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Abnormality Detection in ECG Signal Using Wavelets and Fourier Transform

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ABSTRACT: *Electrocardiogram (ECG) is used to record the electrical activity in the heart. It is the most important physiological parameter that gives the correct assessment regarding the functioning of the heart. The paper proposes a method based on signal processing correlation technique to find out whether the ECG is normal or abnormal. Many of the abnormal ECGs are called Arrhythmias. Aim of this study to analyze the ECG signal using MATLAB and to find whether the signal is normal or abnormal. According to different arrhythmia it helps to analyze the electrocardiogram (ECG) signal, extract the features, for the classification of heart beats. ECG feature extraction system has been developed and evaluated based on the multi-resolution wavelet transform.*

I. INTRODUCTION

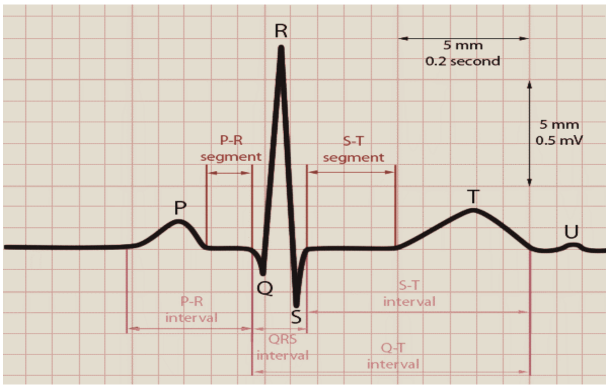
The electrical activity associated with the functioning of the heart is known as Electrocardiogram (ECG). ECG is a quasi-periodical, rhythmically repeating signal synchronized by the function of the heart, which acts as a generator of bioelectric events.

ECG is composite from 5 waves - P, Q, R, S and T. An ECG machine interprets and records the electrical impulses of the heart. An electrocardiogram (ECG) is used to record the electrical activity of the heart. The heart generates electric impulses throughout the body and on its surface. These impulses can be detected by the ECG machine.

The ECG is recorded with the help of several electrodes which are attached to the body of the patient and are connected by leads to the device. The device itself consists of a graphing device. The rhythmic beating of the heart is due to the triggering pulses that originate in the area of specialized tissue in the right atrium of the heart. This area is known as sino-atrial node. This forms a very regular pattern which establishes a control for patients that do have heart problems.

The purpose of this study is to develop a method to distinguish healthy and abnormal subjects using the correlation coefficients of ECG waveforms. There are three steps involved namely Discrete Wavelet Transform, Fast Fourier Transform, comparison of correlation coefficients.

II. NORMAL ECG WAVEFORM



Parameters:

Amplitudes:

- P wave -: 0.25mV
- R wave -: 1.6 mV
- Q wave -:25 percent of R wave
- T wave -:0.1 to 0.5 mV

- Normal Values of Amplitude and Duration of ECG

  Duration:
- P-R Interval -: 0.12 to 0.20 sec
- Q-T Interval -: 0.35 to 0.44 sec
- S-T Interval -: 0.05 to0.15 sec
- P wave Interval -:0.11 sec
- QRS Interval -: 0.09 sec

III. THEORETICAL BACKGROUND

An ECG is the recording (gram) of the electrical activity (electro) generated by the cells of the heart (cardio) that reaches the body surface.The electrical activity associated with the functioning of the heart is known as Electrocardiogram (ECG). ECG is a quasi-periodical, rhythmically repeating signal synchronized by the function of the heart, which acts as a generator of bioelectric events. ECG is composite from 5 waves - P, Q, R, S, and T. An ECG machine interprets and records the electrical impulses of the heart. The heart produces tiny electrical impulses which spread through the heart muscle to make the heart contract. These impulses can be detected by the ECG machine.

IV. BLOCK DIAGRAM

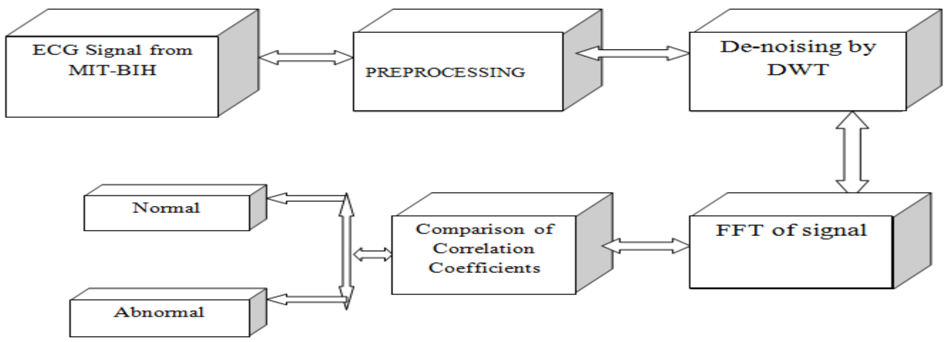


Fig1: Block Diagram of Abnormality Detection Method of ECG Signal

The block diagram of employed method is shown in fig1. As shown in fig1, the whole methodology is divided into four basic parts: Preprocessing, De-noising by DWT, FFT of signal and comparison of correlation coefficients. From the figure, it can be seen that the ECG signal from MIT-BHT is offered for preprocessing. Before applying this original ECG signal to the next stage, it should be pre-processed to eliminate existing noises. The preprocessing stage further proceed for de-noising ECG signal. Final step of the method is to analyze the processed signal is normal or abnormal.

A. De-noising:

In this stage the different noise structures are eliminated using DWT and FFT. De-noising Procedure of the Signal consists of these two important steps.

1. Discrete Wavelet Transform:

It is a Wavelet Transform method for de-noising of the ECG signal. It decomposes the signal into different components that aterialize at different scales. Any continuous function can be represented in the form of discontinuous functions, and by doing so one can go to any level of continuity that one desires. This idea is given by HAAR mathematician. That is, we start from a very discontinuous function and make it smoother and smoother by adding more and more discontinuous functions (additional information) to it. This idea is opposite to the idea of Fourier transform. As in Fourier transform the discontinuous function is represented in the form of smooth continuous function. Discrete wavelet transform is defined as follows:

$$\varphi_{m,n} = \frac{1}{\sqrt{a^m}} \varphi\left(\frac{t - nba^m}{a^m}\right) dt$$

[5]

Where φ is the wavelet function, a is the scale parameter, and the integers m and n control the wavelet dilation and translation respectively.

2. Fast Fourier Transform:

The fast Fourier transform (FFT) is a discrete Fourier transform algorithm which reduces the number of computations. FFTs were first discussed by Cooley and Tukey (1965). Also Gauss had actually described the critical factorization step. Fast Fourier transform algorithms generally divided into two classes: 1) decimation in time and 2) decimation in frequency. A fast Fourier transform (FFT) algorithm computes the discrete Fourier transform (DFT) of a sequence, or it's inverse. Fourier analysis converts a signal from its original domain to a representation in the frequency domain and vice versa. There are different methods for computation of FFT.

One of them is factorizing the DFT matrix into product of sparse factors. it manages to reduce the complexity of computing the DFT from O(n^2) to O(n log n) where, n is the data size. Fast Fourier transforms are widely used for many applications in engineering, science, and mathematics. Formulae for fourier transform are as follows

$$f(t) = \frac{1}{\sqrt{2\pi}} \int_{0}^{\infty} F(\omega)\, e^{i\omega t}\, dt$$

$$f(t) = a_0 + \sum_{n=1}^{\infty}\left[a_n \cos\frac{2n\pi}{T}t + b_n \sin\frac{2n\pi}{T}t\right]$$

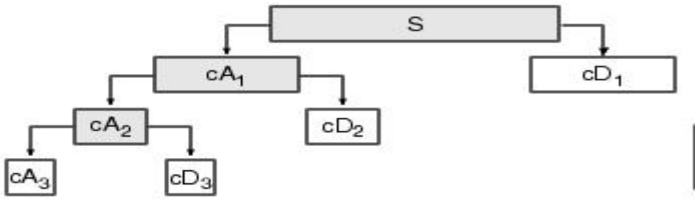
It can be explained by following plots. Results of FFT and DWT of signals S1 are shown in figures as follows.

V. METHODOLOGY

We have reffered MIT-BIH database for the analysis. The correlation Technique is used to classify whether the ECG is normal or abnormal. Out of total 35 signals, we haveconsidered one normal signal as the refference. The refference is then used to correlate with the another signals. Based on the correlation factor the ECG signals are classified.

3.1] Discrete Wavelet Transform

First step is to store the ECG record and take only the specific portion of the signal. The Discrete Wavelet Transform technique is used to denoise the signal. Here, we have decomposed the signal upto third level. The coefficients of Approximations and Details are found out upto third level.



With the help of these coefficents we have construct the Approximations and Details upto third level. Denoised signal can be reconstructed from these Approximations and Details.

3.2]Fast Fourier Transform

Next step is to use the Fast Fourier Transform Technique. The FFT technique is use to find out the Frequency components which are present in Approximations and Details. We have taken the FFT of three Approximations and three Details. The result of FFT is in the form of vector.(Diagrams of fft)

3.3] Correlation

The Correlation Technique is used to find out the correlation between refference signal and the input signal. We have found out the Cross Correlation beetween FFTs of respective Approximations and Details of the refference and the input signal. The rewult of this technique is used to classify the ECG into normal and abnorma

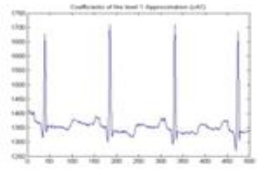


Fig.5.1: Coefficient of level 1 Approximation

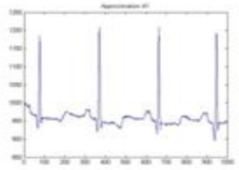


Fig.5.2: Level 1 Approximation

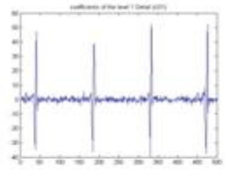


Fig.5.3: Coefficient of level 1 Detail

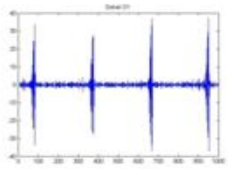


Fig.5.4: Level 1 Detail

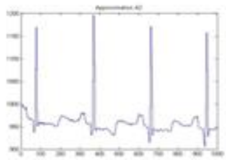


Fig. 5.5: Coefficient of level 2

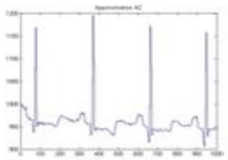


Fig.5.6: Level 2 Approximation

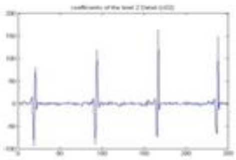


Fig.5.7: Coefficient of level 2 Detail

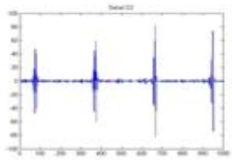


Fig.5.8: Level 2 Detail

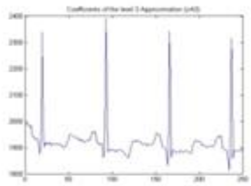


Fig.5.9: Coefficient of level 3 Approximation

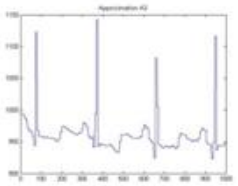


Fig.5.10: Level 3 Approximation

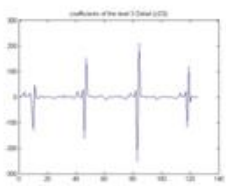


Fig.5.11:Coefficient of level 3 Detail

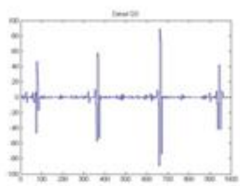


Fig.5.12: : Level 1 Detail

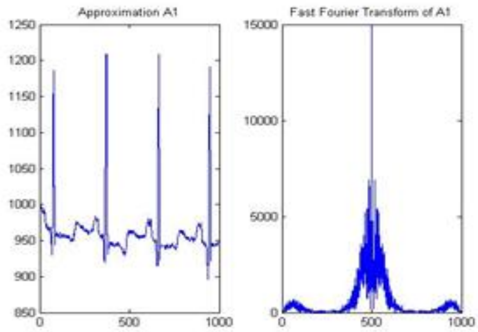


Fig. 5.13: Fast Fourier Transform of A1

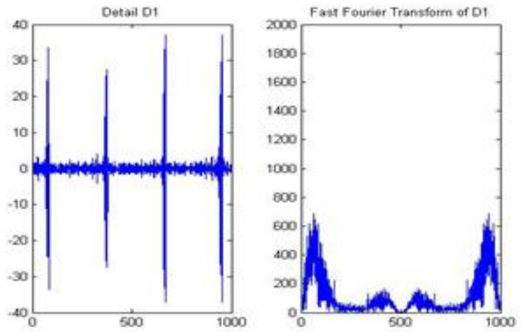


Fig. 5.14: Fast Fourier Transform of D1

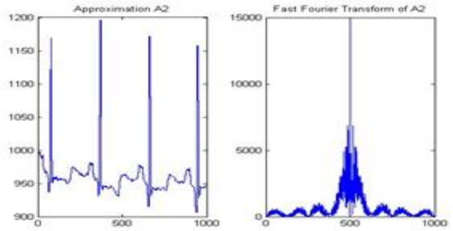


Fig. 5.15: Fast Fourier Transform of A2

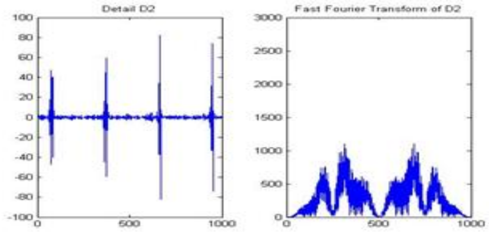


Fig. 5.16: Fast Fourier Transform of D2

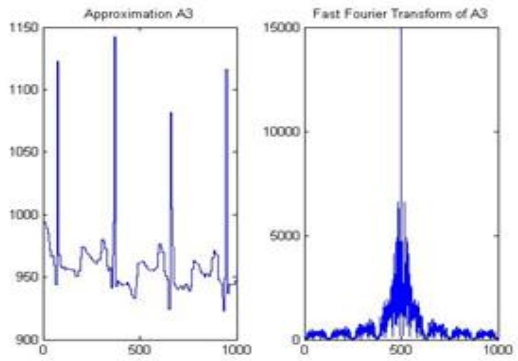


Fig. 5.17: Fast Fourier Transform of A3

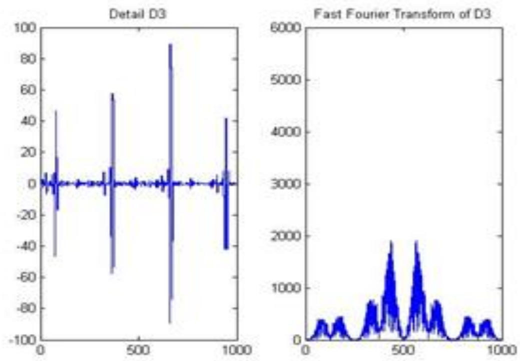


Fig. 5.18: Fast Fourier Transform of D3

VI. EXPERIMENTATION

The given signal is 100_s1 from MIT-BIH database. We have stored this signal in the form of vector as variable s. The signal s is then de-noised using Discrete Wavelet Transform technique. At the first level the original signal s is decomposed into two vectors: one vector containing coefficients of Approximations, cA1 [fig.5.1] and other containing coefficients of Details, cD1 [fig.5.3].The 1stlevel Approximation coefficient ie.cA1is then decomposed into another two vectors: coefficients of Approximations cA2 [fig.5.5] and coefficients of Details [fig.5.7] cD2. And the 2nd level Approximation coefficients ie.cA2 is then decomposed into another two vectors: coefficients of Approximations cA3 [fig.5.9] and coefficients of Details [fig.5.11] cD3

The Approximations and Details (A1,D1,A2,D2,A3,D3) are then constructed using those coefficients [figs.5.2, 5.4, 5.6, 6.8, 5.10, 5.12]. In the third level Approximations we can find that the signal is de-noised. Fast Fourier Transform (FFT) Technique is used to find out the frequency components. We have taken the Fast Fourier Transform of all the Approximations and Details [figs.5.13-5.18].Then we have find out the Correlation Coefficients between Fast Fourier Transforms of respective Approximations and Details. With help of these coefficients the signals are then classified as Abnormal and Normal.

VII. RESULT

We have tested signals of MIT-BIH. We have observed results as follows:

class	Signals
Normal	100,101,103,105,106,112,113,114,115,116,117,121,122,123,201
Abnormal	104,108,109,111,118,119,124,200,203,207,208,210,212,214

Observation Table:

Signal	Actual	Detected	Accuracy
Healthy	17	15	88.23%
Abnormal	16	14	87.50%

VIII. CONCLUSION

This is the simplest method for analysis of abnormality of ECG signals. We have used MIT-BIH database and classified it to normal and abnormal signal by using cross-correlation technique. By comparing coefficients we have plotted signals as shown in above figures. Out of total 35 signals, we got 15 normal signals and 14 abnormal signals and 6 signals are exclude for study. Out of these signals we have plotted results of two signals as shown in above figures to explain concepts clearly.

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