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ECG Signal Denoising using Wavelet Thresholding Method

Preeti Rathee[1], Pooja Sabharwal[2], Dr.Latika Singh[3]
[1]CSE& ITDeptt. , [2]EECE Deptt.,[3]CSE& ITDeptt.
ITM University Sector 23-A Gurgaon, Haryana, India.
[1]Preetirathee09@gmail.com, [2]pooja@itmindia.edu, [3]latikasingh@itmindia.edu

Abstract– Electrocardiogram (ECG) plays a very important role in diagnosis of various cardiac disorders as it represents the electrical activity of heart. ECG signal consist of P-QRS-T waves. ECG signal classification helps in cardiac diseases detection. Features are extracted from ECG signal like amplitude of signal, R-R interval, QRS complex etc. for ECG classification. ECG signal is highly affected by noise . The noise present in ECG signal can be of any type like baseline wandering, power line interface, high frequency noise etc. To find normal and abnormal signal it is necessary to first denoised the signal. Various research and techniques have been developed for ECG signal denoising. This paper discuss about the techniques proposed earlier in literature for denoising and the wavelet method with soft thresholding technique to denoise the signal.

Keywords- ECG (Electrocardiograph), Discrete Wavelet Transform, Thresholding, Baseline Wandering, Power Line Interference.

I. INTRODUCTION

The Electrocardiogram(ECG) has become one of the most important tools in the diagnosis of heart diseases. For the treatment of patients ECG detection and classification is important. Electrocardiogram(ECG) represents the electrical activity of heart showing the regular contraction and relaxation of heart muscle. ECG waveform consist of threebasic waves P wave, QRS wave and T wave and sometime also contain U wave

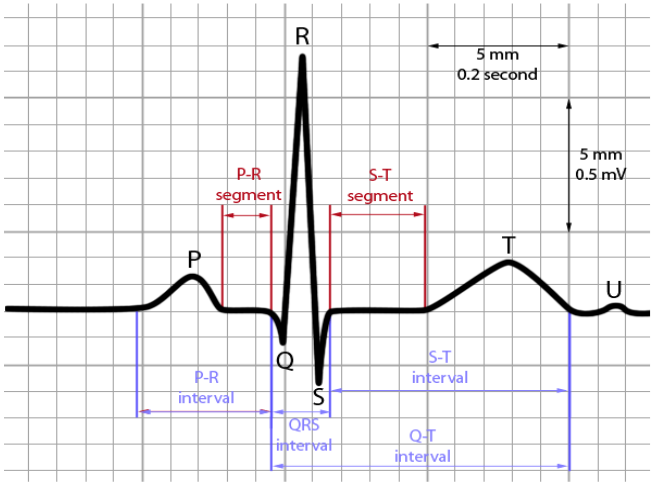

Figure. 1. A Sample ECG signal

P wave arise due to sino-atrial node (SA) depolarization, SA node located in right atrium is the pacemaker of heart.

QRS complex represents the ventricular depolarization and T wave arise due to repolarization of ventricles. The electrical signal moves through the heart muscle with normal rhythmicity. If the electrical system does not function properly, the heart rhythm become abnormal due to transmission of signal throughout the heartmuscle.ECG signals are recorded by placing electrodes on the patient body. ECG signal vary for different individual and even for the same individual, heart beat pattern changes with time and under different physical conditions.ECG interpretation mainly consists of two phases: Feature extraction and ECG classification. Different techniques are used for feature extraction and classification. Most commonly used features are QRS complex, RR interval etc. Noise present in ECG signal highly affects the diagnosis and feature extraction from the signal . So to classify whether the signal is normal or abnormal it is necessary to first denoise the ECG signal. In next section we discuss about various techniques used for denoising the ECG signal.

II. EXISTING METHODS

As noise heavily affects the ECG signal so it is necessary to remove the noise from the signal. In past few years various techniques are used for denoising of ECG signal. Many of the researchers have used digital Infinite Impulse Response (IIR) filter to remove the effects of power line interference and baseline wander from ECG signals [4, 6]. But this method is not suitable for high order non linear signals as it increases the filtering time as well as memory. Adaptive filtering methods used for removing the power line interference and other noises from ECG signals [5, 7,8]. This method is good due to its filtering response and very less error rate. But this requires signal and noise information for filtering. In [10] , the temporal averaging filter method which require time frame for noise reduction is adopted. Independent Component Analysis (ICA) for removing the noises is in [9] and it doesn't require the information about the signal for filtering. However to remove the baseline wandering linear filtering technique ia adopted with frequency 0.5 hz [11]. In recent years, discrete wavelet transforms based thresholding is used to resolve the limitations of above mentioned filtering methods [11]. In this method it is necessary to properly select the wavelet function, thresholding method and rules to denoise the ECG signal. In this paper DWT based denoising was performed to remove the noise from the signal.

III. PROPOSED METHOD

In earlier time fourier transform was used for signals. But this transform gives information only about one domain

either time domain and frequency domain, losses the information about other domain. So to represent the signal in time and frequency both short time fourier transform(STFT) is used by using the concept of moving window. But STFT have limitations in case of multi resolution. So wavelet transform is developed to remove the limitation of multi resolution and to represent bot frequency and time domain. The wavelet transform is scaled and shifted version of mother wavelet .

A. Wavelet Filters:

In DWT two types opf filters high pass filter and low pass filter are used. It is performed by repeated filtering of signal by by using low pass and high pass filters.

DWT is performed by repeated filtering of the input signal with a pair of filters namely, low pass filter (LPF) and high pass filter (HPF), and its cutoff frequency is the middle of input signal frequency as shown in fig 2.

At each level, the two bandlimited inputs (one low-frequency, one high-frequency, both with the same sample rate) are upsampled by a factor of 2 to match the sample rate of the input to the next stage.

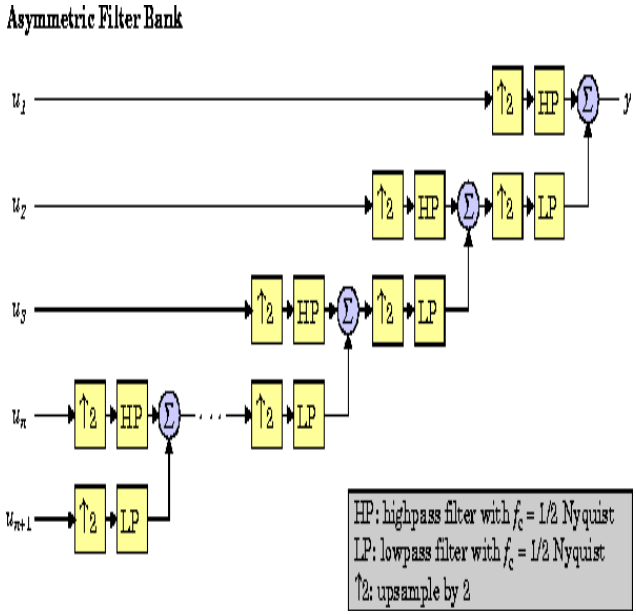

Figure 2. Filter bank structure

They are then filtered by a highpass (HP) and lowpass (LP) filter pair with coefficients calculated to cancel the aliasing introduced in the corresponding dyadic analysis filter stage. The output from each (upsample-filter-sum) level has twice the bandwidth and twice the sample rate of the input to that level (hence "dyadic"). The Lowpass FIR filter coefficients and Highpass FIR filter coefficients parameters specify the filter coefficients to be used for every highpass and lowpass (respectively) filter in the structure. The values of these coefficients are typically computed together with the dyadic analysis coefficients using the wavelet family functions in the Wavelet Toolbox

B. Wavelet Thresholding:

Wavelet Thresholding is defined as technique for signal estimation to define the capabilities of signal. It is characterized into two types as Hard thresholding and Soft thresholding shown in fig3. On the basis of type of thresholding and the rules used, performance is evaluated.

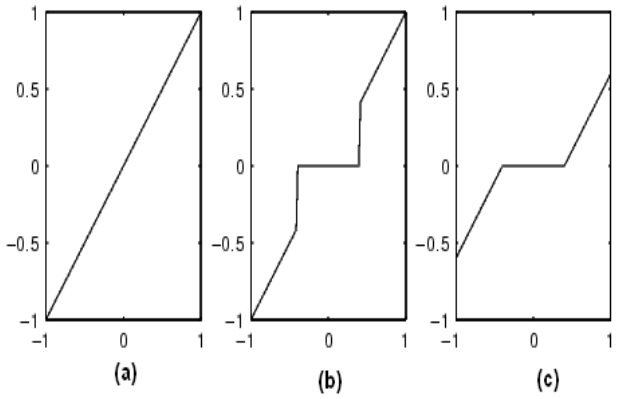

Figure 3.(a) Original signal; (b) Hard threshold signal; (c) Soft threshold signal

C. Method Used:

We noticed that ECG signals are severely affected by using different sources of noises such as power line frequency, baseline wandering, and high frequency noises. However, it is impractical to remove the noises visually on definite duration of the acquired ECG signal and it takes more time. Hence, different techniques are used to process the ECG signal to remove noise from ECG signal.

In this paper, we use “db4” wavelet method to denoise the ECG signal with soft thresholding technique is used. ”db4” comes from y Daubechies transforms. The Daub4 wavelet transform, like the Haar transform, can be extended to multiple levels as many times as the signal length can be divided by 2. Signal is taken from MIT-BIH database. In this signal is first denoised without generating the threshold value by using fixed soft thresholding technique. Coefficients are generated for the signal as shown in fig 6. Then the threshold value is generated for the signal. In this work the threshold value generated is 3.014. by using this threshold value and soft thresholding technique signal is again denoised. The results are satisfactory shown in fig 9. Comparison is shown after original and denoised signal as shown below in fig12.

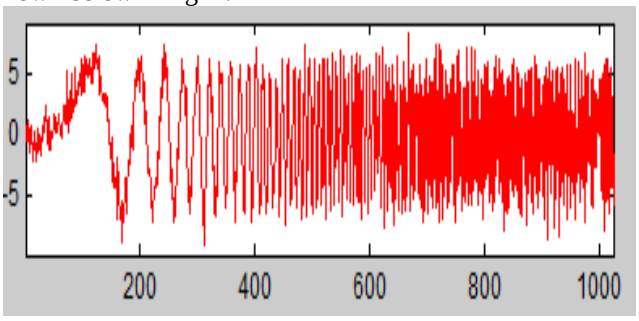

Figure 4. Original signal

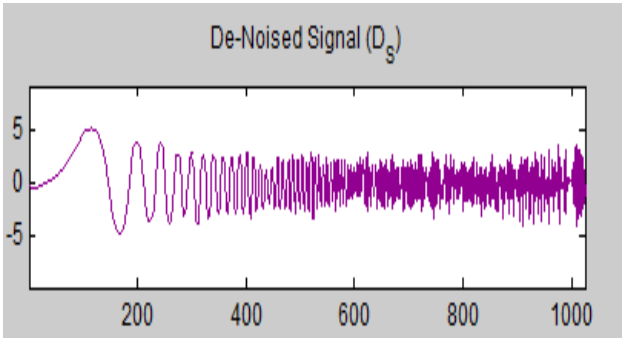

Figure 5. Denoised signal before generating threshold value

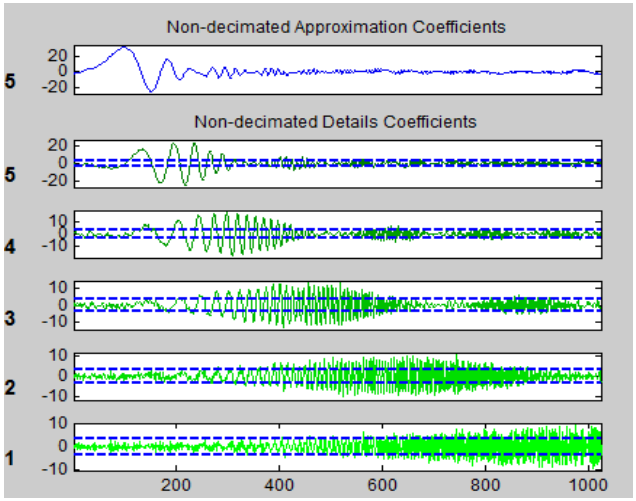

Figure 6. Showing coefficients of original signal

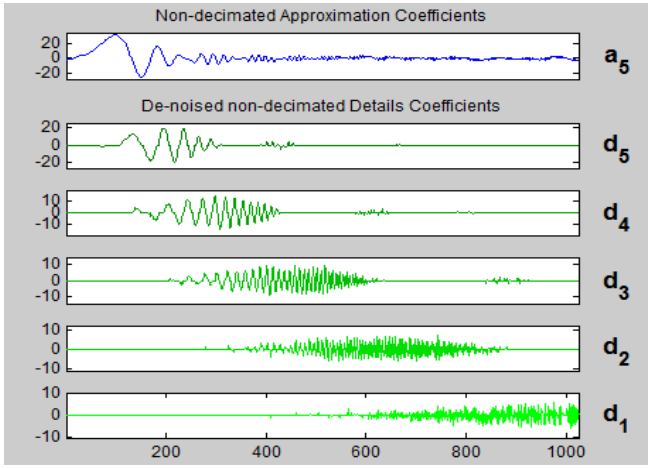

Figure 7. Showing cofficients of denoised signal

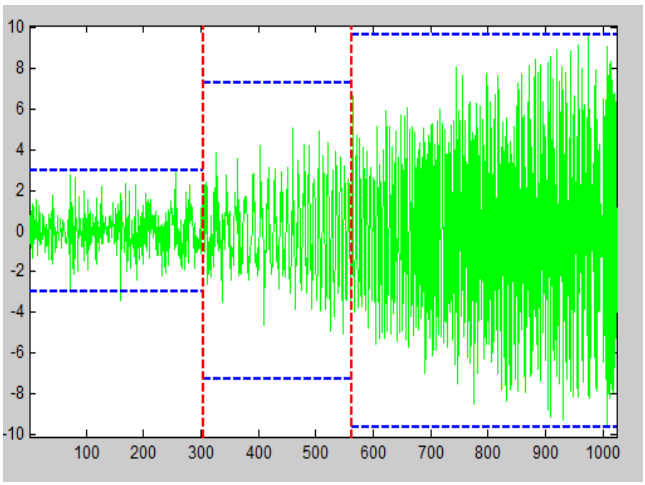

Figure 8. Generating threshod values

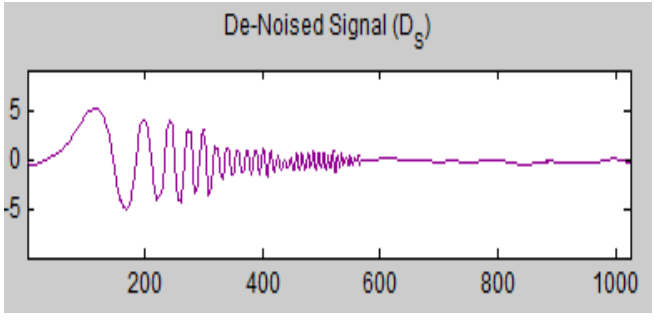

Figure 9. Denoised signal after generating threshold value

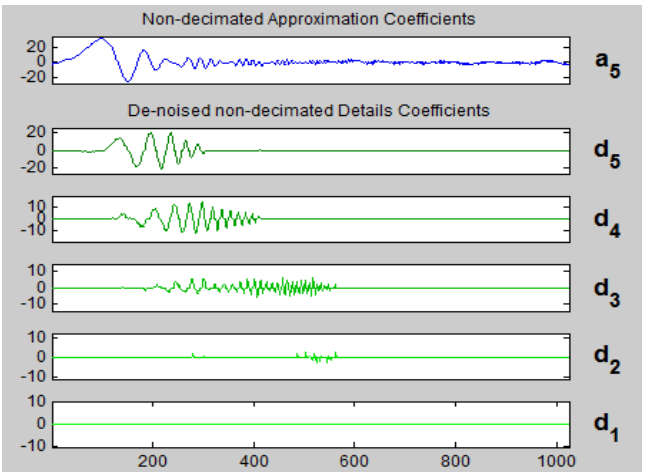

Figure 10. Showing cofficients of denoised signal after threshold

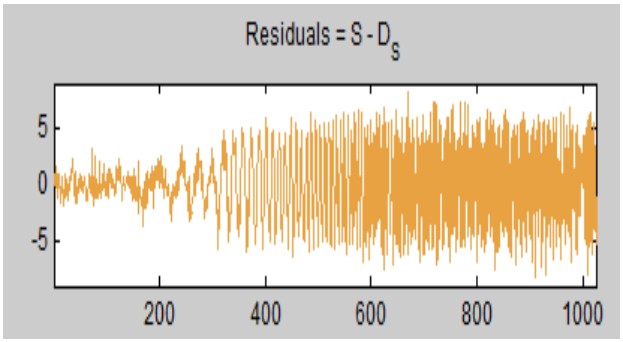

Figure11. Showing residuals

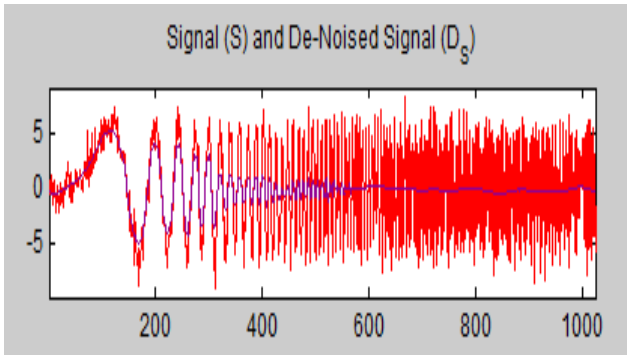

Figure 12. Original and denoised signal

IV. DISCUSSION AND CONCLUSION

In this paper , as we used the DWT method for denoising the ECG signal. “Db4” wavelet transform with Soft thresholding technique is used to denoise the signal. The threshold value generated is 3.014 and the signal is denoised by using this threshold value to find good results. Further comparison can be concluded on this technique.

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