

# Electroencephalography (EEG) based Brain Computer Interface

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**Abstract:** Brain Computer Interface (BCI) generate a direct technique to speak with the outside world. Many sufferers are not able to speak. As an example:- the affected person who're suffered with the numerous diseases like put up stroke - the process of wondering, remembering & recognizing may be tough. Be- purpose of spinal cord accidents or mind stem stroke the patient loss the monitoring electricity. EEG primarily based mind laptop inter- face (BCI) characteristic is beneficial to scale the mind motion & convert them right into a preparation for monitoring. In this paper our goal is to have a look at about numerous applications of EEG based signal of the special disorder like spinal wire damage, submit stroke and ALS (amyotrophic lateral sclerosis) etc.

**Index Terms:** Brain Computer Interface; Electroencephalography (EEG) signal; Amyotrophic lateral Sclerosis (ALS); Post-Stroke; Electrocorticography (ECoG).

## INTRODUCTION

Brain computing interface (BCI) is a computer based totally technology that allows the mortal communicate with electronic gadgets which include motorized wheelchair, robotics arm and synthetic limbs without help of any peripheral's gadgets i.e., nerves and muscle tissues. The goal of BCI is to evaluate the electrical signals thru the mind then amplified them and filter them to get rid of undesirable indicators. And then convert the analogical sign to digitally signal to show on display inside the output shape. Finally, the digitally sign is file in a gadget along with compact disk, document, floppy disk, DVD and so on. This system is arising when the exceptional brain sports are generated thru the mortal thoughts with a purpose to be identified with the aid of the device and translated into instructions which depends on a classification algorithm. Measuring Brain Signals:- Hans Berger who started out the BCI invented the one-of-a-kind electric interest for human brain & developed. Brain waves may be evaluated with diverse techniques that each have advantage & disadvantage. A normally used strategies are:-

**Electroencephalography(EEG)** - EEG is used to analysis the neurochemistry in the brain thru electrodes. EEG is the look at of non-invasive interface that monitors the brain activities from outdoor the skull. It does not require surgery or permanent attachment to the tool. Techniques such as automatic tomography (CT), magnetic resonance imaging (MRI), X-rays, ultrasound have all been extract the mind hobby noninvasively.

**EEG based BCI:-** is refers to the brain activities and that taken into consideration as the Rhythmic Brain Activity. These Rhythms are pretended by means of awesome moves and mind. EEG labeled those rhythms references to their frequencies.

**Delta waves:-** it is our lowest level of mind wave interest. This brain sign that arise throughout deep dreamless sleep whilst the frequency as much as 4 Hz.

**Theta waves:-** when we're in dream, bright imaginary & information beyond our regular aware consciousness & we maintain our stuff worry, nightmares then theta waves are rise up, on this frequency are four to 7 HZ.

**Alpha waves:-** while the mind is in resting kingdom. Or in re- laxation country or the frequency are 8 to 12 HZ then alpha waves alerts are generated via mind.

**Beta waves:-**it is the high-quality activity, gift when we're alert, interest, engaged in trouble fixing and capable of make decisions & judgement. When frequency are 12 to 30 hz then beta waves alerts are generated thru mind.

**Electrocorticography (ECoG)** – EcoG devices are embedded innermost the skull but remain outside the brain, they produce signals with better resolution as related to invasive they have reduced hazard of scar tissue. ECOG that considered cathodes located instantly on the exposed surface of the brain to store electrical activities from the cerebral. It is safer, more consistent and less technologically complicated than invasive BCI.

**ECoG based BCI:-** Is refers to the cursor movement that serve as the prototype for testing a new paradigms & algorithms. While contacting the online observation of tensional cursor patient's activity through one-dim control which allows the participants to control either vertical or horizontal movement and through two-dimensional cursor control which enables the user to control a considerably enhanced interface. ECoG uses different activities for the cursor control testing are :-

**Supplementary Motor Area (SMA)** is the part of cerebral cortex especially for control of movement. SMA is the most important part of the motor imaginary based BCI application because it is based on the control of movement which is basically justified the oscillate persistent activities during the synchronized and unsynchronized movement. The activity is considered an online based measurements of brain activities.

Phase Locking Value (PLV) is an activity that can be used to analysis the performance that caused changes in long range synchronization of neural activity from EEG data.

PLV measurements feature is currently established as BCI motor imaginary application.

BCI Operations:- BCI Operations are essential to record the brain signals by applying the four elements:- signals acquisition, feature extraction, feature translation & device output through brain activities are generated and captured by the system then transmitted into commands which is considered as output.

## I. RELATED STUDY

The connection and control between human brain and computer is called as BCI [1]. BCI is a laptop based totally pastime that gain Brain signal without the help of any peripherals tool which includes nerves & muscle tissue. There are extraordinary techniques of recording signals & then observe BCI operation; sign acquisition, feature extraction, feature translation, device output by means of those operations digital indicators of the brain is captured over the scalp after which transmitted into commands that is considered as output that improved the mission between the person and the device for that green BCI applications are considered that hooked up the beneficial function for the paralyzed humans & invent the digital gadgets which include motorized wheelchair, robotics palms & artificial limbs. To develop the BCI system some of the programs are working effects.

The cause of BCI is to evaluate the electrical indicators through the mind & then amplified them and filter out them to get rid of undesirable signals after which convert the analog sign to virtual signal [2]. This considered the actual time motor imaginary method of BCI thru outside de- vices are manipulate that's beneficial for disabled people that grow to be the verbal exchange media for them. During motor imaginary the BCI is use the physiology of the nervous system which extract or classify rhythms the use of SVM classifier which locate the insects and insufficient indicators and converting them into favored end result. Through SVM evaluation the information of motor imaginary movement of proper & left hand is classified that considered the rhythm. SVM is used to separate or identify classes, it limit the margins to boom the generation capabilities in comparison to LDA classifier which decrease distance within a category & maximize distance among classes.

BCI use method EEG and ECoG. EEG is the non-invasive interface that monitors the brain activity from outdoor the skull [3]. ECoG implanted within the skull however rest out of doors the mind, they produce alerts with better decision compared to invasive so, result suggested that ECoG signals has better resolution in comparison to the EEG due to the fact sometimes EEG records undesirable signals that provide wrong end. Hence ECoG conquer the restrictions of EEG. The ECoG also manage the alerts into cursor motion which operate tongue movement, starting & last hand motion and the opposite actions, they're taken into consideration as the one dimensional or two dimensional BCI manage, while experience the net remark of sufferer's actions. The data is analyzed that facilitates to verify the higher adjustment of frequency bands & anatomic area used for ECoG manage of cursor motion & final accuracy of that manage.

The extraordinary techniques and the applications are used for the capability to generate mind signals which labeled the BCI in manner [4]. Invasive BCI that do not forget as the neurosurgery due to the fact this method take into account the internal running of the brain. It is basically a sort of open surgery so it make impact at the body element. Non-invasive BCI does not smash the pores and skin so it considered to be as compared to the invasive most secure in comparison to the invasive. BCI considered the real time based totally Applications inclusive of prosthetic software which taken into consideration the synthetic limbs. Entertainment programs that encompass gaming, communication via which human mind interface with the electronic gadgets. For the protection & protection additionally BCI Applications are used. BCI also confronted the challenges at the same time as beneath-standing the mind sports, taking pictures the alerts for that BCI operations are considered thru the mind indicators are transmitted within the output shape.

BCI introduced the approach which might be ECoG and EEG primarily based thru which many new gadgets are generated to manipulate the motor disabled humans' sports which advanced the excessive degree of complexity [5]. For the evaluation of motor imaginary activity ECoG statistics & evaluation the observation by using the usage of BCI method which might be Genetic Algorithm (GA), Mutual records (MI), In- formation Gain (IG) & examine them with Bayesian & K- Nearest Neighbor classifiers. For the excessive dimensionality & outliers function extraction Common Spatial Pattern (CSP) utilized in signal processing for separating more than one observation in BCI. The comparative have a look at of these methodology with BCI classifiers purpose to develop the brand-new conversation media to the motor disabled patients.

EEG based totally BCI acting the undertaking by using followed via specific training method that primarily based on intellectual project i.e. Mutual facts (MI), calculate the modifications in mind rhythms [6]. The sensorimotor rhythm (SMR), when the frequency tiers of rhythms is 13 to fifteen Hz then it considered alpha & beta mind waves. Sensorimotor taken into consideration the degree wherein the bodily & cognitive competencies are developed. While calculate the remark of motor imaginary BCI exclusive comments moods are taken into consideration the audible & vibrate result which produce energy or help of user undertaking in high-quality way or to edify enrich attempt of BCI project which consist as negative remarks. After combining the all remarks moods examine them with traditional viewable result. On the basics of compilation different session have to be considered to evaluation the BCI new strategies. The multiple assessment checks is considered in the periods that shows the overall performance of BCI machine.

A motor imaginary BCI transmitted the control indicators through applying the various algorithms which taken into consideration the rhythms according to the frequency [7]. While degree the section synchrony for classifying unmarried trial EEG during motor imaginary that examine or evaluation the sports of Supplementary Motor Area (SMA), is a part of cerebral cortex in particular for manage of motion basically justified the oscillate persistent sports during the synchronized and unsynchronized motion. The hobby is taken into consideration a web primarily based to examined the section synchrony measurements in motor cortex for classifying EEG for the duration of motor imaginary. The segment distinction among frequency & signals that typically oscillate persistent cost. It is essential to test synchrony testing is called Phase Locking Value (PLV), activity that may be used to analysis the performance that caused modifications in lengthy rang synchronized of neural interest from EEG facts. The PLV measurements features is presently hooked up as EEG motor imaginary in BCI utility.

The initial study are appearing motor imagery and BCI utility [8]. In which analysis of scalp in-formation in EEG based to left to right undertaking in BCI. People are suffering for muscular incapacity who want to interact with electrical tool. Most of the challenges and promises struggling human beings in BCI. In which used of BCI Invasive or noninvasive. Invasive BCI used open surgical operation in human being. It is unstable for the suffering human beings as it's miles immediately connect to the scalp of mind and in which used electrocortigraphy. Noninvasive BCI are utilized in connect to the outer-floor of the scalp. In noninvasive BCI used electroencephalography EEG characteristic. BCI based on rhythms that come from motor creativeness. Rhythms record the signal among 8-12Hz to left to right. BCI motor imagery permit the EEG based totally electroencephalography used in scalp of BCI because it isn't always unstable of the suffering people.

BCI is another sort of subject likes contribution of any clinical area to struggling severe accidents [9]. In this subject together with educational machine, self-configuration, advertising and marketing as specific sort of video games and enjoyment system in BCI. BCI of consumer and gadget. There are too many external-inner gadgets to use the muscle to complete iteration with people. In this BCI loss of demanding situations to repair or update the lot of capability. The BCI reason involvement or analysis hand unfastened software manage the frame element and manage the human behavior sending and receiving the statistics. In mind sign there are two kinds of sign are used invasive or noninvasive. Brain computer interface used noninvasive in order that it is connect to the scalp. There are various demanding situations and application utilized in BCI and analysis daily.

BCI is an actual international technique which big training or massive contribution of real machine [10]. The main targets of BCI connect with the actual global gadget growth the increase of utility about helpful disable humans. There are such a sort of signal processing to apply this generation to connect to mind sign.

Challenges of BCI to actual world assignment:-

1. The common sign information find out the sign and seize the sign rate are boom or lower.
2. If the sign fee are very gradual i.e. Statistics are switch range slowly in the frame. That's way blunders are generated. In the frame signal are excessive or nor both low.

Three Autonomy:- Brain signal comes via the machine signal. In these signs are not exchange at the gadget. He absolutely manipulate and manage the body and put off the noisy records.

4. Real international machine are greater issue in creativeness to challenge consistent with formation, emotion, feeling, interplay with every other person. We are having a look at on BCI to govern on everyday use in each degree and scenario

Brain laptop interface connection of mind and system tool to communicate with externally and internally manage by using the sign [11]. It is fluctuating the voltage among neurons and sign applier. Invasive BCI are direct connected to the scalp that's way invasive signal are better excellent of sign however it is risky for human. Noninvasive used EEG or MEG magnetic resonance imaging. EEG utilized in scalp of outside the mind. It is attaching to the cord in in the device to controlling the robots, video games movement of cursor and many others. The channel are chosen EEG signal. This approach BCI are sign equitation of EEG or MEG then pick the useful sign and switch the noise signal then function extraction the class of the sign. Now a days we are look at of the numerous eras dispose of unwanted and noisy signals.

Machine getting to know is a concern of pre- processing generation and EEG base of BCI [12]. This BCI takes minimal time and gives the communicate speed to six-eight in line with minute. In the EEG evaluation on line separation of electrical alerts. The cutting-edge argumentation among feature. Now we are look at of EEG based totally signal. Brain five computer interface verbal exchange with mind signal, from muscles and peripheral tool. Signals are varying the ac- cording voltage to the consumer of consumer tool. Machine getting to know is also evaluation of emotion, sleep degree, feeling, thru and so forth.

BCI venture with the paralyzed human beings. It use the noninvasive of EEG primarily based to the sign [13]. It offer multidimensional motion to control the body part through which the brain. Noninvasive BCI used in scalp activity to provide the signal factor to factor the manage injuries. The studies is the main motive of the offer the communication with the struggling humans. It is providing the communication in two sorts of invasive or noninvasive. Noninvasive used in scalp of EEG based and invasive is open surgical operation. It has provided excessive pace of the verbal exchange. It is a medical risk or inflamed of body.

EEG and motor imagery in actual world to talk with different [14]. In which the classification be- tween EEG and BCI. This paper describe by means of diverse algorithms in actual time trying out. Brain computer interface paintings with left- and right-hand motion and these frequencies are 70 to 95%. It store the statistics to provide quicker feed- lower back. Rapid prototyping evaluation of update very rapid technique software to layout the sign. These are bendy to shop the data.

Here we study EEG primarily based BCI Application for stroke rehabilitation by means of robotics fingers [15]. Stroke is a large harm by which many other problems face by using the sufferers like voice, focusing and sensibility. Rehabilitation assist for monitoring & communicating with each day lifestyles for patients. Rehabilitation is higher than manual remedy due to its instant's upgrades in sufferers' actions sports. BCI enables for tracking the outside gadgets & systems like laptop, switches and robotic

wheelchair. Functional Electric Simulation(FES) of BCI, is utilized for hand sports. In FES we have a look at on two workout first quadriplegia patients that want to grip a tumbler of water with the aid of using BCI FES device and other one is a stroke patient. The children thoughts is very sturdy & it memorize energy is excessive so after the stroke hassle it may take movement via the motion of broken, injured place. The memorizing energy is called as neuro-plasticity which consciousness on each vicinity in which command is given from one element to another. We find out the chances of using non-invasive BCI & robotic rehabilitation for publish-stroke rehabilitation. This method is carried out for converting the fantasy into the coaching by means of obtaining the signal from scalp that recorded with the aid of EEG. It gives better overall performance and accurate end result. We are also examining about translate synchronization to asynchronous position of motor imaginative and prescient where item are controlled via synthetic limbs.

While analyzed the classification algorithms for generate BCI gadget of EEG algorithms that recognize the mind interest and amplified them after that damage down them into distinct stages consistent with signal are generated [16]. BCI have five varieties of classification set of rules which can be linear classifiers, neural networks, non-linear, Bayesian classifiers, nearest neighbor classifiers & combination of classifiers. The SVM are usable for synchronous BCI. The ok nearest neighbor(KNN) set of rules & mahalonobis distance algorithm are used for nearest neighbor classifiers. There are many different category strategies that not use modern day for objective of BCI. If BCI explore greater in scientific sports, new technologies may be carried out into the uses. These techniques are performed on the huge quantity statistics sets of EEG sign.

The ordinary users can absolutely reveal the robots with the aid of the usage of the keyboard, mouse, joystick but it's complicated to strange or paralysis affected person to control [17]. These some interfaces sip & puff system, single switches and eye-tracking structures are help for the ones people. But those technique do not carry out on other injured affected person which includes amyotrophic lateral sclerosis (ALS), a couple of sclerosis (MS) and stroke. Still independent robots have been no longer useful for transferring the unique area for the muscular disable humans this is why those kinds of interfaces or medium are generated for those patients who cannot manage the computer or machine.

EEG is the part of non-invasive interface of brain computer. There are numerous utilities of EEG indicators like-controlling a shifting cursor on the display, choice of letters from a digital keyboard, playing video games, sample recognizing etc.

The EEG based robots are control through the thoughts signal. Brain controlled manipulators & cellular robots these are the two types of mind-controlled robots. A FRIEND system generate by the Graser et al. Which is the manipulator. Non-invasive BCI get entry to the many styles of mind sign like- electroencephalograms(EEG), magnetoencephalogram (MEG), blood-oxygen-stage dependent(ambitious) indicators, but EEG is more annoying because of low value.

As we will talk with the out-side world but many affected persons now not capable of speak [18]. For example:- the patient who cause the several ailments like put up-stroke, the procedure of wondering, remembering & spotting can be tough due to spinal wire disease or brain stem stroke, the affected person loss the monitoring power.

The scientific utility of neurorehabilitation based totally on brain computer interface on EEG for monitoring motor refit. It helps for tracking the patient which have amyotrophic lateral sclerosis & spinal twine sickness & stroke. Many features like sensorimotor rhythms (SMR), slow cortical potentials(SCP), SMR'r SCP's based totally device use the component like frequency or time area. The purpose of scientific application pof bci is useful for patient have disorder like amyotrophic lateral sclerosis(ALS), several CNS harm which includes spinal wire accidents & stroke and epilepsy and interest deficit & hyperactive disorder (ADHD). Result is high shortage in controlling & motor feature.

BCI gives choice & complementary tracking manipulate & motor manipulate refit & down-law of cortical activity. It offers neural network communication with the tool to motor manipulate & full motion of harm vicinity. The cortical physiology that confirm the way in which human mind or thoughts recognize.

Electroencephalography (EEG) primarily based on BCI can examine the people attention, notion & thinking for motor imaginative and prescient [19]. The device relevant for disable people through reading the brain of people which exist left & proper imaginary movement & decide the real actions. Kalman clear out of BCI's is applied for sign manipulation to selection of the green signal. The common spatial sample(SCP) and radial Basis function(RBF) are the classification approach that used for characteristic extraction. The commonplace spatial pattern(CSP) is applied in channel selection. The quality channel choosing on the premise of most vector derived from CSP. The complicated Morlet wavelet transform technique utilized in alpha & beta rhythms. It discover & looked after the left & proper movement imagination. The characteristic subset choice algorithm for function extraction & multilayer backpropagation neural network for the class Increase the efficiency of the type of motor imagery left and right-hand motion with the aid of the use of the Kalman filter.

BCI is a mediator between mortal mind & machine [20]. Electrooculography (EEG) is implemented for better performance & powerful or correct type. Sparse representation is applying for mental assignment classification. This set of rules is split into two lessons according to the BCI information. Common spatial pattern(CSP) become a huge device for using the dictionary. Differential dictionary that intro-duce by means of Zhou et al. Which is basis at the minimization objective feature renovate & differential technique arise in goal feature. Mostly sample of sparse representation are zero by this it provide the accurate end result. It offer separability & adaptivity. Sparse representation is better to different classifiers support vector machine(SVM) and K nearest neighbor(KNN) Because kernel in SVM and neighbor in KNN are hard.

**BCI Based Algorithms :-** During motor imaginary, the BCI makes use of the body structure of the apprehensive machine that are labeled and extract the rhythms based totally on their frequencies. The Classification algorithms used to design BCI system by means of considering the BCI Operations. For the BCI classification algorithms unique classifiers is used to extract the indicators inside the commands.

**Linear Classifier :-** the linear classifier are based totally at the exceptional classifiers algorithms that are

**Linear Discriminant Analysis (LDA) :-**

is a method utilized in sample reputation & system learning to discover a linear aggregate of functions that separates two or more lessons of gadgets or occasions. It decrease distance inside a category & maximize distance between classes. The system usually used for more than one classes is the 'One Versus the Rest'(OVR) which exist in isolating every class from all the others. This method has a totally low seasoned - portioned duty which makes it handy for online BCI be system. This classifier is sincerely to use & commonly produce desirable consequences. LDA classifier be goes with asynchronous BCI & has been used with prosperity in a great number of BCI device which include motor imaginary primarily based BCI. The downside of LDA is it is straightness that produce inferior effects compared to nonlinear EEG facts.

#### Support Vector Machine (SVM):-

This technique is also used to separates or pick out training. By decrease the distance from the closest point & maximize the margins to growth the inference strategies. It's capacity to control the high Spatial boundaries allaying the impact of ' the curse of dimensionality'. It may be used for both linear & nonlinear issues by the usage of the 'kernel trick' which break out the explicit mapping this is needed to get linear getting to know algorithm with radial basis characteristic. Kernel is typically utilized in SVM to pick out the distance between two Vectors.

Nonlinear classifier:- It initiate Bayesian classifiers used for Bayes quadratic has been applied for BCI, it isn't always represented here as it isn't traditional, currently, persistent sufficient for real-time BCI. These classifiers generate nonlinear decision boundaries. It is originated which permits them to operate similarly effective alienation of unreliable styles than discriminative classifiers. However, those classifiers are not as popular as linear classifiers or Neural Networks in BCI programs.

Bayes quadratic:- Bayesian class objective is allotting a detail vector to the class it exists the highest opportunity. The Bayes rule is carried out to evaluate the subsequent opportunities that a element vector has belonging to a given magnificence the use of the MAP (Maximum A Posteriori) rule, the class of this element vector can be taken into consideration Bayes quadratic consist of an exceptional ordinary grouping of records that control quadratic selection limitations. This classifier isn't popularly used for BCI, but encompass in fulfillment to motor imagery and intellectual project classification.

K Nearest Neighbor(KNN):- K nearest neighbor(KNN) is the non-parametric technique that is implemented for the classification. It is used for statistic calculation and pattern recognition. The input have the adjoining example of the k and the output is the magnificence membership like any other classifier or decision tree. Object is assessed by means of most of the people of vote of its magnificence neighbor an ok consult with the range of neighbor which we do not forget and its miles a positive quantity generally small.

If the k=1 then variable is allocating to the magnificence of the closest element it has.

Neural network:- neural community are paintings with linear classify. In which several artificial sports works to take into account the brain sign. These algorithms are paintings on EEG (electroencephalography), to take short time classifier given to the brain. Neural network are applied in fashionable multilayer according to cepton (MLPs) techniques categorized to the brain activities. These community are implemented to examine FIR (finite impulse response) to clean purifying the processing of alerts.

## II. CONCLUSION & FUTURE STUDY

BCI is majorly used in science history which provide capability among thoughts and device which take into account the numerous applications for further use transmission tool for excessive incapacity and synthetic limbs to tracking disabilities such as quadriplegic, cerebromedullospinal. Neurorehabilitation after neurological injuries and entertainment & gaming. Poly- graph take a look at, brain fingerprinting, trust assessment. BCI is a subject of practical examine so it always in it is infancy. The comparative research on numerous additives of BCI is ongoing that look into useful instinctual waves; signal shooting, function extraction and translation strategies for combining brief- and lengthy-range adaptations among human and de- vice to improve the overall performance which are appropriate for BCI packages such as medical applications; conversation, motion manage, Neurorehabilitation.

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