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BRAIN COMPUTER INTERFACE BASED COMMUNICATIVE DEVICE FOR PARALYZED PEOPLE

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***Abstract*—** The concept of interfacing mind with machines has been extensively seized the human illusion. Recent advances in neuroscience are forging this idea to reality, opening a door to rejuvenating and potentially augmenting human physical and mental capabilities. Brain Computer Interface (BCI) systems have been widely used to develop viable assistive technology for physically incapacitated person. It is a powerful communication tool between users and systems. Here we develop a system that uses brain computer interface to enable the paralyzed people to communicate their needs to the external world through a visual interface. The patient will be provided with a screen that consist of options. The system uses the variations in the brain signals that are produced due to the various desires of the human being. Here the signals produced by the brain is recorded by using a sensor called electroencephalogram (EEG). These signals are classified and the need of the patient is identified according to the variation in the signals and are highlighted on a screen followed by an alarm and a message to the caretaker. These systems are very useful to the patients who are suffering from locked in syndrome. These enables them to communicate to their caretakers as well as to the external world.

***Keywords*—** *Brain Computer Interface (BCI), Electroencephalogram (EEG), Common Spatial Pattern (CSP), Linear Discriminant Analysis (LDA)*

I. INTRODUCTION

A brain computer interface (BCI) is a technological system that enables a person to control the external world without relying on muscle activity. Rather than depending on the body's normal output pathways of nerve cells and muscles, the input control signals are represented by electrophysiological impulses recorded directly from the brain. The majority of existing brain computer interface systems, uses electroencephalogram (EEG), as the source of input. The central nervous system (CNS) consists of two main components, the spinal cord and the brain, where the latter is denied as the part that is located inside the skull. A brain computer interface, sometimes called a direct neural interface or a brain-machine interface.

BCI is an extensively used tool that allows humans to control their surroundings. It is a powerful tool that provides communication between users and systems. These systems are widely used in the field of medical science in order to help the people with disabilities to control their living environment. These systems have facilitated to restore the moving ability for people who are suffering for movement ability for physically challenged or locked-in users and replacing lost motor functionality. Nowadays the scope of the research is further extended to non-medical applications. The researches that are conducted are mainly focuses on individuals by exploring the use of BCI as an important input device run many applications as per the need. BCI are widely used in safety applications BCI could be helpful especially for safety applications or applications where it is instantaneously difficult to move and the response time is crucial. Besides they can also be used to increase the accuracy of the HCI systems, resulting in BCI contribution in various fields such as industry, educational, advertising, entertainment, and smart transportation. The major challenges that are faced by these systems is in recording the input accurately. There are numerous techniques that are used to record the signals produced by the brain in which most of them are not accurate. These systems are prone to noise that are produced by various internal activities that are produced by the humans as well as the surroundings.

BCI systems can either invasive or non-invasive. The major difference between invasive and non-invasive BCIs is that in invasive BCI the electrodes are implanted directly on or inside the cortex by a brain surgery. On the other hand in non-invasive BCI we place the electrodes on the surface of the brain. Numerous signals that non-invasive BCI’s take as inputs are electroencephalogram (EEG), magneto encephalogram (MEG), blood oxygen level dependent (BOLD) signals, and oxyhemoglobin concentrations. Among these signals EEG is the most widely used brain signals to control the BCI systems.

There are several frameworks that handle brain computer interfacing. These frameworks vary according to their types of classifiers and analysers that are used to enforce these activities. This paper proposes a new interface of communication to the people who are suffering from locomotive disorders such as locked in syndrome.

II. RELATED WORK

The authors, Sarah N Abdulkadar, Ayman Atia and Mostafa-Sami M Mostafa, provides the various applications and challenges that are faced by the system based brain computer interfacing. The various applications include Mind reading and remote communication have their unique fingerprint in numerous fields such as educational, self-regulation, production, marketing, security as well as games and entertainment. This paper also provides the basic techniques of signal acquisition, signal pre-processing, feature extraction and classification of the various signals that are produced by our brain. It also deals with the challenges that are faced by the brain computer interfacing systems. The challenges include usability challenges, training process, information transfer rate, technical challenges, nonlinearity, non-stationary and noise. These difficulties can be rectified by using various technologies that are currently available.[8]

The authors, Balkis Solehah Zainuddin, Zakaria Hussain and Iza Sazanita Isa, provide the signal frequencies and their various applications. The authors specify that the brain signals are mainly classified into 4 like delta(0.5-4Hz), theta(4-7Hz), alpha(7-13Hz) and beta(>13Hz). They also design and develop a method that can be used to record and separate the brain signals that are produced by the brain. In this they use the EEG sensor to record the bran signal that are produced by our brain. These are pre-processed in order to remove the artifacts and noise. After this the features are extracted by using the various feature extraction algorithms such as ICA, PCA, etc. This output is fed to classifier which uses classification algorithms such as LDA. These are then fed to an interface in order to convert them to commands so that they can control an external applications.[2]

The authors, Mashael M AlSaleh, Mahnaz Arvaneh, Heidi Christensen and Roger K Moore, provides various techniques that are widely used for developing the various speech recognition system. Here they specify how to recognize the various speech imaginations made by humans. These include word imagination, syllable imagination, vowel imagination. In this they have performed experiments on a normal person as well as on a stroke patient. Here the reading taken from the normal person is taken as a reference to the stroke patients readings. This allows them to develop a system that works more accurately than other systems. [3]

The authors, Sumit Soman and B K Murthy, provides a new communication system that allows people to communicate to the external world. This system is developed mainly for the people who are suffering from locomotive disorders such as locked in syndrome. Here they have developed a system that works based on the eye blinks of a person. An LCD screen with a certain number of options will be provided to the paralyzed patient. The patient can select the required option by using his eye blinks. Whenever an eye blink is detected the system will highlight the selected option on the screen. They use three stages of eye blink detection. For example, in the first stage if the patient has chosen help me from the given set of options. By seeing this the system will provide another set of options on the screen like need a doctor etc. The major disadvantage of this system is that the ordinary eye blinks are also detected as a selection criteria which is not required.[1]

III. METHODOLOGY

The major objective of this system is to provide a communication interface for paralyzed people so that they can express their need to the external world.

Block Diagram:

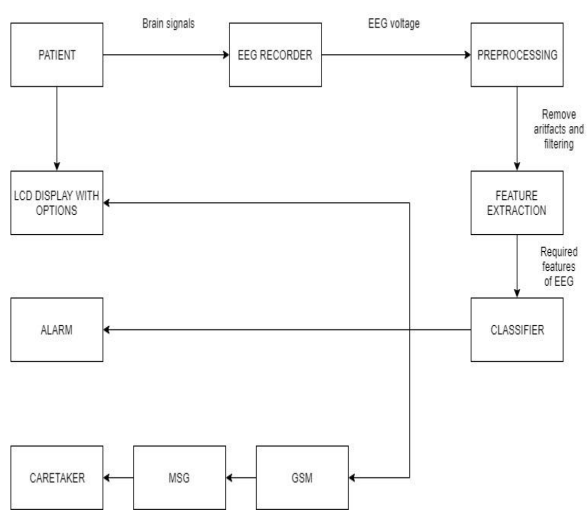

Figure 1: Block Diagram of Communication Device

The BCI system consist of four stages. They are as follows:

i. EEG signal acquisition

ii. Preprocessing and feature extraction
iii. Classification
iv. End user

In the EEG signal acquisitions stage is responsible for providing an interface between EEG recording device and the human brain in order to provide the EEG data stream for further processing.

The preprocessing and feature extraction stage is responsible for removing the artifacts and filtering of the EEG data. It is also responsible for selecting significant components from the EEG data stream.

The next stage is the classification stage in which we classify the EEG data. The output of the classifier will be the required signal frequencies which enables us to retrieve the requested options from the screen.

The last stage is the end user screen. In the end user screen the requested option is highlighted depending upon the frequency derived from the classifier.

Thus the system uses variations of brain signals that are produced by human brain to communicate the various requirements to the external world.

The BCI processing

This section provides the various components of the BCI system. This section also specifies the working of each component that are used in the system.

i. EEG signal acquisition system

This stage essentially involves acquisition of the EEG signals utilizing a congruous contrivance, such as the Emotiv Neuroheadset. During the training phase, the subject sits facing a screen wearing the EEG headset. The EEG of the subject is being perpetually recorded and stored in a file. As the subject performs the action intended for the tribulation, markers are integrated to the file to enable extraction of EEG signals in a time window around the events for further processing. The user's EEG data is acquired for multiple tribulations, which constitutes a session. The sequence of tribulations are randomized to obviate adaptation of the brain.

ii. Preprocessing and Feature extraction

In the preprocessing stage the signals are fed to a preprocessing system that contain four types of filters including low pass filter, high pass filter, band pass filter and notch filter. The resulting signal is fed to a feature extraction system that uses Common Spatial Analysis (CSP). CSP is chosen for feature extraction because of its primary advantage that it addresses the problem of spatial blurring.

In CSP we first compute the covariance matrix of the trials, and then obtain the normalized covariance matrix for data of both classes. These are cumulated to obtain the composite normalized covariance matrix. Next, we obtain the eigenvalue decomposition of the composite normalized covariance matrix and compute the whitening transformation from the decomposition. We then re-compute the eigenvalue decomposition of the whitened matrix and cull the 'k' eigenvectors corresponding to the 'k' highest eigenvalues. Here, 'k' is a configurable parameter of the CSP algorithm. Conclusively, we project the data to the 'k' dimensional subspace spanned by the eigenvectors and take the log-variance of the projected vectors as features for each recording.

iii. Classification

In this stage we use Linear Discriminant analysis (LDA), it is trained to identify the intent from the recorded trials. The main aim of the classification stage is to obtain a linear decision boundary between the features of the classes. This reduces the overall error in the classification. The classifier is trained based on the previously recorded trails and based on this trials the current EEG recording data are separated and assigned to various classes. The output of the classifier is fed to end user.

iv. End user

The output of the classifier is fed as input to this stage. Depending upon the frequency the option on the screen is highlighted and an alarm is turned on so that the caretaker can attend the patient if he is nearby. A GSM module is also attached so that a message is send to inform the caretaker about the patient's need.

RESULTS AND DISCUSSION

The system was developed to help the people who are suffering from locked in syndrome. It provides communication ability to the people so that they can communicate their requirements to the external world. The system consist of an LCD screen which consist of several options that can be chosen by the patient by using his brain waves. The system uses beta signals that are generated by the brain since these signals are caused due to attention of the user. This is then recorded by using an EEG headset and fed to the preprocessing unit which will remove the noise from the signal. This signal is sampled and fed to the feature extraction unit. The feature extraction unit uses CSP to retrieve the specific features from the recorded signal. This is then fed to classification unit that uses LDA to classify the signals. The output of the classifier is fed to the external application which will highlight the chosen option from the set of given option followed by an alarm. Then a message that specify the chosen option is also send to the caretaker. Thus the system works as a communication assistance for paralyzed people.

IV. Conclusion AND FUTURE SCOPE

The research and advancement of Brain Computer Interface systems have earned a tremendous attention because they can help to bring back mobility to people with annihilating neuromuscular disorders and thus elevate their quality of life. In this paper we presented a communication system that enables the communication to the people who are suffering from locomotive disorders. Here the brain computer interfacing technology has been used to identify the various requirements of the patients. The patient is provided with an LCD screen with some of the most required options. From this the person an choose his need by using his attention. The brain signals thus produced will be recorded by using the EEG signal acquisition system and processed to get the unique frequency. Thus the chosen option is highlighted on the screen and an alarm is turned on in order to notify the caretaker. Followed by this a message will be also send to the caretaker. This system is useful in the case of paralysis as well as in the situations where people cannot speak. This system can be extended to involve all the requirements of the user.

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