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Detection of Artial Fibrillation Disorder by ECG Using Discrete Wavelet Transforms

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Abstract: Atrial fibrillation (A-fib) is the most common cardiac disorder. To efficiently treat or inhibit,an automatic detection based on Electrocardiograph (ECG) monitoring is significantlyrequired.Electrocardiogram (ECG) is a key function in the analysis of the heart functioning and diagnostic of diseases. Currently a computer based system is used to analyse the ECG signal. The main aim of this project is to analyse a heart malfunctions named asAtrial fibrillation, using Discrete Wavelet Transforms (DWT). The ECG signals were decomposed into time-frequency representations using DWT and the statistical features were calculated to describe their distribution.The DWT detailed coefficients are used to obtain various parameters of the ECG signal like the mean, variance, standard deviation and Entropy of the signal. An analysis had been made with these parameters of various patients with normal heart functioning and Atrial fibrillation to identify the disorder.

Key words: Atrial fibrillation · Electrocardiogram (ECG) · Discrete Wavelet Transforms (DWT)

INTRODUCTION

Cardiac diseases and heart failure are one of the most significantcausesfor death nowadays. According to the World Health Organization, cardiac disease or cardiovascular diseases (CVD) are the number one cause of death universally. Of these deaths, 82% take place in low- and middle-income countries.Atrial fibrillation (A-fib) is the most common cardiac arrhythmia [1]. Arrhythmia is a kind of disease which shows abnormal beats and such abnormal heartbeats may cause increase or decrease in blood pressure which can be dangerous as it may lead to paralysis or stroke or even sudden death. Cardiac arrhythmias are abnormality or disturbances in the behavior of the heart's electrical activities. These disturbances leads to abnormality in rate and rhythm hence referred as arrhythmic.

The analysis of the electrocardiogram (ECG) signal is the method available for diagnosing cardiac arrhythmias. However it is not life frightening in itself, insistent cases of A-fib may cause palpitations, fainting, chest pain,or congestive heart failure and even stroke. To effectively treat or prevent A-fib, automatic A-fib detection based on Electrocardiograph (ECG) monitoring is extremely necessary [2,3].The Electrocardiogram is the interpretation of the electrical activity of the heart for a period of time. It is the most essential part of heart monitoring for a patient[5]. It is a non-invasive technique to measure the heart functioning and for this reason is used widely in heart monitoring. It records the electrical activity of the heart by electrical signals reached to the surface of the skin.The ECG wave is shown in the Fig. 1.

The ECG graph essentially consists of the PQRS and T components. The P wave is due to the electrical depolarisation of the atria, the QRS complex is due to the ventricular depolarisation and atrial repolarisation of the ventricles of the heart. However the effect of atrial repolarisation is minimal in the QRS complex and the T wave is due to the ventricular repolarisation. The width of the T wave is about 0.16s for a normal healthy heart.

Any defect in the ECG graph can be detected easily and by analysing the ECG doctors can decide on the state of the heart functioning, cardiovascular muscle functioning and also any abnormalities that arise in the valves of the heart.

System Implementation: The ECG data for normal and abnormal is obtained from PhysioNet[11], loaded using MATLAB command. This signal is then pre-processed using notch filter and Discrete Wavelet Transform can be used to obtain the features which are used for diagnosing the disorder as shown in Fig. 2.

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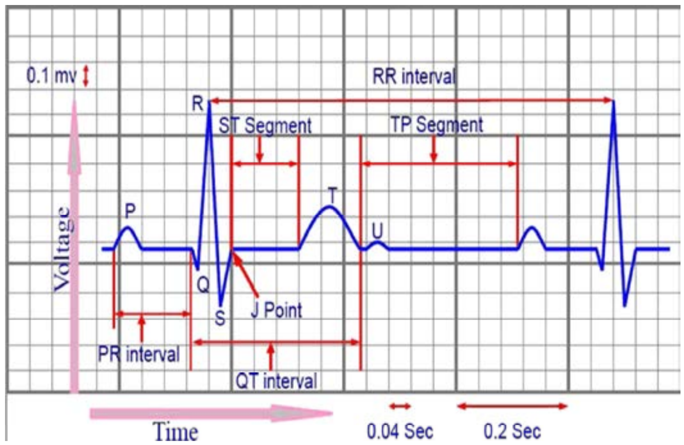

Fig. 1: ECG waveform for a healthy heart

Fig. 2: System Implementation

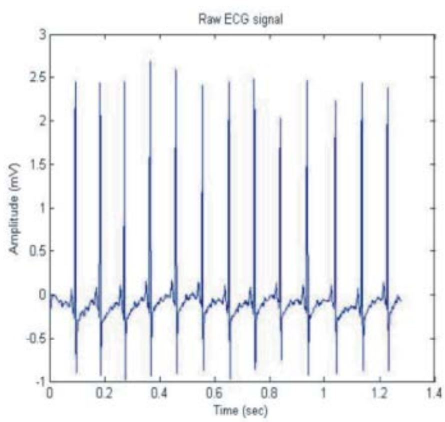

Fig. 3a: Output from normal ECG

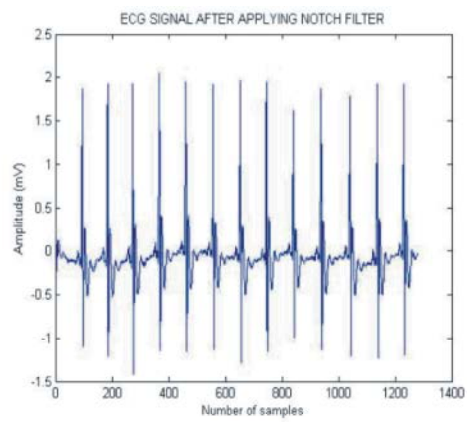

Fig. 3b: Output from notch filter

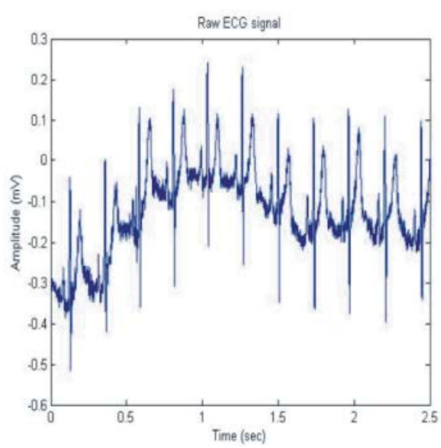

Fig. 4a: Output from Atrial Fibrillation ECG

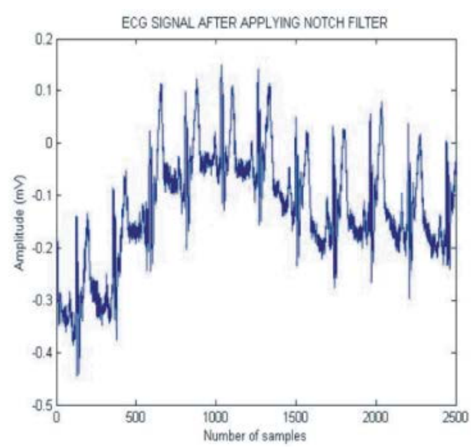

Fig. 4b: Output from notch filter

The normal andatrial fibrillation ECG signal, after loading from the PhysioNet is shown in Fig.3a and 3b. The Pre-processing of ECG signals using notch filter are shown in Fig.4a and 4b.

Discrete Wavelet Transforms: The DWT decomposes the obtained noise-free signal into various levels. Filters of different cut-off frequencies are used to obtain the detailed coefficients of the signal [6,7]. Various low pass and high pass filters are applied to obtain these coefficients. The High pass filter gives the detailed coefficient whereas the low pass filter gives the approximated coefficients. However we have chosen only the detailed coefficients to extract the features of the signals. The obtained signal is decomposed into 6 wavelet signals using Daubechieswavelet transform [10,13]. According to the wavelet theory the $[n-1]^{th}$ signal resembles the original signal. This fifth detailed coefficient is used to obtain the features of the signal like the mean, variance, Standard deviation, entropy, etc.

The DWT, as said above is done by the application of low pass and high- pass filters simultaneously. In this project, a high pass butterworth filter is used to obtain the detailed coefficients of the signal.The processed signal is decomposed into six detailed coefficients and the features are extracted from the fifth coefficient.These above steps are done for both the signals, of a normal heart and that of a heart with atrial fibrillation. The results are plotted as shown in Fig.7.

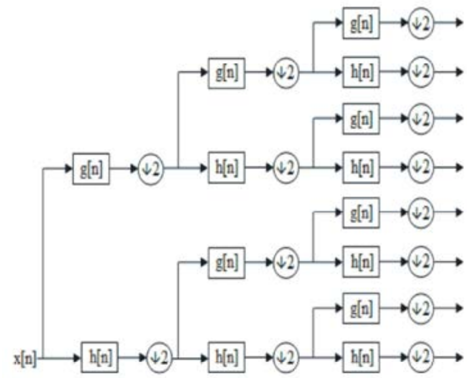

Fig. 6: Wavelet Decomposition

Feature Extraction: Feature Extraction is the extraction of input data in a form that is required for the analyser, by reducing the data representation pattern. The data is extracted by the feature set in order to perform the classification task. It is a non-destructive process, i.e. it does not vary the input signal but just derives a particular data from the signal, which is essential for the analyser to accurately classify the models.

In the feature extraction stage, several different approaches can be used so that numerousdifferent features can be extracted from the same raw data. The wavelet transform (WT) provides very wide-rangingmethods which can be applied to several tasks in signal processing. Wavelets are preferably suited for the analysis of sudden short-duration signal changes.

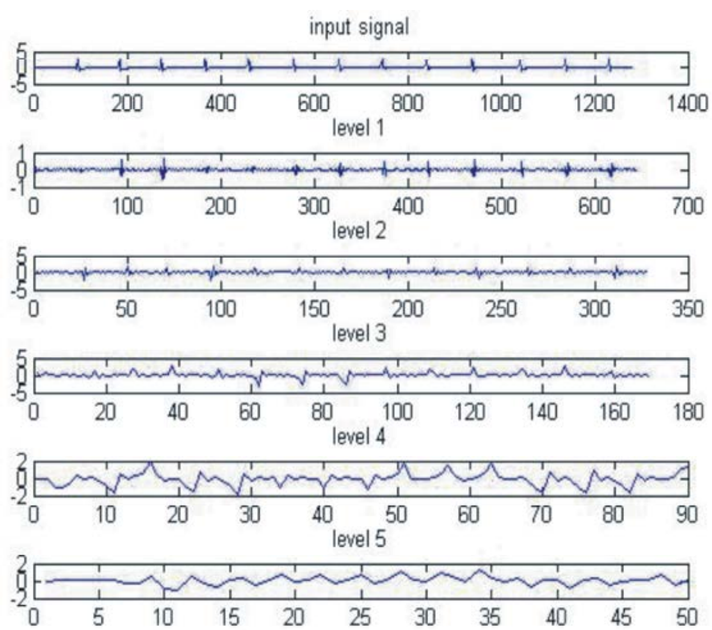

Fig. 7: Wavelet Decomposition upto 5 detail coefficient of Normal ECG Signal

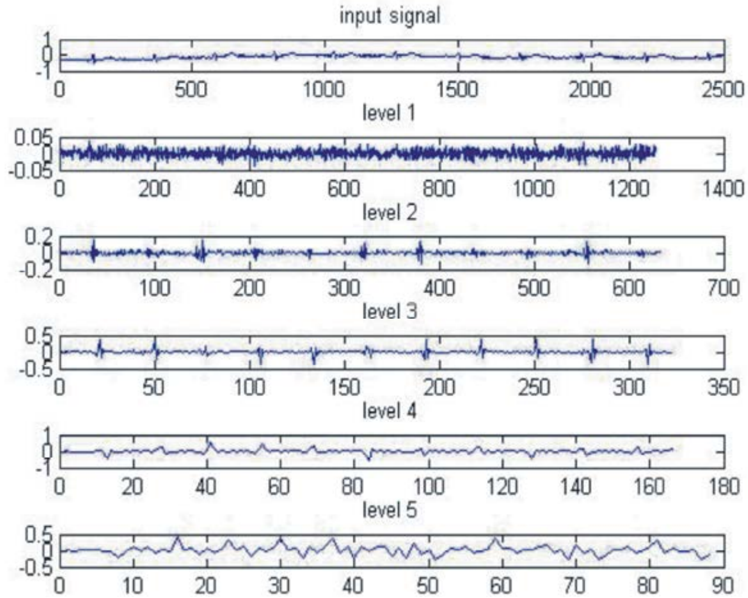

Fig.8 Wavelet Decomposition upto 5 detail coefficient of(A-fib) ECG Signal

One of the importantapplication is the ability to compute and influence data in compressed parameters which are frequently called features [12]. Thus, the time-varying ECG signal, consisting of several data points, can be compressed into a few parameters by the usage of the WT. These parameters describe the performance of the time-varying ECG signal. This feature of using a lesser number of constraints to represent ECG signal is predominantly important for recognition and diagnostic purposes [14–17].

RESULT AND DISCUSSION

The extracted features for normal and atrial fibrillation using DWT arecompared and tabulated in the Table 1. From the table, the statistical parameters for normal ECG is higher than the atrial fibrillation and the extracted features show the differences more clearly.

Features	Normal	Atrial fibrillation
MEAN	0.057623	0.015957
VARIANCE	0.23544	0.021782
NORM	0.23073	0.021534
STD DEVIATION	0.48523	0.14759
COVARIANCE	0.23544	0.021782
ENTROPY(LOG ENERGY)	-107.2528	-301.2876
ENTROPY(SHANNON)	3.283	3.1108

CONCLUSION

Automatic detection of heart arrhythmias might be very essential in medicalpractice and lead to early detection of aequitably common disorder and mightaid contribute to reduced mortality. In this study, the use of discrete wavelet transform(DWT) for extraction of features from the ECG signal hasbeen presented.The main advantage of this study is that, by using 5scales in computing DWT of signals, the morphologicaldifferences between several types of ECG signal are emphasized and the extracted features show thedifferences more clearly.

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