FREQUENCY BAND SEPARATION OF NEURAL RHYTHMS FOR IDENTIFICATION OF EOG ACTIVITY FROM EEG SIGNAL

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ABSTRACT

The identification of EOG activity from the electroencephalogram (EEG) recorded from the parietal occipital region is analysed. The occurrence of ocular biosignals from scalp EEGs is mandatory for both the automated and visual analysis of underlying brainwave activity. The most prominent eye-induced artefacts are caused by the potential difference between the cornea and retina, which is quite large compared to cerebral potentials. As the occipital region of the brain is concerned with the potentials related to the vision, the EEG potentials recorded from occipital parietal lobe is analysed for EOG signal after frequency band separation.

Keywords: EEG, EOG, Artifacts, Sub Band Frequency

I INTRODUCTION

1.1 GENERAL

The electrical activity in the brain is due to the various activities from the organs of the body which is summated and appears on the surface of the brain. The summated signal is recorded from the surface of the brain by electroencephalogram (EEG) through the electrodes placed on the scalp of person. Evaluation of the EEG for various diagnostic procedure including the diagnosis of neurological disorders, sleep patterns, epilepsy, monitoring the of depth of anesthesia are interfered with the occurrence of EOG signals.

The EEG is characterized into alpha, beta, delta and theta waves based on frequency and amplitude. Based on their amplitudes the amplitudes are designated as low (20µV), medium (20µV-50µV) and high (above 50µV)

The activity of eye such as eye movements and eye blinks mostly contaminate the EEG signal. Any activity in the human eye is reflected as an electric field created which are two orders of magnitude greater than the desired electrical activity. This electric field which propagates across the scalp and hence distorts the EEG signal. The eye blink artifact has 10 time larger amplitude than the electrical signals originating from cerebral cortex which is defined as the electrical activity associated with the eye movement (EOG artifact)[1].

II REVIEW OF LITERATURE

EEG signals contain more relevant information about brain disorders and different types of artifacts. The corruption of EEG by different kinds of artifacts such as eye movements and blinks caused improper diagnosis and analysis of EEG. The artifact may affect the detection of EEG data of interest and obstruct the analysis of EEG recordings. Signals in the form of dataset are already loaded to the tool so the signals are used to plot the data and visualization of the time-frequency domain plots which can be displayed all together.

Basically EEG signals are recorded according to the placement of electrodes which is called montages. After that EEG signals are observed to recognize and eliminate different disease related artifacts. The algorithms for the detection and separation of spikes are generally implemented in two stages (Kadambe et al., 1992). The first stage consists of emphasizing the spike portion of the signal and the second stage is the decision making stage. In the frequency or spectral domain, spikes can be described as having high frequency components. As a result different high pass filtering techniques have been used for the separation of spikes. Most of the recent methods are based on the linear prediction error filtering scheme. Analogue filtering was used by Solomonow et al. (1985) who implemented an eighth order Chebyshev low pass filter at 550 Hz for filtering EMG artefacts. While successful in eliminating high frequency components of the artifact, the method allows low frequency components of the artifact to be passed. This predicament was observed by Winchman (2000) (EEG) who noted that in the frequency domain, it is very difficult to remove the stimulus artifact using conventional filters, as there exists a significant overlap between the spectral components of the neuronal signal and the artefact (Winchman,2000). Another artefact removal method was suggested by Roskar and Roskar (1983) (EMG) who used a digitally controlled amplifier gain to suppress the stimulus artifact signal. A gain of ×1 was used during stimuli changing to a gain of ×1000 in between stimuli. However, the authors discussed only qualitative results and it has been suggested that a gain ratio of 1000 may not always be sufficient to remove the stimulation artifact (Knaflitz, 1988). Nenadic and Burdick in 2005 employed the continuous wavelet transforms with basic detection theory to develop a new unsupervised method for robustly detecting and localizing spikes in noisy neural recordings [2].

2.1 EXISTING METHOD

The traditional method of the eye-blink suppression is the removal of the segment of EEG data in which eye blinks occur. The spectrum of ocular electrical activity is typically characterized by few predominant low-frequency components. Eye blinks are usually detected by means of data recorded from electrodes placed above and below the subject's eye. An eye blink is said to have occurred if the signal amplitude exceeds a given threshold. All EEG segments in which eye blinks take place are then removed [3].

2.2 LIMITATION

A number of methods have been proposed for EOG artifact correction from EEG. Due to the limitation of EEG signal recording technology, physiological artifacts, especially those generated by eye with EEG, may change the characteristics of the neurological events in EEG [4].

2.3 PROPOSED METHOD

Wavelet transform has emerged as one of the superior techniques in analyzing non-stationary signals like EEG. Its capability in transforming a time domain signal into time and frequency localization helps to understand the behaviour of a signal better [5].

In EEG data sets, there may be some specific components or events that may help the clinicians in diagnosis. They may tend to be transient (localized in time), prominent over certain scalp regions (localized in space) and restricted to certain ranges of temporal and spatial frequencies (localized in scale).

Wavelet analysis provides flexible control over the resolution with which neuro-electric components and events are localized in time, space and scale. Samar describes the basic concepts of wavelet analysis and other applications.

2.4 SOFTWARE USED

In this work for the detection of those eye movement artifacts in EEG signal the MATLAB 7.10 is used. Wavelet transforms are a mathematical means to perform signal analysis when signal frequency varies over time. The toolbox, together with the power of MATLAB software, one to write complex and powerful applications in very short amount of time [6].

III METHODOLOGY

3.1 Proposed System

Wavelet analysis in principle offers the researcher or clinician a superior alternative to standard Fourier analysis techniques. Fourier techniques are certainly adequate for some applications. Wavelet analysis offers increased power to resolve transient and scale-specific events in neuroelectric data sets, to precisely filter neuroelectric waveforms for noise reduction, to efficiently store and transmit neuroelectric waveforms and images, and to observe and quantify their small-scale structure in time and space [7].

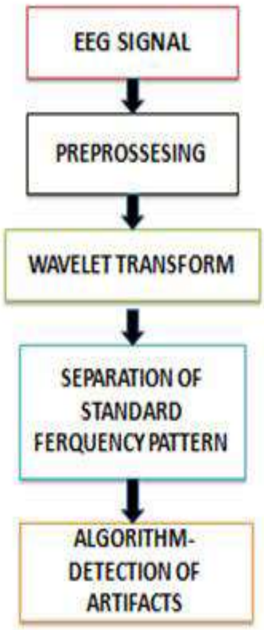

Fig.1 Block Diagram of Proposed System

3.2 EEG Recording And Data Collection

Data collection is obtained by the placement of gold cup electrodes is based on 10-20 international electrode system which says that the distance between the adjacent electrodes is 10% or 20 % of the total distance on the scalp[8].

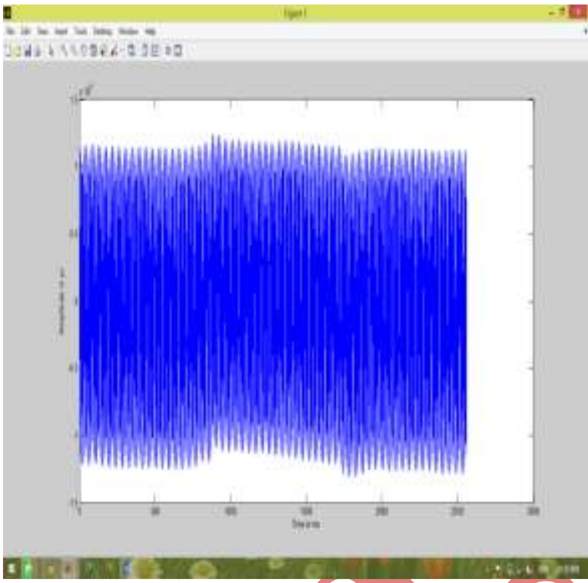

Fig.2 Compressed EEG Signal

In the first stage of parameter analysis, the EEG signals of patients who are free of neurological disorder were analyzed and clearly understood their characteristics and clinical significance. The compressed EEG signal is shown in Fig.2. This compressed EEG signal may have the artifacts. There are lots of variations in the EEG signal in terms of shape, frequency, amplitude. If the amplitude of EEG signal is below 20 µV, then it is considered as low, if the amplitude is between 20 µV-50 µV, it is considered as medium and if amplitude is above 50 µV then it is considered as high.

3.3 Preprocessing

Pre-processing includes filtering. Maximum frequency of input signal is between 0.5 Hz to 100 Hz. As the sampling frequency is twice the maximum frequency therefore it is equal to 250 Hz. So after sampling, the normalized signal is obtained. The EEG signal and EOG data were band pass filtered with a broadband anti-aliasing filter from 0.5 to 100 Hz and a 50 Hz notch filter, sampled with 250 Hz and 12 bit quantization. The dynamic ranges for EEG and EOG were ±100 mV and ±1 mV respectively.

The digital EEG signal is stored electronically and then filtered. Typical settings for the HPF and a LPF are 0.5-1 Hz and 35–70 Hz, respectively. The high-pass filter filters out slow artifact, such as electro galvanic signals and movement artifact, whereas the low-pass filter filters out high-frequency artifacts, such as electromyographic signals. An additional notch filter is typically used to remove artifact produced by electrical power lines (50 Hz-60Hz) [9].

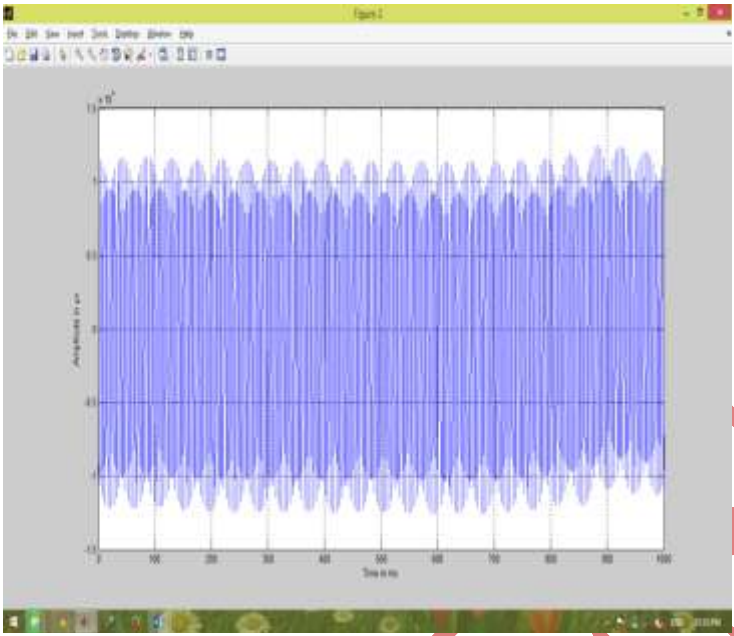

Fig. 3 Plot of 1000 samples

3.4 Frequency Band Separation

The spectrum of ocular electrical activity is typically characterized by few predominant low frequency components. Such type of signal can be easily identified by decomposing the signal by using wavelet transform and then by fixing the threshold range. From the number of 'detail' coefficients obtained at each level of wavelet decomposition, the detail coefficients are selected in the form dj> dj-1, dj+, j= 1,2,...n. Normally, every spike contains three coefficients. Next spike identification starts with dj+1 treated as d j−1and checks the next two coefficients. Based on this arrangement, the spikes in the contaminated EEG have to be identified. On decomposing this with a Daubachies wavelet (dB – up to eight levels), the final 'detail' yielded the waveform [8].

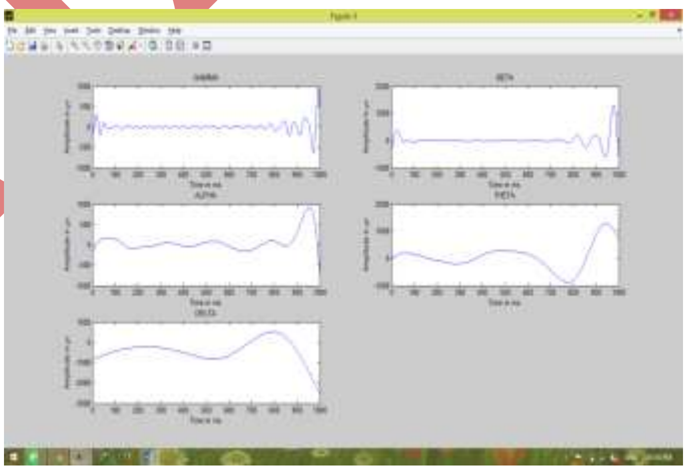

Fig. 4 Frequency Band Separation for Neural Rhythms

There are different neurological rhythms like alpha, beta, gamma, theta, and delta. In this stage these rhythms were separated by means of frequencies. Wavelet transform has emerged as one of the superior techniques in analyzing nonstationary signals like EEG. Its capability in transforming a time domain signal into time and frequency localization helps to understand the behaviour of a signal, better. Daubachies wavelet is implemented. Its efficiency will increase based on its orders like 'db4', 'db8'. Here 'db8' is used because its efficiency is high.

3.5 Identifying Ocular Artifact Zones

After decomposing the EEG signal, at every level, the 'detail' part is considered. However, the 'approximation' part of the signal can also be retained reconstruction. Using the spike zone coefficients (dj, dj-1, dj+1), the coefficient of variation for every spike zone is calculated. Among the coefficient of variation values, the larger values have to be selected. Since, larger coefficient of variation indicates less reliable or high frequency (noise) amplitude.

Threshold value = $N*(1x+ \sigma)$

Threshold function = Hard

(Where x and σ denote the mean and standard deviation of artifact zones and N varying from 10 to 150).

The threshold function used in this work is as follows:

If

Wavelet coefficient value > threshold value

then

new wavelet coefficient value = (- 0.7) * (wavelet coefficient value)

else

new wavelet coefficient value = (old) wavelet coefficient value

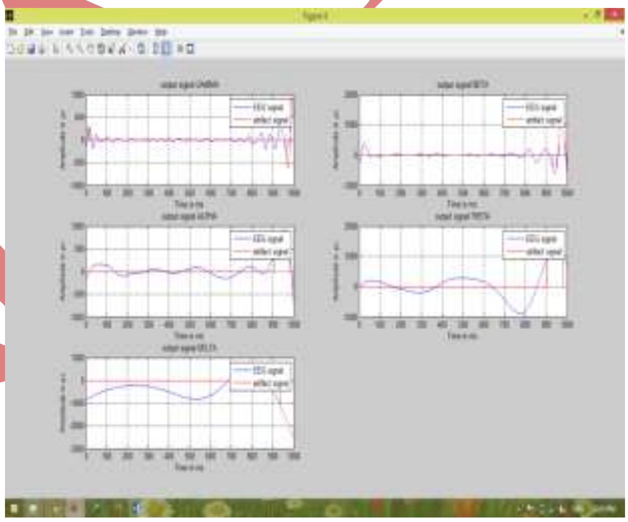

Fig.5 Artifact Identification

IV. CONCLUSION

The data taken from P4-O2 were frequency bands separated for these channels and finally artifacts were identified at different zones. It is known that EOG artifact is enhanced in gamma wave, because its origin is from lateral occipital region where eye blinks easily affects the original signal. The analyses revealed a high level of accuracy with respect to frequency and topography for the gamma-band modulations Oscillations in the gamma band (around 40 Hz) play a functional role in many aspects of information processing.

A recent study has revealed that also prestimulus gamma-band fluctuations in lateral occipital areas correlate with certain aspects of visual processing Oscillations in the gamma band are extremely susceptible to brain artifacts, such as eye or muscle movement, which occur in a common frequency range. In particular, micro saccadic eye movements can affect gamma band activity gamma-band oscillations in the lateral occipital cortex (LOC) are related to visual object processing.

As a future work, it has been planned to remove the identified EOG artifact without affecting the original signal coefficients which may lead to the loss of critical information in the analyzed data. This method will help the neurologists to diagnose the patient's data and provide an error free analysis and interpretation

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