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Methods for the Analysis of EEG signals: A Review

Malika Garg[1], Jasbir Kaur[2], Neelam Rup Prakash[3]
[1, 2, 3]PEC (deemed to be university), Chandigarh

Abstract: Electroencephalography (EEG) helps to predict the state of the brain. It tells about the electrical activity going on in the brain. Difference of the surface potential evolved from various activities get recorded as EEG. The analysis of these EEG signals is of utmost importance to solve the problems related to the brain. Signal pre-processing, feature extraction and classification are the main steps of the EEG signal analysis. In this article we discussed various processing techniques of EEG signals.
Keywords: EEG, analysis, signal processing, feature extraction, classification.

I. INTRODUCTION

Human brain is the most complex part of the human body. Its behaviour is very unpredictable and as cryptic as a black box.(Hosseinifard et al.) Due to this it is very difficult to study and solve any problem if there is any failure in its functioning.
The different task performing activities evolving from the brain are reflected as the difference of surface potentials on the scalp. These variations in the surface potentials can be recorded by placing an arrangement of electrodes at the scalp of the brain(Mumtaz et al.). The recording of the measurements of these potentials results in EEG. The analysis of EEG signal can be divided into five phases. EEG signal acquisition for a particular application is the first phase followed by the second phase of signal pre-processing for the removal of artifacts from the raw data. In this phase raw data gets converted into a dataset for the next phase. Then the third phase is the extraction of the information stored in the signal called feature extraction. In the fourth phase, on the basis of extracted information, classification of EEG signals is done. Then in the last phase performance evaluation is done using Statistical metrics(Shoeibi et al.). The middle three phase's i.e. pre-processing, feature extraction and classification are the critical phases and thus are investigated in this paper. In the first phase during the data acquisition, the patient have to lie down keeping their head near the EEG setup. The electrodes are placed to the scalp of the patient's brain by wires attached to the hardware setup and the reflections of activities of the brain will get recorded as a series of electrical pulses to a computer.(Faust et al.) These electrodes are placed with the help of conducting gels according to a Standard System of Electrode Placement.(Garcés Correa et al.)

II. PRE-PROCESSING OF EEG SIGNALS

After the data acquisition, the raw EEG signal is obtained which comprises some non-cerebral signals known as artefacts. These are actually adulterations in the signal. These adulterations can be due any movement related potentials, movement of facial muscles, eye blinks, etc. These are biomedical artefacts and are the most difficult to remove because of their resemblance to the actual EEG signal. Another group of artefacts are the environmental artefacts like external noise in the surroundings, noise due to power supply, electrode popping i.e. when electrode connection is not proper, temperature etc.(Xie and Oniga) It is very important to remove these artefacts as a small mistake in the diagnosis of EEG signal can turn deadly to the patient. Environmental artefacts are the externally generated and therefore can be removed with the improving technology in which different types of filters can help.(Behri et al.) But biomedical artefacts can only be removed by applying different signal processing techniques after the recording is done.(Dauwan et al.) Table 1 shows various methods that can be used for signal pre-processing.

Table 1: Method for Signal Pre-Processing

Sr no.	method
1	Filtering (High pass filter, Low pass filter, Notch filter, Band pass filter)
2	Blind source separation
3	Data averaging
4	Multichannel Wiener filter
5	Independent component analysis (ICA)
6	Wavelet Transform (WT)
7	Fourier Series
8	ICA+ WT
9	Adaptive filter
10	Optimisation

III. FEATURE EXTRACTION

After the removal of noise from the signal by using various pre-processing techniques the next step is to extract various features from the signal.(Hussain et al.) There are numerous methods that can be used to extract various features in time domain, frequency domain and time-frequency domain. Table 2 shows different categories of features that can be used for the analysis of the signal.

Table 2: different categories of features

Categories of Features	Features
Statistical/wavelet features.	Mean Median Variance Standard deviation Kurtosis Maximum Minimum RMS Skewness Energy Average rectified value Peak-to-peak amplitude
Spectral features	Mean frequency Band power Relative power Median frequency Power Spectrum Density
Non-linear features.	Entropy based features Fractral dimension Other complexity measures
Functional connectivity based features.	Cross-correlation

IV. CLASSIFICATION

The next step after the feature extraction is to classify the signal in its categories on the basis of these features. There are number of classification methods that can be used are mentioned in table 3.

Table 3: Classification Methods

Artificial Neural Network	Based on the neural structure of brain, artificial neural networks is crude electronic network of neurons. They process records one at a time, and learn by comparing their classification of the record (i.e., largely arbitrary) with the known actual classification of the record. The errors from the initial classification of the first record is fed back into the network, and used to modify the networks algorithm for further iterations(Ibrahim et al.)
Deep Learning	Deep neural networks are a powerful category of machine learning algorithms implemented by stacking layers of neural networks along the depth and width of smaller architectures.(Dement)
K-Nearest Neighbours	For the sample to be classified, find the similarity between the sample and the training sample set. Select the k samples with the highest similarity. The classes of the sample to be classified are determined by the classes of k samples. K-NN is a kind of instance-based learning, or lazy learning. The expense of KNN is excessive calculating complexity. (Blanco et al.)
Support Vector Machine	SVM is a type of widespread linear classifier that achieves binary classification of data according to supervised learning. The basic principle is to find the optimal decision surface in space so that different types of data can be distributed on both sides of the decision surface to achieve classification.(Wang et al.)
Naive Bayes	NB classifier is an uncomplicated and practical classifier based on Bayes' theorem. The main idea of NB is: for a given item to be classified, solve the probability of each category appearing under the condition that this item appears. The item to be classified belongs to the category with the supreme possibility. The NB algorithm considers that the samples are independent and uncorrelated. NB classifiers have the outstanding characteristics of fast speed, high efficiency and simple algorithm structure with processing high-dimensional data.(Ibrahim et al.)

V. STATISTICAL METRICS

After the classification, performance evaluation of the system is done using statistical metrics.

There are seven parameters that can be used for the evaluation of the performance of the classifier. These parameters are: sensitivity, precision, specificity, accuracy, Mathew's correlation coefficient, f1 score. The equations to get these parameter values is given below:

1) Accuracy = TP + TN / TP + FP + TN + FN
2) Sensitivity = TP / TP + FN
3) Specificity = TN / TN + FP
4) Precision = TP/ TP + FP
5) F1 score = 2 ∗ Precision × Sensitivity/ Precision + Sensitivity
6) MCC = TN × TP − FN × FP _ (FP + TP) × (FN + TN) × (FP + TN) × (FN + TP)

In these equations, each two-letter variable shows the number of samples with an assigned label and whether it was classified correctly or not; the first letter referring to classification result, true or false and second letter to the assigned label, positive or negative. So, for example, FN means the number of samples assigned to negative class falsely (they belonged to positive class).(Garcés Correa et al.)

VI. DISCUSSION

For the analysis of physiological signals, EEGs are widely used because of their non-invasive nature. In this process of EEG signal analysis, pre-processing, feature extraction and classification plays the important role in determining the performance of the system. Due to non-stationary nature of EEG signals, the selection of these methods is very important. Also there are a lot of limitations in the acquisition of EEG signals: instability, interference, low spatial resolution, etc. which make it difficult to read the information accurately. Speed and accuracy depends on the processing technique used and final result depends on the classification algorithm. Also the choice of data processing and classification algorithm depends upon the type of research problem and the amount of data required. From the perspective of pattern recognition, the validity of the original input information and accurate interpretation of the original data determine the overall performance of the system.

There has been a lot of researches carried on EEG signal processing and pattern recognition methods. However, the choice of best method is still a challenging area due to lag in signal acquisition methods and understanding of correct neural activity due to non-stationary nature of EEG signal.

VII. CONCLUSION

In the field of biomedical engineering, EEG signals have gained a lot of importance and with the advancement in technology and increasing demands in this field has encouraged the researchers to determine new methods to solve the problems related to EEG signals. In this paper we present the various techniques that can be implemented for the analysis EEG signals that can be used according to the need of the research problem. Also the combination of these techniques can be used to get more appropriate results.

REFERENCES

[1] Behri, Miznan, et al. "Comparison of Machine Learning Methods for Two Class Motor Imagery Tasks Using EEG in Brain-Computer Interface." 2018 Advances in Science and Engineering Technology International Conferences, ASET 2018, IEEE, 2018, pp. 1–5, doi:10.1109/ICASET.2018.8376886.

[2] Blanco, Justin A., et al. "Single-Trial Cognitive Stress Classification Using Portable Wireless Electroencephalography." Sensors (Switzerland), vol. 19, no. 3, 2019, pp. 1–16, doi:10.3390/s19030499.

[3] Dauwan, Meenakshi, et al. "EEG-Based Neurophysiological Indicators of Hallucinations in Alzheimer's Disease: Comparison with Dementia with Lewy Bodies." Neurobiology of Aging, vol. 67, Elsevier Inc., 2018, pp. 75–83, doi:10.1016/j.neurobiolaging.2018.03.013.

[4] Dement, Dis. "Alzheimer ' s Disease & Dementia." Alzheimer's & Dementia, vol. 1, no. 2, 2017, pp. 38–46, doi:10.1016/j.tins.2011.05.005.Neuroimaging.

[5] Faust, Oliver, et al. "Wavelet-Based EEG Processing for Computer-Aided Seizure Detection and Epilepsy Diagnosis." Seizure, vol. 26, BEA Trading Ltd, 2015, pp. 56–64, doi:10.1016/j.seizure.2015.01.012.

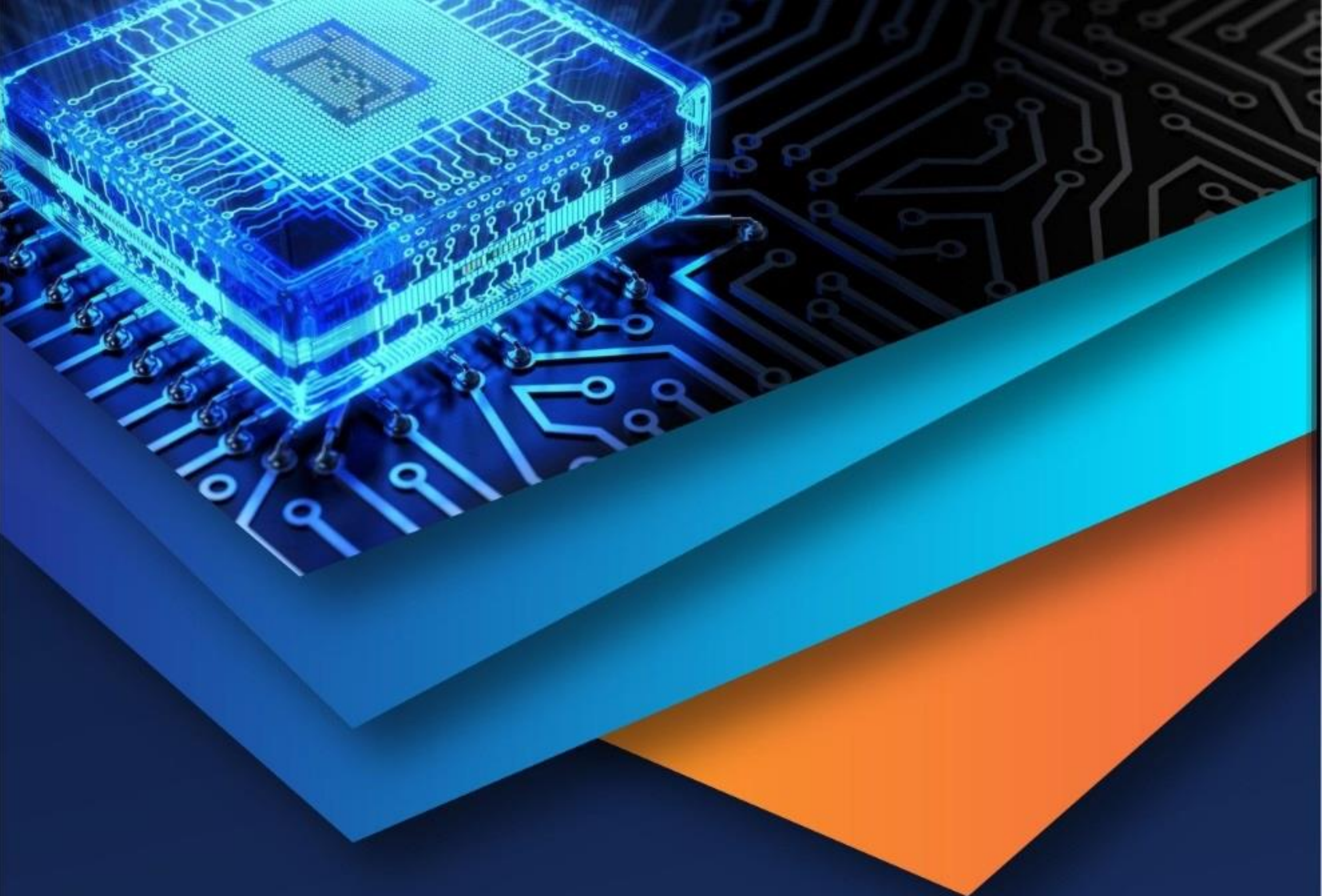
[6] Garcés Correa, Agustina, et al. "Automatic Detection of Drowsiness in EEG Records Based on Multimodal Analysis." Medical Engineering and Physics, vol. 36, no. 2, Institute of Physics and Engineering in Medicine, 2014, pp. 244–49, doi:10.1016/j.medengphy.2013.07.011.

[7] Hosseinifard, Behshad, et al. "Classifying Depression Patients and Normal Subjects Using Machine Learning Techniques and Nonlinear Features from EEG Signal." Computer Methods and Programs in Biomedicine, vol. 109, no. 3, Elsevier Ireland Ltd, 2013, pp. 339–45, doi:10.1016/j.cmpb.2012.10.008.

[8] Hussain, Lal, et al. "Complexity Analysis of EEG Motor Movement with Eye Open and Close Subjects Using Multiscale Permutation Entropy (MPE) Technique." Biomedical Research (India), vol. 28, no. 16, 2017, pp. 7104–11, doi:10.21506/j.ponte.2016.7.26.

[9] Ibrahim, Sutrisno, et al. "Electroencephalography (EEG) Signal Processing for Epilepsy and Autism Spectrum Disorder Diagnosis." Biocybernetics and Biomedical Engineering, vol. 38, no. 1, Nalecz Institute of Biocybernetics and Biomedical Engineering of the Polish Academy of Sciences, 2018, pp. 16–26, doi:10.1016/j.bbe.2017.08.006.

[10] Mumtaz, Wajid, et al. "An EEG-Based Functional Connectivity Measure for Automatic Detection of Alcohol Use Disorder." Artificial Intelligence in Medicine, vol. 84, Elsevier B.V., 2018, pp. 79–89, doi:10.1016/j.artmed.2017.11.002.
[11] Shoeibi, Afshin, et al. "A Comprehensive Comparison of Handcrafted Features and Convolutional Autoencoders for Epileptic Seizures Detection in EEG Signals." Expert Systems with Applications, vol. 163, no. July 2020, Elsevier Ltd, 2021, doi:10.1016/j.eswa.2020.113788.
[12] Wang, Qiangqiang, et al. "Ensemble Learning Algorithm Based on Multi-Parameters for Sleep Staging." Medical and Biological Engineering and Computing, vol. 57, no. 8, Medical & Biological Engineering & Computing, 2019, pp. 1693–707, doi:10.1007/s11517-019-01978-z.
[13] Xie, Yu, and Stefan Oniga. "A Review of Processing Methods and Classification Algorithm for EEG Signal." Carpathian Journal of Electronic and Computer Engineering, vol. 13, no. 1, 2020, pp. 23–29, doi:10.2478/cjece-2020-0004.



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