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Analysis of ECG Signal Classification Methods for Diagnosis of Heart Disease Using DWT and RBF Neural Network

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ABSTRACT

Heart diseases are common diseases which affects the human health. The arrhythmias, which might not be critically life-threatening but still, need attention and therapy to avoid deterioration. There is no fast and accurate method to analyse ECG signal. In this paper a new approach is designed for heartbeat classification based on DWT and RBF neural network. Discrete Wavelet transform will be applied separately to each heartbeat to extract static features. In addition, RR interval information like QRS points is computed to provide dynamic features. These two different types of features are concatenated as feature vector and a Radial Basis Function Neural Network classifier is utilized for the classification of heartbeats into one of different classes. The work is done on the data from two ECG leads and both decisions are fused for the final classification decision. It will be validated on the baseline MIT/BIH arrhythmia database for accuracy and different performance parameter. The clinical results are compared for diagnosis. The result of the work gives an automatic heartbeat classification.

Keywords : RBF neural network QRS, DWT

I. INTRODUCTION

For heart disease diagnosis, electrocardiogram (ECG) has become most useful signal. The effective analysis of these signals is necessary for classification as well as diagnosis of various heart diseases [1]-[2]. With the development of different tools for signal assessment, wavelet-based approach has become very effective for analysis of non-stationary signals. In this work, attempt has been made to apply discrete wavelet transform based wavelet decomposition techniques for classification of ECG signals and diagnosis of various heart diseases in effective way [4]. Now a days, the automatic ECG signal analysis faces a difficult problem due to a large variation in morphological and temporal characteristics of the ECG waveforms of different patients and the same patients. At different times, the ECG waveforms may differ for the same patient to such an extent that they are unlike each other and at the same time alike for different types of beats. Owing to this, the beat classifiers perform well on the training data but provide poor performance on the ECG waveforms of different patients. The overall aim of the work carried is to process and extract the useful information from the ECG signal for clinical purposes and automatic cardiac beat detection using digital signal processing and pattern recognition algorithms.

II. METHODS AND MATERIAL

2. PREPROCESSING

2.1 Normalization

Pre-processing of ECG signals first step is normalization.

It normalizes the amplitude of the ECG signals to zero mean and standard deviation of unity which reduces the DC offset and eliminates the amplitude variance for each ECG signal. Let, x be a raw ECG signal taken from the MIT-BIH arrhythmia database [8]. The standard deviation of the signal is defined as

$$\sigma = \sqrt{\frac{1}{(N-1)} \sum_{i=1}^{N} (x_i - m)^2}$$

σ is the standard deviation of the signal and m is the mean value of the signal. Then the normalized signal is determined as

$$S_n = \frac{(x-m)}{\sigma}$$

Where, S_n is the normalized signal. This normalized signal is applied as input to R-peak detection.

2.2 R-PEAK DETECTION: The determination of R peak helps to extract the features from ECG signal [1]. The QRS complex detection that is locating the R-peak for each beat of the signal is an important step towards feature extraction [4]. Once the R-peak is determined, all other important peaks of the ECG signal are determined with respect to the R-peak [7]. Thus, QRS complex detection of the ECG signal is a valuable task for ECG signal analysis.

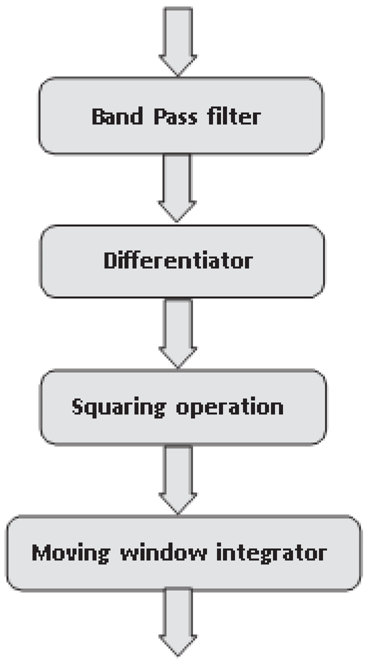
Normalized ECG signal

R peak detection

Figure 1. Block diagram of the Pan-Tompkins's algorithm for R-peak detection

3. FEATURE EXTRACTION

3.1 Wavelet transform based feature extraction method [5].



The choice of appropriate wavelet and the number of decomposition levels are very crucial in the analysis of ECG signals using discrete wavelet transform (DWT) [3],[6].The decomposition levels are selected based on the maximum frequency components of the signal such that selected parts of the signal correlate well with the wavelet coefficients. The wavelet-based feature extraction method is briefly described in algorithm [1]. The decomposition levels are taken as 4. Thus, four detail coefficients D1-D4 and one approximation coefficient A4 are extracted from the

ECG signal. In the reported work the Daubechies wavelet of order 2 (db2) is chosen due to its similar morphological structure with the ECG signals [2]. The wavelet coefficients give a compact representation of the signal that indicates the distribution of signal energy in time and frequency domain. The computed detail and approximation wavelet coefficients of the ECG signals of each record are used as the feature vectors representing the ECG signal. For each ECG cardiac cycle, a window of -250 ms to +250 ms around the R-peak is chosen to extract the efficient features. Since each MIT-BIH ECG signal is sampled at 360 Hz, hence, the extracted number of DWT coefficients at a specific level for each ECG beat is the same. For each ECG beat the number of details coefficients are computed at the first, second, third and fourth levels.

3.2 Morphological feature

The proposed morphological features extraction technique is briefly described in algorithm.

Algorithm:

Morphological feature extraction

- Select a window of 250ms around the R peak as found in the QRS detection algorithm that is 180 samples are selected around the R peak.
- Apply the S- transform on the selected ECG signal to represent in time-frequency domain.
- Select the frequency band (3-20Hz) from the time-frequency representation of ECG signal because most of the QRS complex energy and least amount of high and low frequency noises exists in this frequency range.
- Obtain the morphological features from each sample by averaging its frequency from time frequency domain of the ECG signal.
- The proposed combined feature vector is generated by coupling of DWT Kurtosis and Skewness approximation coefficient-8, DWT Kurtosis and Skewness details coefficient-8, DWT mean Kurtosis and skewness detail coefficient-4 RR interval features-4.

4. RBF NEURAL NETWORK CLASSIFIER

RBF Neural Network

RBF Neural Network based on the comparative study ECG signals have been classified. Normal ECG signals have been isolated from those suffering from heart diseases. Signals of heart patient have again been classified based on the statistical parameter obtained by DWT based wavelet decomposition. With the help of radar, histogram and other effective tool diagnosis of heart diseases have been done.

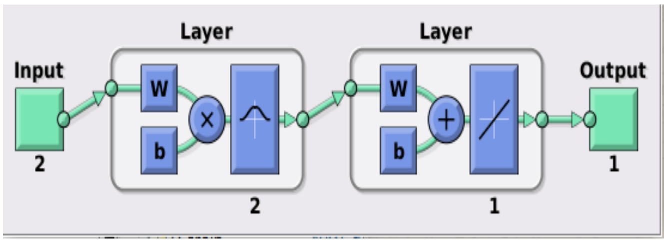


Figure 2. Typical RBF trained neural network in MATLAB

III. RESULTS AND DISCUSSION

Execution result

After executing, GUI interface will be displayed for different fetched ECG signal.

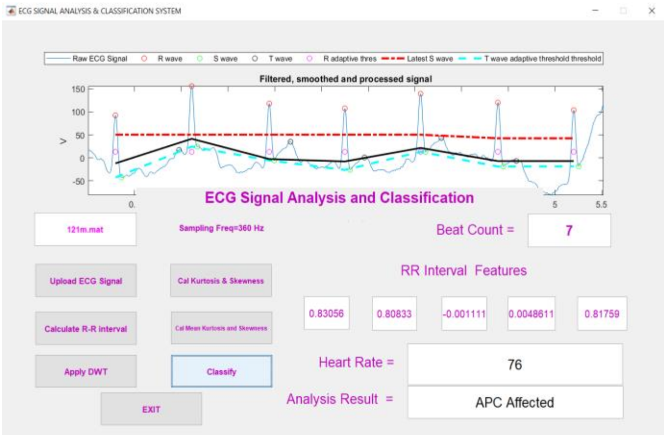


Figure 3. APC affected result

Comparison Results

Kurtosis of approximate coefficients for MI, CHF, Arrhythmia and Apnea has been compared with that of normal healthy person as shown in Fig. 4. It shows that values of KA are distinctly different at DWT level

1, 2 & 3 and therefore KA at DWT level 1,2 and 3 may be used for diagnosis of these diseases.

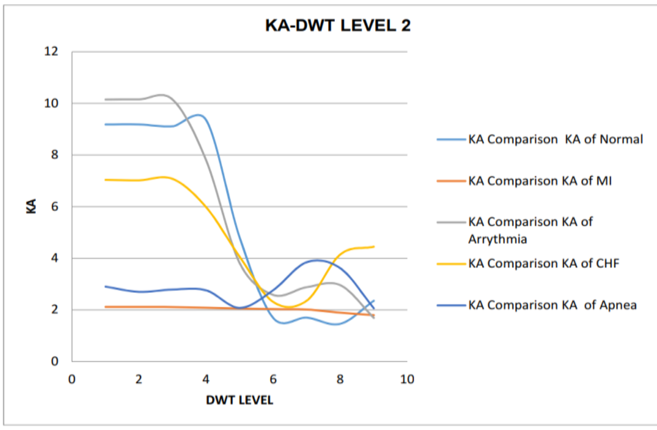


Figure 4. KA vs. DWT a patients and normal person

Kurtosis of details coefficients for MI, CHF, Arrhythmia and Apnea have been compared with that of normal healthy person as shown in Fig. 5. It shows that values of KD are distinctly different at DWT level 1 and therefore, KD at DWT level 1 may be used for diagnosis of these diseases.

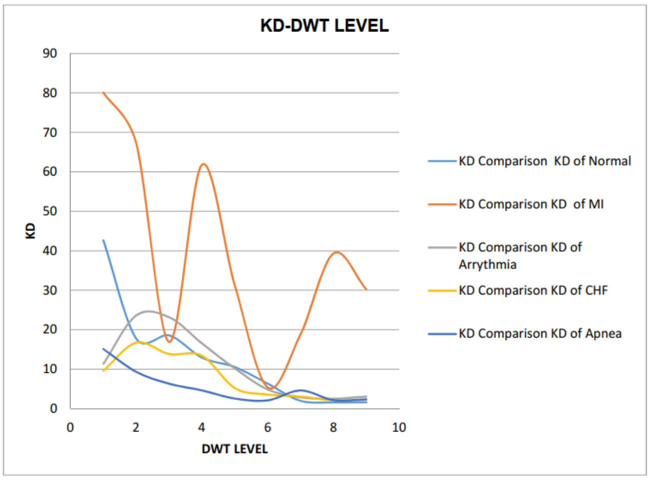


Figure 5. KD vs DWT Level for patients and normal person

Skewness of approximate coefficient for MI, CHF, Arrhythmia and Apnea has been compared with that of normal healthy person as shown in Fig. 5.4. It shows that values of SA are distinctly different at DWT level 1 and therefore, SA at DWT level 1 may be used for diagnosis of these diseases.

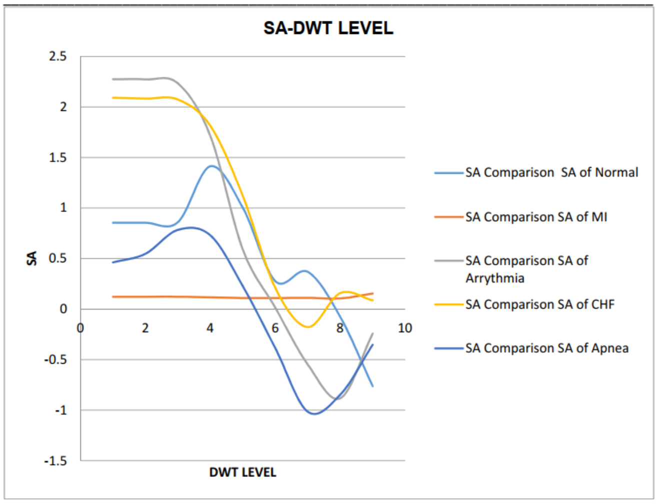


Figure 6. SA vs DWT Level for patients and normal person

Skewness of details coefficient for MI, CHF, Arrhythmia and Apnea has been compared with that of normal healthy person as shown in Fig. 5.5. It shows that values of SD are distinctly different at DWT level 4 and therefore, SD at DWT level 4 may be used for diagnosis of these diseases.

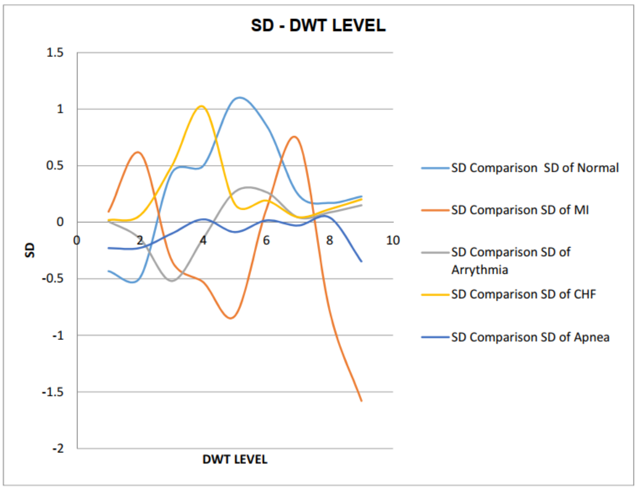


Figure 7. SD vs DWT Level for patients and normal person

IV. CONCLUSION

The proposed technique is the effective use of discrete wavelet transformation based statistical parameter in the analysis of ECG signal. As ECG signals are non-stationary therefore, wavelet transformation is suited which give information in time frequency domain. As in present day data capture is done in digital format, use of discrete wavelet transform is found effective option.

Accuracy

Percentage accuracy of individual class for MIT-BIH database is as shown in following table where results are quite promising and 100% accuracy for Normal ECG is achieved which indicates there will be no false positive error in algorithm.

Class wise Accuracy of algorithm

Type	Accuracy in %
APC	90
PVC	72
LBBB	92
RBBB	94
Normal	100

V. REFERENCES

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