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REMOVAL OF ELECTROENCEPHALOGRAPHY (EEG) EYE-BLINK ARTIFACT USING WAVELET FUNCTION

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ABSTRACT
This paper presents a study related to awareness about concepts of Electroencephalography (EEG) and it's 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 analyse 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. Discrete Wavelet Transform provides sufficient information both for analysis and synthesis of the original signal.
MODWT, IMODWT and MODWTMRA are the wavelet functions used to localise required pattern and remove from the signal.

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

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 locationson the scalp. Thus EEG has capability to display both normal and abnormal electrical activity of the brain. Hence it has profound 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]
The frequency of brain waves can differ based on the state of the person being monitored. These brain waves are categorized into 5 brain rhythms based on their frequency.
•Delta rhythm. 3.5 Hz or lower. Detected during deep sleep.
• Alfa rhythm. 8–12 Hz. Detected during relaxation, especially with eyes closed.
• Beta rhythm. 12–30 Hz. Detected during active thinking or high concentration.
• Theta rhythm. 3–7.5 Hz. Correlates with drowsiness and agitation.
•Gama rhythm. 30 Hz or higher.[3]

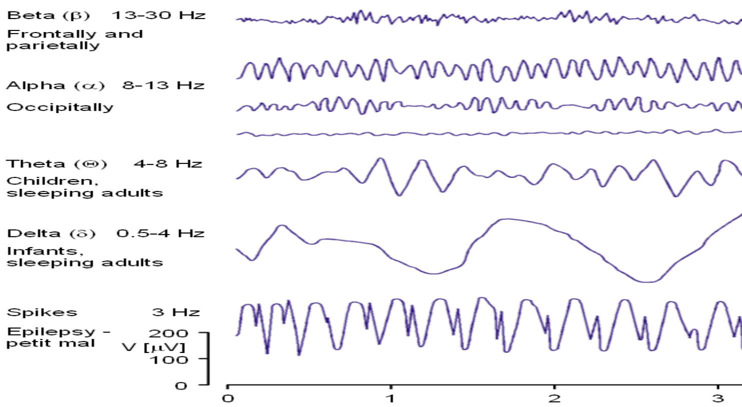

Fig 1: Brain waves

Purpose of the Electroencephalography
- To identify and evaluate the cause of seizures
- To aid in the diagnosis of intracranial (within the skull) lesions, such as an abscess or tumour.
- To evaluate brain wave activity in people with brain or spinal cord infections (such as meningitis or encephalitis); head injury; and psychiatric conditions
- To diagnose a stroke and determine the extent of damage that has occurred
- To diagnose Alzheimer's disease, certain psychoses, a sleep disorder called narcolepsy, and other disorders that influence brain activity
- To monitor brain wave activity during surgery
- To help evaluate sleep disorders
- To diagnose a coma
- To confirm brain death[1]
- EEG can also be used in intensive care units for brain function monitoring:
    1. To monitor for non-convulsive seizures/non-convulsive status epileptics
    2. To monitor the effect of sedative/anaesthesia in patients in medically induced coma (for treatment

of refractory seizures or increased intracranial pressure)

3. To monitor for secondary brain damage in conditions such as subarachnoid haemorrhage (currently a research method).[3]

NOISE IN EEG: ARTIFACT

The electrical signals of brain activities are weak, so real EEG is susceptible to various non-neural physiological unwanted signals. Such noises are termed as Artifact in Neuroscience. The most severe artifactincludes eye movement (Electrooculography (EOG)) and muscle movement (Electromyography (EMG)) artifact. These undesired signals can complicate EEG data or can be misread as the physiological phenomena of interest. Thus, eliminating the effects of artifact and extracting the most relevant information from brain activities are key challenges for researchers.
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:[4]

- 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.

OCULAR ARTIFACT

The human eye generates an electrical dipole caused by a positive cornea and negative retina. Eye movement and blink change the dipole causing an electrical signal known as an EOG. The shape of the EOG waveform depends on the direction of eye movement. A fraction of EOG spread across thescalp and is super imposed on EEG. Voltage changes generated by eye movements and blinks produce large electrical potential around the eyes known as Electrooculogram (EOG). Electrooculogram (EOG) is a non-cortical activity that spread across the scalp and contaminates EEG. Ocular Artifact is a collective term used to describe number of contaminating voltage potentials caused by eye movement and blinks.[5]

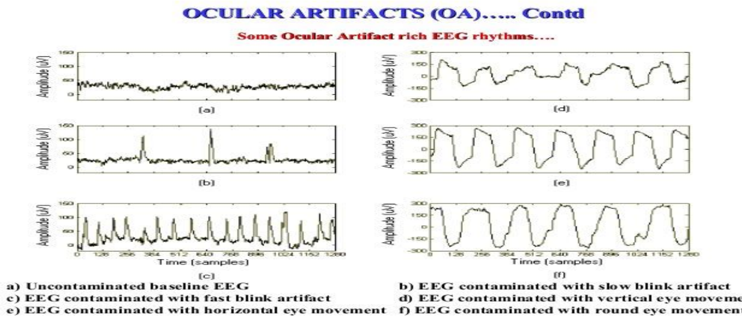

Fig 2: EOG types[6]

WAVELET ANALYSIS

Wavelets are used in analyzing the signalaccording to scale.It provides the time-frequency representation.Wavelet algorithms are capable to process data at differentscale or resolution. For studying signal with its gross features, it is needed to look at a signal with a large a window. Similarly, for small and minute features, we look at asignal with a small window. The wavelet analysis procedure is to adopt a wavelet prototype function, called an *analyzingwavelet* or *mother wavelet*. Temporal analysis is performed with a contracted, high-frequency versionof the prototype wavelet, while frequency analysis is performed with a dilated, low-frequency versionof the same 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 canbe performed using just the corresponding 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, which are associated with low pass and highpass filters, respectively. The decomposition of the signal into different frequency bands is simply obtained by successive highpass and lowpass filtering of the time domain signal. We can also analyse the image at different frequency bands, and reconstruct the original image by using only the coefficients that are of a particular band. The resolution of the signal, which is a measure of the amount of detail information in the signal, is changed by the filtering operations, and the scale is changed by upsampling and downsampling operations. Subsampling a signal corresponds to reducing the sampling rate, or removing some of the samples of the signal. [8]

MATERIALS AND METHODS

Data used is 'eyeblink-256.mat' file. This file includes Eye blink 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 are represented by Low Frequency signal (<4 Hz) with high amplitude. It is mainly located on the front electrodes with low propagation.[9]

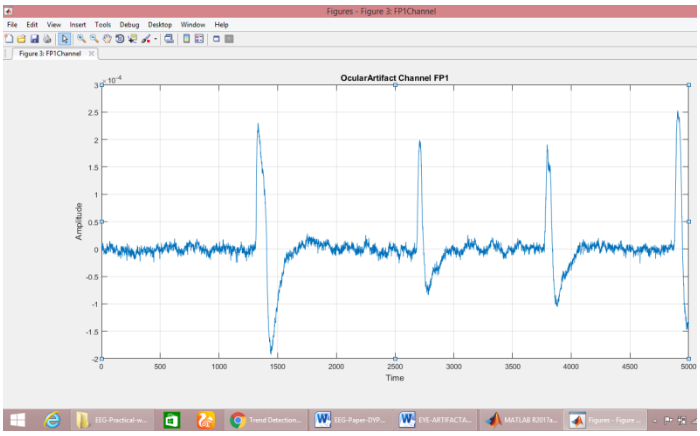

Fig 3: Eye Blink Signal

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 subband.

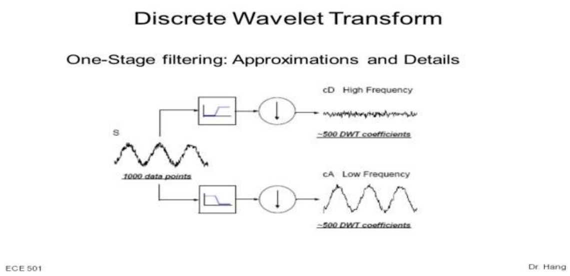

Fig 4: DWT[10]

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.

RESULT

When data is loaded in Matlab, it is originally with eight channels. So it is first converted to FP1 channel data. One function was customised to visualise data with required trend to be analysed.

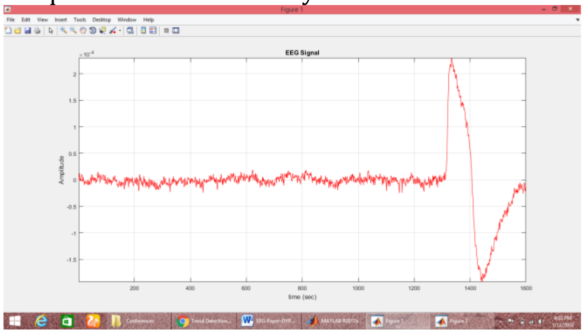

FIG 5: EEG with trend

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.

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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