IJDACR
ISSN: 2319-4863

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary Research
Website: www.ijdacr.com (Volume 4, Issue 7, February 2016)

De-noising of ECG Signal Using Wavelet Filter-A Review

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***Abstract*— Noise is the factor which degrades the quality of ECG signal. Removing noises from ECG is complicated due to time varying nature and subject of wide research. The ECG signal is the graphical representation of the bioelectrical and biomechanical activities of the cardiac system, which is useful in diagnosing and analyzing heart diseases. Artifacts mask and degrades the quality and features of ECG signal .Some artifacts are mostly noticed, i.e. Power line interference, Base line wander, Muscles tremors. Removal of noises is necessary for proper analysis and display of ECG signal .These such noises are difficult to remove using typical filter. In such cases , signal noise reduction is only possible with wavelet de-noising techniques This paper is presenting a review on various methods developed for de-noising using wavelet filtering, delineation of characteristics points and classification of diseases along with their respective advantages and disadvantages.**

***Keywords*— ECG, de-noising, delineation, Wavelet, filtering.**

I. INTRODUCTION

In the world of medical sciences, Electronics is playing an major and important role. Electrocardiogram (ECG) system is an example of it. In these systems, Electrocardiogram signals produced by heart and analyzed for detecting the abnormalities of the heart .By analyzing graphical representation, various signal waves (P, QRS and T) present in ECG signals. Out of all the waves in an ECG signal, the QRS complex is the most characteristic wave set and represents depolarization of the ventricles. In this signal, each heartbeat is represented by an electrical impulse from special cells in right upper chamber of heart. These impulse travels to the other parts of the heart. Then it causes the heart to squeeze and pump blood. Finally, it can be detected on the surface of body as ECG patterns [1]. Then, the physician can study the patterns of the recorded signals. There could be several diseases and disorders of various types that affect the ECG pattern. The normal ECG signal wave is given in figure

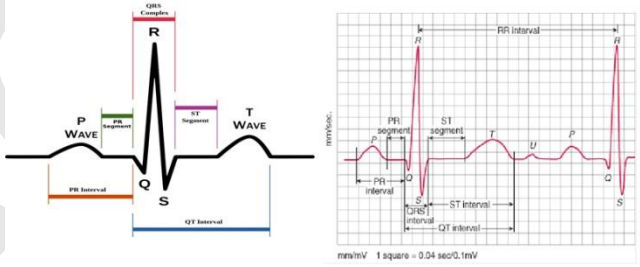

Fig. 1 – Normal ECG Signal Wave.

During recording of ECG, ECG noises (anything other than muscular activity of heart) are superimposed with the recorded ECG [2]. The desired ECG signal can be interrupted due to the presence of AC interference in the power supply, loose electrode connections, malfunctioning of recording machine and sometimes even due to patient movements such as respiration etc. Collectively, these can be labeled as artifacts. Baseline wander, power line interference and muscle tremors are mostly noticed artifacts/noises. So for accurate delineation of characteristics points of ECG, these artifacts must be removed so that it can be used for proper diagnosis. In the present paper, the survey is based on some of the approaches used for analysis of de-noising ECG signal using Wavelet filtering.

II. NOISE IN ECG

In electrocardiography, rather than using the term noise, the term artifact is more suitable to point out something that is not "heart-made". The word artifact is alike to

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artificial in the sense that it is frequently used to indicate something that is synthetic (i.e. not natural). These are electrical disturbances created by electrical noise from elsewhere in the Body i.e. any outside sources, placement or poor contact of leads, and machine malfunctions. Artifacts removal is primer requirement to prevent misinterpretation of a heart's rhythm. These are of following types:-

A. Power-line interference (or AC interference)

Power line interference consists of 50/60 Hz AC (Alternating current) pickups and harmonics present in the power supply. AC more precisely describes the type of electricity that can be obtained from the power line. It is 50 Hz of AC electricity in India and Europe. Major factors that cause such interferences are:

- Stray effect of AC fields induced because of loops in electricity cables.
- Connection or disconnections of electrodes are not proper.
- ECG machine grounded unconventionally.
- Heavy power line current drawn from the electrical equipment such as elevators , X-ray , air conditioner which induce 50Hz signals in the input circuit of the ECG machine.
- Electromagnetic interference generated from the power-line supply.

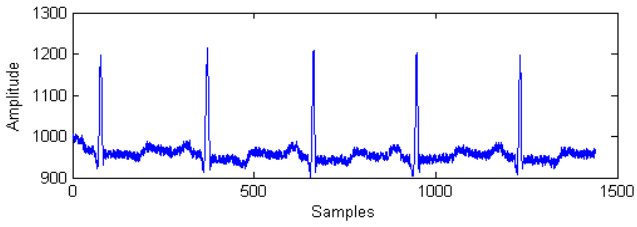

Figure.2: ECG Signal with power line interference

B. Baseline Wandering

Caused by respiration or patient movement which creates problems in the detection of peaks. Due to wander T peak would be higher than R peak which might be detected as R peak instead. Amplitude variation is 15% of peak to peak ECG amplitude.

C. Muscle Tremor/Noise

Muscle contractions are also called as EMG (electromyography) noise. It is induced by the patient's movement. It generates art factual milli-volt level potentials as the heart is not the only organ in our body that produces measurable electricity. Even when skeletal muscles undergo tremors there is random activity in the ECG signal. These low amplitude muscle tremor noise can sometimes mimic the baseline in atrial fibrillation.

D. Reversed Leads/Misplaced Electrodes

The placement of electrodes is very important task while recording ECG. The connection between patient and measuring system is interrupted for a short duration due to improper contact of the electrodes which creates electrode contact noise of 1 second duration and amplitude of which is peak recorded output of ECG signal with frequency of 60Hz.

E. Pacing Spikes

The pacemaker rhythm can easily be recognized on the ECG. These pacing spikes are mainly observed in patients whose implanted pacemaker is firing. These are vertical signal that represents the electrical activity of the pacemaker. The wide QRS complex represents the ventricular depolarization.

F. Absolute Heart Block

Absolute heart blockage (also known as 4th degree heart blockage) occurs seldom, only in made-up settings. Spacious and bottle-shaped QRS complexes are observed. The QRS complexes observed here has no relationship with the P wave.

III. Introduction of Wavelet Transform

A wavelet is a small wave-like oscillation with amplitude that begins at zero, increases and then decreases back to zero. As a mathematical tool, wavelet can be used to extract information from many different kinds of data [3]. Recently, wavelet transform has been widely used in signal and image processing due to its time-frequency localization characteristic. The wavelet transform is based on a set of analysis wavelet allowing the decomposition of ECG signal in a set coefficient. Each analysis wavelet has its own time duration, time location and frequency band. The wavelet coefficient resulting from the wavelet transform corresponds to a measurement of the ECG components in the time requirements and frequency band. The theory of wavelet transform based on signal processing and developed from the Fourier transform basis.

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By applying the wavelet transform, ECG signals were decomposed to the approximate (low frequency component) and detailed (high frequency component) information. Decomposition is shown in figure .2

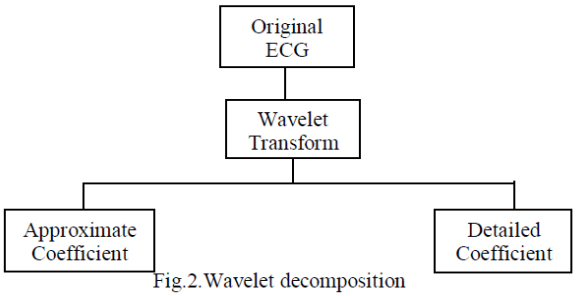

Fig.2.Wavelet decomposition

IV. Literature Review

Donoho is used in wavelet domain to remove some coefficients of wavelet transform Sub-signal the measured signal which results the reduction in noise content of the signal under non-stationary environment. The presented method decomposes the signal into five levels of wavelet transform by using Daubechies wavelet and determining a threshold after using a loop of calculating minimum error between the denoised wavelet subsignals and original noise free sub signals. The resulting threshold method is better than the Donoh's threshold in ECG denoising [4]. One dimensional wavelet analysis with daubechies wavelet based is used; to eliminate the noise component (Power line interference at 50 Hz). Soft and hard thresholding techniques have been implemented and effect on the signal reconstruction is observed in terms of Signal to Noise Ratio [5]. Its evident that biorthogonal wavelet (bior3.5) is optimal function for the ECG signal denoising [6]. Multi-resolution analysis of the digital ECG signal and got ECG signal components in different sub bands. For the purpose of wavelet filtering, the ECG signal was reconstructed with the signal components in sub bands which reflect the characteristics of ECG and ideal effect of ECG was obtained. Multi-resolution analysis works better in removing the higher and lower frequency interferences. Especially, the problem of the ECG baseline drift can be solved effectively [7].

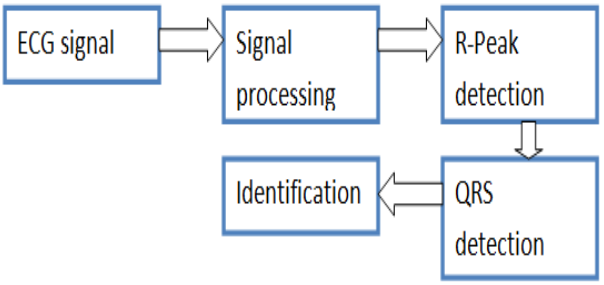

Fig 3. Proposed system

TABLE I
PERFORMANCE OF DIFFERENT WAVELET TRANSFORMS BASED ON LEVEL THRESHOLDING (α=1.5)

ECG signal	Wavelet filter	RE	SNR	PRD	MSE
MIT-BIH Rec. 100: M,69	Haar	99.19	20.86	9.09	5.03×10-4
MIT-BIH Rec. 112: M,54	Haar	99.95	33.09	2.21	2.23×10-4
MIT-BIH Rec. 117: M,69	Haar	99.59	23.89	6.39	1.40×10-3
MIT-BIH Rec. 100: M,69	db10	99.63	24.16	6.20	2.35×10-4
MIT-BIH Rec. 112: M,54	db10	99.97	34.16	1.96	1.76×10-4
MIT-BIH Rec. 117: M,69	db10	99.88	29.03	3.53	4.24×10-4

V. Conclusions

By using the wavelet transform, we came to know that, it is the most powerful tool for analyzing the non-stationary signals. These papers shows that how it is useful in denoising non-stationary signals and are able to detect various features from ECG signal. The evaluation result presented in this paper provides a basic reference for family selection for ECG signal denoising applications. Since the application for wavelet transform in electro cardiology is

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relatively a new field of research, many modern aspects of the wavelet technique will require further investigations in order to improve the clinical use with novel signal processing technique

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