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 artifacts, while external artefacts are from outside the body due to the environment or measuring devices. Recognition, identification and elimination of artifacts 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 inacceptable 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 Elertroretinogram 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 glossokenetic (chew/swallow), surface electrode myoghraphy, 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

2.4.3.2 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 fig 9.electrical character shown in table 1

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

Artefact	Source/ Cause	Frequency range	Amplitude	Morphology
cardiac	Heart	>1Hz	1-10mv	Epilepsy
Transmission line noise	Transmission line	50-60Hz	low	Beta or gamma wave
Muscle Artefact	Body Muscle	<=35Hz	low	Beta frequency
EOG	Eye	0.5-3 Hz	100mV	Tumor , delta wave
Phone Artefacts	Mobile and landline phone	high	high	Morphology different from actual EEG
Electrode artefact	Electrode and sweating	Very low	High	Morphology different from actual EEG
Physical movement artefact	Physical movement	Very low	Very high	Morphology different from 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 used for removal of transmission line frequency. Low pass filter can 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.

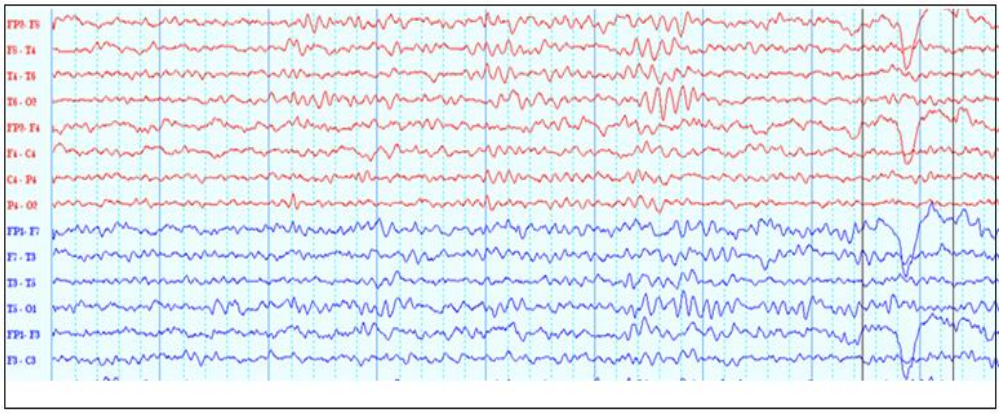

Fig 1: Eye movement artefact shown in window

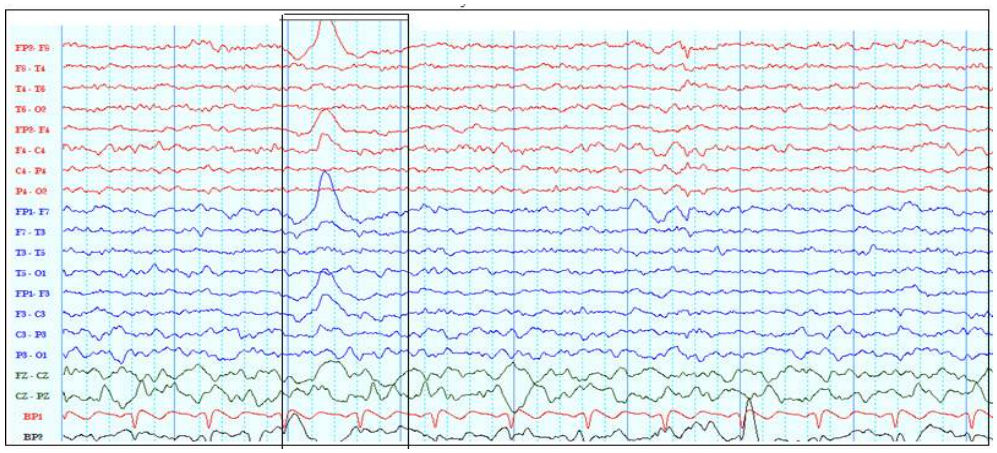

Fig 2: Eye blink artefact shown in window

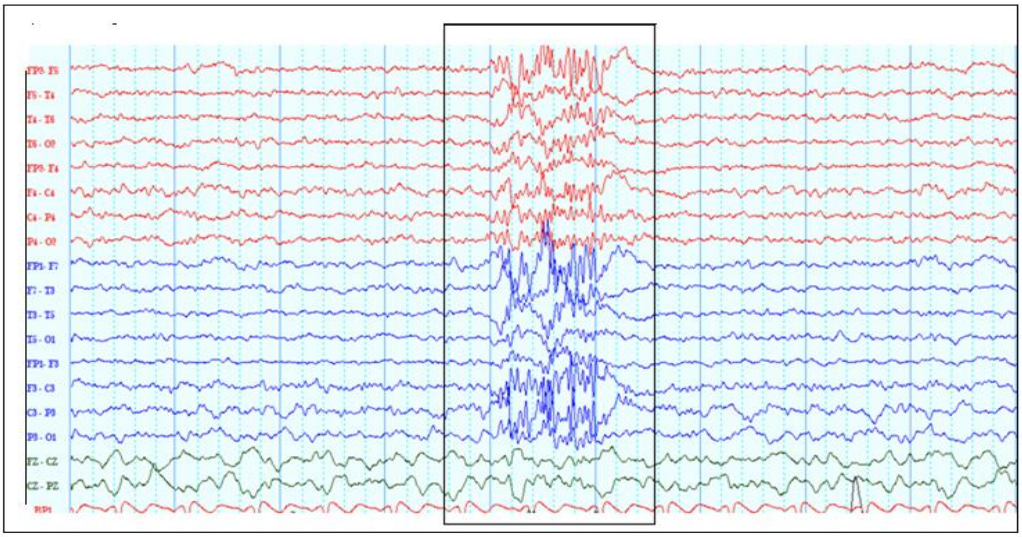

Fig 3: Muscle artefact shown in window

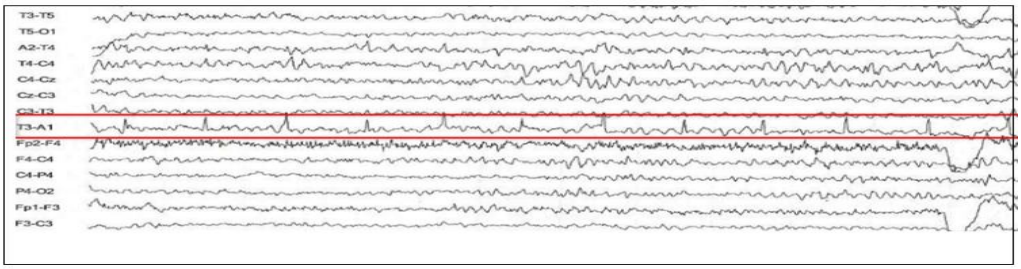

Fig 4: Cardiac artefact shown in window

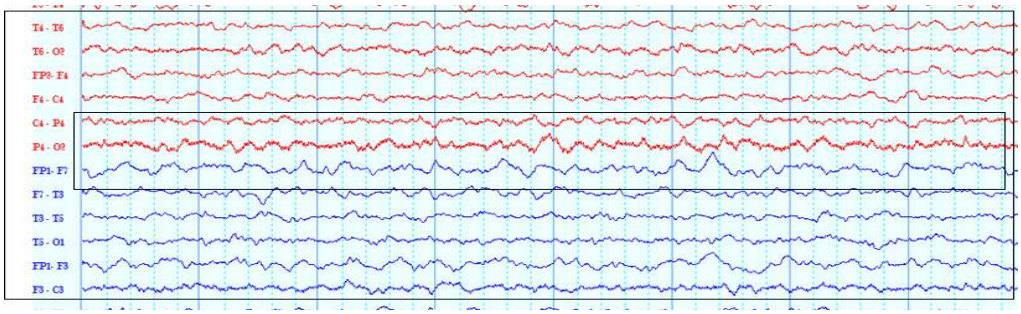

Fig 5:-50 Hz transmission line artefact shown in window

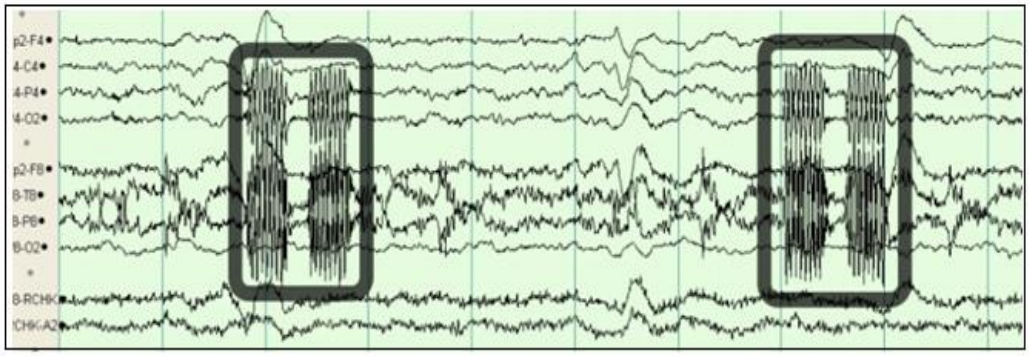

Fig 6:-phone artefact shown in window

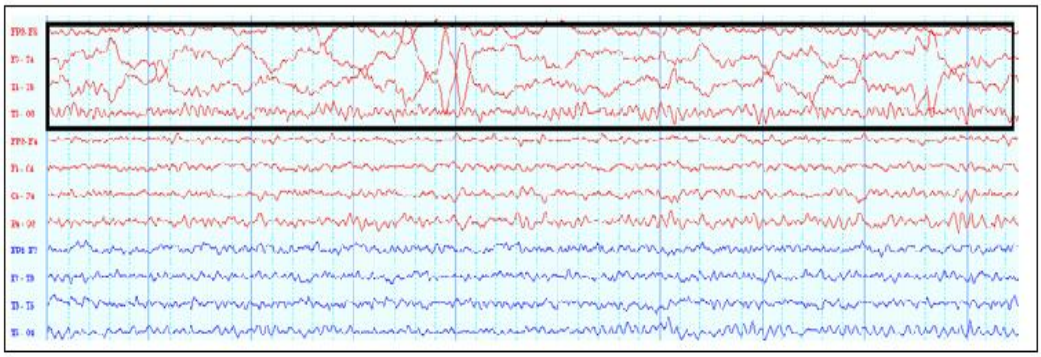

Fig 7: Electrode Pop artefact shown in window

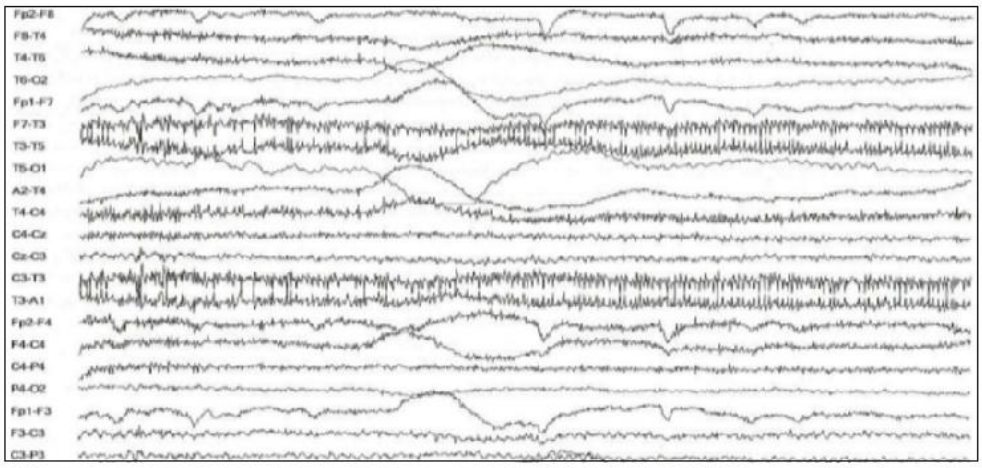

Fig 8: Lead movement artefact shown in window

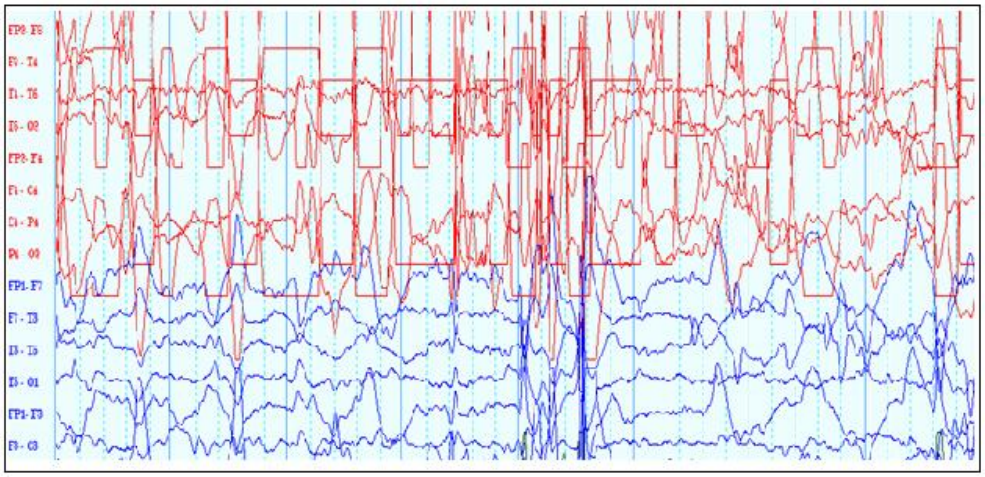

Fig 9: physical movement artefact

6. REFERENCES

[1] Tandle, A., & Jog, N. (2013). NON-INVASIVE MODALITIES OF NEUROCOGNITIVE SCIENCE USED FOR BRAIN MAPPING : A REVIEW, *1*, 621–628.

[2] Marella, Sudhakar. "Eeg-artifacts-15175461." Slide Share. 29 May 2015.

[3] Vigon, L., Saatchi, M. R., & Mayhew, J. E. W. (n.d.). Quantitative evaluation of techniques for ocular artefact filtering of EEG waveforms, (ii).

[4] Nandini K. Jog Electronics in Medicine and Biomedical Instrumentation ISBN 81-203-2926-0 \

[5] Teplan, M. (2002). FUNDAMENTALS OF EEG MEASUREMENT,

[6] Dhiman, R., Saini, J. S., & Mittal, a P. (2010). Artifact Removal From Eeg Recordings – an Overview. *Science*, (March), 19–20.

[7] Barlow, J. S. (1979). Computerized Clinical Electroencephalography in Perspective, (7), 377–391.

[8] Soomro, M. H., Badruddin, N., Yusoff, M. Z., & Malik, A. S. (2013). A Method for Automatic Removal of Eye Blink Artifacts from EEG Based on EMD-ICA, 8–10.

[9] Joyce, C. a., Gorodnitsky, I. F., & Kutas, M. (2004). Automatic removal of eye movement and blink artifacts from EEG data using blind component separation. *Psychophysiology*, *41*, 313–325. doi:10.1111/j.1469-8986.2003.00141.x

[10] Jafarifarmand, A., Badamchizadeh, M. A., & Seyedarabi, H. (2014). Evaluation Criteria of Biological Artifacts Removal Rate from EEG Signals, 123–128.

[11] Kelly, J. W., Siewiorek, D. P., Smailagic, A., Collinger, J. L., Weber, D. J., & Wang, W. (2011). Fully automated reduction of ocular artifacts in high-dimensional neural data. *IEEE Transactions on Biomedical Engineering*, *58*(3), 598–606. doi:10.1109/TBME.2010.2093932

[12] Jafarifarmand, A., Badamchizadeh, M. A., & Seyedarabi, H. (2014). Evaluation Criteria of Biological Artifacts Removal Rate from EEG Signals, 123–128.

[13] Khandpur Handbook of Biomedical Instrumentation ISBN-13:978-0-07-047355-3