Comparative Analysis of De-noising of ECG Signal using DWT

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ABSTRACT

In the transmission of any signal it is often contaminated with different noise. ECG (electrocardiograph) is the measure of electrical activity of heart and it is used for the diagnosing cardiac diseases, but before the analysis of this ECG signal we have to de-noise this signal. Since ECG is non-stationary signal, wavelet based de-noising of ECG signal is considered and performance of wavelets is compared in terms of signal to noise ratio.

Keywords:—ECG,SNR,WAVELET, DENOISING.

INTRODUCTION:

ECG signal plays a very vital role in clinical monitoring and diagnosis of the health condition of human heart. A standard ECG signal is given in fig.1. which is consists of P,Q,R,S,T,U waves and gives important information of amplitude and intervals which is important for diagnosis cardiac diseases. During process it can be affected by power line interface, base line wonder ,high frequency noise etc. the remedy or processing for cancel out these noise is take major part. The development of accurate and quick method for ECG de-noising is necessary.

Power line interference signals have frequency of 50Hz so it is easily recognizable. The instability of the electrode skin contact is due to either loose contact or the dirty electrodes. Now the power line interference may be the part of the ECG waveform if machine or patient is not properly grounded Electrical and power system induce extremely rapid pulse as the spike in the trace. The baseline wandering can be eliminated by the selection of proper electrode material and the proper attachment of electrodes [1].

A. Morphology

The morphology of the electrocardiogram is very necessary to understand for diagnosis of heart ECG waveform of a normal individual consists of P wave, QRS complex, ST segment, T wave and U wave. The labels of Fig. 1. are commonly used in medical ECG terminology.

P wave: When the electrical impulse is conducted from the SA node towards the AV node and spreads from right to left atrium, the depolarization (contraction) of the atria occurs. The depolarization of atria results the P Wave in the ECG.

QRS complex: The QRS complex consists of three waves, sequentially known as Q, R and S. The rapid depolarization of both the ventricles results this complex. The muscles of the ventricles have large muscle mass than that of atria, hence its amplitude is much larger than that of P wave.

T wave: Ventricular re-polarisation results the preceding of ST segment and the T wave.

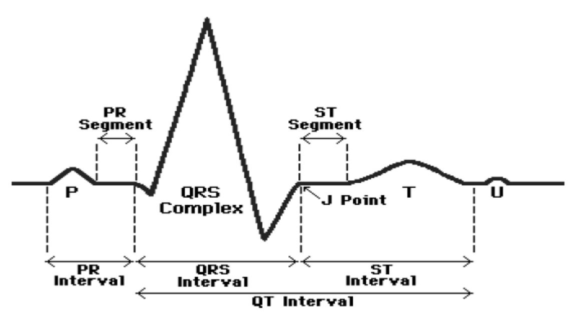


Figure 1 Standard ECG Waveform

U wave: The origin of U wave is not clear and it is rarely seen. It is probably produced due to the re-polarisation of the papillary muscles **[2].**

The biomedical signals such as ECG signal, noise reduction is only possible if we using more advanced signal processing method as wavelet de-noising technique. earlier ECG signal analysis is of time domain but always it is not sufficient to represent all features, so frequency domain analysis required the fast Fourier transform (FFT) technique is applied but it not tells about location of frequency components .next tool available is STFT in which time and frequency is not very much optimal and (STFT) uses a sliding window to find spectrogram, which gives the information of both time and frequency. But still another problem exists i.e. the length of window limits the resolution in frequency. Wavelet transform seems to be a solution to the problem above. Wavelet transforms (WT) are based on small wavelets with limited duration.

B. Wavelet De-noising:

The wavelet transform is similar to the Fourier transform. For the FFT, the basic functions are sine and cosines. For the wavelet transform, the basic functions are more complicated called wavelets, mother wavelets or analyzing wavelets and scaling function. In wavelet analysis, the signal is broken into shifted and scaled versions of the original (or mother) wavelet**.[3]** The fact that wavelet transform is a multi-resolution analysis makes it very suitable for analysis of non-stationary signals such as the ECG signal [4].

The Fourier transform is useful tool to analyze the frequency components of the signal. However, if we take the Fourier transform over the whole time axis, we cannot tell at what instant a particular frequency rises. In WT both the time and frequency resolutions vary in time-frequency plane in order to obtain a multi resolution analysis.

$$x(t) = \sum_{k} a_{j0,k}\ \varphi_{j0,k}(t) + \sum_{j=j0}^{\infty}\sum_{k} b_{j,k}\ \psi_{j,k}(t) \qquad (1)$$

Where a, b are the coefficients associated with φj,k(t) and ψj,k(t) respectively.

The coefficients a, b can be calculated as we calculate the coefficients in Fourier transform. The expression of a, b are given in the following equations:

$$a_{j0,k} = \int_{-\infty}^{\infty} x(t)\ \varphi_{j0,k}(t)dt \qquad (2)$$

$$b_{j,k} = \int_{-\infty}^{\infty} x(t)\ \psi_{j,k}(t)dt \qquad (3)$$

$$\psi(t) = \sum_n h_\psi(n)\sqrt{2}\,\varphi(2t-n) \qquad (4)$$

$$\varphi(t) = \sum_n h_\varphi(n)\sqrt{2}\,\varphi(2t-n) \qquad (5)$$

Generally there are two types of wavelet transform continuous wavelet transform and discrete wavelet transform

(1) DISCRETE WAVELET TRANSFORM

The discrete wavelet transform (DWT) is an implementation of the wavelet transform using a discrete set of the wavelet scales and translations obeying some defined rules. In other words, this transform decomposes the signal into mutually orthogonal set of wavelets.

The scaling function φj,k(n) and the mother wavelet function ψj,k(n) in discrete domain are:

The DWT of an discrete signal x(n) . It is quite similar to the Eq. (1)

$$x(n) = \sum_{k} w\,\varphi(j0,k)\varphi_{j0,k}(n) + \sum_{j=j0}^{\infty}\sum_{k} w_{\psi}\ (j_0,k)\psi_{j,k}(n) \qquad (6)$$

Here Wφ(j0,k) and Wψ(j0,k) are called the wavelet coefficients. φj,k(n) and ψj,k(n) are orthogonal to each other. Hence we can simply take the inner product to obtain the wavelet coefficients.

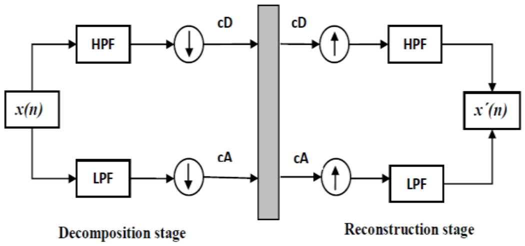
(2) CONTINUOUS WAVELET TRANSFORM

The original signal can be reconstructed by an appropriate integration and this is performed after projecting the given signal on a continuous family of frequency bands. A continuous wavelet transform (CWT) is used to divide a continuous-time function into wavelets. Mathematically, the continuous wavelet transform of a function x(t) is defined as

$$X\ (a,b) = \frac{1}{\sqrt{a}}\int_{-\infty}^{+\infty} x(t).\Psi\left(\frac{t-b}{a}\right)dt \qquad (7)$$

METHODOLOGY:

By applying the wavelet transform, ECG signals were decomposed to the approximate (low frequency component) and detailed (high frequency component) information. Each stage consists of two digital filters and two down samplers by 2.The first filter, g [n] is the high pass filter and h[n] is the low pass filter. The down sampled output of first high pass filter is called detail coefficients (D1) and output of low pass filter is the approximation coefficients (A1).The first approximation (A1) is further decomposed and this process is continued. . The reverse process of combining the coarser approximation and detail coefficients to yield the approximation coefficients at a finer resolution is referred as reconstruction or synthesis [5]



. Figure-2

The general wavelet based method for de-noising estimation is to transform the data into wavelet domain, threshold the wavelet coefficients and invert the transform **[6].**It follows three steps:

(1) Decomposition: Choose a wavelet, and compute the wavelet decomposition at level N.
(2) Thresholding: For each level from 1 to N, select a threshold and apply different thresholding to the detailed coefficients.
(3) Reconstruction after decomposition thresholding is applied to detail coefficients and after that signal is reconstructed by using original approximate coefficients and modified detail coefficients.

In the second step thresholding is used which is major part of wavelet, the selection of right thresholding method will provide better noiseless output .In this paper 4 types of thresholding are used:

1. 'Rigrsure' uses for the soft threshold estimator.
2. 'Sqtwolog' uses a fixed-form threshold
3. 'Heursure' is a mixture of the two previous options.
4. 'Minimaxi' uses a fixed threshold chosen to yield minimax performance for mean square error against an ideal procedure [7]

ANALYSIS METHOD

The first step is to obtain ECG signal form a data base. The data base used for the experiments is MIT-BIH Arrhythmia database, available online **[8].].**All the 48 signals from database has been used for experiment. Wavelet toolbox is used in matlab. Four different types of thresholding and ten different filters are analyzed for comparison of different techniques and to get the best combination of thresholding and filter. The performance is evaluated in terms of the SNR. **[9]**

$$\text{SNR (DB)} = 10\ \log_{10}\left(\frac{A^2{}_{signal}}{A^2{}_{noise}}\right)$$

RESULT AND DICUSSION

All the 48 ECG signal from the MIT-BIH database are taken and added with the BLW(base line wonder) noise which is due to very low frequency interference ,the proposed method is applied for all 4 thresholding and different filters. For example Figure 3 shows 100m signal, Figure 4 shows noise added with it, Figure 5 shows signal with better SNR.

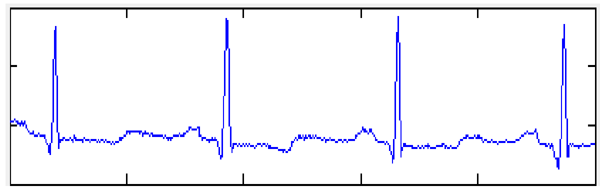


Figure -3

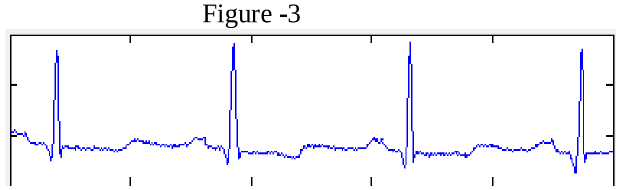


Figure-4

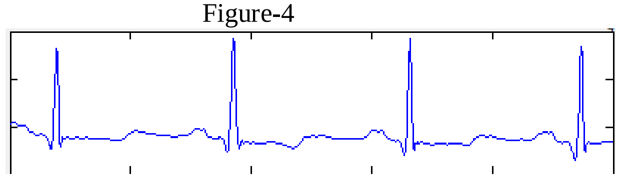
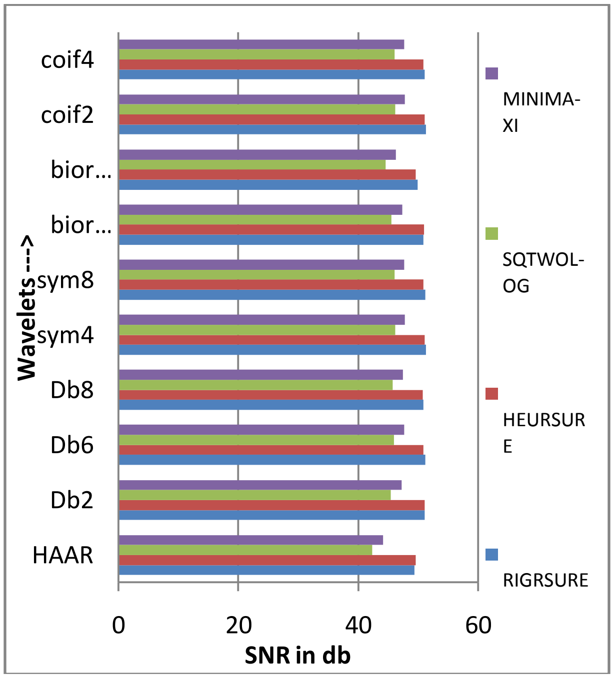


Figure-5

TABLE 1.1 shows the mean SNR of 48 signals and comparison of 4 thresholding

	MEAN VALUE OF 48 SIGNAL'S SNR			
FILTERS	**RIGRSU-RE**	HEURSUE	SQTW-OLOG	MINIMA-XI
HAAR	49.43949	49.58559	42.36489	44.22216
Db2	51.09609	51.11763	45.45471	47.25555
Db6	51.2140	50.93929	46.02129	47.68925
Db8	50.96063	50.81631	45.80209	47.48253
sym4	**51.30962**	51.10221	46.15066	47.8126
sym8	51.2498	50.86949	46.09377	47.73005
bior2.2	50.92039	51.02619	45.57702	47.35564
bior3.3	49.92829	49.62404	44.60951	46.35506
coif2	51.21968	51.09613	46.19009	47.85314
coif4	51.14259	50.87462	46.09518	47.72041

From the table it is observed that SYM4 filter AND RIGRSURE thresholding is giving best SNR for all 48 signals experimented. Which can be drown in graph



CONCLUSION-

ECG signals are affected by noise from electric interference, electromyography, and baseline wandering. In this paper we propose a de-noising technique based on discrete wavelet transform coefficients and base line wonder noise source. The results obtained from the SNR computation show that the SNR is better in symlet filters and rigrsure thresholding which can be easily test by graph and table.

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