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"Analysis of Adaptive Wavelet Wiener Filtering for ECG Signals": Review

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Abstract- **In recent years, ECG signal plays an important role in the essential determination, prognosis and survival examination of heart diseases. However, in real situations, ECG recordings are often corrupted by antiques. Two prevailing antiques display in ECG recordings are: (1) High-frequency noise caused by broadband myopotentials (EMG), power line interferences, or mechanical forces acting on the electrodes; (2) Baseline wanders (BW) that may be due to respiration or the movement of the patients or the instruments. These antiques seriously restrict the utility of recorded ECGs and accordingly need to be removed for better clinical evaluation. To remove such types of noise wavelet transform is used. Thus several methods have been developed for ECG signal enhancement. This paper gives the survey about the techniques useful for ECG denoising. The different techniques are compared and from that we can decide which one is more suitable technique.**

Keywords: **Broadband myopotentials (EMG), Electrocardiogram (ECG) signal, stationary wavelet transform (SWT), wavelet transform (WT), Wiener Filtering.**

I. INTRODUCTION

Electrocardiogram (ECG) signal is a graphical representation of cardiac action and it utilizes the essential measure for recognizing different heart diseases and heart irregularities. As a rule, ECG indicators have remarkable morphological aspects (P-QRS-T complex) and it is highly significant than other biological signals. It is conceivable to diagnose numerous heart diseases by investigating the varieties of this morphology visually. However, the vicinity of noises in ECG signals will seriously influence the visual determination and characteristic extraction of different requisitions (stress estimation, emotion estimation and human PC interfaces, and so on). In order take out the noises and to concentrate the productive morphology of ECG indicators, a few pre-processing routines have been proposed over past few decades. A number of the researchers have utilized digital Infinite Impulse Response (IIR) filter to evacuate the impacts of power line interface and baseline wander from ECG signals. Since, the configuration of IIR filter is simple, on other hand; higher order IIR filters are performing well to remove the noise from the signals. On the other hand, it has the impediment of expanded sifting time, memory and unable to filter the highly non-linear signals in the whole ECG range. Resent years, adaptive filtering techniques are utilized for removing the power line interference and other noises from ECG signals .This system is all the more well-known because of its faster filtering response and smaller residual errors. In any case, this system requires reference signal (either signal or noise aspects) data for effective filtering process.

A Recorded ECG signal is a mixture of a signal and interference that may complicate computer signal delineation. Unlike narrowband interference (hum and drift), linear filtering is not suitable for the suppression of broadband myopotentials (EMG) because it leads to a significant cropping of peaks in QRS complexes. It also leads to signal distortions at the beginning and end of QRS complexes, which causes widening of the QRS complex. Myopotentials spectrum is predominant at higher frequencies and significantly overlaps with the spectrum of the ECG signal, primarily with the spectrum of the QRS complex. Thus, the automatic interpretation, following accurate detection of characteristic ECG points and waves, and measurement of signal parameters, become difficult. EMG noise is caused by increased muscle activity. The resting ECG signal interference level is usually often low but becomes troublesome in high-resolution ECG signals [2], stress-test signals [3], ECG signals of very young children, or in Holter ECG signals. The use of discrete time wavelet transform (WT) can increase effectiveness of suppression of wide-band EMG noise in comparison with linear filtering. WT decomposes the signal so that the highest bands contain EMG noise and some additive components of QRS complexes and the lower bands contain more components of QRS complexes. The signal can be filtered by appropriate adjustments in the transform coefficients depending on the estimated level of interference. The important feature of WT-based filtering is that it keeps additive components of QRS complexes even in the highest bands of decomposition. The nonlinear filter that uses reversible WT allows estimating noise level in individual decomposition bands and proportionally adapting correction

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of WT coefficients. In this way, we can achieve effective noise suppression while distortion of the ECG signal is minimized. Besides the choice of decomposition and reconstruction filter banks, the choice of the level of decomposition and the strategy of WT coefficient adjustment are also important.

Different strategies of thresholding the WT coefficients with down sampling are discussed in [4]. The attempt to optimize the threshold parameters for a wavelet filter with WT with decimation [5], and concludes that the optimal parameter values depend on the level of interference. The disadvantage of filtering with WT with down sampling is that the result is dependent on the choice of the beginning of the filtering and the need for interpolation in reverse transform, which is always a source of errors. Transform without down sampling, the so called stationary (redundant) wavelet transform (SWT), is more preferable for filtering [6]. Better results can be achieved by using the wavelet Wiener filtering, when each transform coefficient is adjusted separately. The Wiener filter requires an estimate of a noise-free signal, which is necessary to calculate the correction factor for the adjustment of transform coefficients. The estimate of the noise-free signal was performed using another wavelet filter, both implemented with decimation.

II. METHODOLOGIES

A. *"De-noising of high-resolution ECG signals by combining the discrete wavelet transform with the Wiener filter" [2]. By H. A.Kestler,M.Haschka,W.Kratz, F. Schwenker, G. Palm,V.Hombach, and M. Hoher.*

In this study the authors applied a mixture of the discrete wavelet transform and the Wiener filter to the noise lessening of high-resolution ECG signals. The methodology is ideal at all squares sense in that it divides a signal from additive noise. It was compared to a popular de-noising algorithm by Donoho on artificially generated signals and on a high-resolution ECG signal corrupted by noise, so that high resolution ECG signals can be easily denoised.

B. **"***Comparing stress ECG enhancement algorithms" [3]. By V. X. Afonso, W. J. Tompkins, T. Q. Nguyen, K. Michler, and S. Luo.*

In this paper there are two predominant types of noise that sully the electrocardiogram (EGG) obtained throughout an anxiety test: the baseline wander noise (BW) and electrode motion artifact, and electromyogram-induced noise (EMG). BW noise is at a low frequency, created by breath and movement of the subject or the leads. The frequencysegments of BW noise are generally underneath 0.5 Hz, andreach out into the frequency extent of the ST segment throughout an anxiety test. EMG noise, then again, is prevalently at higher frequencies, brought on by expanded muscle action and by mechanical force following up on the electrodes. The frequency range of the EMG noise covers that of the ECG signal and expands considerably higher in the frequency area. In this article, the writers audit a percentage of the distributed ECG upgrading strategies to conquer the noise issues, and think about their execution on anxiety ECG signals under unfavourable noise scenarios. They also describe the filter bank-based ECG enhancing algorithm.

C. *"Wavelet-based denoising using subband dependent threshold for ECG signals" [4].By S. Poornachandra.*

This paper employs a wavelet-based denoising technique for the recovery of signal sullied by white additive Gaussian noise and explores the noise free remaking property of universal threshold. Another thresholding technique is proposed, called subband adaptive. The parameters of this technique are picked by contrast in mean strategy. Simulations are done in MATLAB utilizing different ECG signals. The outcomes demonstrate that the proposed thresholding system outflanks the existing thresholding techniques.

D. *"Genetic algorithm and wavelet hybrid scheme for ECG signal denoising" [5]. By E.-S. A. El-Dahshan.*

This paper introduces a compelling hybrid plan for the denoising of electrocardiogram (ECG) signals undermined by non-stationary noises utilizing genetic algorithm (GA) and wavelet transform (WT). We initially connected a wavelet denoising in noise lessening of multi-channel high resolution ECG signals. Specifically, the impact of the choice of wavelet function and the decision of decay level on productivity of denoising methodology was recognized. Determination of a suitable wavelet denoising parameters is basic for the accomplishment of ECG signal filtration in wavelet domain. Consequently, in our noise disposal strategy the genetic algorithm has been utilized to select the ideal wavelet denoising parameters which prompt expand the filtration execution. The proficiency execution of our plan is assessed utilizing percentage root mean square difference (PRD) and signal to noise ratio (SNR). The test outcomes demonstrate that the presented crossover plan utilizing GA has acquire preferable execution over the other reported wavelet thresholding algorithms and also the nature of the denoising ECG signal is more suitable for the clinical diagnosis.

E. *"The Optimal De-noising Algorithm for ECG Using Stationary Wavelet Transform" [6]. By S. Li and J. Lin.*

The paper describes the artifacts of ECG signals incorporate baseline wander (BW), muscle (EMG)antique, electrode motion artifact and force line impedance. Keeping in mind the end goal to get the ideal and robust de-noising algorithm among the mostly utilized de-noising techniques based on stationary

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wavelet transform (SWT), author adjusted the signal-to-noise ratio (SNR) of the noisy signal from 1 db to 10 db, also assess the outcomes by means of SNR and visual review, then conclude utilizing Symlet4, disintegration at level 5, and hard shrinkage function with empirical Bayesian (Ebayes) threshold can get constantly prevalent de-noising execution. Also, test the proposed algorithm utilizing MIT-BIH noise stress database, the outcomes exhibit that the proposed technique enhances the SNR and preserves the waveform, which might be utilized for clinic analysis.

III. RESULTS

A. *De-noising of high-resolution ECG signals by combining the discrete wavelet transform with the Wiener filter.*

In this paper the ECG signals are compared with known denoising algorithms on artificially generated signals and on a high-resolution ECG signal corrupted by noise, so that high resolution ECG signals can be easily denoised.

B. *Comparing stress ECG enhancement algorithms.*

Cardiac stress test (or Cardiac diagnostic test) is a test utilized in medicine and cardiology to measure the heart's ability to respond to external stressin a controlled clinical environment. In this article, the authors review some of the published ECG enhancing techniques to overcome the noise problems, and compare their performance on stress ECG signals under adverse noise scenarios.

C. *Wavelet-based denoising using subband dependent threshold for ECG signals.*

In this paper the proposed subband thresholding technique outperforms the existing thresholding techniques.

D. *Genetic algorithm and wavelet hybrid scheme for ECG signal denoising.*

The experimental results show that the introduced hybrid scheme using GA has obtain better performance than the other reported wavelet thresholding algorithms as well as the quality of the denoising ECG signal is more suitable for the clinical diagnosis.

E. *The Optimal De-noising Algorithm for ECG Using Stationary Wavelet Transform.*

The outcomes exhibit that the proposed system enhances the SNR and preserves the waveform, which can be used for clinic analysis.

IV. CONCLUSION

The above mentioned denoising techniques can eliminate artifacts in ECG signals like power line interferences, Baseline wanders (BW) seen as an undulating low frequency waves, and High-frequency 60 cycle (60 Hz) noise that appears as, “fuzz,” all over the signal. Also the analysis of high resolution ECG signals and cardiac diagnostic testing has been carried out.But broadband myopotentials (EMG) in ECG signals is one of the main artifact in ECG signals thus reducing EMG using the wavelet Wiener filtering with noise-free signal estimation is one of the further scope in ECG denoising, thus using dyadic stationary wavelet transform (SWT) in the Wiener filter and finding suitable filter banks and to pick different parameters of the Wiener filter with reference to the signal-to-noise ratio (SNR) obtained.To improve the filtering performance, we can use adaptive setting parameters of filtering according to the level of interference in the input signal, so we can use the adaptive wavelet wiener filtering technique which may provide better filtering results than classic wiener filters by increasing the average SNR.

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