DETECTION OF ELECTROENCEPHALOGRAPHY (EEG) EYE-BLINK ARTIFACT TREND USING DISCRETE WAVELET FUNCTION

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Abstract :This paper presents a brief documentation about concepts of Electroencephalography (EEG) and its one type of artifact i.e. Eye-Blink Artifact. This is one form of Ocular Artifact. To study brain functioning and problems if any, Neurologists uses Electroencephalography technique. But while recording brain signals, noise (Artifact) gets induced and became part of EEG recording. This creates problems for Nero Experts to analyze and interpret it and hence it is necessary to remove such artifact from recordings. Ocular artifact related to Eye movement is in existence which may also resemble to disordered pattern. One can detect and remove this using Wavelet Function available. Sub sampling and multi resolution analysis of signal is the key idea for identifying typical trendy pattern of required frequency band and nullifying their impact. One may get sufficient information about analysis and components of the original signal using Discrete Wavelet Transform.MODWT, IMODWT and MODWTMRA are the Discrete Wavelet functions used to localize required pattern and remove that from the signal.

Keywords :Electroencephalography, Artifact, Ocular,Modwt, Imodwt, Modwtmra

I. INTRODUCTION

Electroencephalography (EEG) is a valuable measure of the brain's electrical function. Electrodes are placed on the head i.e. scalp surface. Underlying electrical activity of brain structure is carried by conductive material. Such activities are recorded in the form of graphics which is actually difference in voltages from two sites of the brain.[1] EEG displays the continuous and changing voltage fields as per the different locations on the scalp. Thus EEG has capability to display both normal and abnormal electrical activity of the brain. Hence it has greater application in the field of Neurology and Clinical Neurology.

Brain Waves: Brain wavesare commonly sinusoidal. Normally they are measured from peak to peak and ranges from 0.5 to 100 microvolts in amplitude. [2]

Brain waves consist of different frequencies. They are seen in different parts of brain depending on the situation of the subject being monitored. Mainly categorization is done in accordance with their frequency range.

- Delta waves. 3.5 Hz or lower. Observed during deep sleep.
- Alfa waves. 8–12 Hz. When subject is relaxing while eyes closed.
- Beta waves. 12–30 Hz. Observed during active thinking and concentration.
- Theta waves. 3–7.5 Hz. Seen in the stage of drowsiness and anxiety.
- Gama waves. 30 Hz or upper range. [3]

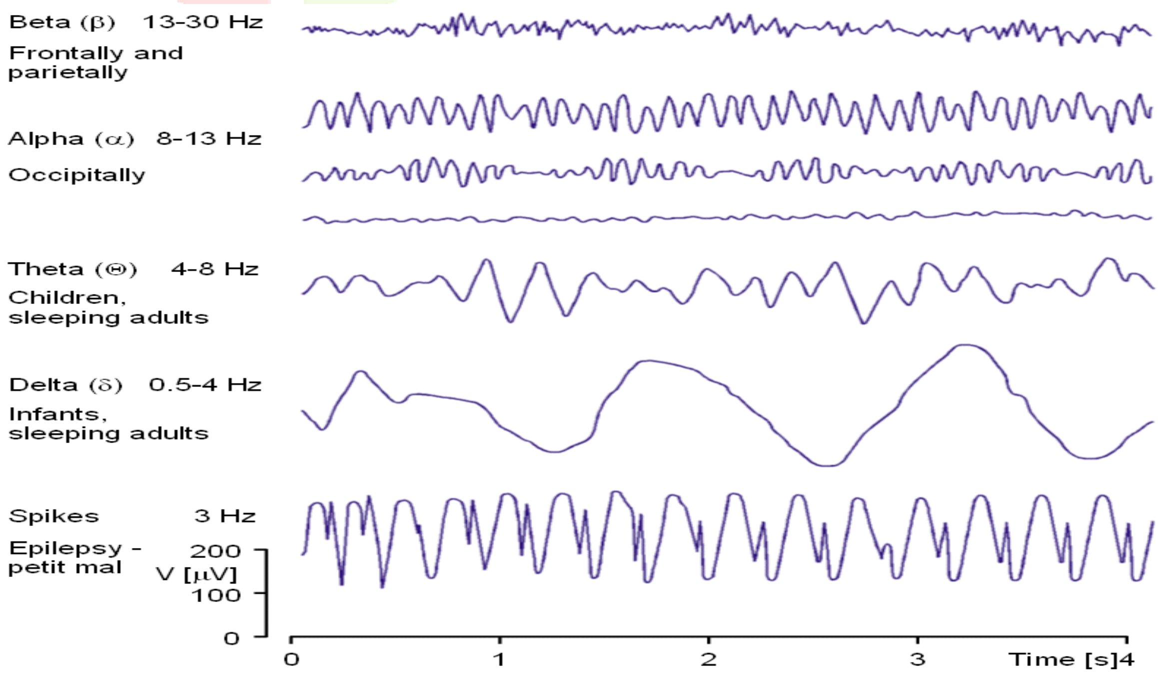

Fig 1: Brain waves

Purpose of the Electroencephalography

- To diagnose cause of seizures
- To notify if there is any structural brain abnormality (brain tumor or abscess)
- To detect and evaluate activity in people suffering from meningitis or encephalitis (brain or spinal cord infections)
- To assess the extent of damage due to stroke and record time period of it.
- To diagnose disorders that influence brain activity (Alzheimer's disease)
- For monitoring brain functioning during surgery.
- For identifying sleep disorders such as Narcolepsy
- For confirming Coma state and dead Brain. [1]
- EEG can also be used in intensive care units for brain function monitoring:
    1. Such as non-tonic-clonic seizures (Grand Mal Seizure)
    2. The effect of anesthesia when patient is in medically induced coma (refractory seizures)
    3. In ruptured aneurysm (balloon like bulge) which leads to subarachnoid hemorrhage. One need to observe for secondary brain damage in such conditions [3]

II. NOISE IN EEG: ARTIFACT

EEG is designed to record cerebral activity. But it also records electrical activities produced from other sources. Such other activity that is not of cerebral origin is named as artifact. Artifact can be divided into Physiologic and Extra- physiologic artifact. Physiologic artifacts arise from sources other than the brain (ie, body). Extra physiologic artifacts arise from equipment, environment i.e. outside the body. [4]

The electrical signals of brain activities are weak. So while recording various non-neural physiological unwanted signals gets mixed with EEG. The most severe artifact includes eye movement (Electrooculography (EOG)) and muscle movement (Electromyography (EMG)) artifact. These undesired signals complicate EEG data. Many times can be misread as the physiological phenomena. So one must try to eliminate the effects of artifact and extracting the meaningful information.

EEG interpretation procedure needs to know or find out characteristics of the artifact that differ from those of the signal of interest, i.e., signals generated by activity in the brain. A few such possibilities are as follows: [5]

- The artifact known to be in a limited frequency range can be removed by frequency filtering.
- The artifact of discrete frequencies can be removed by notch filtering. (50 Hz or its harmonics)
- The artifact limited to certain time slot, e.g. Eye Blink (Ocular) can be removed by observation and removal of particular time slot where the artifact appears.

Noiseless clean EEG data will help to interpret and diagnose the disorder in a faster way with minimized time and efforts.

III. OCULAR ARTIFACT

Eye movement generates an electrical dipole. It is separation of positive and negative charges generated due to positive cornea and negative retina. Any movement will change the dipole, which happen with Eye movement and blink. This causes an electrical signal known as an EOG. The shape of the EOG waveform depends on the direction of eye movement. EOG get mixed with EEG and became part of it. Electrooculogram (EOG) is actually electrical potential around the eyes. It is Voltage change generated by Ocular movements. Thus Electrooculogram (EOG) is caused due to a non-brain activity. It is spread across the scalp and contaminates EEG. Ocular Artifact is a collective term used to describe number of unwanted voltage potentials caused by eye movement and blinks. [6}

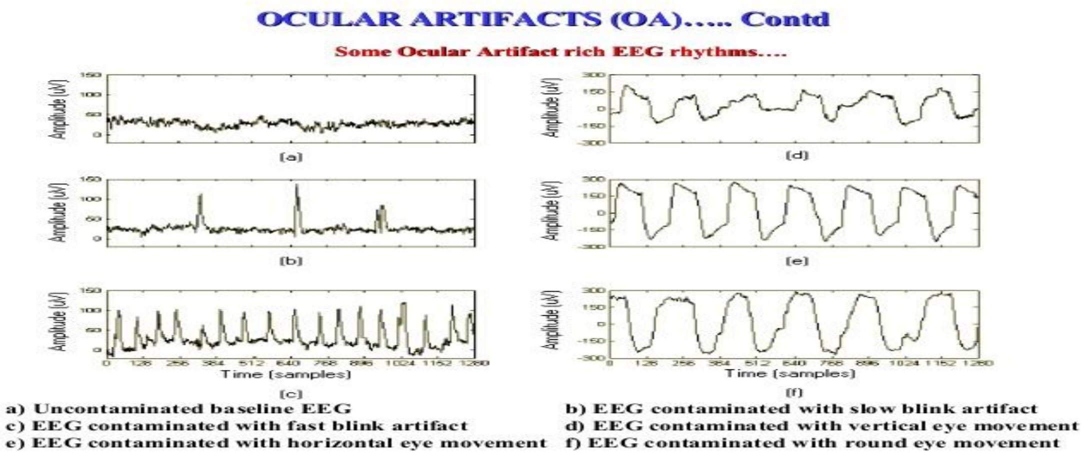

Fig 2: EOG types [6]

IV. WAVELET ANALYSIS

Wavelets are used in analyzing the signal according to scale. It provides the time-frequency representation.Wavelet algorithms are capable to process data at different scale or resolution. For studying signal with its gross features, it is needed to study a signal with a large frame. Similarly, for small and minute features, we study a signal with a small frame. In wavelet analysis a wavelet prototype function, called an *analyzing wavelet* or *mother wavelet* is used. Temporal analysis is performed with a contracted, high-frequency version of the prototype wavelet. Frequency analysis is performed with a dilated, low-frequency version of the same wavelet. The original signal or function can be represented in using coefficients in a linear combination of the wavelet functions. So data operations can be performed using respective wavelet coefficients. [7]

Discrete Wavelet Transform uses filters of different cut off frequencies which are used to analyse the signal at different scales. The signal is passed through a series of high pass filters to analyse the high frequencies, and it is passed through a series of low pass filters to analyse the low frequencies. DWT employs two sets of functions, called scaling functions and wavelet functions. These are associated with low pass and high pass filters. The decomposition of the signal into different frequency bands is simply obtained by successive high pass and low pass filtering of the time domain signal. We can also analyse the image at different frequencies. We can reconstruct the original image by using only the coefficients that are of a particular band. The resolution is a measure of the amount of detail information in the signal. It is changed by the filtering operations, and the scale is changed by up sampling and down sampling operations. Subsampling relates to reducing the sampling rate, or removing some of the samples of the signal. [8]

V. MATERIALS AND METHODS

Data used is ‘eyebrow-raise-256.mat’ file. This file includes Eye Brow raise EEG Recording from eight electrodes for thirty seconds. Sampling rate is 256 Hz. Electrode position used are FP1, FP2, C3, C4, O1, O2, vEOG, hEOGand correspond respective to the columns of Data Matrix. For e.g.(:,1) gives recording for Channel FP1.

Eye blinks mainly located on the front electrodes (FP1 and FP2) with low propagation, are represented by Low Frequency signal (<4 Hz) with high amplitude.[9]

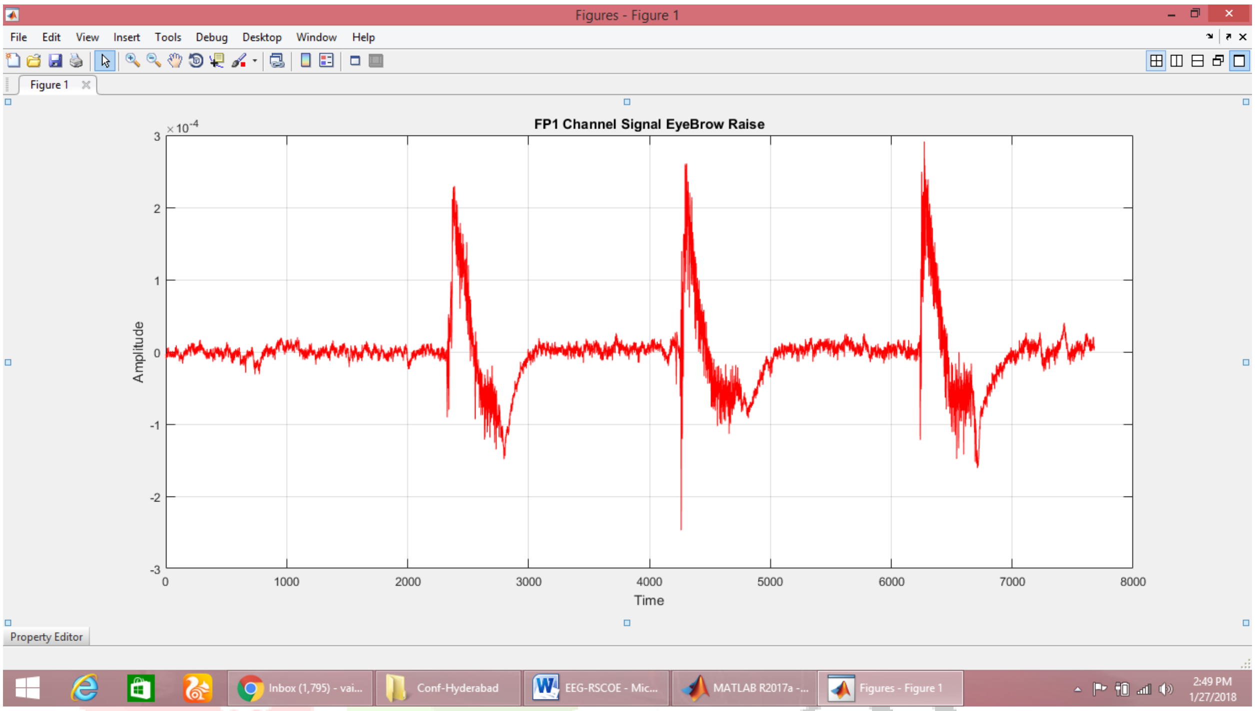

Fig 3: Eye Brow Raise Signal Channel FP1

In the above figure it is easy to manually trace eye blink artifact or trendy pattern in the particular electrode. Trend detection in signal is an important pre-processing step.

Wavelet finds useful application in detecting such trendy pattern and hence can be used in Ocular artifact detection. Discrete Wavelet Transform (DWT) is used to localize the trend information. Then it gives coefficients corresponding to particular frequency band of interest. In this case Eye Blink artifact is below four hertz. When DWT is applied, it split up the Input signal into Low Frequency (LP) and High Frequency (HF) sub bands, which are known as Approximation and Detailed Sub Bands respectively. For subsequent levels, Approximation Sub band is again split into Sub bands, yielding narrower sub band.

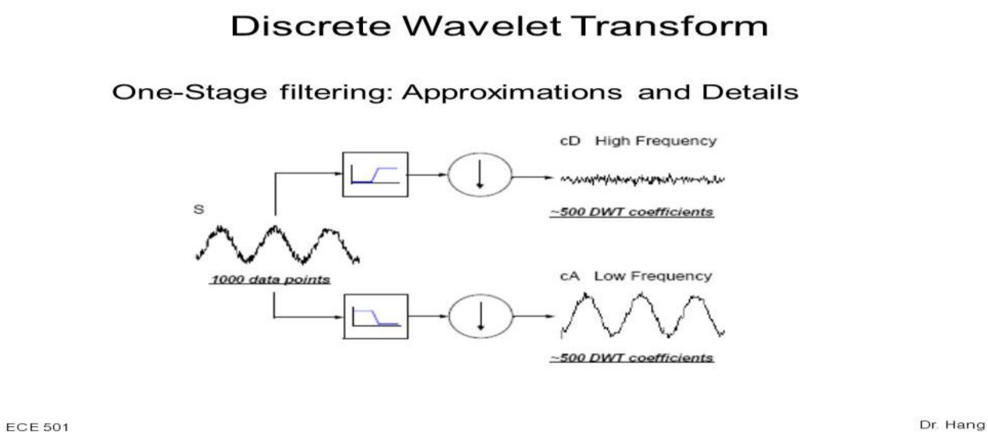

Fig 4: Discrete Wavelet Transform [10]

In the used datasampling frequency is 256 Hz , so it needed to use DWT up to six levels. This will yield 5-8 Hz as Detailed Coefficients and 0-4 Hz as Approximation Coefficients. To remove trend set approximation coefficient obtained in the last level to Zero and then reconstruct the signal using Inverse maximal overlap discrete wavelet transform (imodwt) Function.

VI. RESULT

When data is loaded in Matlab, it is originally with eight channels. So it is first converted to FP1 channel data. One helper function was customized to visualize data with required trend to be analyzed.

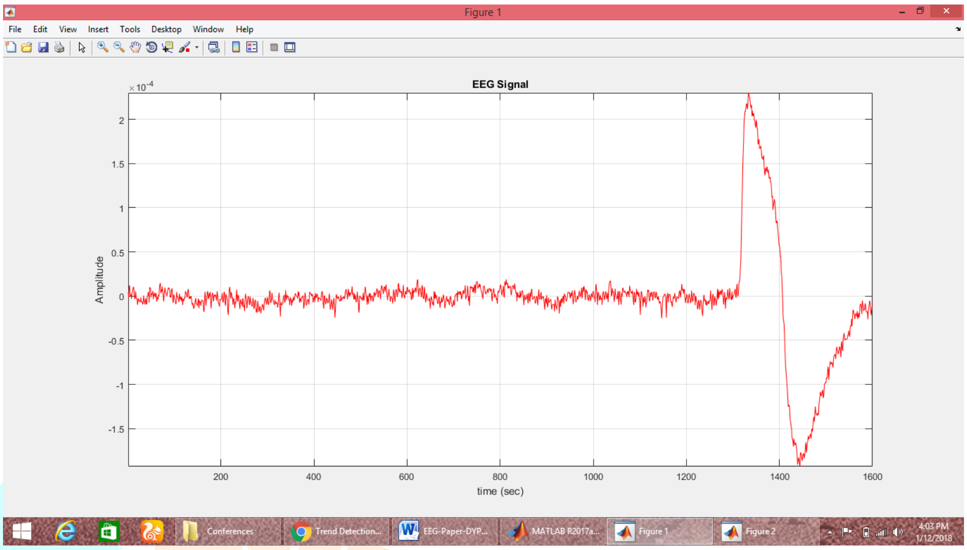

FIG 5: EEG with trend

This short slot of signal was decomposed into six bands using MODWT (Maximum Overlap Discrete Wavelet transform). Sixth level decomposition gives trend of frequency range up to 4 Hz. Output of MODWT contains seven rows. First six rows contain wavelet detailed coefficients and seventh row is approximation coefficient.

VII. CONCLUSION

Electroencephalography (EEG) Signal contains variety of artifact. In the said paper, only one type of ocular artifact (Eye Blink) is considered. Basically artifact from the same source have particular trend which can be located and detected using Wavelet. This experiment can be extended further for other types of Ocular artifact such as Eye Roll, Raising Eyebrows, which also needs to be detected and removed. Further it can be considered for other artifact, removal of which will provide much cleaner EEG data. Such noiseless EEG data will be used by Neuro Experts to study it in effective and faster way.

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