An Efficient Mechanism for Brain Activity Recognition using Deep Neural Network

[1]CH Narsimha Reddy, [2]Shanthi Mahesh, [3] K Manjunathachari

[1]Department of Electrical, Electronics & Communication Engineering, GITAM Deemed to be University, Hyderabad ,India. raju83431@gmail.com

[2]Department of Information Science & Engineering, Atria Institute of Technology, Bangalore, India. isehod@atria.edu

[3]Department of Electrical, Electronics & Communication Engineering, GITAM Deemed to be University, Hyderabad,India. mkamsali@gitam.edu

ABSTRACT

The signals from brain are used by Brain Computing Interface (BCI) systems to monitor external devices. The interface is intended to interpret the expectation signal data to the related PC task. This mind sign to PC movement transformer can improve the capacities of cripple individuals. BCI's performance is affected by user status such as attention. Recognizing client's consideration float because of inside or outer variables is extremely fundamental for exact brain movement acknowledgment. This paper provides information about the various techniques used recently to recognize the brain activity. This paper also throws light on how artificial intelligence techniques like Artificial Neural Network along with deep learning is used to increase the accuracy of recognizing the brain activity

Key words: Artificial Intelligence, Artificial Neural Network, Brian Computing Interference, Deep Learning.

1. INTRODUCTION

Brain action acknowledgment is one of the most encouraging exploration regions in the course of the most recent couple of years. It can possibly alter a wide scope of utilizations, for example, ICU (Intensive Care Unit) checking apparatus control helped living of incapacitated individuals and old individuals and conclusion of neurological ailments. [20].In highbrow neuroscience, the fundamental issue is to locate the intellectual capacities of dissimilar assignments and how those psychological conditions are transformed into neuronal action of mind. The planning of the brain is distinct as the connection of mental expressions perceptual with examples of motion of the mind. FMRI or ECOG is used to faithfully measure multi-unit cognitive exercise varieties. EEG and NIRS (Near Infrared Spectroscopy) are used non-persistently to measure cognitive capacity. Mind Computer Interfacing (BCI) is a clever correspondence method, which can delineate brain sign to the PC directions or activities. BCI correspondence structure perceives the sign and maps it to different directions and exercises. An astute framework is required to perceive the goal of the client and regularize it to the PC order. For example, the minute course[14] arrangement for hand, tongue, feet or finger movement can be acquired utilizing BCI. In order to detect the shift in development or action the incited oscillatory reaction in the ghastly space can be emphasized. The unearthly thickness and engine symbolism highlights can be used by BCI in different applications which includes the wheelchair course, a robotic manipulate, prosthesis and so forth. Specific brain imaging modalities were applied to execute BCI frameworks by the aim of speaking those sufferers in LIS. Along with those, electroencephalography (EEG) has been the maximum generally utilized methodology in view of its movability, non-obtrusiveness, excessive worldly desires, and a sensible rate contrasted with different neuro imaging devices, as an example, close infrared spectroscopy (NIRS), utilitarian attractive reverberation imaging (fMRI), and magneto- encephalography (MEG) [9]. Electroencephalography (EEG) is an electrophysiological strategy to record electric movement of the brain.

1.1 Brain Computer Interface Systems

Fig 1 shows the structure of a BCI framework, which gets mind flag and changes over them into control directions for PCs. The key segments of the framework incorporate mind signal assortment, signal pre-preparing, include designing, characterization, and brilliant hardware. To start with, the framework gathers and pre-forms mind signals from people. Pre- handling is critical for diminishing the clamor and enhancing the low SNR indicators. For instance, amassing EEG signals calls for placing a development of anodes on the scalp of the human head to document the brain's electric statistics. Because the ionic cutting-edge is ejected inside the brain but expected at the scalp, the skull ought to vigorously diminish SNR. The pre-getting ready segment consists of numerous approach, for instance, signal cleansing, sign standardization, signal development, and sign lower. By then, the system conducts feature working by expelling isolating features from arranged sign. Conventional highlights are separated from the time space (e.g., fluctuation, mean worth, kurtosis), recurrence area (e.g., quick Fourier change), or time- recurrence area (e.g., discrete wavelet change).
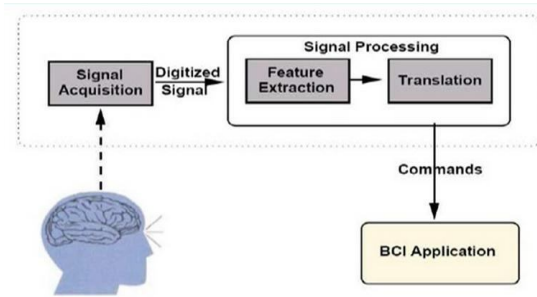
Figure 1:.Structure of Brain Computing Interface

The highlights advance the discernable data in regard to client aim. Highlight designing is exceptionally reliant on the area information. For instance, it requires biomedical information to take in instructive highlights from mind signals for the determination of epileptic seizure. As shown the figure 1 the manual component extraction is additionally tedious and testing. As of late, profound learning gives a superior alternative to removing the recognizable highlights consequently. At last, a classifier perceives signals dependent on the extricated highlights and changes over them into outside gadget directions. Profound learning calculations are indicated more dominant by and large than customary AI strategies. BCI has immense existing and potential applications for both ordinary individuals and the handicapped. For instance, patients with movement challenges can control family unit apparatuses thinking carefully flag viva BCI framework. Such a framework can fill different needs, for example, diversion and security.

1.2 Electro-Encephalography(EEG)

The EEG as a non-intrusive methodology has great worldly goals, transportability and ease contrasted with other non-obtrusive BCI techniques, for example, utilitarian close to infrared spectroscopy (fNIRS) [9], and useful attractive reaction imaging (fMRI) [9]. EEG is a medicinal imaging strategy that checks mind action by estimating, by means of metal anodes situated on the scalp, the voltage variances on the scalp coming about because of neurons' activity possibilities. EEG signals reflect electrical action starting because of neuronal terminating when an assignment or action is performed. This action is estimated as contrasts in voltage among various areas on the outside of the head. The distinctions are brought about by postsynaptic possibilities in the cell levels of cortical neurons[10].As a methodology for BCI, EEG is the most well- known strategy for recording neuronal sign, because of its compactness. The sign most every now and again utilized for BCI get from engine symbolism (MI), consistent state visual evoked possibilities (SSVEP), and the P300 evoked potential. These three signs have been utilized for controlling wheelchairs and quadcopters. EEG signal-based grouping has been viably utilized, for example, epilepsy (seizure issue), driving languor acknowledgment, kid rest waking circumstance distinguishing proof, epileptic seizure, stress structures recognizable proof, eye squinting recognition of human and so on [5]. In [11], a specific framework is produced for distinguishing hazardous degrees of lethargy during driving dependent on eyes' flickering recurrence. Jongkees and Colzato detailed about late research utilizing eye flicker rate

as an indicator for intellectual capacity. Besides, observing eye squint rates can bolster volunteers to dodge eye ailments, for example, PC vision disorder[12].

1.3 Introduction to Artificial Neural Networks

Artificial Neural Network (ANN) has created as gossip of arithmetic model of whole anxious methods. A first rush of enthusiasm for quite a while urbanized after the arrangement of streamlined neurons by McCulloch and Pitts (1943) otherwise called connectionist models. An Artificial Neural Network is a system of assortments of basic processors ("Neurons") each perhaps having a (limited quantity of) neighborhood memory. Now working of units nearby data sources means of associated or connected by unidirectional [15] system unit has a standard for adding the sign coming in and a standard for figuring a yield signal that is at that point, sent to other system units.As indicated by Callen the guidelines for computing the yield is known as the actuation work [15]. A neural framework needs three levels in its structure. 1st level may be enterlevel which may be authentically coordinate for outside universes; second level may be for disguised unit the place figuring is done Toward worth of effort gave, the most recent level will be yield level from the place we get yield. Data On neural frameworks will be place away as synaptic loads the middle of neurons. The framework induces the illumination data from level on level until the yield data may be processed. In the occasion that those framework may be multilevel perception with Back-spread figuring and the yield will be not very those same Similarly as those yearning yield, toward that perspective a screw up is decided Also proliferated to opposite through those framework. The synaptic loads would modified Likewise the screw up is proliferated. [8]. Presently a Days Researchers are endeavoring to construct a silicon-based electronic system that is demonstrated on the working and type of the human mind. Speculation is the main capacity that makes ANNs so amazing asset. How the human mind functions, it figures out how to acknowledge examples and recollects that them. Additionally, the neural systems created can learn designs and recollect.

2. DEEP LEARNING MODELS

In this segment, we quickly present normally utilized profound learning calculations, including ideas, structures, and strategies utilized in BCI. Profound learning is the part of AI systems that learns portrayals and therefore achieving propelled errands dependent on various neural levels. While the standard design of neural system contains an information level, a shrouded level, and a output level, a "profound" neural system for the most part contains more than one concealed level. Profound learning falls into a few classifications' dependent on the point: Discriminative profound learning models, which characterize the information into realized classes by learning discriminative highlights adaptively. Discriminative calculations learn highlights through non- direct change and grouping dependent on probabilistic forecast. Discriminative calculations can be utilized for both component building and order.

They fundamentally incorporate Multi-Level Perceptron (MLP), Recurrent Neural Networks (RNN) (counting Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRU)), Convolution Neural Networks (CNN), and their varieties. •Representative profound learning models. Such models take in unadulterated delegate highlights from the info information. Such calculations serve for highlight designing instead of characterization. Normally utilized calculations of this classification incorporate Auto encoder (AE), Restricted Boltzmann Machine (RBM), Deep Belief systems (DBN), and their varieties. •Generative profound learning models. Such models gain proficiency with the joint likelihood dissemination of the information alongside the objective name. Generative calculations are generally utilized in remaking or produce a bunch of mind signals tests to upgrade the preparation set in BCI. The generally utilized models of this classification incorporate variation Auto encoder (VAE) and Generative Adversarial Networks (GANs). • Hybrid profound learning models. Such models consolidate in excess of two profound learning models. There are two run of the mill crossover profound learning models: 1) the blend of LSTM and CNN, which is well known in spatial-fleeting component extraction.2) the mix of a portrayal calculation (for include extraction) and a discriminative calculation (for grouping).

2.1 Existing Works In Brain Activity Recognition Using Artificial Intelligence

Various categories gaining knowledge of methods of classifying the cognitive nation of human challenge primarily based on fMRI facts had been found over unmarried-time c program language period. The principle aim of these tactics is to expose the facts stand for in voxels of the neurons and organize them in applicable lessons [1]. After education, the categorizers were able to distinguish cognitive states likes: (1). Does the challenge watching is a utterance telling homes, people, meals? (2). Does the challenge is analyzing an ambiguous or non- ambiguous sentence and (3). Does the human challenge is a sentence or a photograph and many others. This painting sum up the special categorizers received for above research to train categorizers for human mind activities: The contrast between unique categorizers shows that linear support vector device (SVM) and Gaussian naive Bayes (GNB) categorizers outperform okay-nearest neighbor. The accuracy of SVMs increases quickly than the exactness of GNB because the measurement of information is decreased thru feature choice. Also, it's located that the characteristic choice strategies constantly beautify the category mistakes in all 3 researches. For the noisy, excessive-dimensional, sparse records, characteristic assortment is a great thing in the design of categorizers. The outcomes confirmed on these paintings that, it is feasible to apply linear guide vector machine class to a sit should be predict a human observer's ability to apprehend a herbal scene photograph.

In the work proposed in [2] ideal grouping of EEG signal is focused on. The motivation behind this arrangement is to distinguish the diverse mental information of crippled individual. The principle work is thinking about the hybridization of neural system alongside fluffy methodology. The hybridization is measured to defeat the cons inside every one of these techniques. The EEG signal information brought from impaired individual is measured as the input. The test yield displays that the exhibition of the projected mixture framework beats than the presentation of individual calculation. The projected half breed framework showed 97% precision in examination with neural system of 76%. In the following work [3] creator Lukasz Piątek and others, thought about various AI calculations for the arrangement of eye states dependent on EEG chronicles. Every classifier was investigated on four diverse datasets. The tried categorizers satisfied the decided prerequisites of high grouping and can be chosen as material for the procedure of continuous EEG eye state order. In this work, the outcomes have demonstrated that it is conceivable to foresee eye states utilizing EEG accounts with exactness about 95% to over 99% in an ongoing framework. In paper [4] a novel and productive EEG based eye state acknowledgment framework is proposed. The proposed framework comprises of four sections: EEG signal handling, include extraction, highlight determination and characterization. It has an altogether quicker order speed and higher exactness contrasted and the K* calculation. Contrasted and the K*algorithm, the ideal execution in this examination arrives at the exactness of 99.8% and the characterization velocity of in any event 639.5 examples every subsequent, production it fit to continuous BCIframeworks.

The forecast and arrangement of EEG eye state dataset decides different parameters, for example, Mean total mistake, relative outright blunder, True positive rate, bogus positive rate, and so on. ROC zone has additionally been graphically watched for different conditions [5]. Six sorts of categorizers have been applied in this work to speak to a near examination. The presentation results show that Naïve Bayes Multinomial gives most elevated relative outright blunder 105.681%. Furthermore, the second most elevated relative total mistake is 90.8109% which gives Logistic categorizer. PART and KNN gives similar suitably confidential Instances 83.6515 % and gives similar in suitably confidential Instances 16.3485%, But this classifier Kappa measurement esteem is unique. In the work did by Kapil Juneja, and Chhavi Rana, the preparation includes limiting a non-smooth and non-arched cross entropy misfortune work [6].The neural system model does a projection inside a concealed level for low dimensional element extraction. The sub-issue for every factor is demonstrated to be either curved or piece-wise arched with a limited number of minima. The sub-issues are tackled utilizing the cut technique with separation interims systematically determined.

The general iterative AM technique is diving and united, free of step size (learning parameter) in the standard inclination drop strategy. Trials comprise of non-intrusive numerous terminal accounts and the order of brain wave information. Numerous perspectives including time space, recurrence area and least square assessment-based highlights are handled under ELM classifier to perceive the human-exercises. Different evaluated highlights are produced under each time, recurrence and the least square classes [7]. These highlights are prepared independently and commonly with probabilistic assessment to extend

the handling highlight set. This extended composite listing of competencies is prepared under ELM (extreme gaining knowledge of gadget) classifier to perform intra-magnificence and among class order. The similar assessment is completed on five free examinations with the distinct wide variety of getting ready and testing signals. The proportionate assessment is finished on ANN, SVM and KNN categorizers carried out on character and composite highlights.

Every other Convolution Neural community (CNN) engineering to signify non-desk bound biomedical signal utilizing their time–recurrence portrayals are proposed. The prevailing technique utilizes the spectrogram of the biomedical flag as a contribution to CNN, furthermore Non-negative lattice factorization (NMF) phrase reference components are utilized as an additional detail to get better the exhibition of the CNN model. The proposed approach became carried out to Electroencephalography (EEG) information for grouping of eye kingdom [8]. To begin with, the spectrogram of EEG sign is received and utilized as a picture contribution to CNN, all the whilst the NMF spotlight is likewise sustained to CNN. Further, the 2 highlights are joined in completely related level of CNN design. The projected technique is contrasted and other current strategies for eye state popularity and suggests remarkable arrangement exactness with 96.16%. The expectation charge for the projected approach is 134 perceptions/2nd, which is affordable for brain computer interface applications. The proposed approach offers us wonderful order exactness with high-quality predication velocity. The primary constraint of the proposed approach is it requires some investment with bunches of making readystatistics.

2.2 Background Exertion

During recent years, assortment of works has been conveyed to beat the trouble associated with expanding the exactness of perceiving the fitting mind-action. The test looked by brain movement acknowledgment is the low acknowledgment precision because of the gigantic commotions and the low sign to-clamor proportion in EEG signals [15].Another issue is the way that the vast majority of the mind exercises are tried in controlled research center conditions where the client can easily focus well on mental undertakings; though in genuine circumstances, execution of fixation subordinate mental assignments (e.g., engine symbolism, mental math, and so forth.) is considerably more testing [13].The fundamental mind action acknowledgment challenge in such manner is to extricate valuable data from crude brain signals for control-directionage. In [6], MSW-KELM is produced for brain action order. Here, MSW-KELM is widely never been analyzed on ancient rarity's comprehensive sign for the constant utilization of ailment characterization.

3. RELATED WORK

Albeit conventional BCI frameworks have gained colossal ground, BCI examine still faces huge difficulties. To begin with, mind signals are effectively adulterated by different organic (e.g., eye squints, muscle artefact's, exhaustion, and the fixation level) and natural ancient rarity's (e.g., commotions) . Along these lines, it is vital to distil instructive information from adulterated brain flag

and construct a hearty framework that works in various circumstances. Second, BCI faces the low SNR of non-stationary electrophysiological mind signals. The low SNR can't be effectively tended to by conventional pre-preparing or highlight designing techniques because of the time unpredictability of that strategy and the danger of data misfortune [16]. Third, highlight building exceptionally relies upon human ability in the area. For instance, it requires the essential organic information to examine resting state through Electroencephalogram (EEG) signals. Human experience may help on certain perspective however fall deficient in progressively broad conditions. A programmed highlight extraction technique is profoundly attractive. Additionally, most existing AI inquire about spotlights on static information and subsequently, can't order quickly changing brain flag precisely. For example, the best in class characterization exactness for engine symbolism EEG is just 60% to 80% [17]. It requires novel learning strategies to manage dynamical information streams in BCI frameworks. Up to this point, profound learning has been applied broadly in BCI applications and indicated achievement intending to the above difficulties. Profound learning has two focal points. Initially, it works legitimately on crude brain signals, hence maintaining a strategic distance from the tedious pre-handling and highlight designing. Second, profound neural systems can catch both agent significant level highlights and inert conditions through profound structures.

4. METHODOLOGY

Present paper we survey that technique by main regularize the input EEG information after that naturally investigate the characteristic representational of the normalized information. In last, we embrace that XGBoost classifier to arrange those trained features

4.1 Normalization

Standardization assumes a significant job in an information disclosure process for taking care of various units and sizes of highlights Intended for occurrence, specified information highlight ranges from 0 to 1 while other extents from 0 to 100, the examination results will be overwhelmed by the last component. For the most part, there are three generally utilized standardization strategies: Min-Max Normalization, Unity Normalization, and Z-score Scaling (also called standardization).

4.2 Min-Max Normalization

Min-Max Normalization ventures all the components in a vector to the scope of [0, 1]. This strategy maps highlight to the comparable range notwithstanding of their unique mean and standard deviations. The recipe of Min-Max standardization is given underneath:

$$x_{new} = \frac{x - x_{min}}{x_{max} - x_{min}}$$

The place x_{min} and x_{max} independently means the base What's more greatest in the characteristic x. Solidarity standardization. Solidarity standardization re-scales those

Characteristics by the rate or the weight for each single component. It calculates those aggregate of every last one of components et cetera isolates every component by the whole of cash. Those comparison is:.

$$x_{new} = \frac{r}{\sum r}$$

The place x means the whole of cash about characteristic x. Comparable should Min-Max Normalization, the outcome about for this system likewise have a place with those go about [0, 1].

Z-score scaling. Z-score scaling constrains Characteristics under typical. Gaussian appropriation (zero imply and unit variance), utilizing those. equation below:

$$x_{new} = \frac{x - \mu}{\sigma}$$

The place μ means that desire for characteristic x Furthermore σ means the standard deviation.Contingent upon the element attributes of datasets, these 3 classifications of standardization techniques might prompt contrasted investigation results.

4.3 Feature Representation

To abuse the more profound correlation ship among EEG signals, we embrace Auto encoder to claim a more grounded demonstration of EEG. The Auto encoder [16] is an unofficial machine learning rule that investigates a lower-dimensional demonstration of high dimensional information record for spatial property decrease. In structure, Auto encoder might be a multi-level back proliferation neural system that enclosed 3 types of level: the info level, the shrouded level, and the yield level. The methodology from the info level to the concealed level is named encoder though the strategy from the shrouded level to the yield level is named decoder. Each encoder and the decoder yield a gathering of loads W and predispositions b. Auto encoder is named either Basic Auto encoder once there is just one shrouded level or Stacked Auto encoder when there is more than one concealed level. In view of our earlier investigation experience, fundamental Auto encoder works higher than stacked Auto encoder once overseeing EEG signals. Consequently, in this paper, we will in general receive the central Auto encoder structure.

Let $X = \{X_i \mid i = 1, 2 \cdots , N\}, X \in R^N, X_i \in R^d$

Let the whole preparing information (unlabeled), where X_i indicates the Ith test, N signifies the quantity of preparing tests, and d means the quantity of components in every example.

$h_i = \{h_{ij} \mid j = 1, 2, \cdots , M\}, h_i \in R^M$

represents to the educated feature in the concealed level for the Ith test, where M indicates the quantity of neural units in current level (the quantity of components in greetings). For effortlessness, we use x and h to speak to the info information and the information in the shrouded level, individually. Initially, the encoder changes the information x to the relating portrayal h by the encoder loads Wen and the encoder

Biases b_{dc} ; $h = W_{en}x + b_{en}$

At that point, the decoder changes the shrouded level information h to the yield level information x' by the decoder loads W_{de} and the decoder

Biases b_{de} ; $X = W_{de}h + b_{de}$

The capacity of the decoder is to reproduce the encoded include h and make the recreated information x^l as like the information x as could be expected under the circumstances. The inconsistency among x and x^l is determined by the MSE (mean squared blunder) cost work which is upgraded by the RMS Prop Optimizer.

In outline, preparing Auto encoder is the undertaking of upgrading the boundaries to accomplish the base expense between the information x and the reproduced information x^l. Finally, the concealed level information h would contain the refined data. Such data can be viewed as portrayal of the information, which is additionally the result of Auto encoder. In above definition, the element of the info information x and the refined component (the shrouded level information h) are d and M, separately. The capacity of the Auto encoder is either dimensional decrease if d > M or dimensional climb if d < M.

4.4 Brain Activity Recognition

To identify the brain activity the drawn component, in this area, we tend to utilize the XG Boost [15] classifier. XG Boost, furthermore called Extreme Gradient Boosting, might be a managed versatile tree boosting calculation. Contrasted and inclination boosting calculation, XG Boost proposes a great deal of regularized model formalization to stop by fitting, with the building objective of pushing the restriction of calculation assets for helped tree calculations to acknowledge better. The target capacity of XG Boost incorporates misfortune capacity and regularization. The misfortune work assesses the differentiation among each ground truth name yi and the anticipate result yi. It very well may be picked dependent on different conditions, for example, cross-entropy, calculated, and mean square blunder. The regularization part is the most extraordinary commitment of XG Boost. It ascertains the multifaceted nature of the model and a more mind boggling structure brings bigger punishment.

5. CONCLUSION

Present paper we targeted on multi-class electroencephalogram signal classification supported electroencephalogram information that return from totally dissimilar subjects (multiperson). to realize this aim to tend to aim at discovering the approaches within the discrepancy among totally dissimilar electroencephalogram categories by strength over the distinction among numerous subjects. Initially, we tend to study 3 wide usage of social control strategies within the pre-processing stage. train the Autoencoder model. Autoencoder basically maps the info to a brand-new feature house once meaty options assume a dominating job. At long last, we will in general worth our methodology over Associate in Nursing electroencephalogram dataset of 600,000 examples (has a place with five classes) and win the exactness of 0.824. Contrasted and the exactness of around 0.34 accomplished by ancient AI strategies, our results 0.824 show vital improvement. what is more, we tend to explore the result of 2 factors (the coaching information size and the somatic

cell size in Auto encoder hidden level) on the training results.

REFERENCES

1. B.Rakesh, T. Kavitha, K. Lalitha, K. Thejaswi, and Naresh Babu Muppalaneni,"Cognitive State Categorizers for Identifying Brain Activities", Computational Intelligence and Big Data Analytics pp 15-20, September 2018. https://doi.org/10.1007/978-981-13-0544-3_2

2. Rajalakshmi Krishnamurthi and Mukta Goyal, "Hybrid Neuro-fuzzy Method for Data Analysis of Brain Activity using EEG Signals", Soft Computing and Signal Processing pp 165-173, January2019.

3. Lukasz Piątek, Patrique Fiedler, Jens Haueisen, "Eye state classification from electroencephalography recordings using machine learning algorithms", Digital medicine, vol.4, no.2, pp.8, May2019.

4. Zijia Zhou, Pan Li, Jianqi Liu, and Weikuo Dong, "A Novel Real-Time EEG Based Eye State Recognition System", In proceedings of International Conference on Communications and Networking in China, pp.175-183,2018.

5. Subrato Bharati, PrajoyPodder, and Md. Raihan- Al-Masud, "EEG Eye State Prediction and Classification in order to Investigate Human Cognitive State", International Conference on Advancement in Electrical and Electronic Engineering, pp.22-24, November 2018.

6. Kapil Juneja, and Chhavi Rana, "Individual and Mutual Feature Processed ELM Model for EEG Signal Based Brain Activity Classification", Wireless Personal Communications, pp.1-23, April 2019. https://doi.org/10.1007/s11277-019-06423-w

7. Grant Sheen, "An Alternating Minimization Method to Train Neural Network Models for Brain Wave Classification", SIAM Undergraduate Research Online (SIURO), 11, pp.49-69,2018.

8. Dharmendra Gurve, and Sridhar Krishnan, "Deep Learning of EEG Time–Frequency Representations for Identifying Eye States", Advances in Data Science and Adaptive Analysis, vol.10, no.2, pp.1840006, 2018.

9. Chang-Hee Han, Yong-Wook Kim, Do Yeon Kim, Seung Hyun Kim, Zoran Nenadic and Chang-Hwan Im,"Electroencephalography-based endogenous brain–computer interface for online communication with a completely locked-in patient", Journal of Neuro engineering and rehabilitation, 2019. https://doi.org/10.1186/s12984-019-0493-0

10. Keum-Shik Hong, M. Jawad Khan, and MelissaJ. Hong, "Feature Extraction and Classification Methods for Hybrid fNIRS-EEG Brain-Computer Interfaces", Frontiers in human neuroscience, June2018.

11. Mervyn V.M.Yeo, Xiaoping Li, Kaiquan Shen, and Einar P.V.Wilder-Smith ,"Can SVM be used for automatic EEG detection of drowsiness during car driving?",Safety Science Volume 47, Issue 1, January 2009, Pages115-124.

12. Bryant J. Jongkees, Lorenza S. Colzato, "Spontaneous eye blink rate as predictor of dopamine- related cognitive function—A review", Neuroscience and Biobehavioral Reviews, vol.71, 58–82,2016.

13. G. Purtscheller and C. Neuper, "Motor imagery and direct braincomputer communication", Proc. IEEE, vol. 89, pp. 1123–1134, 2001.

14. H.-J. Hwang, K. Kwon, and C.-H. Im, "Neurofeedback-based motor imagery training for brain–computer interface (BCI)", J. Neurosci. Methods, vol. 179, pp. 150–156, 2009 https://doi.org/10.1016/j.jneumeth.2009.01.015

15. Tianqi Chen and Carlos Guestrin. .Xgboost: A scalable tree boosting system. In Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining. ACM, 2016.

16. Thanh Nguyen, SaeidNahavandi, Abbas Khosravi, Douglas Creighton, and Imali Hettiarachchi. 2015. EEG signal analysis for BCI application using fuzzy system. In Neural Networks (IJCNN), 2015 International Joint Conference on. IEEE, 1–8.

17. Ravimal Bandara1 ,LochandakaRanathunga 2 , Nor Aniza Abdullah ," Nature Inspired Dimensional Reduction Technique for Fast and Invariant Visual Feature Extraction, Volume 8, No.3, May - June 2019 International Journal of Advanced Trends in Computer Science and Engineering https://doi.org/10.30534/ijatcse/2019/57832019