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Denoising Of ECG Signal Using Multi-Resolution Techniques Based On Stationary Wavelet Transformation With Different Coefficients

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Abstract:

Digitization of bio medical signals has brought a drastic change in analysis of signals. Electrocardiogram (ECG) is an important tool for the primary diagnosis of heart disease.ECG signal, the electrical interpretation of the cardiac muscle activity is very easy to interfere with different noises while gathering and recording. The ECG signal must be clearly represented and filtered to remove all noise and artifacts from signal. In this paper a new approach to filter the ECG signal from noise using Multi resolution Technique based on Wavelet Transform. This method gives better results than the other technique applied in this field.

Index Terms — ECG; Signal processing; wavelet Denoising, noise.

I. Introduction:

The electrocardiogram (ECG) is the recording of the cardiac activity and it is extensively used for diagnosis of heart diseases. It is also an essential tool to allow monitoring patients at home, thereby advancing telemedical applications. Recent contributions in this topic are reported in.

Even though these contributions are for different projects, the issue common to each is the use of ECG for remote monitoring and assistance under different telecommunication platforms. The transmission of ECG often introduces noise due to poor channel conditions. Moreover,
there are other types of noise inherent in the data collection process.

These artifacts are particularly significant during a stress test. The main sources of such artifacts are: the baseline wander (BW) mainly caused by respiration, and (2) high-frequency noise such as the electro myographic (EMG) noise caused by the muscle activity. Moreover, the motion of the patient or the leads affects both types of artifacts. In ECG enhancement,the goal is to separate the valid ECG from the undesired artifacts so as to present a signal that allows easy visual interpretation. Many approaches have been reported in the literature to address ECG enhancement. Some recent relevant contributions have proposed solutions using a wide range of different techniques,such as perfect reconstruction maximally decimated filter banks and nonlinear filter banks, advanced averaging, the wavelet transform, adaptive filtering, singular value decomposition, and independent component analysis.The ECG signal is one of the bio-signals that is considered as a non-stationary signal and needs a hard work to denoising. The Wavelet

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Transform is one of the efficient techniques for a non-stationary signal. The wavelet transform can be used as a bgdecomposition of a signal in the time-frequency scale plane.

There are many application areas of wavelet transform like as sub-band coding data compression, characteristic points detection and noise reduction.

Thresholding is used in wavelet do-main to remove some coefficients of wavelet transform sub signals of the measured signal. The denoising method that applies thresholding in wavelet domain has been proposed by Donoho as a powerful method.

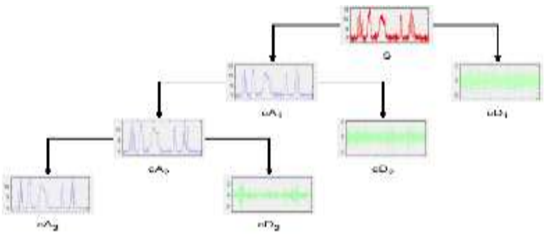


Fig -1 Multilevel Wavelet Decomposing

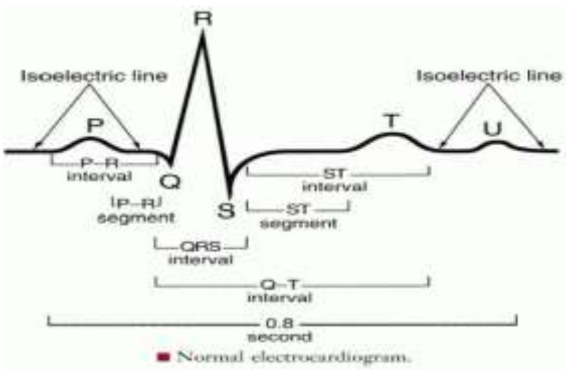
It has been proved that the Donoho's method for noise reduction works well for a wide class of one-dimensional and two-dimensional signals. Wavelet thresholding de-noising methods deals with wavelet coefficient using a suitable chosen threshold value in advance. The wavelet coefficients at different scales could be obtained by taking DWT of the noisy signal. Normally, those wavelet coefficients with small magnitudes than the preset threshold are caused by the noise and are replaced by zero, and the others with larger magnitudes than the preset threshold are caused by original signal mainly and kept (hard-thresholding case) or shrunk (the soft-thresholding case). Then the denoised signal could be reconstructed from the resulting wavelet coefficients . One of signal processing step in wavelet transform is to remove some coefficients of produced wavelet sub signals using thresholding. The electrocardiogram signal contains an important amount of information that can be exploited in different manners. The ECG signal allows for the analysis of anatomic and physiologic aspects of the whole cardiac muscle. Different ECG signals are used to verify the proposed method using MATLAB software. Method presented in this paper is compared with the Donoho's method for signal denoising meanwhile better results are obtained for ECG signals by the proposed algorithm. The ECG signal from noise is proposed using wavelet transform .

Different ECG signals are used & the method evaluated using MATLAB software. In this paper to adapt the discrete wavelet transform to enhance the ECG signal. A New thresholding technique is proposed for denoising of ECG signal. This new denoising method is called as improved thresholding denoising method could be regarded as a compromising between hard & soft-thresholding denoising methods. This method selects the best suitable wavelet function based on DWT at the decomposition level of 5, using mean square error (MSE) & output SNR

II.Standard ECG Waveform:

A normal ECG signal waveform composed of P wave, QRS complex and T wave. A small U wave is occasionally present. The detection of these parameter is important to analyse the ECG signal. The cardiac cycle begin with the P wave which corresponds to the atrial depolarization inthe heart. The most striking part of the ECG is the QRS complex which is followed by P wave. The T wave follows the QRS complex and corresponds to the ventricular repolarization. The end point of the T wave represents the end of cardiac cycle [3] (assuming the absence of u wave). The duration and amplitude level of particular parameter of the ECG is of great importance since it provide a measure of the state of the heart and indicate the certain cardiological condition.

The below diagram shows the normal electrocardiogram waveform.



Iii. Circuit Operation:

Labview data logger is connected to the ECG Machine and produces the ECG signal. This generated ECG signal is the input of the Matlab Software.

Iv. Different Transformations For Denoising:

Wavelet Transform(WT) is one of the time-frequency analysis and has been used successfully in many applications. In the wavelet transform, the original signal (1-D, 2-D, 3-D) is transformed using predefined wavelets. The wavelets are orthogonal, orthonormal or biorthogonal, scalar or multi-wavelets.

Here we are using 2 types of transformations for the denoising of ecg signals

1.continuous wavelet transformation

2.discrete wavelet transformation

Continuous Wavelet Transformation:

The continuous wavelet transform was developed as an alternative approach to the short time Fourier transform to overcome the resolution problem.

The wavelet analysis is done in a similar way to the STFT analysis, in the sense that the signal is multiplied with a function wavelet similar to the window function in the STFT, and the transform is computed separately for different segments of the time domain signal.

$$Ws(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} f(t)\, h^{*}\left(\frac{t-b}{a}\right) dt$$

Where h(t) is called mother wavelet, a is the scaling parameter in y-axis and b is the shift parameter in x-axis.

The signal f(t) can be recovered from the wavelet coefficients ws(a,b) by the inverse wavelet transform and is given by

$$f(t) = \frac{1}{c} \iint_{-\infty}^{\infty} Ws(a,b)\, h\left(\frac{t-b}{a}\right) \frac{da}{a^2}\, db$$

With admissibility condition given as

$$c = \int_{-\infty}^{\infty} \frac{|(w)^2}{w} dw \; <$$

Discrete Wavelet Transformation:

Discrete wavelet transform which is based on sub band coding perform fast computation of wavelet transform In the case of dwt, a time scale representation of the digital signal is obtained using digital filtering technique

The signal to be analysed is passed through filters with different cut-off frequencies and different scalars

the general equation for dwt signal is

$$X[a,b] = \sum_{n=-a}^{a} x(n) \phi_{a,b}(n)$$

Where

$$\varnothing_{a,b}(n) = \frac{1}{\sqrt{a}}\, \phi\left(\frac{n-b}{a}\right)$$

V. Proposed Method:

Stationary Wavelet Transformation:

To overcome the drawbacks of the cwt&dwt,here we are proposed a 'stationary wavelet transformation'.The DWT is non-invariant and non-redundant in its nature. The time invariant property is useful for feature extraction.On other

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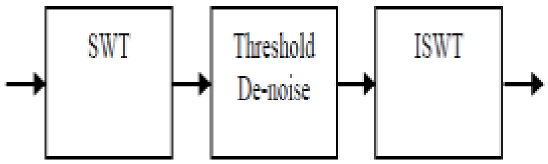
hand the SWT is time invariant and gives better denoising effect compared to DWT. The SWT suppresses the noise effectively and retains better information regarding amplitude and location of the signal features.

Comparing with DWT the approximation and detailed coefficients of the filters are not down sampled when the SWT is applied to the signal. Instead an up sampling is performed by padding the zeros between the coefficients at each stage.

Thus SWT introduces some redundancy in the signal but no information is lost and precise reconstruction of the signal is possible. And reconstructed signal does not produce translation along time axis.

Therefore SWT gives better signal denoising effect, feature extraction and accurate localization of signal.



Inverse Stationary Wavelet Transformation:

iswt performs a multilevel 1-D stationary wavelet reconstruction using either a specific orthogonal wavelet ('wname', see wfilters for more information) or specific reconstruction filters (Lo_R and Hi_R).

X = iswt(SWC,'wname') or

X = iswt(SWA,SWD,'wname') or

X = iswt(SWA(end,:),SWD,'wname') reconstructs the signal X based on the multilevel stationary wavelet decomposition structure SWC or [SWA,SWD] (see swt for more information).

X = iswt(SWC,Lo_R,Hi_R) or

X = iswt(SWA,SWD,Lo_R,Hi_R) or

X = iswt(SWA(end,:),SWD,Lo_R,Hi_R) reconstruct as above, using filters that you specify.

Lo_R is the reconstruction low-pass filter.

Hi_R is the reconstruction high-pass filter.

Lo_R and Hi_R must be the same length.

Vi. Multiresolution Technique:

A way to construct a wavelet basis in L2(R) and to compute the basis coefficient of a signal s efficiently is given by the concept of a multiresolution analysis (MRA), due to Mallat and Meyer. It is a concept that was originally used as a signal-processing tool by means of perfect reconstruction filter banks. The defi- nition of such an MRA is given by an increasing sequence of closed subspaces Vj, j €Z, in L2(R), Such that

· · · V−2 V−1 V0 V1 V2 · · ·,

1. Vj is dense in L2(R), j€Z

2. Vj = {0}, j€Z

3. f € Vj Df = f(2·) € Vj+1, j€Z,

4. f € V0 T f = f(· − 1) € V0, j€Z,

5. ϕ€ L2(R): {T kϕ | k €Z} is a Riesz basis for V0, With D: = D 1/2 and T = T1, following (1.3), and ϕ a real-valued function in L2(R), refered to as a scaling function. Observe that the latter condition of an MRA equals the condition that there exists a scaling function ϕ such that {DjTkϕ | k €Z} is a Riesz basis for Vj, for any j €Z. This scaling function ϕ is often referred to as a father function. Obviously this follows directly from Condition 3 and from the fact that D is a unitary operator that does not affect the Riesz constants. Constructing wavelet bases via an MRA is based on the inclusion V0 V1. Obviously, we can de- fine a subspace W0 V1/V0. For a unique definition of W0, we takeW0 perpendicular to V0, givingW0 = V1 ∩V0 ⊥. Using the invariance of the subspaces Vj under the action of the unitary operator D we

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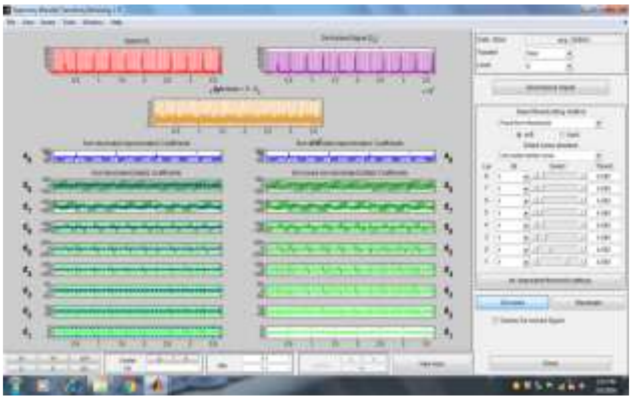
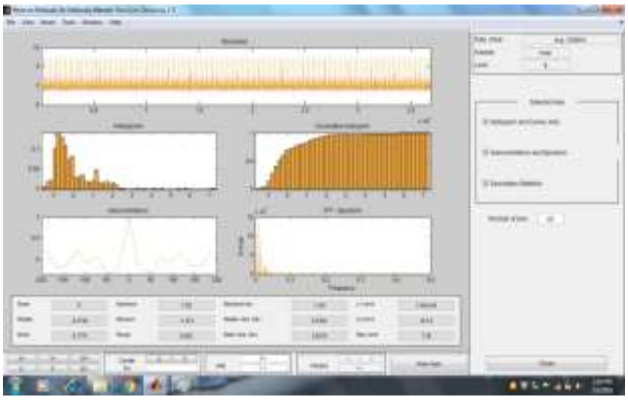
arrive in a natural way at the definition of the closed subspaces W_j $L2(R)$ by putting $W_j = V_{j+1} \cap V_j$

Vii. Outputs:

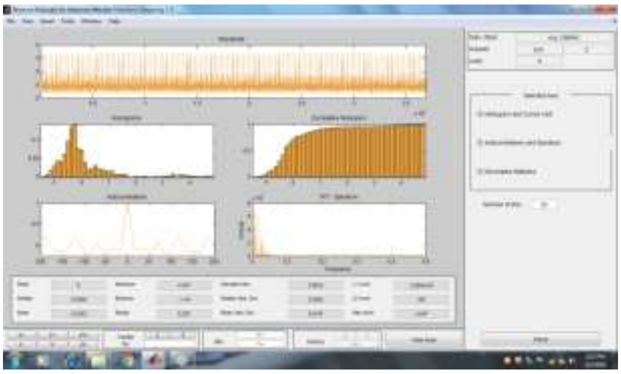


1.denoising with haar wavelet



Residuals for haar wavelet

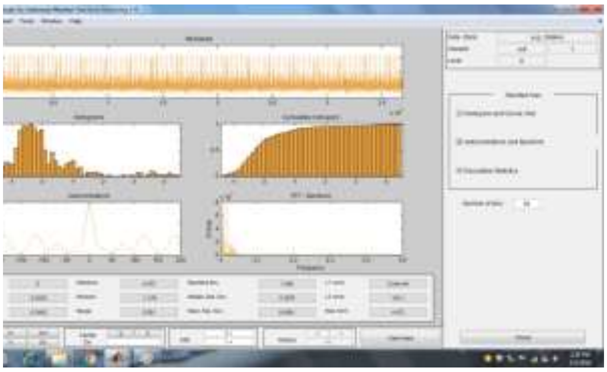
2.denoising with sym wavelet



wavelet	level	mean	median	range	Std deviation	Max. Norm
haar	*8*	-0.77	-0.37	8.855	1.15	7.28
Db	8	-0.77	-0.37	8.855	1.15	7.28
Sym	8	-0.24	-0.26	6.287	0.96	4.847
coif	8	-0.38	-0.25	5.851	1.00	4.472
bior	8	-0.77	-0.37	8.855	1.15	7.28
Rbio	8	-0.77	-0.37	8.855	1.15	7.28
dmey	8	-0.34	-0.25	6.856	1.08	5.34

Residuals for sym wavelet

3.denoising with coif wavelet



Residuals for coif wavelet

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4.denoising with dmey wavelet

Residuals for dmey wavelet

Comparision of different wavelets for Denoising of ECG signal

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