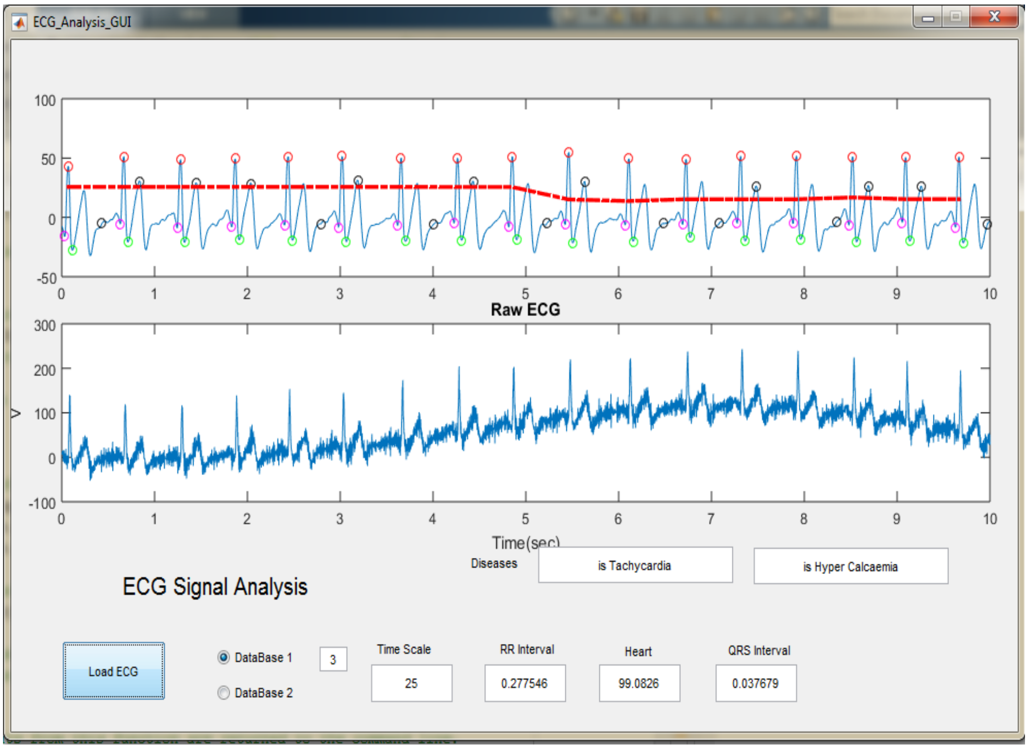

Fig. 4. imlemented gui

VII. CONCLUSION

Some heart disease classification techniques are reviewed in this paper. ECG signals transmit important information about the abnormalities in heart. It is therefore very essential to analyze the ECG signal correctly which helps the doctors to make conclusion correctly. Therefore there is a need to decrease the human interaction in analyzing the ECG data and use some digital signal processing algorithms to analyze the abnormalities in the data available. The future work will include feature extraction using Discrete Wavelet Transform (DWT) and linear prediction coefficients of the algorithm (LPC) and the classification algorithm based on the Artificial Neural Network (ANN) will be developed. The system presented in this paper is an effort to simplify and maximize the accuracy of heart disease detection system.

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