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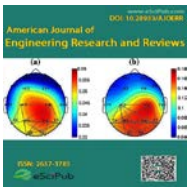

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DETECTION AND REMOVAL OF ARTIFACTS FROM EEG RECORDS- A REVIEW

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ABSTRACT

Electroencephalogram or EEG is a trace of Brain action from different locales of the cerebrum. It is the electrical movement and activity determined by putting the electrode terminals on the scalp. Artifacts are unnecessary noise signals in an EEG record. These noise in recording EEG sham a major mortification for EEG interpretation and disposal. Categorization of artifacts depends on source of its creation similar to Physiological artifacts along with Exterior artifacts. Recognition of artifacts, identification of artifacts as well as eradication of artifacts is a significant procedure to diminish the possibility of false impression of EEG not only for clinical but also for non-clinical fields. The majority of recording convention. There are various strategies for artifact removal which incorporates manual and automatic techniques. Morphology and Electrical distinctiveness of artifacts can show the way to fake elucidation that is intolerable in support of clinical as well as non clinical utilization. Thus artifacts in EEG signals must be removed or minimized before further interpretation. The presented paper describes a review on detection, classification and removal/ minimization of the recorded EEG signal artifacts.

Keywords: EEG Signal, Artifacts, Artifact Detection, Artifact Removal.

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INTRODUCTION

The EEG is the brain electrical movement estimated via placing electrode terminals all over the human head known as scalp. The consolidated action of a huge number of cortical neurons, by the side of the profundity of a few millimeters, delivers an electrical field that is adequately solid to be estimated commencing the human head. As a rule, the electrode terminals are positioned by a universally acknowledged "10-20" arrangement. In the "10-20" arrangement, electrodes are positioned all over the human scalp. "10" and "20" alludes to separations connecting adjoining electrode terminals. The frequency of signal depicts the action dimension of cerebrums. Various frequencies and related appearances are ordered in the table beneath:

TABLE I: COMPARISON OF BRAIN ACTIVITY

	Frequency/ Hz	***Activity***
Beta	13-35	Wakefulness
Alpha	8-12	Light Sleep
Theta	4-8	Sleep
Delta	0-4	Deep Sleep

Commonly, EEG signal amplitude is roughly from 40µV to 100µV amid the frequency band commencing 0 Hz to 100 Hz. The representation of EEG signal is with the help of a chart or a graph of voltage or potential difference against time. The deliberate voltage is gotten as the potential distinction amid 2 terminal destinations set on the scalp. The principle apparatus of the EEG is used for the diagnosis along with investigation of neurological illnesses for example epilepsy. The EEG estimations may be utilized to analyze diverse phases of rest and examine a nature of subjects rest. Moreover, the cerebrum sign or the brain signal can likewise be utilized to screen a medication impact, for example a perfect measure of portion amid anesthesia. [1][2][19]

I. BACKGROUND

A. ARTIFACTS IN EEG SIGNAL

The EEG Signal contains artifacts by and by. Artifacts are well thought-out as undesirable signals or impedance or intrusion in signal. Various kinds of artifacts can be alienated into external/ exterior artifacts and internal/ interior artifacts. Exterior Artifacts are brought about by external activities and interior artifacts are related with the activities which are made by the subject itself. External Artifacts result regularly from unacceptable innovation. EEG estimation innovation comprises of contraption and associations. The frequency of the mains possibly will origin an artifact by showing up as a 50 Hz element in EEG signal. This equivalent event might show up too in chronicles where in a battery is utilized as a power source. The encompassing dividers and electric links are responsible for creating a constant electric field. Moreover, external electronic gadgets could blame estimated signal by making electric and attractive fields. Interior Artifacts emerge from body actions that are either because of developments or bioelectrical possibilities. The categorization of artifacts is summarized in the table below:

Furthermore, the progressions and changes of skin potential as well as obstruction is one potential reason for artifacts. Sweat or perspiration is a typical reason for change in impedance among skin and electrode terminals.

Great scheduling of recordings and good putting of electrode terminals might assist.[22][24][31][34]

B. ARTIFACT DETECTION AND REMOVAL

There are various techniques for artifact deletion, which incorporate manual and automated methods and strategies. Automated artifact elimination strategies utilize numerical calculations and are utilized in digital EEG trace. The manual artifact removal technique is an offline method.

- **Filter Method:** In filter technique, a bandpass filter is utilized, having a frequency band of artifact, wherein specific artifacts might be expelled. This strategy is anything but a dreadfully down to earth technique for examination of the whole EEG bandwidth, since artifacts may transpire at some occurrence. A 50 Hz notch filter may be utilized in order to evacuate transmission line frequency. For Oculogram artifact deletion and removal, low pass filter (LPF) can be utilized. [1][19]
- **Manual Method:** It is also called as offline method. It is the most dependable strategy for artifact exclusion. After EEG recording, technologist outwardly investigates the EEG record and expels the artifact exaggerated slots or else does not mull over this space for development examination.[1][19][23]
- **Automatic Rejection of Artifacts:** Automatic artifact removal technique utilizes scientific calculations as well as mathematical algorithms like EOG subtraction, Independent Component Analysis (ICA), Principle Component Analysis (PCA), Joint Approximate diagonalisation of Eigen Matrices. [22][]24]

TABLE II: EXTERNAL AND INTERNAL ARTIFACTS

Extrinsic Artifacts	*Intrinsic Artifacts*
Mains Frequency	Oculogenic Potential
Electrode malfunction	Myogenic Potential
Machine Fault	ECG Artifact
Electrode Press	Pulse Artifact
Ventilation	Skin Resistance
Bed Vibration	Patient Movement

The next segment presents and explains a study of literature work being approved out by the founders and pillars in the related domain.

I. LITERATURE REVIEW

(1) **[Avinash Tandle et-al, 2015]** claims that Morphology and electrical distinctiveness of artifacts can show the way to forged elucidation, which is intolerable not only for the clinical use but also for the nonclinical use. Hence, artifacts were handled appropriately by means of artifact proof etiquette of EEG recording and by diverse artifacts removing methods. [1]

(2) **[Antti Savelainen et-al, 2010]** called attention to that, it is critical to be conscious of the artifacts, inside EEG recording in ICU. In this manner one does not portray incorrect judgment of recording. In order to demonstrate the annoying substance of artifacts, the non convulsive epileptic seizures were broke down. Seizures as well as artifacts are effectively stirred up, which can reason genuine mind wounds or brain injuries. This offers ascend to extra research to at first expulsion of artifacts as well as automatic revealing of seizures. Accordingly the quantity of genuine cerebrum wounds or brain injuries could be limited. [2]

(3) **[Ahmad Mayeli et-al, 2016]** recorded EEG signals and pointed out that recording EEG amid FMRI prompts EEG information corruption with vast fMRI surrounding artifacts. In the majority of EEG-fMRI studies, they have limited offline artifacts; then again just a couple have concerned real time remedy. They have presented Independent Component Analysis based real-time EEG artifact amendment or rectification for the duration of fMRI. The epic methodology was effectively actualized and enhanced real-time EEG artifact recognition and expulsion throughout fMRI on every one of the 6 hale and hearty subjects. The algorithm proposed by the author might be adequately accomplished for different applications that engage a realtime EEG signals, with artifacts stifled/limited. [3]

(4) **[Weidong Zhou et-al, 2009]** proposed utilization of ICA to consequently expel ocular artifacts from EEG with no requirement for additional ElectroOculoGram (EOG) recording. Contrasted and additional artifact removal strategies, ICA has a few focal points. The ICA algorithm is proficient, in terms of its computational ability. It can concurrently isolate the EEG as well as artifacts into (ICs) independent components devoid of depending on the accessibility of reference artifacts. This maintains a strategic distance from the issue of contamination among EOG and EEG channels that couldn't be solve with filters, regression and Principle Component Analysis. The redressed EEG can without much of a stretch be determined by a amalgamation of components excluding artifacts. This strategy gave off an impression of being generally pertinent and compelling technique for reluctantly expelling ocular artifacts (OAs) from EEG recordings, even if slow waves as well as OAs share comparable frequency distributions. [5]

(5) **[Nadia Mammone et-al, 2012]** claims that wide assortment of artifacts in EEG signal might be adequately evacuated by utilizing the novel automatic procedure acknowledged as Automatic Wavelet Independent Component Analysis (AWICA). It expects to triumph more than one of the fundamental restrictions of ICA, to be specific, that the expulsion of the artifactual Independent Components unavoidably suggests the evacuation of a few EEG action. AWICA depends on the administration of the distinctive data substance in the 4 frequency rhythms gotten by the wavelet transform step that goes before Independent Component Analysis. AWICA has 2-step artifact recognition process dependent on the appraisal of Renyi's entropy as well as kurtosis. The Wavelet Transform permits to totally recoup the EEG channels neural components undermined by the artifacts external to the grimy frequency range. AWICA additionally for the most part saves the cerebral action due to the augmented redundancy of the input to the Independent Component Analysis step. Additionally, the planned calculation is completely automated. It maintains a strategic distance from the want of any constant visual examination of the EEG traces. By amalgamating a real-time artifact free EEG with a lot of synthesized artifacts, a stimulated artifactual EEG dataset was made. AWICA has appeared great artifact concealment execution additionally on real-time artifactual EEG records. AWICA have appeared to show improvement over a near system as of late proposed in writing, as far as both RMSE and correlation [7]

(6) **[Carrie Joyce et-al, 2004]** introduced a system for automated rectification of OAs in EEG report utilizing blind source separation as well as correlation metrics. The system offered here will be able to be stretched out to dispense with certain different wellsprings of artifacts also. Electron drift and electro-cardiac signals can be tended to in a clear way by this methodology despite the fact that utilizing diverse turning parameter to categorize the signals dependent on their precise attributes. Vocalization and cranial muscle movement artifacts are like EOG artifacts and in this manner likewise can be evacuated by adjusting the given procedure, provided electrode terminals are put where signals from these artifacts will be able to caught. [9]

(7) **[Andrea Mognon et-al, 2011]** proposed an entirely automatic technique for the recognition of artifacted Independent Components from EEG information known as ADJUST. The synchronized utilization of numerous spatial as well as temporal highlights to recognize the artifacted ICs, is the center property of ADJUST. The key handy part of ADJUST is its totally automatic nature, where no preliminary and-mistakes systems are fundamental for fine-tuning parameters, as highlights are characterized from the earlier and the calculation that figures include limits is absolutely unendorsed. The effectiveness of ADJUST was checked by a critical characterization. Accurateness of 95.2%, for all artifacts and by its capacity to recreate clean ERP topographies as of intensely artifacted data. [10]

(8) **[Thea Raduntz et-al, 2017]** built up another technique to eliminate EEG artifacts, which will be able to dismiss every kind of artifacts from EEG records. They guaranteed that their technique is superior to the as of now accessible strategies since it isn't limited to specific kinds of artifacts, for example blinks, and it can run without human intervention. Likewise, it isn't restricted to explicit facts plus positions for the electrode terminals, and the arrangement should be skilled just once. Thus, it acts comparatively to human experts amid the score procedure of topo plots that is likewise autonomous of the electrode arrangement as a result of the alike image patterns in the topo plots of every artifact kind. [11]

(9) **[Tzyy-Ping Jung et-al, 2015]** proposed a new strategy for barring a broad assortment of artifacts from the EEG records. Their technique depends on broadened adaptation of ICA algorithm. Their outcomes demonstrated that Independent component analysis can productively recognize, discrete and evacuate action in EEG record with those got utilizing regression based techniques. [14]

(10) **[Djuwari Djuwari et-al, 2005]** announced examination of the confinements of utilizing ICA for bio-signal investigation particularly artifact expulsion. They detailed that, ICA can effectively isolate the bio-signals, if number of chronicles are at the very least number of sources. Their test exhibited that the outcomes are not solid and along these lines they prescribed that alert must be practiced before utilizing ICA. [15]

(11) **[Tapan Gandhi et-al, 2010]** proposed a plan which depends on discrete wavelet transform and the energy estimation at every node of the decomposition tree is trailed by utilization of Probabilistic neural network for characterization. The authors found that with the proposed plan, the detection is 99.33% accurate and 99.6% and 99% of sensitivity and specificity respectively was achieved in seizure detection using EEG signature. [20]

(12) **[Kiret Dhindsa et-al, 2017]** utilized FBAR toolbox so as to accomplish superior real-time artifact detection with couple of EEG channels. They proposed that FBAR is best for EEG applications, for example, BCI, NF, ERPs and so on [23]

(13) **[Luis Fernando Nicolas-Alonso et-al, 2012]** has evaluated the best in class of BCI frameworks. They examined key parts of BCI framework structure. Numerous leaps forward were accomplished in BCI inquire about. The creators tried wide assortment of sign highlights in BCI plans. Despite the ongoing significant advances in BCI field, a few issues are yet to be understood for instance, the relative points of interest and inconveniences of the distinctive sign obtaining strategies are as yet indistinct. [24]

(14) **[Ian Daly et-al, 2015]** built up a completely computerized and online antiquity evacuation technique for EEG for usage in BCI. The technique depends on a novel blend of WT, ICA and thresholding. The proposed technique is superior to the current relic expulsion strategy.[28]

(15) **[K. G. Anjana Laxmi et-al, 2017]** developed a technique for compelling de-noising of EEG signals. EEG is acquired by account the unconstrained electrical movement of the mind over some stretch of time and it might

contain a mess of data. This data can be decoded by sign handling strategies, yet much of the time curios intrude on these sign. The prescribed methodology depends on ICA which is demonstrated better by execution investigation having 96% precision and can deteriorate EEG recording into various occasion related and artifacts related possibilities. This investigation demonstrates that the proposed strategy essentially upgrade the arrangement exactness, by compelling identification and expulsion of artifacts.[36]

(16) **[Faridah Abd Rahaman, et-al, 2015]** suggested that ongoing applications on EEG gadgets require on the web preparing which likewise interest for the conservativeness and elevated compactness of the gadget. Henceforth, strategies that might execute well particularly in single-channel EEG relevance got substantially more consideration in the course of recent years. Customary ICA require some upgrade and alteration to be utilized in single-channel applications. In the mean time, the significant test for versatile separating technique is to thought of a superior reference that could speak to the commotion segments as nearest as conceivable as opposed to utilizing artifact electrode as reference contribution to save the smallness and versatility in genuine condition. [38]

(17) **[Rui Huang, et-al, 2014]** displayed a technique to expel Ocular Artifacts from electroencephalograms (EEGs) which can be utilized in biomedical investigation in versatile condition. A significant issue in EEG examination is the means by which to evacuate the ocular artifacts which unleash devastation among investigating EEG signals. The authors projected a mix of Wavelet Transform with viable limit and versatile channel which can extricate the reference sign as per visual relics circulating in low recurrence area generally, and versatile channel dependent on Least Mean Square (LMS) calculation is utilized to expel visual curios from recorded EEG signals. The outcomes demonstrate that this technique can evacuate ocular artifacts and better than an examination strategy on holding uncontaminated EEG signal. This strategy is appropriate to the versatile condition, particularly when just one channel EEG are recorded. [37]

(18) **[Raymundo Cassani et-al, 2014]** have examined the impacts of three best in class mechanized AAR (Automated Artifact Removal) calculations on AD demonstrative frameworks dependent on 4 diverse classes of EEG highlights, to be specific, ghostly, abundancy regulation rate of progress, intelligibility, and stage. The three AAR calculations tried are factual curio dismissal (SAR), dazzle source partition dependent on second request daze distinguishing proof and standard relationship examination (BSS-SOBI-CCA), and wavelet improved free segment investigation (wICA). Test results dependent on 20 channel resting-conscious EEG information gathered from 59 members demonstrated the wICA calculation unaccompanied beating additional upgrade calculation blends crosswise over three undertakings: analysis (control versus gentle versus moderate), early identification (control versus mellow), and sickness movement (gentle vs.moderate), in this manner opening the entryways for completely mechanized frameworks that may help clinicians with before time identification of AD, just as malady seriousness movement appraisal. [41]

(19) **[Priyanka Jain et-al, 2014]** anticipated a blend of Adaptive Filtering (AF) as well as Stationary Wavelet Transform (SWT) to expel artifacts from EEG signal. Measurable Parameters have been figured from the perfect EEG signal. The outcome uncovers the varieties of the parameters during typical, pre-ictal and ictal status. [43]

(20) **[Samnesh Valipour et-al, 2015]** have gathered some assessment measurements, that have utilized and approved in investigation papers for assessment of the Ocular Artifact expulsion calculations utilizing genuine also, mimicked signals. It is discovered that, in spite of the fact that assessment of these calculations utilizing recreated signal has greater effortlessness, yet assessment utilizing genuine

signal is more reliable than reproduced signals. Likewise, in light of the non-stationary idea of genuine EEG flag, the examination of a calculation with different calculations will be important, just by applying these calculations on a similar EEG information. [45]

(21) **[Akram Rashid et-al, 2014]** tried to expel the artifacts utilizing Independent Components Analysis(ICA). The scalp EEG is seriously utilized as an significant clinical apparatus for analysis and treatment of maladies. The probabilistic altered ICA calculation is utilized to isolate EEG signals from artifacts for effectively cerebrum tumor recognition. This examination work expects to recognize epileptic action for an electroencephalogram having sixteen-channels. The examination comprises of three significant stages First one is information gathering from patients, second is include extraction and third one is EEG signal investigation. In highlight extraction the pressure is to identify epileptic type of movement from the patient gathered sign. In sign examination organize the pressure is to get data about the kind of the mind tumor. [50]

(22) **[David Achanccaray et-al, 2008]** depicted the use of a technique which depends on the decomposition of the EEG signal through wavelet transform, removing then high-order insights as the entropy of Renyi and the kurtosis. With these measures, two neural systems are prepared for the recognition of ocular and muscle artifacts, one for every sort. The procedure is approved through tests on an EEG executed in this work, with hit rates of up to 94.6% for 300 preliminaries. [51]

(23) [Aina Puse et-al, 2017] reasoned that the EEG/MEG people group is developing, with specialists from various controls joining the push to consider the mind. Examination techniques keep on improving, yet in addition become progressively intricate. It is significant that a typical wording dependent on strong ideas must be utilized for conveying the science. This incorporates announcing information procurement and examination methodology such that different specialists can repeat the techniques and can recreate the investigation. the creators have given recommendations and assets towards this end, just as talking about a portion of the entanglements and potential arrangements. [52]

(24) **[Shaibal Barua et-al]** introduced a writing audit of ML (Machine Learning) algorithms that are habitually utilized in EEG artifacts dealing with. They gave a diagram of how certain machine inclining strategies have been connected in taking care of various EEG artifacts. From the examination, it is uncovered that countless programmed and self-loader strategies are accessible for EEG artifacts expulsion. Be that as it may, the use of ML is constrained. It is additionally discovered that ML give preferable order exactness over different methodologies. Most famous strategy for EEG signal arrangement is Independent Component Analysis however to recognize artifacts from autonomous parts of Independent Component Analysis it requires master perception, where ML algorithms can be connected to facilitate the characterization procedure. Besides, correlation of various systems is likewise considered and in a few examinations it is proposed that SVM is preferred classifier over other order techniques.[53]

(25) **[Johal P. K et-al, 2016]** condensed three unique strategies of artifact removal. All the referenced strategies have their possess points of interest just as downsides. They finished up that any of the strategies can give adequate outcomes contingent on the client necessity however a few bargain should be done as far as multifaceted nature and calculation time. [59]

(26) **[Petr Nejedly et-al, 2018]** The creator presented a new ML (Machine Learning) loom for recognition of artifacts in iEEG signals in clinically prohibited conditions utilizing CNN (Convolutional Neural Networks) and benchmarks the strategy's exhibition against master comments. They demonstrate that the planned strategy may be utilized as a summed up model for iEEG artifact identification. Additionally, an exchange learning procedure may be utilized for retraining of the summed up

adaptation to frame an information explicit model. The summed up model may be effectively retrained for use with various EEG obtaining frameworks and commotion conditions. The summed up and concentrated model F1 scores on the testing dataset were 0.81 and 0.96, separately. The Convolutional Neural Network model gives quicker, progressively target, and increasingly reproducible iEEG curio location contrasted with manual methodologies. [61]

(27) **[Martina Rohalova et-al, 2001]** introduced another methodology for location of artifacts in rest electroencephalogram (EEG) accounts. The proposed methodology depends on Kalman channel. The possibility of this methodology comprise in installing the AR model into the Kalman Filter which causes conceivable to utilize such To kf AR (Kalman Filter AR) models for straight forecast of non-stationary sign. Such model can be set up to recognize what's more, pursue discrete powerful changes of the sign. The assessment of the outcomes was finished by the Receiver-Operator Characteristics (ROC) bends - as far as the explicitness and the affectability. For 90% of the particularity the best accomplished estimation of the affectability utilizing KF AR model was 33%. So as to accomplish better outcomes they have attempted the accompanying alteration: rather than the Kalman Filter they have utilized expanded Kalman Filter and rather than the AR model a neural system. The primer outcomes look promissing: for 90% of the specificity they have accomplished 65% of the sensitivity. [64]

(28) **[S. Suja Priyadarshini et-al, 2014]** The creators proposed a half and half learning calculation dependent on ANFIS (Adaptive Neuro-Fuzzy Inference System) for taking out ECG artifact from EEG signal. The proposed crossover learning calculations, ANFIS-PSO utilizes Particle Swarm Optimization (PSO) calculation for tuning the forerunner and resulting some portion of the ANFIS. Execution of the proposed system is contrasted and ANFIS. Upgrades in the yield SNR, LMSE and PSD plot are utilized as the criteria for looking at the exhibition of the calculation. It is discovered that the proposed ANFIS-PSO calculation works better, and outflanks the ANFIS method in limiting the ECG antiquities from the ruined EEG signals. [66]

(29) **[Rajesh Patel et-al, 2017]** executed a typical approach to stifle both muscle and OA signal, by corresponding the deliberate tainted EEG signals with the spotless location EOG and EKG information and eliminating the scaled EOG and EKG from the debased EEG recording. In the projected procedure, the clean EOG and EKG sign are removed by oppressing the crude reference time-arrangement information to outfit exact mode decay to get the natural mode capacities. At that point, an unsupervised strategy is utilized to catch the artifact segments. The bending brought into the mind signal behind artifact concealment utilizing the planned strategy with those got utilizing customary relapse alone and with a wavelet-based methodology is analyzed. The outcomes demonstrate that the planned strategy beats different systems, with an extra preferred position of being a typical procedure for the concealment of two sorts of artifacts. [67]

(30) **[Snehal Gaikwad et-al, 2016]** have proposed another strategy for expelling artifacts from multichannel EEG data wherein a blend of ICA and wavelet-based noise diminution is conveyed for identification and evacuation of Ocular Artifact. In the primary phase, autonomous parts of OA are processed utilizing SOBI calculation. In second stage a DWT work by symlet wavelet is intended for clamor undoing of disintegrated boisterous sign. Applying delicate and hard thresholding, adequately artifactfree EEG sign is acquired. This methodology works both for eye squints and eye developments. [68]

II. GAPS IN LITERATURE

(i) Which algorithm is the best performing algorithm depends upon the type of EEG Signal as more than one optimal technique is needed to eradicate artifacts from the EEG record i.e for

different EEG artifacts, combination of more than one algorithm is needed.

(ii) Although Independent Component Analysis (ICA) is an efficient and appropriate technique to get rid of known artifacts from EEG record, it requires more computation.

(iii) In spite of the fact that sufficient information is present in the signal which a trained onlooker uses to recognize the Independent Components capturing neural activity, the data content is spread transversely several features of a signal that does not permit recognition making it difficult to identify and remove EEG artifacts.

(iv) The automated methods for artifact rejection shows meager consequences with bad channels. They were able to detect less than half of the components recognized. For this reason, bad channels must be known in advance.

(v) The researchers evaluated several methods as well as algorithms for recognizing blinks, saccades, muscle, noise, bad channels by making use of different setups. All manual and automated methods are not entirely constant. This shows that, there are intrinsic limits to the accuracy of artifact assortment using Independent Component Analysis.

(vi) In order to effectively remove EEG artifacts using ICA, statistical measures are not fully capable of making decisions as it may mistakenly remove neural signals from the EEG data.

(vii) Researchers suggested that a perfect agreement of their research was never achieved across the methods they deployed. Their work reflected the complexity of defining trustworthy refusal criterion. This limitation proves that for any automated method, there is for all time a positive stage of agreement with human user. The major confront faced by the experimenters is to evade by all way eradicating vital neural data.

(viii) The important challenge is to create or design an approach which will potentially preserve the neural signal while discarding the artifacts.

III. SCOPE OF RESEARCH

Recognition, detection and eradication of artifacts is a significant procedure to diminish the likelihood of false impression of EEG, not only for clinical fields but also for non-clinical fields. Thus artifacts in EEG signals must be removed or minimized before further interpretation. The manual method is the most trustworthy strategy of artifact removal. Morphology and Electrical distinctiveness of artifacts can show the way to fake elucidation that is intolerable in support of clinical as well as non clinical utilization. Thus artifacts in EEG signals must be removed or minimized before further interpretation.

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