

EEG Based Brain Computer Interface - A Virtual Keyboard Control Using Brainwave Sensor

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ABSTRACT: The Brain Computer Interface is an interface that makes an individual use of machine by using their brain signals. The electrical activity of the brain is determined by an ElectroEncephaloGram (EEG). EEG records brain wave patterns by tracking the signals that are in the form of electrical impulses. The Brain wave sensor is placed on the scalp; the signals are transmitted to a computer to record the results. The BCI technology will translate the electrical activity of the brain into a command or signal for a device to perform its action. The project is about designing and developing a Virtual Keyboard which is based on electroencephalogram and Brain Computer Interface. The People having severe movement disorders like Locked in Syndrome or Amyotrophic Lateral Sclerosis (ALS), and also the people with injured hands or paralysed people can be benefited with the help of this application of virtual Keyboard using brain wave sensor to communicate or to share their views. Brain-computer interface (BCI) systems has the low bandwidth of the communication channel, especially while communicating and controlling assistive devices, such as a keyboard controlling system, to select the key board character based on the eye blink. To address this, an adaptive user-centric graphical user interface referred to as the Intelligent Adaptive User Interface (iAUI) based on an adaptive shared control mechanism is proposed. The iAUI offers multiple degrees of freedom control of a robotic device by providing a continuously updated prioritized list of all the options for selection to the BCI user, thereby improving the information transfer rate. Results have been verified with multiple participants controlling a simulated as well as physical establish robot.

KEYWORDS: Brain Computer Interface, BCI, Virtual Keyboard, Brainwave Sensor, ElectroEncephaloGram, EEG, Amyotrophic Lateral Sclerosis, ALS, Intelligent Adaptive User Interface, iAUI.

I. INTRODUCTION

Brain Computer Interface (BCI) is a computer aided interface. An individual's brain signals are used to access a system. Brain signals are in the form of patterns of electrical brain activity. The electrical activity of the brain is analyzed and measured by the electroencephalogram (EEG). For this process of analyzing and measuring the electrical signals, a brain sensor is placed on the scalp of a human brain which has small metal discs. This small metal disc is called the electrode. The electrode carries the electrical waves (or) signals which pass through the skull of a human brain. These electrical signals extracted are categorized and recorded. The electrical signals are then translated into meaningful orders to make a machine or application to perform its activity as per the order from the brain signal. This is also used to provide accurate control of a device. Electroencephalography (EEG) is the non-invasive BCI method which is most studied technology, it measures the signals of the brain by electrodes placed on the surface of the scalp without surgery [1]. EEG is a test that identifies the activity of a human brain. Electrical signals are generated during the communication in the brain. EEG will generally show the type and location of the activity in the brain during a seizure. Internet provides a variety of information and communication facility. It connects devices or computers together for sharing data in various ways. In recent days

many devices are being connected with Internet. In reality, the Internet of Things (IoT) was termed based on this. Any category of device that contains the required connectivity and computational power can connect to the Internet and interact with it [3]. The Internet of things (IOT) actually refers to internetworking of physical devices and machines (i.e.) everyday objects have network connectivity that allows them to send and receive data. Sensing and controlling an object across a network is called IoT - to directly integrate the physical world into computer-based systems. This results in accuracy and improved efficiency. On combining IoT with actuators and sensors, the technology becomes an instance of the general class of physical systems, which also comprises technologies such as smart homes, intelligent transportation and smart cities. This is uniquely identified through embedded computing system. The five senses are utilized to communicate with our general surroundings. Presently we can utilize them to associate with the Internet also. The sensor gadget with a camera is utilized so we can see something that are occurring, cerebrum wave sensors are utilized in order to detect the musings and solid exercises around the scalp. The Human Machine Interface (HMI) is an advancing field of numerous capable advances, with a more prominent positive effect on society and individual.

Proposed System

Individuals experiencing motor skills impairment related diseases may lose capacity of voluntary action to control PCs. Human – computer interaction (HCI) involves the combination of both Electroencephalograph (EEG) and eye controls. The virtual keyboard here works as a hands free model. It will analyze the data from the sensors and based of the gathered data the software can control the type using this specially designed keyboard, allowing the patients to control the computers using their eyes and mind.

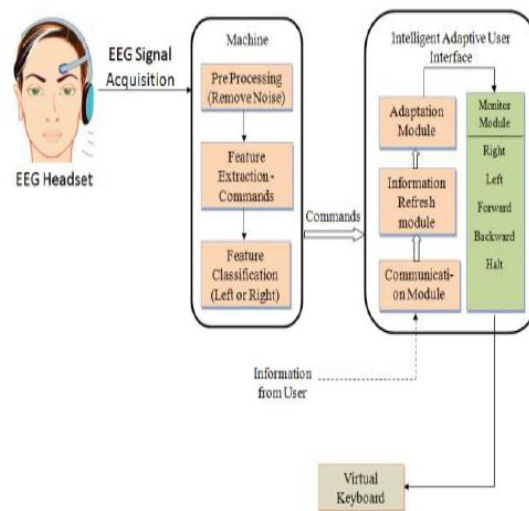


Fig.1 Proposed System Architecture

System Proposal Stages

Brain computing interface (BCI) is a computer based technology that allows the mortal mind to communicate with electronic devices such as motorized wheelchair, robotics arm and artificial limbs without assist of any peripherals devices i.e., nerves and muscles. The objective of BCI is to assess the electrical signals through the brain then amplified them and filters them to remove unwanted signals. And then convert the analogical signal to digitally signal to display on screen in the output form. Finally the digitally signal is record in devices such as compact disk, document, floppy disk, DVD etc. This process is occur when the different brain activities are generated through the mortal mind that will be identified by the system and translated into commands which depends on a classification algorithms.



Measuring Brain Signals:

Hans Berger who started the BCI invented the different electrical activity for human brain & developed. Brain waves can be evaluated with various techniques that each have advantage & disadvantage. Commonly used techniques are:

Electroencephalography (EEG)

EEG is used to analysis the neurochemistry in the brain through electrodes. EEG is the study of non-invasive interface that monitors the brain activities from outside the skull. It doesn't require surgery or permanent attachment to the device. Techniques such as computerized tomography (CT), magnetic resonance imaging (MRI), X-rays, ultrasound has all been extracting the brain activity noninvasively. EEG based BCI is refers to the brain activities and that considered as the Rhythmic Brain Activity. These Rhythms are pretended by distinct actions and thoughts. EEG classified these rhythms references to their frequencies.

Delta Waves: It is our lowest level of brain wave activity. This brain signal that occur during deep dreamless sleep when the frequency up to 4 Hz.

Theta Waves: When we are in dream, vivid imaginery & information beyond our normal conscious awareness & we hold our stuff fear, nightmares then theta waves are arise, in this frequency are 4 to 7 hz.

Alpha Waves: When the brain is in resting state or in relaxation state or the frequency are 8 to 12 hz then alpha waves signals are generated through brain.

Beta waves: It is the best activity, present when we are alert, attention, engaged in problem solving and able to make decisions & judgment. When frequency is 12 to 30hz then beta waves signals are generated through brain.

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 reduce 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

It refers to the cursor movement that serve as the prototype for testing a new paradigms & algorithms. While contacting the online observation of ensional cursor patients activity through one-dimcontrol 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 imaginery based BCI application because it is based on the control of movement which is basically justified oscillates persistent activities during the synchronized and unsynchronized movement. The activity is considered online based measurements of brain activities.

A. Existing System Summary

A Brain Computer Interface (BCI) is any system which can derive meaningful information directly from the user's brain activity in real time. The most important applications of the technology are mainly meant for the paralyzed people who are suffering from severe neuromuscular disorders. Most BCIs use information obtained from the user's encephalogram (EEG), though BCIs based on other brain imaging methods are possible. The information transfer rate, given in bits per trial, is used as an evaluation measurement in a brain-computer interface (BCI). Three subjects performed four motor-imagery (left hand, right hand, foot, and tongue) and one mental-calculation task. Classification of the electroencephalogram (EEG) patterns is based on band power estimates and hidden Markov models (HMMs). The proposed method that combines the



EEG patterns based on reparability into subsets of two, three, four, and five mental tasks. Based on the information transfer, a method is proposed to determine the types of mental tasks and their combination in order to achieve the maximum information transfer rate.

Limitations / Disadvantages

- A common feature between all BCIs is that, since the recorded brain signal is very noisy and has a large variability, either the uncertainty on the command will be high, or the time between consecutive commands will be long, in the order of seconds.
- Brain Computer Interface is typically considered by a very low information transfer rate.
- Brain-computer interface (BCI) systems is the low bandwidth of the communication channel, especially while communicating and controlling assistive devices, such as a smart wheelchair or a tele-presence mobile robot, which requires multiple motion command.

II. RELATED WORKS

In the year of 2017, the authors "jeremiah d. Wandera,1,timothy blakelya, kai j. Millerb,2, kurt e. Weaver, c, lise a. Johnson,et al", presented a paper titled "Distributed cortical adaptation during learning of a brain-computer interface task", in that they described such as the majority of subjects who attempt to learn control of a brain-computer interface (BCI) can do so with adequate training. Much like when one learns to type or ride a bicycle, BCI users report transitioning from a deliberate, cognitively focused mindset to near automatic control as training progresses. The following are the methods and outcome of the paper:

Methods:

The neural correlates of this process of BCI skill acquisition. Seven subjects were implanted with electrocorticography (ECoG) electrodes and had multiple opportunities to practice a 1D BCI task. As subjects became proficient, strong initial task-related activation was followed by lessening of activation in prefrontal cortex, premotor cortex, and posterior parietal cortex, areas that have previously been implicated in the cognitive phase of motor sequence learning and abstract task learning.

Results:

These results demonstrate that, although the use of a BCI only requires modulation of a local population of neurons, a distributed network of cortical areas is involved in the acquisition of BCI proficiency.

In the year of 2014, the authors "joanacabralabmorten I.kringelbachbcgustavodecoad- Felix Darvas et.al", presented a paper titled "Exploring the network dynamics underlying brain activity during rest", in that they described such as: the intriguing dynamics of the brain at rest has been attracting a growing body of research in neuroscience. Neuroimaging studies have revealed distinct functional networks that slowly activate and deactivate, pointing to the existence of an underlying network dynamics emerging spontaneously during rest, with specific spatial, temporal and spectral characteristics. Several theoretical scenarios have been proposed and tested with the use of large-scale computational models of coupled brain areas. However, a mechanistic explanation that encompasses all the phenomena observed in the brain during rest is still to come. A motor cortex-based brain-computer interface (BCI) creates a novel real world output directly from cortical activity. Use of a BCI has been demonstrated to be a learned skill that involves recruitment of neural populations that are directly linked to BCI control as well as those that are not. The nature of interactions between these populations, however, remains largely unknown. The following are the methods mentioned in the paper:

Methods:

A data-driven approach to assess the interaction between both local and remote cortical areas during the use of an electrocorticographic BCI, a method which allows direct sampling of cortical surface potentials. Comparing the area



controlling the BCI with remote areas, we evaluated relationships between the amplitude envelopes of band limited powers as well as non-linear phase-phase interactions. We found amplitude-amplitude interactions in the high gamma (HG, 70–150 Hz) range that were primarily located in the posterior portion of the frontal lobe, near the controlling site, and non-linear phase-phase interactions involving multiple frequencies (crossfrequency coupling between 8–11 Hz and 70–90 Hz) taking place over larger cortical distances. Further, strength of the amplitude-amplitude interactions decreased with time, whereas the phase-phase interactions did not. These findings suggest multiple modes of cortical communication taking place during BCI use that are specialized for function and depend on interaction distance.

In the year of 2015, the authors "swati vaid; preeti singh; chamandeep kaur et.al", presented a paper titled "EEG signal analysis for bci interface: a review", in that they described such as: Brain Computer Interface (BCI) systems are the devices which are proposed to help the disabled, people who are incapable of making motor response to communicate with computer using brain signal. The aim of BCI is to interpret brain activity into digital form which acts as a command for a computer. One key challenge in current BCI research is how to extract features of random time-varying EEG signals and its classification as accurately as possible. The following are the feature extraction and conclusion of the mentioned paper:

Feature Extraction:

Feature extraction techniques are used to extract the features which represent a unique property obtained from pattern of brain signal. Earlier EEG analysis was restricted to visual inspection only. The visual inspection of the signal is very subjective and hardly allows any standardization or statistical analysis. Hence, several different techniques were intended in order to quantify the information of the brain signal. Many linear and non-linear methods for feature extraction exist.

Conclusion:

The purpose of this paper is to give a brief introduction to the EEG signals and BCI system. The paper also includes a review on the conventional methods that are used for feature extraction of the signal.

III. PROPOSED SYSTEM SUMMARY

A Brain-Computer Interface (BCI) is a system that enables a communication that is not based on muscular movements but during brain activity. This activity can be measured through electroencephalographic (EEG) signals. Several EEG signals can be detected, resulting in different types of BCI. Simple two-class BCI system, there are normally only two output commands e.g., a left hand motor imagery (MI) or a right hand/foot MI, for every trial rendering control of assistive devices such as a keyboard selection, which requires multiple motion commands, a significant challenge. MI is used in this paper to control the proposed interface using the synchronous mode of BCI operation (cue based and computer driven). It involves selecting the movement tasks, to select the keyboard. The class information (left hand or right hand movement imagery) from the features of the filtered EEG signal is sent to the iAUI. The iAUI is composed of four main modules namely the communication module (CM), the information refresh module (IRM), the adaptation module (AM) and the MM. The following are the modules used in this system and all are listed below:

- Measurement of EEG
- Preprocessing
- Feature extraction
- Classification
- Device control

Measurement of EEG

This is done by using the electrodes. Many BCIs use a special electrode cap, in which the electrodes are already in the right places, typically according to the international 10-20 system. It saves time because the electrodes do not have to be attached one by one. Typically, less than 10 electrodes are used in online BCIs with sampling rates of 100-400 Hz.

Preprocessing

This includes amplification, initial filtering of EEG signal and possible artifact removal. Also A/D conversion is made, i.e. the analog EEG signal is digitized.

Feature Extraction

In this stage, certain features are extracted from the preprocessed and digitized EEG signal. In the simplest form a certain frequency range is selected and the amplitude relative to some reference level measured. Typically the features are certain frequency bands of a power spectrum. The power spectrum can be calculated using, for example, Fast Fourier Transform (FFT), the transfer function of an autoregressive (AR) model or wavelet transform. No matter what features are used, the goal is to form distinct set of features for each mental task. If the feature sets representing mental tasks overlap each other too much, it is very difficult to classify mental tasks, no matter how good a classifier is used. On the other hand, if the feature sets are distinct enough, any classifier can classify them.

Advantages

- Low bandwidth of the communication channel problem overcome by using the intelligent adaptive user interface (iAUI) based on an adaptive shared control mechanism.
- The iAUI is the user-centric design that presents all the control options to the BCI user at all times.
- Better control as shown with the BCI accuracy assumption can be achieved with more training on the paradigm.
- The proposed interface designs have the potential to provide true independence to the BCI user with a combination of autonomous and adaptive designs while not compromising much on the overall cost for the device control task.

IV. RESULTS AND DISCUSSION

The following figure, Fig.2 illustrates the Brainwave Signal Graph view of the proposed system.

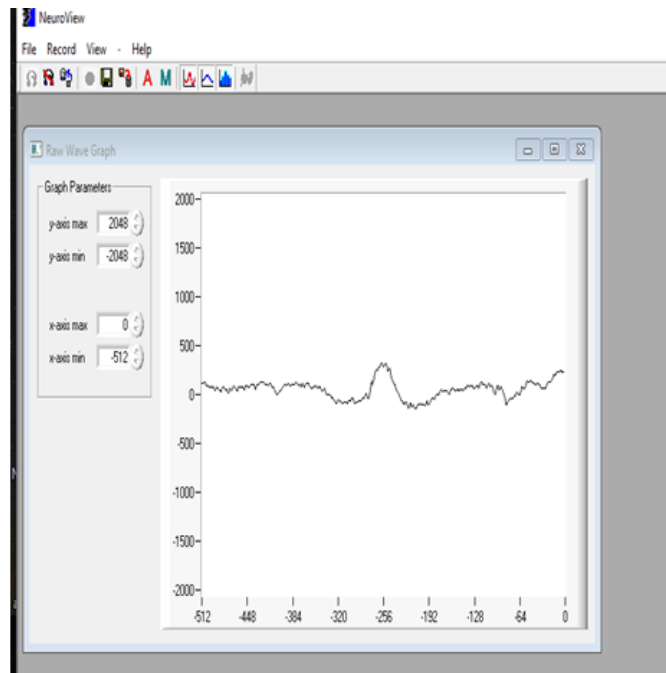


Fig.2 Brainwave Signal View

The following figure, Fig.3 illustrates the Attention level of Brainwave signal view of the proposed system.

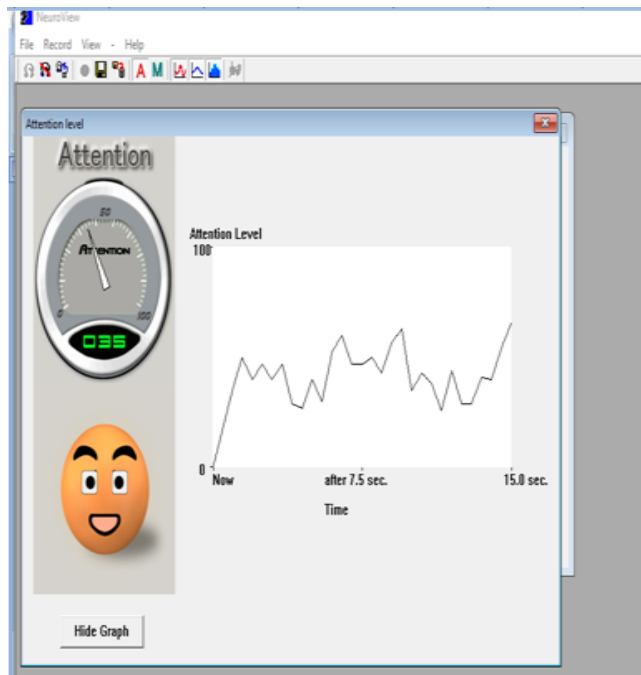


Fig.3 Attention level of Brainwave signal

The following figure, Fig.4 illustrates the Barchart representation of Brainwave signal view of the proposed system.

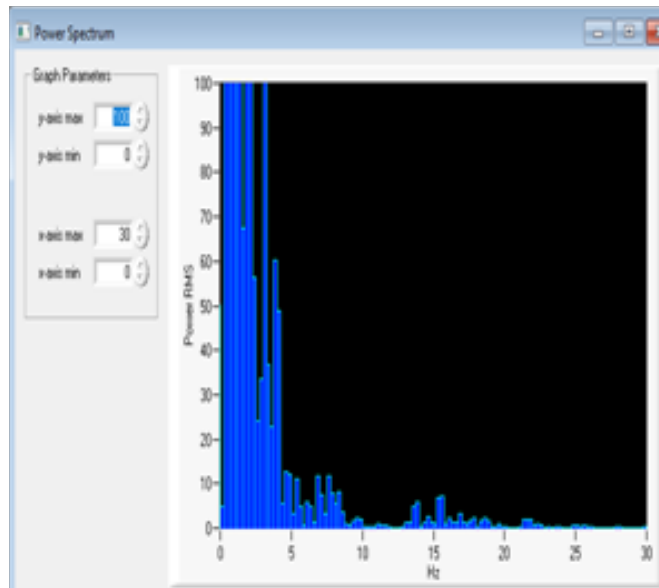


Fig.4 Barchart representation of Brainwave signal

The following figure, Fig.5 illustrates the Mediation Level of Brainwave Signal view of the proposed system.

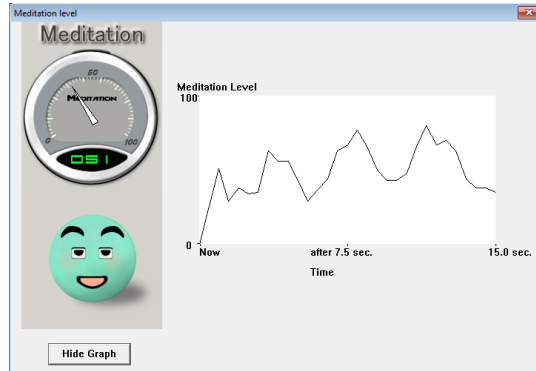


Fig.5 Mediation Level of Brainwave Signal

The following figure, Fig.6 illustrates the Wave Representation of Brainwave signal view of the proposed system.



Fig.6 Wave Representation of Brainwave signal

The following figure, Fig.7 illustrates the Low Level Attention view of the proposed system.



Fig.7 Low Level Attention

The following figure, Fig.8 illustrates the Medium Level Attention view of the proposed system.



Fig.8 Medium Level Attention

The following figure, Fig.9 illustrates the High Level Attention view of the proposed system.

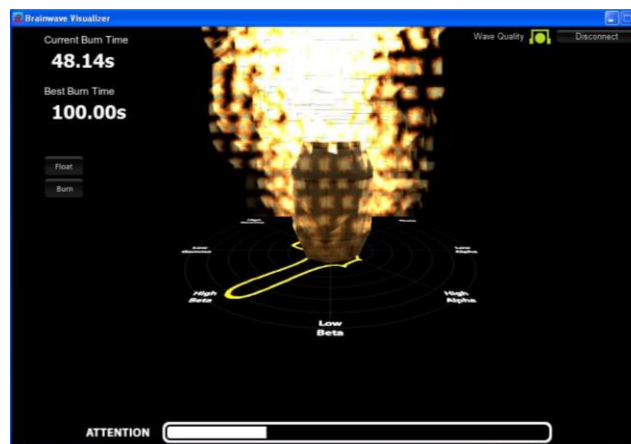


Fig.9 High Level Attention

V. CONCLUSION AND FUTURE SCOPE

BCI is majorly used in science history which provides functionality between mind and gadget which consider the many application for further use transmission tool for severe disability and artificial limbs to monitoring disabilities such as quadriplegic, cerebromedullospinal. Neurorehabilitation after neurological injuries and entertainment & gaming. Polygraph test, brain fingerprinting, trust assessment. BCI is a field of practical study so it always in it's infancy. The comparative research on various components of BCI is ongoing that investigate useful instinctual waves; signal capturing, feature extraction and translation methods for combining short- and long-range adaptations between human and device to improve the performance that are suitable for BCI applications such as clinical Applications; communication, movement control, Neurorehabilitation.

The motivation for making more user friendly, faster, cheaper and public available systems will be totally different and become of a much higher priority. The targeted groups of users are not forced to utilize BCI systems, and thus needs better



reasons for wanting to, other than it is cool to be able to control your computer with the mind. Current systems do not meet such standards. The motivating thought is that approaching this issue from an entertaining point of view could help getting BCIs to such standards faster.

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