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Classification of Artifacts in Eeg Signal Recordings

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Abstract
The EEG (electroencephalographic) recordings determine the electric driving forces produced in the brain, in reaction to the given stimulus. The unconstrained EEG information is utilized for conclusion and treatment of some brain ailments/ diseases. For the information to be utilized for clinical applications, it should be liberated from the different artifacts like the eye blinks, movements, head movements as well as muscle activity. These artifacts should be rectified or the influenced parts should be evacuated in the pre-processing of the EEG dataset. With enormous number of datasets to be investigated, it is important to have consistency in the examination. Uniformity, reproducibility and reliability in the pre-processed information can be acquired if a statistical approach is taken while pre-processing the datasets. In a perfect world, this can be semi-or completely automated. This loom therefore, should be taken while eradicating the less frequently occurring artifacts and correcting the more frequently occurring artifacts, in order to retain more complete datasets for additional research or clinical purposes. In this paper broad classification of EEG artifacts and methods to detect and its removal is discussed.

Index Terms— EEG Signal, Artifacts, Artifact Detection, Artifact Classification, Artifact Removal.

I. INTRODUCTION

The neurons, which are present in the brain are electrically active cells. When these neurons are activated, they generate action potentials. The action potential roving down the axon, releases chemical neurotransmitters at the synapse where activation of the chemical neuro-receptors located on the dendrite of the post-synaptic neuron is observed. This generates a postsynaptic potential at the synapse. Electrode terminals when set on the scalp of the subject record a spatial average of these post-synaptic potentials. The recorded signal is known as the electroencephalogram (EEG). Determined proportions of EEG action are informative biomarkers for brain activity. The electrical vacillations in the brain are usually in the range of ±50 μV. The obtained EEG information should be pre-processed before it could utilize it for clinical purposes. [1][2]

Pre-processing of the EEG data is principally required to dispose of the artifact signals which, are gained alongside the EEG signal. The most harming artifacts are those seen with the biggest change in the amplitude of the recorded EEG signal. Artifact signals in the information are typically thought to be uncorrelated with the signal of interest for example the EEG signal.[1][13]

II. BACKGROUND

EEG imaging procedure is basic and efficient and has various clinical just as non-clinical applications. In the year 1958, International Federation in Electroencephalography and Clinical Neurophysiology (IFECN)received adjustment for placement of electrodes which is known as 10-20 system of electrode placement. This arrangement standardized the physical pose of electrodes and the labels of electrodes placed over the scalp. The head of the human is partitioned into various lobes: central, temporal, posterior and occipital lobes. The electrodes set on the left half of the head are given odd numbers and those on the right side are given even numbers as depicted in fig. 1. The separations among nasion and inion is estimated and the separation amid

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the two ears is estimated, and electrode are put at 10% and 20% space as appeared in fig.1, henceforth the name 10-20 system. Electrode positions are named as per brain areas: F - frontal, C – central, T - temporal, P-Posterior, and O –occipital. The electrical characteristics of EEG is its amplitude range in µV and recurrence band in 0.5Hz to 60Hz. Electrical properties of EEG signal are defenseless against outer undesirable signals called artifacts. Artifacts can mimic about a wide range of EEG patterns and in that capacity, artifacts incorporated in usual scrutiny can critically change the results, which ultimately leads to erroneous findings. EEG might be tainted by different commotion sources. The noise generated from the recording system can fundamentally be diminished vigilant design of the system and by following suitable signal recording techniques. EEG tainted by various electrophysiological signals created from different portions of the body of a human can offer ascent to inaccurate examination for instance, Electro-Oculo-gram signal artifact resulted due to eye blink and movement of cornea, Electro-myogram (EMG) artifacts caused by movement of muscle of different body portions of the patients.[1][2][15][19]

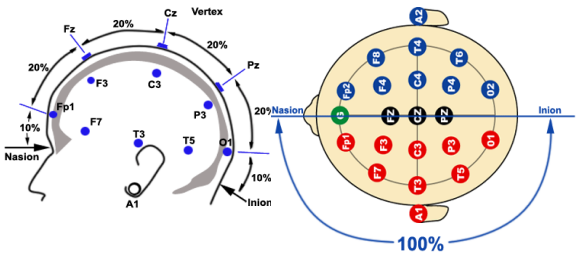

Fig. 1: Standard 10-20
Electrode Placement System

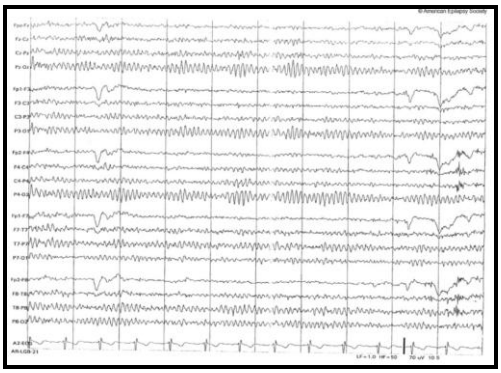

Fig. 2: Normal EEG

III. Artifacts in EEG

Contamination of the EEG signal at the different time focuses is seen while the EEG data is being procured. Artifacts are characterized as any signal whose source is unessential to the brain. The artifacts in an EEG dataset can be comprehensively grouped into two classifications, in particular, physiological artifacts and extra-physiological artifacts. Physiological artifacts are produced from sources in the body of patient whereas, extra-physiological artifacts are created by sources outside the body of patient. [1][3][4][21]

IV. Classification of Artifacts in EEG

The artifacts in an EEG dataset can be comprehensively grouped into two classifications, in particular, physiological or internal artifacts and extra-physiological or external artifacts as shown in fig. 3. Internal artifacts are produced from sources in the body of patient whereas, external artifacts are created by sources outside the body of patient. [1]

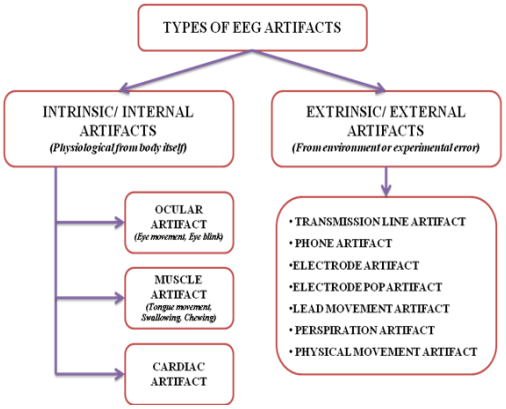

Fig. 3:Classification of Artifacts in EEG

1. Physiological Artifacts:

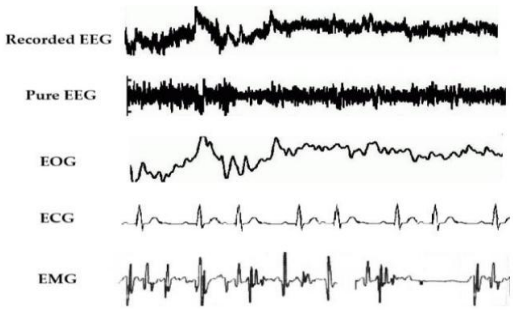

Fig. 4: Physiological Artifacts present in EEG

Physiological artifacts are the artifact which occur due to the electrical commotion of additional body parts of the subject and incomprehensible EEG recordings as depicted in fig. 4 above. [1][4][7]

A. Artifacts commencing the Eyes/ Eyelids: Alteration of potential in the electrodes close to the eyes at Fp1-Fp2 (Fronto-Parietal) is caused due to the movement of the eyes and eyeballs. Shaking of the eyelids look as a 3Hz to 10Hz signal. [1]

B. Eye Blink: Eye blinks causes elevated amplitude signals that may be commonly more prominent than the amplitude of EEG signals of concern. Recurring blinks create moderate wave, that appear like delta waves.

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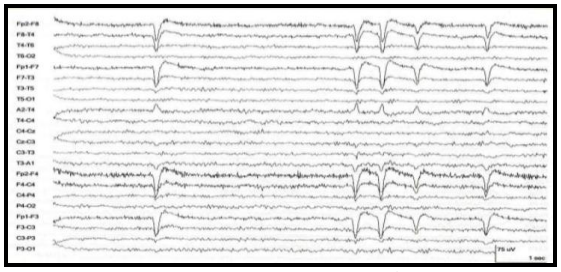

Fig. 5: Eye Flutter/ Blink Artifact

2. Muscle Artifacts: Muscle artifact are categorized into glosso-kenetic (chew, swallow and tongue movement) and are seen in surface electrodes in EEG. Its profile depends on the extent of muscle narrowing. Feeble reduction results in small amplitude spike train. Muscle artifacts arise fewer in sleep and overlie amid beta-band (13-35Hz). Muscle artifacts normally appear in the frontal along with temporal electrodes.[1][15]

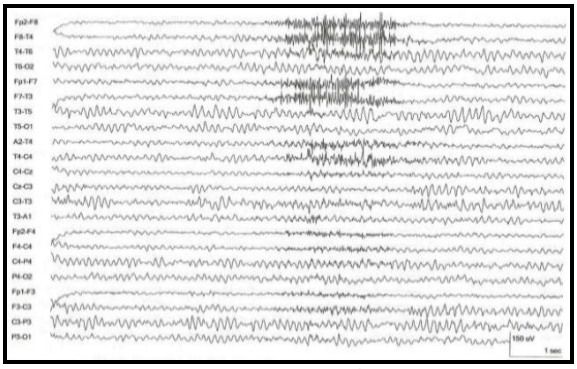

Fig. 6: Muscle Artifact

3. Cardiac Artifacts: Two types of artifacts are produced by the heart; mechanical and electrical artifacts that emerge as ECG signal close to temporal left region and are generally observed in the subjects with petite neck. This electrical artifact seems to be ECG waveform which forms the QRS complex. The frequencies of the cardiac artifact are close to 1 Hertz and amplitude is in several milli-volts (mV). [1][15]

4. External Artifacts: External Artifacts arises from electronic gadgets, transmission lines etc.

A. Transmission- line Artifact : The bandwidth of EEG signal ranges from 0.5Hz to 60Hz whereas, the frequency of transmission lines is 50Hz or 60Hz. Due to this, the signal with no trouble gets mixed with the beta-band of EEG signal. This artifact affects all the channels or channels in the company of meager impedance matching. Transmission Line artifact can be effortlessly removed by making use of a notch filter having recurrence range of 50 Hz or 60 Hz. [1][12][16][21]

B. Phone Artifact: Phone artifact is mainly due to the signal of mobile phone. A lofty frequency signal emerge as a false signal on the EEG records. Phone artifact can be minimized by not carrying a mobile phone while recording the EEG signal.[1]

C. Electrode Artifact: Meager electrode contact results into stumpy frequency artifacts, they are short transients which gets restricted to one electrode and coordinate with respiration because of the electrode movement. [1][11][13]

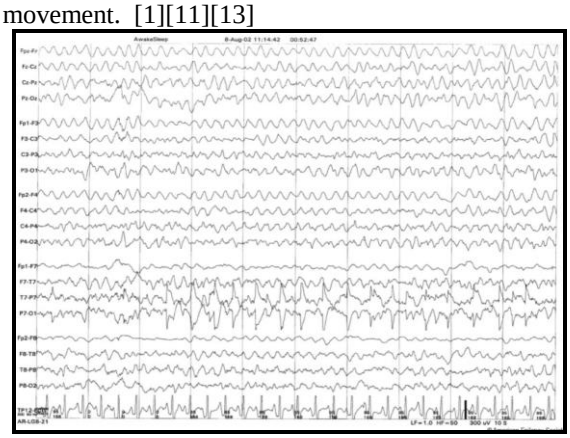

Fig. 7: Electrode Artifact

E. Perspiration/ Sweat Artifact: Perspiration artifact are small amplitude waveforms. Enlarged waves that usually have timings larger than 2S; thus, they are away from the frequency range of EEG produced by the human brain. [1]

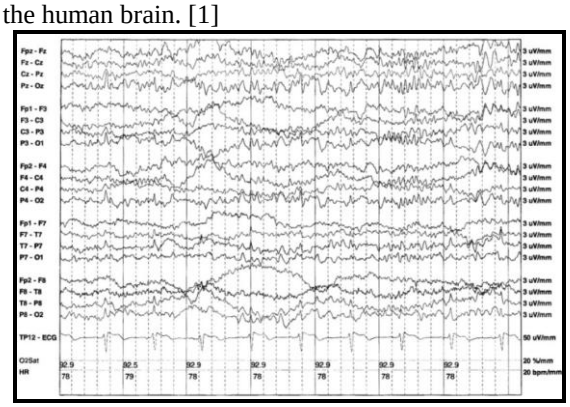

Fig.8: Sweat Artifact

(F) Movement/ Motion Artifact: This artifact appears due to lose in contact of electrode caused by unexpected substantial activity of subjects. Its morphology is diverse as of real EEG.[1][14][17]

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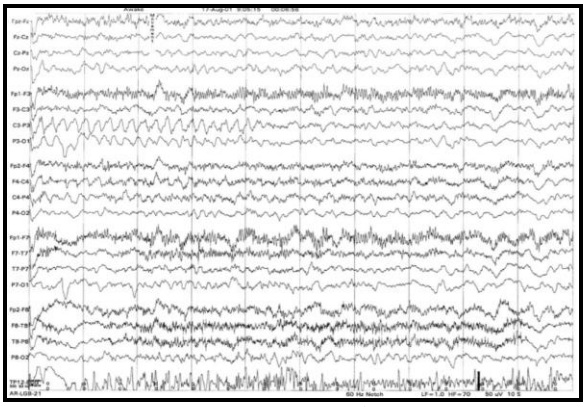

Fig. 9: Motion Artifact

TABLE I: ELECTRICAL DESCRIPTION OF ARTIFACTS AND MORPHOLOGY WITH GENUINE EEG

Artifact	*Source/ Cause*	*Frequency Range*	*Amplitude*	*Morphology*
Cardiac Artifact	Heart	> 1Hz	1-10mv	Epilepsy
Transmission Line noise	Transmission Line	50-60Hz	Low	Beta or Gamma Wave
Muscle Artifact	Body Muscle	<=35Hz	Low	Beta frequency
EOG Artifact	Eye	0.5-3Hz	100mv	Tumour, delta wave
Phone Artifact	Electrode and Sweating	Very Low	High	Dissimilar from real EEG
Electrode Artifact	Electrode Sweating	Very Low	High	Dissimilar from actual EEG
Physical Movement Artifact	Physical Movement	Very Low	Very High	Dissimilar from genuine EEG

I. Detection and Removal of Artifact

The majority of the artifacts can be forestalled whilst recording by building a decent recording procedure, that incorporates openhanded directions to the subject regarding eye faction, bodily movement and not permitting cell phone in room where recording is to be done. Knowledgeable technologist perceives artifacts by the procedure of visual investigation, re-montaging, and digital filtering. [1][16][19]

II. Methods of Artifact Removal

There are various techniques for artifact expulsion, that incorporates automated and manual strategies. Automated artifact elimination strategies utilize mathematical set of rules which are utilized in digital EEG records. It is an on line technique, though the manual strategy is an offline technique. [1][7][8][18]

A. Filter Method:

Specific artifacts can be expelled, by utilizing a band pass filter with a frequency band of artifact. This strategy is certainly not a valuable technique for investigation of the whole bandwidth of EEG, as artifacts can happen at any frequency. Transmission line frequency can be expelled by a 50 Hz notch filter. For evicting oculogram artifacts, low pass filter can be utilized [5][9][10]

B. Manual Method

Manual technique likewise called offline strategy is the most trustworthy strategy for artifact evacuation. Subsequent to recording, the technician outwardly investigates the record and evacuates the slots influenced by artifact or does not think about this slot for additional examination. [1][5][16][17]

C. Algorithm based dismissal of Artifact

Automatic artifact evacuation technique utilizes mathematical algortithms such as EOG Subtraction, ICA (Independent Component Analysis), PCA (Principle Component Analysis), Joint approximate diagonalisation of Eigen matrices, Regression methods, wavelet transforms, hybrid methods etc. [1][4]

III. Conclusion

The fundamentals of electroencephalography, for example EEG and related estimation installations utilized in these recordings were introduced. Moreover, unique kind of brain activities and wellsprings of artifacts were dissected. Moreover, the sources artifacts were classified to external and internal classes. Artifacts are showed diversely in EEG signal and there is not such one single technique to manage. It is constantly relied upon the specific circumstance, how to concern artifact, whether it is required or not. In spite of the fact that, the most widely recognized strategies to identify artifacts were introduced, that depend on essential numerical capacities, for example, derivation and Fourier transform and estimation hypothesis. After the artifacts have been recognized, the expulsion of artifactual periods from the signal is significant. It was called attention to that it is essential to be mindful of artifacts inside EEG recording . Consequently one doesn't reach wrong inferences of recordings. Morphology and electrical distinctiveness of artifacts may show the way to fake interpretations. This is unsuitable for clinical just as non-clinical use. Subsequently, artifacts ought to be managed appropriately utilizing artifact proof convention of EEG recording. Additionally unique artifact expelling procedures ought to be utilized. Manual strategy for artifact evacuation is the best procedure to expel practically all types of artifacts except few.

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