Classification of Artefacts in EEG Signal Recordings and Overview of Removing Techniques

Avinash Tandle  
Assistant Professor Electronics and  
Telecommunication Department  
MPSTME NMIMS University  
Swami Bhakti Vedanta Marg  
Vile Parle (W), Mumbai -56

Nandini Jog  
Professor Electronics and Telecommunication  
Department  
MPSTME NMIMS University  
Swami Bhakti Vedanta Marg  
Vile Parle (W), Mumbai-56

ABSTRACT
EEG is a record of brain activity from various sites of the brain. Artefacts are unwanted noise signals in an EEG record. Classification of artefacts based on source of its generation like physiological artefacts and external artefacts. Body of the subjects are main source of Physiological artefacts, while external artefacts are from outside the body due to the environment or measuring devices. Recognition, identification and elimination of artefacts is an important process to minimize the chance of misinterpretation of EEG, not only for clinical and non-clinical fields such as brain computer interface, intelligent control system robotics etc. This paper classifies the artefacts from the database collected at Dr. R. N. Cooper Mun. General Hospital Mumbai India.

Keywords
EEG, artefact, EOG, EMG.

1. INTRODUCTION
In 1924 German neurologist, recorded EEG signals. He used the word electroencephalogram for brain signals. EEG imaging technique is simple and economical [1]. EEG has various clinical as well as non-clinical applications. The electrical characteristic of EEG its amplitude range in µV and frequency band is in 0.5Hz to 60Hz [1][2][4][5]. These electrical properties of EEG signal make them vulnerable to external unwanted signals called artefacts. Artefacts can imitate nearly all types of EEG patterns and as such, artefacts included in automatic analysis can seriously affect the results eventually leading to mistaken readings. Substantial amount of artefacts, renders the analysis inceptible if these are not removed or dealt with properly depending upon the type of analysis. Several times artefacts themselves may contain valuable information. In sleep study eye movement and muscle artefacts in the EEG recordings might expedite sorting of sleep stages.

EEG may contaminated by various noise sources. The noise generated from the recording system can significantly reduced by a careful design of the system and by following appropriate signal recording procedures. EEG contaminated by a number of electrophysiological signals generating from various parts of human body. Electro-Oculogram term used for artefact caused because of eye blink and cornea movement. Electromyogram (EMG) are the artefacts caused because of muscle activity of various body parts of subjects.

2. CLASSIFICATION OF ARTEFACT
Classification of artefact depending upon their source of generation. If their source are from the subject’s body, that artefacts called physiological artefacts and if the source is external, called external artefacts.

2.1 Physiological Artefacts
Physiological artefacts are the artefact originated because of electrical activity of other body parts of the subject and obscure the EEG signals.

2.1.1 Artefacts from the eyes and eyelids.
A movement of the eyes and eyeballs causes a change of potential in the electrodes near the eyes at Fp1-Fp2 (Fronto Parietal). Fluttering of the eyelids appears as a 3Hz –10Hz signal.

2.1.2 Eye movement artefacts.
ERG or Electretroretinogram is a potential difference between retina and cornea of the eye and with incident light; it changes, causing artefacts in EEG signals. Voltage amplitude is proportional to the angle of gawk. Can be mixed with slow EEG Prominent in REM sleep [4][12] shown in fig1.

2.1.3 Eye blink.
Eye blinks produce high amplitude signals that can be many times greater than the amplitude of EEG signals of interest. Repetitive blinks produce slow wave, which appear like delta waves shown in fig2.electrical character shown in table 1.

2.2 Muscle artefacts
Classified into glossokinetic (chew/swallow), surface electrode myography, photogenic [2]. Get measured with EEG. Tongue movement; swallowing, grimacing, chewing. Shape depends on the degree of muscle contraction: weak contraction give a low-amplitude spike train. Occurs less in sleep overlap with beta band (15-30Hz) [7][2].Most commonly appears in the frontal and temporal electrode as shown in fig3.and table 1.

2.3 Cardiac Artefact
The heart produces two types of artefacts; mechanical electrical artefacts which appear as ECG signal near temporal left region and are most commonly seen in short neck subjects. This electrical artefact appears as ECG waveform recorded from scalp and forms the QRS complex. Most of the cardiac artefact frequencies are near 1Hz and amplitude is in several millivolts. As shown in fig4.and table 1.
2.4 External Artefacts
The sources of these artefacts are electronic gadgets, transmission lines, environment lines etc.

2.4.1 Transmission-line Artefact
As the bandwidth of EEG signal is 0.5Hz-60Hz and the frequency of transmission lines is 50 Hz, the signal easily mixes with beta band of EEG signal. This artefact affects all channels or channels with poor impedance matching. This artefact can easily remove by using a notch filter of frequency range 50 Hz. Electrical character shown in table.

2.4.2 Phone Artefact
This artefact is because of mobile phone signal. A high frequency signal appears as a spurious signal on the EEG signals. Remedy for this artefact is not to carry a mobile phone while recording this artefact shown in fig6. Electrical character shown in table 1.

2.4.3 Electrode Artefact
Poor electrode contact gives rise to low frequency artifacts, they are brief transients that are limited to one-electrode and synchronize with respiration due to the motion of the electrode.

2.4.3.1 Electrode pop Artefact
Appear as sharply contoured transients that interrupt the background activity misinterpreted as tumor. Shown in fig7. Electrical character shown in table 1.

2.4.3.2 Lead Movement Artefact
Lead movement has a more disorganized morphology that does not look like factual EEG activity in any form and often includes double phase reversal, that is, phase reversals without the evenness in polarity that indicates a cerebrally generated electrical field.[2] Shown in fig8. Electrical character shown in table 1.

2.4.3.3 Perspiration Artefact
Perspiration artifact exhibited as low amplitude, swelling waves that typically have durations greater than 2 sec; thus, they are beyond the frequency range of cerebrally generated EEG.

2.4.3.3 Physical movement Artefact
This artefact appears because of lose contact of electrode due to abrupt physical movement of subjects. Its morphology different from actual EEG. Shown in fig9. Electrical character shown in table 1.

<table>
<thead>
<tr>
<th>Artefact</th>
<th>Source/ Cause</th>
<th>Frequency range</th>
<th>Amplitude</th>
<th>Morphology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac</td>
<td>Heart</td>
<td>1-10mv</td>
<td>1-10mv</td>
<td>Epilepsy</td>
</tr>
<tr>
<td>Transmission line</td>
<td>Transmision line</td>
<td>50-60Hz</td>
<td>50-60Hz</td>
<td>Beta or gamma wave</td>
</tr>
<tr>
<td>Muscle</td>
<td>Body</td>
<td>&lt;=35Hz</td>
<td>&lt;=35Hz</td>
<td>Beta frequency</td>
</tr>
</tbody>
</table>

Table 1. Electrical characteristics of artefacts and Morphology with actual EEG

3. ARTEFACT DETECTION and REMOVAL
Most of the artefact can prevented while recording by making good recording protocol, which include giving instructions to the subject about eye movement, physical movement and not allowing mobile phone in recording room. Experienced technologist recognizes artefact by the process of visual analysis, remontaging, and digital filtering.[4][2].

4. METHOD of REMOVAL
There are different methods of artefact removal, which include manual and automated method. Automated removal methods use mathematical algorithms and are used in digital EEG record; this is an on line method, whereas the manual method is offline method.

4.1 Filter method
Using a band pass filter with a frequency band of artefact, particular artefact can be removed. This method is not a very useful method for analysis of the entire bandwidth of EEG, as artifacts can occur at any frequency. A 50 Hz notch filter can be used for removal of transmission line frequency. Low pass filter can be used for Oculogram artefact removal.

4.2 Manual Method
Manual method also called offline method this is most reliable method of artefact removal. After recording, technologist visually inspects the record and removes the artefact-affected slots or does not consider this slot for further analysis.

4.3 Automatic rejection of Artefact
Automatic artefact removal method uses mathematical algorithms like EOG subtraction, Independent component analysis, principle component analysis, Joint approximate diagonalisation of Eigen matrices (JADE)[3][7][8][9][10].

5. CONCLUSION
Morphology and electrical characteristics of artefacts can lead to false interpretation, which is unacceptable for clinical use and nonclinical use. Hence, artefacts dealt with properly using artefact proof protocol of EEG recording and using different artefacts removing techniques.
Fig 1: Eye movement artefact shown in window

Fig 2: Eye blink artefact shown in window

Fig 3: Muscle artefact shown in window
Fig 4: Cardiac artefact shown in window

Fig 5: 50 Hz transmission line artefact shown in window

Fig 6: Phone artefact shown in window

Fig 7: Electrode Pop artefact shown in window
6. REFERENCES