ISSN 2229-5518

Wavelet for ECG denoising using multi-resolution technique

Alka Yadav, Naveen Dewangan, Subra Debdas

Abstract— 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.

1 Introduction

The ECG signal is one of the biosignals that is considered as a non-stationary signal and needs a hard work to denoising [1, 2]. The Wavelet Transform is one of the efficient techniques for a non-stationary signal. The wavelet transform can be used as a decomposition 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 domain 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 [3, 4]. 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 [5, 6, 7, and 8]. One of signal processing step in wavelet transform is to remove some coefficients of produced wavelet subsignals using thresholding [9]. 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 [10]. 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 [11].

2 Wavelet Transfform

Recent years, the time-frequency analysis has been successfully applied in some biomedical signals to detect both temporal and spectral features of biomedical signals. 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. A Wavelet is a "small wave" having the oscillating wavelike characteristics and the ability to allow simultaneous time and frequency analysis by the way of a time-frequency localization of the signal. Wavelet systems are generated by dilating and translating a single prototype basic wavelet ψ (t),

$$\Psi_{a,b}(t)=|a|^{-(1/2)}\ \psi(t-b/a) \qquad 1$$

Where the scaling factor a and translation factor b are real (a≠0). The basic wavelet is stretched by a large value of a to analyze the low frequency components of the signal. A small value of a gives a contracted version of the basic wavelet and thus allow the analysis of high-frequency components.

A Wavelet ψ is a function of zero average:

$$\int_{-\infty}^{+\infty} \psi(t)dt = 0 \qquad 2$$

Suppose that ψ is a real wavelet. Since it has a zero average, the wavelet integral measure the variation of f in a neighborhood of u, whose size is proportional to s.

$$Wf\,(u, s) = \int_{-\infty}^{+\infty} \frac{f(t)}{\sqrt{s}} \psi\left(\frac{t-u}{s}\right) dt \qquad 3$$

The wavelet analysis procedure is to adopt a wavelet prototype function, called an "analyzing wavelet" or "mother wavelet." Temporal analysis is performed with a contracted, high-frequency version of the prototype wavelet, while frequency analysis is performed with a dilated, low-frequency version of the prototype wavelet. Because the original signal or function can be represented in terms of a wavelet expansion (using coefficients in a linear combination of the wavelet functions), data operations can be performed using just the corresponding wavelet coefficients. And if you further choose the best wavelets adapted to your data, or truncate the coefficients below a threshold, your data is sparsely represented. This "sparse coding" makes wavelets an excellent tool in the field of data compression.

2 Multiresolution Technique

A way to construct a wavelet basis in $L_2(R)$ 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 definition of such an MRA is given by an increasing sequence of closed subspaces Vj, j €Z, in $L_2(R)$,
Such that

$$\cdots \subset V_{-2} \subset V_{-1} \subset V_0 \subset V_1 \subset V_2 \cdots,$$

1. $\cup$ V_j is dense in $L_2(R)$, j€Z

2. $\cap$ $V_j = \{0\}$, j€Z

3. f € $V_j \leftrightarrow Df = f(2\cdot)$ € V_{j+1}, ∀j€Z,

4. f € $V_0 \leftrightarrow T f = f(\cdot - 1)$ € V_0, ∀j€Z,

5. ∃φ€ $L_2(R)$: {T kφ | k €Z} is a Riesz basis for V_0,
With D: = D
1/2 and T = T1, following (1.3), and φ a real-valued function in $L_2(R)$, 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 $\{D^jT^k\varphi$ | k €Z} is a Riesz basis for V_j, 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 $V_0 \subset V_1$. Obviously, we can define a subspace $W_0 \cong V_1/V_0$. For a unique definition of W_0, we takeW_0 perpendicular to V_0, giving$W_0 = V_1 \cap V_0^{\perp}$. Using the invariance of the subspaces V_j under the action of the unitary operator D we arrive in a natural way at the definition of the closed subspaces Wj $\subset$ $L_2(R)$ by putting $W_j = V_{j+1} \cap V_j^{\perp}$.Type equation here.

3 Circuit Operation

Labview data logger is connected to the ECG Machine (in fig.1.) and produces the ECG signal. This generated ECG signal is the input of the Matlab Software.

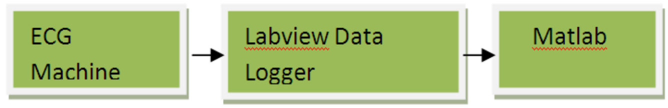

FIG.1.

4 METHODOLOGIES

All following experiments, ECG Signal with sampling frequency f_s equals to 500 Hz. The ECG signal is summed with random noise signal (Fig. 2). The noising ECG signal decomposed in the 4th decomposition level by selecting db wavelet transform. Stationary Wavelet Transform use high-pass filter to obtain high frequency components so-called details (D) and low-pass filter to obtain low frequency components so-called approximations (A). As a result the high and low frequency component are obtained (Fig.5 & Fig.6).

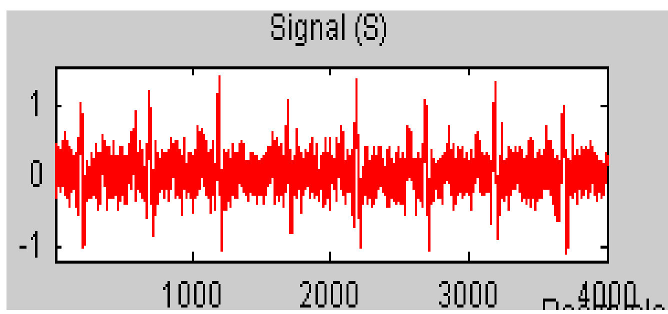

Fig.2 Noisy ECG Signal

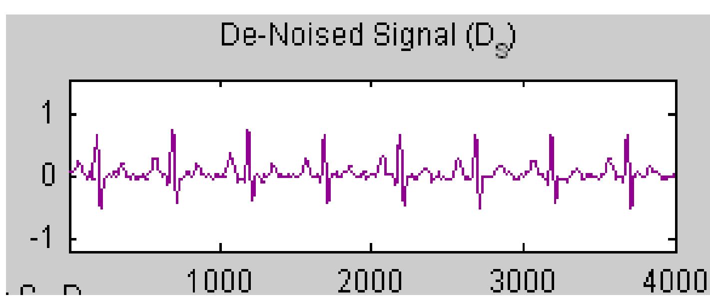

Fig.3 De-Noised ECG Signal

- *Alka Yadav is currently pursuing masters degree program in instrumentation& control engineering in CSVTU Bhilai, India,0 9926849998. E-mail: alka.yadav26@gmail.com*
- *Mr.Naveen Dewangan is assistant professor in BIT Durg,India, 09425245883. E-mail:devanaveen2002@yahoo.co.in*
- *Mr. Subhra Debdas,research scholar NIMS University Jaipur,India ,09589185174.E-mail:subhra_16in@rediffmail.com*

ISSN 2229-5518

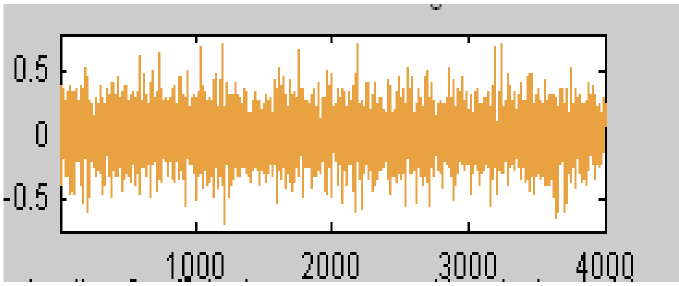

Fig.4 Residuals = S-Ds

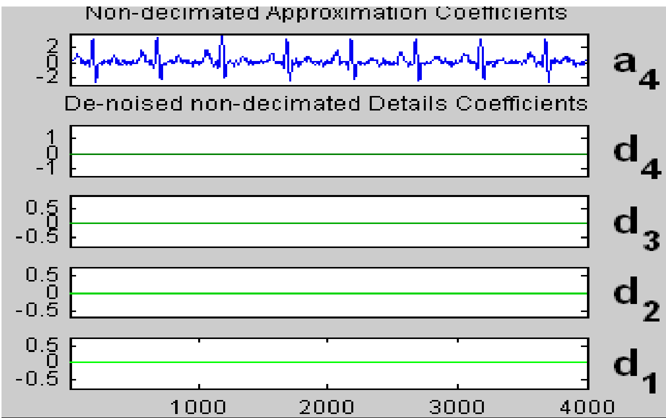

Fig.5 Non-decimated Approximated Coefficient

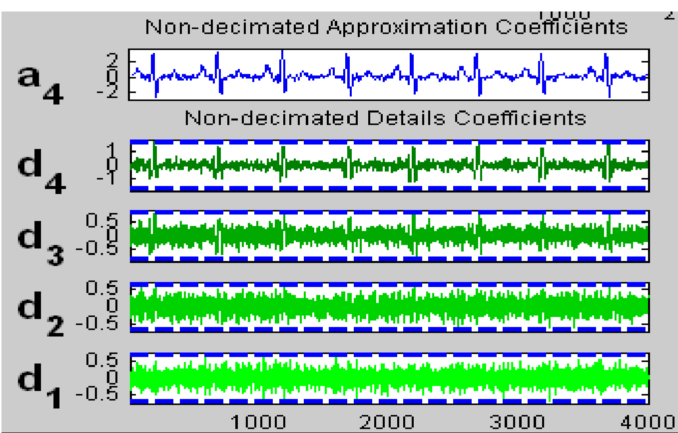

Fig.6 Non-decimated Approximated Coefficient

5 Conclusions

The wavelets transform allows processing of non-stationary signals such as ECG signal.This is possible by using the multi resolution decomposition into subsignals. This assists greatly to remove the noise in the certain pass band of frequency. The proposed method using the Stationary Wavelet Transform Denoising, by selecting db wavelet,the noisy signal decomposed,in the 4^{th} decomposition level. As a result approximate coefficients a_j and detail coefficients d_j are obtained. It was clearly seen in all Figures that we had separated the ECG signals and the noises over all frequency bands.

REFERENCES

[1] Ł_ski J., 1991, Detectja zespołów QRS dla zakłóconych signałów EKG, Post. Fiz. Mid., 26, 3- 4 PL ISSN 0137-8465.
[2] Shrouf A. 1994. The lineal prediction methods analysis and compression, PhD thesis of _l SK Technical University in Gliwice.
[3] D. L. Donoho, 1991. De-noising by softthresholding, IEEE Transaction on Information Theory, Vol. 41, pp. 613–627, May 1995.
[4] Bruce, Andrew, 1996. Applied Wavelet Analysis with S-plus, New York: Springer-Verlag, XXI, 3385: IL.
[5] R.R. Coifman and D.L. Donoho. "Translation-invariant denoising", in Wavelets and Statistics, Springer Lecture Notes in Statistics 103, Newyork: Springer-Verlag, pp.125-150, 1994.
[6] T.D. Bui and G. Chen, "Translation-invariant de-noising using multiwavelets", IEEE Trans. Signal Processing, vol.46, pp. 3414-3420, 1998.
[7] S.A. Chouakri, and F. Bereksi-Reguig, "Wavelet denoising of the electrocardiogram signal based on the corrupted noise estimation", Computers in Cardiology, Vol.32, pp.1021-1024, 2005.
[8] S.A. Chouakri, F. Bereksi-Reguig, S. Ahmaidi, and O.Fokapu, "ECG signal smoothing based on combining wavelet denoising levels", Asian Journal of Information Technology, Vol. 5(6), pp. 666-627, 2006.
[9] Mikhled Alfaouri and Khaled Daqrouq, 2008.ECG Signal Denoising By Wavelet Transform Thresholding, American Journal of Applied Sciences 5(3): pp: 276-281.
[10] G.Umamaheswara Reddy, Prof.M. Muralidhar and Dr.S.Varadarajan.ECG De-Noising using improved thresholding based on Wavelet Transforms VOL.9 No.9,Septmber 2009.
[11] ABDEL-RAHMAN AL-QAWASMI AND KHALED DAQROUQ 2010.ECG Signal Enhancement Using Wavelet Transform.