Performance comparision of various thresholding techniques on the removal of ocular artifacts in The EEG signals

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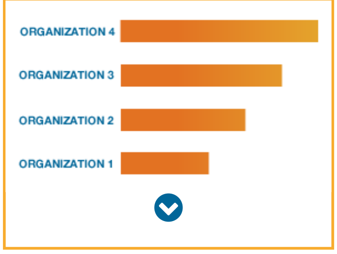
3 Author(s) B. Krishna Kumar ; K.V.S.V.R. Prasad ; D. Alekhya **View All Authors**



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Electro-encephalogram (EEG) is the electrical activity of brain cell groups in the cerebral cortex or the scalp surface. It plays an important role in studying the patient mental condition and Human Machine interfacing. Normal EEG signals can avail in the band of DC to 60 Hz frequencies with a few hundreds of micro volts of strength. Ocular artifacts and muscular noise with similar statistical properties are the major challenges which make the analysis more complex and may yields wrong interpretation. Here in this paper we discussed various thresholding techniques in the removal of ocular artifacts (OA) present in the EEG signal and there by compared performance these thresholding techniques in the removal of OA's with the help of various statistical parameters. In this paper the collected EEG signal is decomposed to 4 levels using db10 and sym8 wavelets and later threshold the detail coefficients using various thresholding techniques and estimated the statistical parameters of it.

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Performance Comparision Of Various Thresholding Techniques On The Removal Of Ocular Artifacts In The EEG Signals

B.Krishna Kumar[1], Dr.K.V.S.V.R .Prasad[2] and D.Alekhya[3]
[1] Research Scholar,JNTU Hyderabad, TS, INDIA. E-mail : saisantu2004@yahoo.co.in
[2] Prof &Head Dept. of ECE, D.M.S.S.V.H Engg.College, Machilipatnam, AP, INDIA. E-mail: kvsvr@yahoo.com
[3]IV B.Tech (ECE) student, JNTU Hyderabad, TS, INDIA.E-mail: alekhyapatel4a4@gmail.com

Abstract— **Electro-encephalogram (EEG) is the electrical activity of brain cell groups in the cerebral cortex or the scalp surface. It plays an important role in studying the patient mental condition and Human Machine interfacing. Normal EEG signals can avail in the band of DC to 60 Hz frequencies with a few hundreds of micro volts of strength. Ocular artifacts and muscular noise with similar statistical properties are the major challenges which make the analysis more complex and may yields wrong interpretation. Here in this paper we discussed various thresholding techniques in the removal of ocular artifacts (OA) present in the EEG signal and there by compared performance these thresholding techniques in the removal of OA's with the help of various statistical parameters. In this paper the collected EEG signal is decomposed to 4 levels using db10 and sym8 wavelets and later threshold the detail coefficients using various thresholding techniques and estimated the statistical parameters of it.**

Keywords— EEG, EOG, Ocular artifacts and Wavelet transform.

I. Introduction

Electrooculography (EOG) artifacts inevitably and frequently interfere with the electroencephalogram EEG) signals. Eye-movement and eye-blink artifacts are the main sources of ocular artifacts. The frequency components of EEG signals are in the order of just a few up to 200 µV, and their frequency content differs among the different neurological rhythms, such as, alpha, beta, delta and theta rhythms [1]. However, artifacts and noise are the outstanding enemies of high quality EEG signals. Their presence is thus crucial for the accurate evaluation of EEG signal. They fall into two major categories: technical and physiological artifacts. The technical artifacts are often found in power line noise 50/60Hz results from poor electrode application on the scalp and transducer's artifacts. The physiological artifacts are often due to ocular, heart and muscular activity; are the EMG, EOG and ECG artifacts respectively [2].

To date, many method are presented to remove EOG artifacts.. Some methods based on regression in the time domain or frequency domain [3-5] is proposed for removing eye blink artifacts. However, they always need a reliable reference channel. Moreover, EOG Reference channel often contains brain signals which will be also removed inevitably from the EEG by the procedure of regression. Therefore, the methods based on regression may not be the best way to remove EOG artifacts.

In this study, the EEG signal is decomposed into a level 4, which gives us approximate and detail coefficients. The detail coefficients which are having more noise information are processed with various thresholding techniques and later estimated the statistical parameters.

The noisy EEG signal is convolved with a low and high pass filter whose impulse response is determined by the wavelet chosen. The output of each filter produces the same number of samples as the original signal, so both outputs are down sampled by 2 resulting in the Approximate and detail coefficients each with half the number of points as that of the original signal.

The coefficients represent a correlation between the signal of interest and wavelet chosen at different scales and during translation. Because all of the coefficients are preserved, the original signal or any level of decomposition can be reconstructed using a filter scheme similar to decomposition shown in Figure 1. The process is reversed and now the coefficients are up sampled (interpolated), filtered, and summed.

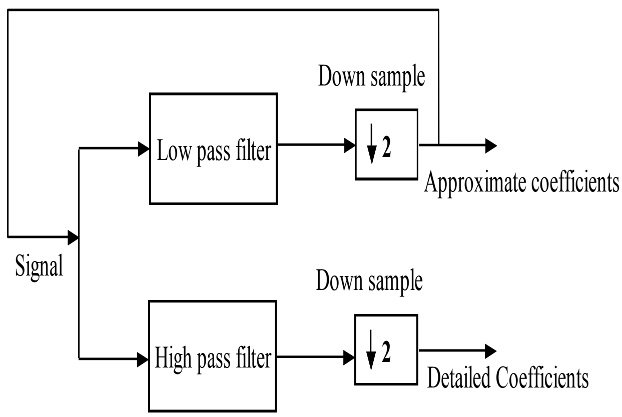

Figure.1.Block diagram to show DWT decomposition

The EEG signal is decomposed into 4 levels using dB10 and Sym8 wavelets and corresponding approximate and detail coefficients. From derived coefficients high frequency components will be distributed in approximate coefficients and low frequency components presents in Detail coefficients cD4, cD3, cD2, cD.

II.WAVELET TRANSFORM

A wavelet transform is the representation of a function by wavelets. The wavelets are scaled and translated copies (known as "daughter wavelets") of a finite-length or fast-decaying oscillating waveform (known as the "mother wavelet"). Wavelet transforms have advantages over traditional Fourier transforms for representing functions that have discontinuities and sharp peaks, and for accurately deconstructing and reconstructing finite, non-periodic and/or non-stationary signals.

Wavelet Transform can be represented as a linear transformation i.e. *Y= WX*, where *X, Y* are input and output of the transformation and *W* is orthogonal mother wavelet transformation matrix. Mother wavelet is defined as

$$\psi_{u,s}(t) = \frac{1}{\sqrt{s}}\psi\left(\frac{t-u}{s}\right) \quad (1.1)$$

Wavelets are oscillating functions of time that must satisfy several conditions: A wavelet ψ has zero time average and unit energy corresponds to orthonormality property of wavelets. The amplitudes of a wavelet have large fluctuations within a designated time period and extremely small values outside of that time while being band-limited in terms of their frequency content. The CWT of a signal *f (t)* can be calculated using equation

$$F(u,s) = \int f(t)\frac{1}{\sqrt{s}}\psi^*\left(\frac{t-u}{s}\right)dt \quad (1.2)$$

By varying the values for *s* and *u* results in an infinite number of combinations, can be used to decompose the signal *f (t)*. Here *u* and *s* are the translation and dilation respectively.

A much more computationally efficient approach is the use of the discrete wavelet transform (DWT), which was developed by Mallat. Knowing only the values of the DWT coefficients, the waveform can be perfectly reconstructed. All of the extra coefficients of the CWT create a redundancy in calculation because they are highly correlated with the ones of the DWT. In implementation, the DWT performs even better because waveforms are already digitally sampled and have finite duration so the number of coefficients is limited DWT or CWT can be seen as a number on the time scale plane representing the correlation between the *signal* vector and the wavelet function at a given time-scale point. The DWT produces as many wavelet coefficients as there are samples in the noisy EEG signal by using a filter scheme shown in Fig. 1.

III METHODOLOGY

The EEG and EOG data sets are collected form Physionet data base[6].The collected EEG and EOG signals were normalized by subtracting the mean and later divided by the standard deviation. The EEG signal is mixed with the EOG signal to obtain a noisy EEG signal. The noisy EEG signal is convolved with a low and high pass filter whose impulse response is determined by the wavelet chosen. The output of each filter produces the same number of samples as the original signal, so both outputs are down sampled by 2 resulting in the approximation and detail coefficients each with half the number of points as the original signal.

The EEG signal will be corrupted by ocular artifacts during the process of signal acquisition. The corrupted EEG signal (observed) is given as

$$y = y_i = s_i + v_i \qquad i = 1............n. \quad (1.3)$$

Where s_i is original EEG signal, v_i represents the EOG signal with variance $N(0,\sigma^2)$ here the problem is to remove or attenuate the maximum no. of v_i from the output signal 'y'.

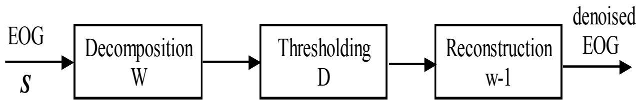

Figure 2. Wavelet denoising

Noisy corrupted signal is decomposed into 4 levels with all the mother wavelets. The sub bands thus formed contains the frequencies in the bands of 0-10 Hz, 10-20 Hz, 20-40 Hz and 40-80 Hz. These sub bands contains almost all the energy contained by the signal. Since the mother wavelet resembles the signal's' and large coefficients are generated corresponding to the eye moments and low coefficients corresponding to the noise. Various thresholding techniques such as Heursure, Rigrsure, minimaxi, and sqtwolog[6] along with soft and hard thresholding.

- Soft thresholding:

$$\begin{aligned} y &= \text{sgn}(x).(|x|-t) & |x| \geq th \\ &= 0 & |x| \leq th \end{aligned} \quad (1.4)$$

- Hard thresholding:

$$\begin{aligned} y &= x & |x| \geq th \\ &= 0 & |x| \leq th \end{aligned} \quad (1.5)$$

One of the sample results obtained using one of the thresholding technique namely Heursure –hard thresholding technique using matlab [7] are shown in the Figure 3.The process is repeated using Rigrsure, minimaxi and sqtwolog thresholding techniques using dB10 and Sym8 wavelets and the results are tabulated in the table1.1 and table 1.2 respectively.

Table 1.1 Statistical parameters of EEG signal obtained using dB10 with various thresholding techniques

Parameters/ wavelet and thresholding	dB10							
	Heursure (h)	Heursure (s)	Rigrsure (h)	Rigrsure (s)	Minimaxi (h)	Minimax (s)	Sqtwolog (h)	Sqtwolog(s)
Mean Square Error	0.0937	0.1094	**0.0453**	0.0670	0.0701	0.0877	0.1179	0.2283
Mean Absolute Error	0.2365	0.2554	**0.1609**	0.2028	0.1974	0.2167	0.2650	0.3647
Signal to Noise Ratio (dB)	10.2705	9.5973	**13.4237**	11.7258	11.5309	10.5611	9.2730	6.4054
Peak Signal to Noise Ratio(dB)	17.6678	16.9946	**20.8210**	19.1231	22.0915	21.1218	16.6703	13.8027
Correlation Coefficient	0.9519	0.9440	**0.9770**	0.9667	0.9643	0.9551	0.9390	0.8790

Table 1.2 Statistical parameters of EEG signal obtained using sym8 with various thresholding techniques

Parameters/ wavelet and thresholding	**Sym8**							
	Heursure (h)	Heursure (s)	Rigrsure (h)	Rigrsure (s)	Minimaxi (h)	Minimaxi (s)	Sqtwolog (h)	Sqtwolog(s)
Mean Square Error	0.0820	0.0961	0.0406	**0.0403**	0.0636	0.1109	0.1179	0.1870
Mean Absolute Error	0.2210	0.2375	0.1564	**0.1558**	0.1961	0.2635	0.2650	0.3349
Signal to Noise Ratio (dB)	10.8515	10.1611	13.9012	**13.9423**	11.9549	9.5412	9.2730	7.2714
Peak Signal to Noise Ratio(dB)	18.2488	17.5584	21.2985	**22.2340**	19.3522	16.9385	16.6703	14.6687
Correlation Coefficient	0.9580	0.9508	0.9794	**0.9796**	0.9676	0.9439	0.9390	0.9018

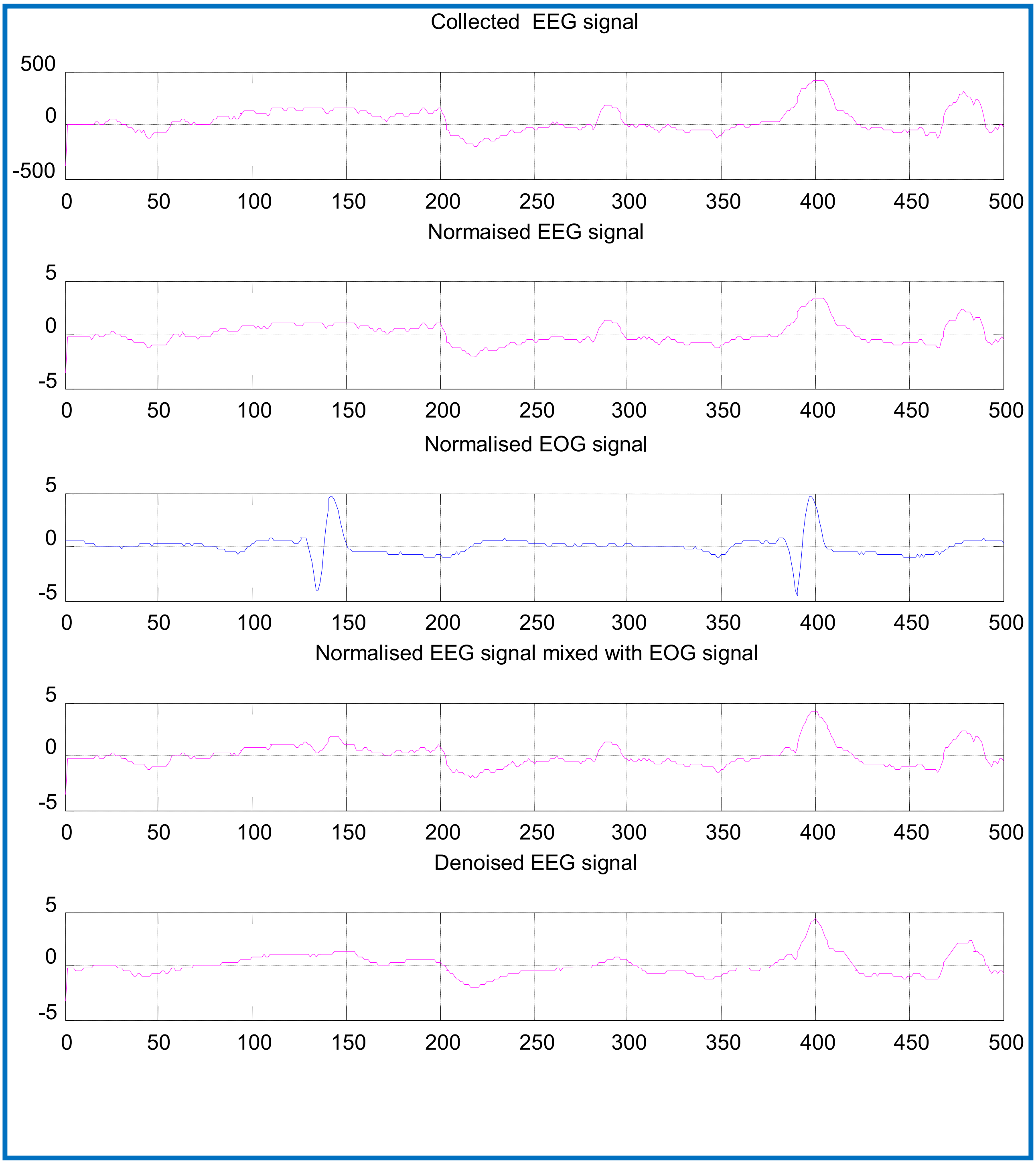

Figure 3. Collected, Noisy and Denoised EEG Signal Using Heursure-Hard Thresholding

IV CONCLUSION

The noisy EEG signal is processed with dB10 and Sym8 wavelets using Heursure, Rigrsure, minimaxi and sqtwolog thresholding techniques and later estimated the various

Statistical parameters of EEG signal. From the Table 1.1 and Table 1.2, it is observed that the better results obtained in the denoising process of noisy EEG signal using dB10 wavelet with the help of Rigrsure-hard thresholding technique, providing better SNR of 13.4237dB, PSNR of 20.8210 dB , MSE of 0.0453 and Correlation Coefficient of 0.9770.

In case of sym8 wavelet the better results obtained in the denoising process of noisy EEG signal with the help of Rigrsure-soft thresholding technique, providing better SNR of 13.9423 dB, PSNR of 22.2340 dB , MSE of 0.0403 and Correlation Coefficient of 0.9796.

The originality of the signal is not going to be affected by the decomposition of EEG signal and the noise can be reduced considerably using Sym8 wavelet with the help of Rigrsure-soft thresholding.

In order to process the noisy EEG signal for the removal of OA, the Sym8 wavelet with the help of Rigrsure- soft thresholding providing better results than dB10.

REFERENCES

[1]. N.V. Thakor et al. (1993). "Multi resolution Wavelet Analysis of Evoked Potentials", IEEE Transactions on Biomedical Engineering, Vol. 40, No 11, pp. 1085-1093,November.

[2]. S. Ventakaramanan, P. Prabhat, S.R Choudhury, H.B Nemade, and J.S. Sahambi. (2000). "Biomedical Instrumentation Based On Electrooculogram (EOG) Signal Processing And Application To A Hospital Alarm System", Indian Institute Of Technology (IIT) Gunawati, Proceedings of IEEE ICISEP, pp.535-539.

[3] Schlogl A, Keinrath C, Zimmermann D et al. 2007. A fully automated correction method of EOG artifacts in EEG recordings. Clinical Neurophysiology.118, 98–104.

[4] Jung T-P, Makeig S, Humphries C, Lee T-W, McKeown MJ,Iragui V and Sejnowski TJ. 2000a. Removing Electroencephalographic artifacts by blind source separation.Psychophysiology.37, 163 –178.

[5] Gratton G, Coles MG and Donchin E. 1983. A new method for off-line removal of oucular artifact. Electroencephalography Clin.Neurophysiol. 55, 484– 486.

[6] www.physionet.org

[7] Mathworks.com