



## Literature Survey about Brainwave Test

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### Abstract

*The EEG (Electroencephalogram) is a representative signal containing information about the condition of the brain. The shape of the wave may contain useful information about the state of the brain. In recent years, brain computer interface and intelligent signal segmentation have attracted a great interest ranging from medicine to military objectives. To facilitate brain-computer interface assembly, a professional method of feature extraction from EEG signal is desired. The brain electrical activity is represented by the electroencephalogram (EEG) signals. This paper presents a short review of mathematical methods for extracting features from EEG signals. The review considers different methods such as FFT, WT, CWT and DWT for EEG signal extracting. The adopted approach is such that a full literature review is introduced for the different techniques, summarizing their strengths and weaknesses. The purposes of this paper, therefore, shall be discussing some conventional methods of EEG feature extraction methods, comparing their performances for specific task, and finally, recommending the most suitable method for feature extraction based on performance.*

**Keywords**— ERP, EEG, fMRI, EEG- fMRI integration, EEG classification, EEG diseases

### INTRODUCTION ABOUT EEG

EEG is the recording of electrical action along the scalp. EEG measures voltage changes coming about because of ionic current streams inside the neurons of the brain.[1] In clinical settings, EEG alludes to the recording of the mind's spontaneous electrical action over a brief time of time, typically 20–40 minutes, as recorded from various cathodes set on the scalp. Indicative applications by large concentrate on the ghastly substance of EEG, that is the sort of neural motions that might be seen in EEG signals. Brain cells correspond with one another by creating modest electrical indicators, called driving forces.

An EEG measures this action. The test is carried out by an EEG technologist in your specialist's office or at a healing center or research.

### BIO SIGNAL

Biosignal is a compressing term for different varieties of indicators that could be consistently measured and observed from organic creatures. The term biosignal is frequently used to mean bio-electrical sign however actually, biosignal alludes to both electrical and non-electrical indicators. Electrical biosignals ("bio-electrical" signs) are normally taken to be changes in electric ebbs and flows created by the total of electrical potential contrasts over a particular tissue, organ or cell

framework like the sensory system. The various types are as follows,

1. Electroencephalogram (EEG)
2. Electrocardiogram (ECG)
3. Electromyogram (EMG)
4. Mechanomyogram (MMG)
5. Electrooculography (EOG)
6. Galvanic skin reaction (GSR)
7. Magneto encephalogram (MEG)

EEG, ECG, EOG and EMG are measured with a Differential enhancer which enrolls the contrast between two anodes appended to the skin. Nonetheless, the galvanic skin reaction measures electrical safety and the MEG measures the Magnetic field impelled by electrical flows (Electroencephalogram) of the mind. Electrical momentums and changes in electrical resistances crosswise over tissues can additionally be measured from plants.

Bio-signs might additionally allude to any non-electrical indicator that is equipped for being checked from biotic creatures, for example, mechanical indicators (e.g. the mechanomyogram or MMG), acoustic indicators (e.g. phonetic and non-phonetic articulations, breathing), synthetic signs (e.g. ph, oxygenation) and optical signs.

### ORIGIN OF EEG

Generators of electric field which might be enlisted by scalp anodes are gatherings of neurons with consistently arranged dendrites. The neurons for all time get driving forces from different neurons. These signs influence dendritic synapses actuating excitatory and inhibitory postsynaptic possibilities. Flows determined from synapses travel through the dendrites and cell body to a trigger zone in the axon base and pass through the film to the extracellular space along the way. EEG is an after effect of summation of possibilities inferred from the mixture of extracellular ebbs and flows produced by populaces of neurons. Thus the EEG relies upon the cyto architectures of the neuronal populaces, their integration including the criticism circles, and the geometries of their extracellular fields (Freeman 1992). The primary physical wellsprings of the

scalp possibilities are the pyramidal cells of cortical layers III and V (Mitzdorf 1987).

The presence of EEG musical movement in scalp recordings is just conceivable as an after effect of the synchronized actuation of massifs of neurons, the summed synaptic occasions of which get to be sufficiently huge. The cadenced action may be created by both pacemaker neurons having inward capacity of musical motions and neurons which cannot create a musicality independently however can synchronize their movement through excitatory and inhibitory associations in such a way, to the point that constitute a system with pacemaker properties. The recent may be assigned as neuronal oscillators (Madler 1991; Kasanovich and Borisjuk 1994; Abarbanel et al 1996). The oscillators have their own particular release recurrence, different among diverse oscillators and reliant on their inner integration, despite close characteristic electrophysiological properties of single neurons which constitute distinctive oscillators. The neuronal oscillators begin to act in synchrony after application of outside tangible incitement (Lopes da Silva 1991; Basar 1992) or concealed indicators from inward sources, for instance, as a consequence of cognitive stacking (Basar 1989).

The itemized hardware of the neuronal oscillators underlying EEG rhythms was given in the Report of International Federation on Clinical Neurophysiology (IFCN) Committee on Basic Mechanisms (Steriade 1990).

### TYPES OF EEG RHYTHMS

The common characterization of the principle EEG rhythms focused around their recurrence reaches is as takes after: delta - 2-4 Hz, theta - 4-8 Hz, alpha - 8-13 Hz, beta - 13-30 Hz, gamma - higher than 30 Hz. Anyway this arrangement just somewhat reflects the useful variety of cadenced exercises.

The EEG is recorded between terminals set in standard positions on the scalp and has a common sufficiency of 2-100 microvolts and a recurrence range from 0.1 to 60 Hz. Most action happens inside the accompanying recurrence groups; delta (0.5 - 4

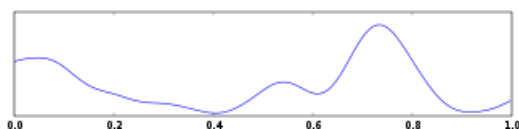
Hz), theta (4-8 Hz), alpha (8-13 Hz), beta (13-22 Hz) and gamma (30-40 Hz).

The potential at the scalp infers from electrical action of vast synchronized gatherings of neurons inside the mind. The movement of single neurons or little gatherings is constricted excessively by the skull and scalp to be recognized at the scalp surface.

EEG action specifically recurrence groups is regularly related with specific cognitive states. Motions in the alpha band, for instance, are connected with unwinding. In this way, a terminal set over the visual cortex that recognizes alpha band indicators is recognizing visual unwinding. A terminal over the engine cortex getting alpha band signs is locating engine unwinding (the mu beat).

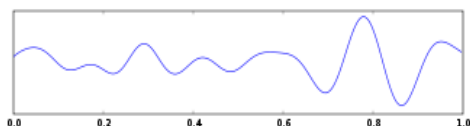
Data about waveform recurrence and shape is joined together with the age of the patient, state of sharpness or slumber, and area on the scalp to focus importance.

#### A. Delta waves (0.5 to 3 Hz)



Delta brainwaves are the slowest but loudest brainwaves (low frequency and deeply penetrating, like a drum beat). They are generated in deepest meditation and dreamless sleep. Delta waves suspend external awareness and are the source of empathy. Healing and regeneration are stimulated in this state, and that is why deep restorative sleep is so essential to the healing process.

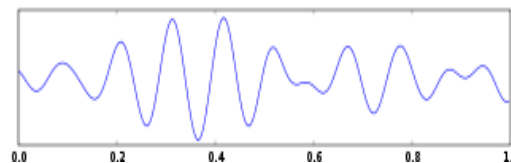
#### B. Theta waves (3 to 8 Hz)



Theta brainwaves occur most often in sleep but are also dominant in the deep meditation. It acts as our gateway to learning and memory. In theta, our senses are withdrawn from the external world and focused on signals originating from within. It is that twilight state which we normally only experience

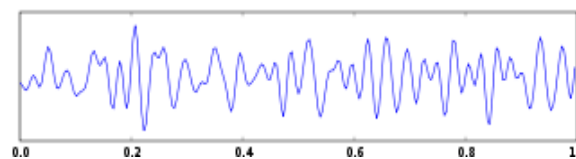
fleetingly as we wake or drift off to sleep. In theta we are in a dream; vivid imagery, intuition and information beyond our normal conscious awareness. It's where we hold our 'stuff', our fears, troubled history, and nightmares.

#### C. Alpha waves (8 to 12 Hz)



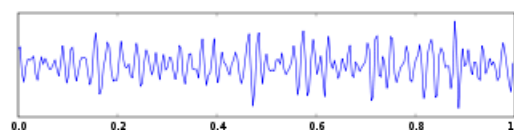
Alpha brainwaves are present during quietly flowing thoughts, but not quite meditation. Alpha is 'the power of now', being here, in the present. Alpha is the resting state for the brain. Alpha waves aid overall mental coordination, calmness, alertness, mind/body integration and learning.

#### D. Beta waves (12 to 38 Hz)



Beta brainwaves dominate our normal waking state of consciousness when attention is directed towards cognitive tasks and the outside world. Beta is a 'fast' activity, present when we are alert, attentive, engaged in problem solving, judgment, decision making, and engaged in focused mental activity. Beta brainwaves are further divided into three bands; Low Beta (Beta1, 12-15Hz) can be thought of as a 'fast idle, or musing. Beta (aka. Beta2, 15-22Hz) as high engagement. Hi-Beta (Beta3, 22-38Hz) is highly complex thought, integrating new experiences, high anxiety, or excitement. Continual high frequency processing is not a very efficient way to run the brain, as it takes a tremendous amount of energy.

#### E. Gamma waves (38 to 42 Hz)



Gamma brainwaves are the fastest of brain waves (high frequency, like a flute), and relate to simultaneous processing of information from

different brain areas. It passes information rapidly, and as the most subtle of the brainwave frequencies, the mind has to be quiet to access it. Gamma was traditionally dismissed as 'spare brain noise' until researchers discovered it was highly active when in states of universal love, altruism, and the 'higher virtues'. Gamma rhythms modulate perception and consciousness, disappearing under anaesthesia. Gamma is also above the frequency of neuronal firing, so how it is generated remains a mystery. The presence of Gamma relates to expanded consciousness and spiritual emergence.

### EEG RECORDINGS

EEG recording, as it was said first and foremost of the part, is a fairly standard strategy, especially in facilities. Consequently the supplies for EEG is made in very nearly all created nations and its promoting and detail is displayed in the diaries of fitting profile. This gear is supplied with nitty gritty guidelines for its utilization. By and by it is advantageous to present underneath a few subtle elements of EEG recording method helpful for specialists guileless in this field.

#### A. VARIOUS STEPS IN EEG RECORDINGS

1. A subject is situated in agreeable seat in faintly lit up room.
2. Electrodes are set on his head as indicated by certain plan;
3. The reference cathodes are picked;
4. Parameters of electroencephalograph and programming for EEG obtaining and stock piling are created.
5. Calibration of electroencephalograph and information obtaining programming is executed.
6. EEG is recorded.
7. Artifacts are evacuated.

#### B. EEG CABIN

The EEG recordings is performed ordinarily in a room protected from external electrical and attractive fields. Yet cutting edge enhancers can dismiss these impacts. Amid the recording system the subject ought to dodge developments, which can result in curios in a record.

### C. TERMINALS AND THEIR SITUATION PLANS

The most proper terminals for the EEG scalp recording are Ag-Agcl which stay away from potential movement because of anode polarization. To get a decent (i. e., with impedance beneath 5 Kilo-Ohms) contact in the middle of cathode and skin surface, the skin must be cleaned with ether or liquor for fat or soil evacuation. A few abrasives were in practice prior to bring down the impedance, yet it is unsatisfactory because of danger of bacterial, HIV and prion disease. A cathode gel or salt results are utilized to enhance potential conduction in the middle of skin and anode surface.

### NATIONAL SCENARIO

National scenario endeavors in atmosphere arrangement that build the assembling expenses of household organizations imperil occupations and do little for the worldwide atmosphere. As new observational examination results from the Ifo Institute show, one-sided measures lead to the supplanting of clean residential assembling with Co2-concentrated imports. Outflows relocate abroad, while the expenses of such an approach stay national. These impacts could be demonstrated for the Kyoto Protocol, actualized by the EU through the European Emission Trading System (ETS), in the period from 1997 – 2007.

The Info Institute, be that as it may, While the ETS is predominantly an European solo exertion, Germany has additionally put it all out there inside the EU with its Renewable Energy Act (or EEG). On account of food in duty costs and the necessity given to alleged green force, costs have climbed more strongly in Germany than in most other OECD nations. The EEG characteristics an exceptional remuneration plan: power escalated makers that are greater than a base size get high discounts on the reallocation charge demanded to back the EEG. These refunds are legitimized with the contention that they constitute an endeavor to keep the movement of discharges and quality creation abroad (the purported spillage wonder).

## INTERNATIONAL SCENARIO

The electrical signs produced by the cerebrum speak to the mind work as well as the status of the entire body. This surface potential variety might be recorded by attaching a cluster of terminals to the scalp, and measuring the voltage between sets of these cathodes, which are then separated, increased and recorded [24]. Evoked possibilities or occasion related possibilities (Erps) are noteworthy voltage vacillations coming about because of evoked neural action. Evoked potential is started by an outer or inner jolt [25]. These electrical indicators reflect just that movement which is reliably connected with the jolt transforming in a period bolted manner. The ERP consequently reflects, with high fleeting determination, the examples of neuronal action evoked by a jolt [164]. The phantom investigation focused around the Fourier convert established technique accepts the sign to be stationary, and disregards whenever shifting unearthly substance of the indicator inside a window [27]. EEGLAB, runs under the cross-stage MATLAB environment for preparing accumulations of single-trial and/or found the middle value of EEG information of any number of channels. Accessible capacities incorporate EEG information, channel and occasion data importing, information visualization, preprocessing, autonomous part investigation (ICA) and time/recurrence deteriorations including channel and segment cross-soundness backed by bootstrap measurable routines focused around information resampling. EEGLAB capacities are composed into three layers. Top-layer capacities permit clients to associate with the information through the realistic interface without expecting to utilize MATLAB sentence structure. Menu alternatives permit clients to tune the conduct of EEGLAB to accessible memory. Center layer capacities permit clients to alter information transforming utilizing order history and intelligent pop capacities

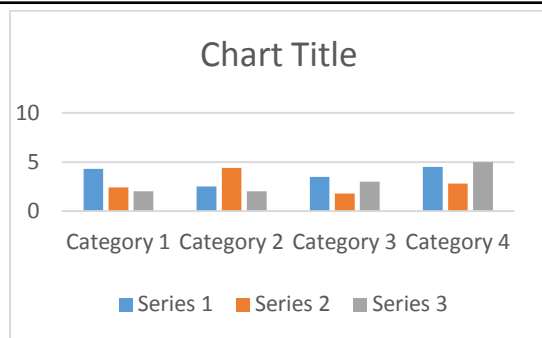
## BRAIN COMPUTER INTERFACES

Cerebrum Computer interfaces use EEG signs which might be controlled by the client. These sorts of EEG signs fall into two fundamental classes;

evoked reactions which are EEG segments evoked by a particular tactile jolt, for example, a glimmering light, and spontaneous EEG indicators which comprise of EEG parts that happen without boost, for example, the alpha musicality or the mu mood. Note, then again, that a few spontaneous EEG indicators, for example, the mu mood could be influenced by jolts. The capability of subjects to create without restraint solid spontaneous EEG rhythms, for example, the alpha mood or the mu musicality might be upgraded by the utilization of biofeedback or operant molding. This is a methodology whereby the client is given a sign in the matter of how well he/she is controlling a gadget (eg. by taking a gander at it). This constitutes the 'feedback'. The subject then changes their EEG motion because of this input. In this way, the subject to learns control the gadget through a learning methodology which can take a few hours, days or weeks to finish. BCI frameworks created in the 1960s and 1970s depended on biofeedback. It has the focal point of being straightforward yet obliges long preparing times for every client.

## CURRENT TRENDS IN ERP ANALYSIS USING EEG AND EEG/FMRI SYNERGISTIC METHODS

Analysis of electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) data provides useful insight on how the brain works and provides important information for the diagnosis of different brain pathologies. EEG provides excellent temporal resolution for the study of brain activity while, on the other hand, fMRI provides good spatial localization of different cognitive functions. Although the combination of the two modalities looks very promising, there are still problems and challenges that need to be addressed in order to take advantage of their supplementary nature.



## WHAT HAPPENS DURING THE EEG?

Amid an EEG rest on the inspecting table or cot while something like 20 terminals are appended to your scalp. You are asked to unwind and lie first with your eyes open, then later with them shut. You may be asked to inhale profoundly and quickly or to gaze at a glimmering light - both of these exercises produce changes in the mind wave designs. On the off chance that you are inclined to seizures, it is uncommon that you may encounter one amid the test. On the off chance that you are continuously assessed for a slumber issue, EEG may be performed consistently amid the night while you are snoozing. Such a recording, which may include an assessment of other body capacities amid slumber, for example, breath and beat, is alluded to as polysomnography.

## WHAT HAPPENS AFTER AN EEG?

At the point when the EEG is carried out, the anodes are evacuated and the paste that held them set up is washed away with ch3)2co. You may need to utilize extra ch3)2co at home to totally evacuate the paste. Unless you are heartily having seizures or are limited by your specialist, you may drive home. In the event that the EEG was performed overnight, you ought to orchestrate to have somebody drive you home. On the off chance that you quit taking anticonvulsant medications for the EEG, you can generally begin taking them again.

A neurologist inspects the EEG recording for anomalies in the mind wave design, which may reflect illnesses of the sensory system.

Scalp EEG action shows motions at a mixed bag of frequencies. A few of these motions have trademark

recurrence ranges, spatial dispersions and are connected with distinctive states of cerebrum working. These motions speak to synchronized movement over a system of neurons. The neuronal systems underlying some of these motions are comprehended, while numerous others are not. Explore that measures both EEG and neuron spiking finds the relationship between the two is intricate, with a mix of EEG power in the gamma band and stage in the delta band relating most emphatically to neuron spike movement.

## ARTIFACTS

### A. Biological artifacts

Electrical signs caught along the scalp by an EEG, however that begin from non-cerebral beginning are called ancient rarities. EEG information is just about constantly polluted by such relics. The sufficiency of curios could be expansive in respect to the measure of adequacy of the cortical signs of investment. This is one of the reasons why it takes impressive experience to accurately decipher EEGs clinically. The absolute most normal sorts of living antiquities incorporate:

1. Eye-actuated curios
2. ECG ( heart ) curios
3. EMG ( muscle enactment )-impelled antiques
4. Gloss kinetic antiquities

The most conspicuous eye-impelled antiques are created by the potential distinction between the cornea and retina, which is huge, contrasted with cerebral possibilities. At the point when the eyes and eyelids are totally still, this corneo-retinal dipole does not influence EEG. However, flickers happen a few times each moment, the eyes developments happen a few times each second. Eyelid developments, happening basically amid flickering or vertical eye developments, evoke a substantial potential seen for the most part in the contrast between the Electrooculography channels above and underneath the eyes. A made clarification of this potential views the eyelids as sliding anodes that short out the decidedly charged cornea to the

additional visual skin .Rotation of the eyeballs, and therefore of the corneo-retinal dipole, expands the potential in terminals towards which the eyes are turned, and abatement the possibilities in the restricting cathodes. Eye developments called saccades likewise create transient electromyography possibilities, known as saccadic spike possibilities.

### B. Environmental artifacts

Notwithstanding curios created by the body, numerous antiquities start from outside the body. Development by the patient, or even simply settling of the terminals, may cause anode pops, spikes starting from a flitting change in the impedance of a given cathode. Poor establishing of the EEG anodes can result in critical 50 or 60 Hz antique, relying upon the nearby power framework's recurrence. A third wellspring of conceivable impedance might be the vicinity of an IV dribble; such gadgets can result in cadenced, quick, low-voltage blasts, which may be befuddled for spikes.

### C. Artifact correction

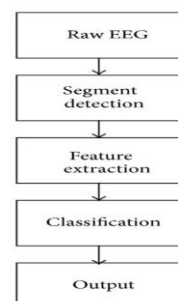
As of late, free part examination procedures have been utilized to redress or evacuate EEG contaminants. These procedures endeavor to "unmixed" the EEG indicators into some number of underlying parts. There are numerous source partition calculations, frequently expecting different practices or natures of EEG. In any case , the standard behind any specific system generally permit "remixing" just those parts that would bring about "clean" EEG by invalidating the weight of undesirable segments . Completely robotized ancient rarity dismissal techniques, which utilize ICA, have additionally been produced.

In the last few years, by thinking about information from deadened and unparalleled subjects, EEG tainting by muscle has been indicated to be much more pervasive than had long asgo been acknowledged, especially in the gamma extend over 20 Hz. However, Surface Laplacian has been indicated to be compelling in killing muscle antiquity, especially for focal anodes, which are further from the strongest contaminants.

### D. Abnormal activity

Irregular action can comprehensively be divided into epileptiform and non-epileptiform movement. It can likewise be differentiated into central or diffuse. Central epileptiform releases speak to quick, synchronous possibilities in an extensive number of neurons in a to a degree discrete territory of the mind. These can happen as interracial action, between seizures, and speak to a range of cortical crabbiness that may be inclined to delivering epileptic seizures. Interracial releases are not wholly solid for figuring out neither if a patient has epilepsy nor where his /her seizure may begin. More developed measures of strange EEG signs have likewise as of late got consideration as could be allowed biomarkers for diverse issue, for example, Alzheimer's illness .

## MATHEMATICAL METHODS



### A. Fast Fourier transform Method(FFT)

This method employs mathematical means or tools to EEG data analysis. Characteristics of the acquired EEG signal to be analyzed are computed by power spectral density (PSD) estimation in order to selectively represent the EEG samples signal. However, four frequency bands contain the major characteristic waveforms of EEG spectrum [18].

### B. Wavelet Transform Method (WTM)

WT plays an important role in the recognition and diagnostic field: it compresses the time-varying biomedical signal, which comprises many data points, into a small few parameters that represents the signal [14].

As the EEG signal is nonstationary [7], the most suitable way for feature extraction from the raw data

is the use of the time-frequency domain methods like wavelet transform (WT) which is a spectral estimation technique in which any general function can be expressed as an infinite series of wavelets [20–22]. Since WT allows the use of variable sized windows, it gives a more flexible way of time-frequency representation of a signal. In order to get a finer low-frequency resolution, WT long time windows are used; in contrast in order to get high-frequency information, short time windows are used [13]. This method is just the continuation of the orthodox Fourier transform method [23]

In the WT method, the original EEG signal is represented by secured and simple building blocks known as wavelets.

#### *C. Continuous Wavelet Transform Method (CWT)*

The coefficients of the wavelet for all available scales after calculation will consume a lot of effort and yield a lot of unused information [14].

#### *D. Discrete Wavelet Transform Method (DWT)*

In order to address the weakness of the CWT, discrete wavelet transform (DWT) has been defined on the base of multiscale feature representation. Every scale under consideration represents a unique thickness of the EEG signal [23].

By precisely describing the features of the signal segment within a specified frequency domain and localized time domain properties, there are a lot of advantages that overshadow the high computational and memory requirement of the conventional convolution based implementation of the DWT [14, 23].

### **ADVANTAGES**

1. Low spatial determination on the scalp. fmri, for instance, can straightforwardly show zones of the mind that are dynamic, while EEG requires extreme translation simply to estimate what regions are actuated by a specific response.[39]
2. Dissimilar to PET and MRS, can't recognize particular areas in the cerebrum at which different neurotransmitters, drugs, and so forth might be found.[38]

3. Indicator to-clamor degree is poor, so complex information examination and generally huge amounts of subjects are required to concentrate helpful data from EEG[40]

### **CONCLUSION**

Four of the well-known methods for frequency domain and time-frequency domain methods were discussed. Acclaim about the definite priority of methods according to their capability is very hard. The findings indicate that each method has specific advantages and disadvantages which make it appropriate for special type of signals. Frequency domain methods may not provide high-quality performance for some EEG signals. In contrast, time-frequency methods, for instance, may not provide detailed information on EEG analysis as much as frequency domain methods. It is crucial to make clear the of the signal to be analyzed in the application of the method, whenever the performance of analyzing method is discussed. Considering this, the optimum method for any application might be different.

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