CHAPTER 1

INTRODUCTION

A Brain Computer Interface (BCI) system is a communication system where a person has the ability to communicate with a computer through his or her brain signals rather than using the peripheral nerves and muscles. A BCI system effectively allows for the conversion of patterns of electrical brain activity into commands to control specific equipment.

BCI technology relies on the acquisition of electrical signals generated by billions of neurons inside the brain. The electrical fluctuations that arise from these neurons reach the scalp where they can be detected and recorded by means of non-invasive metal electrodes through a process known as electroencephalography (EEG).

In a BCI system EEG data is recorded from the human subject and this is then processed to extract reliable features which can then be mapped into computer based commands such as moving a cursor on a screen or selecting from sets of letters.

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1.1 Purpose

Historically, assistive technologies(AT) have relied on the person being able to manoeuvre at least one part of their body. For example, an Augmented Communication Device may require them to press buttons on a keyboard that has pre-designated questions, statements or responses. These devices can be adapted in order for the buttons to be pressed with a finger, a toe, or a metal-pointer attached to their head.

The issue is with people with severe disabilities such as locked-in syndrome who aren't capable of motor function other than eye movements.

Technology in the form of the brain computer interface (BCI) provides hope for these and many other people because we no longer have to imagine being able to use our thoughts to control a wheelchair or a communication device. The BCI Operated Media Player designed by us promises to enhance life immensely for those with severe disabilities such as locked-in syndrome.

1.2 Scope

The BCI Operated Media Player has been designed keeping in mind the needs of people who are partially or completely locked in. Assistive technology fails in the case of such severe disability due to lack of or limited motor function.

1.3 Definitions, Acronyms and Abbreviations

EEG : electroencephalography

LIS : Locked-in-Syndrome

BCI : Brain Computer Interface

AT : Assistive Technology

1.4 Literature Survey

In their paper titled **"Mu and Beta Rhythm Topographies During Motor Imagery and Actual Movements",** Dennis J. McFarland, Laurie A. Miner, Theresa M. Vaughan, and Jonathan R. Wolpaw compared the effects of motor imagery on mu and beta rhythms, and compared it with that of actual movement. They found that the the **mu and beta rhythm topographies are similar for movement and imagery**.

For both movement and imagery, mu desynchronization is greatest at CP3 and beta desynchronization is greatest at CZ.

Dandan Huang, Peter Lin, Ding-Yu Fei, Xuedong Chen and Ou Bai found that the reason for the fact that motor imagery has less robust performance than physical movement might be that **motor imagery is not a natural behaviour** and thus requires more effort than performing physical movement. Besides, compared with physical movement, there is no neural feedback in motor imagery which may exhibit less activity (ERS) in the motor cortex and result in a lower signal to noise ratio. Considering that motor imagery is more meaningful for BCI application, training may be needed to enhance the involvement of subjects with motor imagery. These findings have been published in **"Decoding human motor activity from EEG single trials for a discrete two-dimensional cursor control"**

In their research paper titled **"Patients with ALS can use sensorimotor rhythms to operate a brain-computer interface"**, Kubler et. al showed that using motor imagery based BCI can improve the quality of life in patients with severe motor disabilities. This is done by establishing a means of communication that is independent on muscle control via. In their experiment, our **people severely disabled by ALS learned to operate a BCI with EEG rhythms** recorded over sensorimotor cortex.

Ho¨hne J, Holz E, Staiger-Sa¨lzer P, Mu¨ ller K-R, Ku¨bler A, et al. showed that **non-invasive BCI using motor imagery can be used to overcome severe motor impairments in patients that are locked-in and almost completely locked-in** in their paper titled **"Motor Imagery for Severely Motor-Impaired Patients: Evidence for Brain-Computer Interfacing as Superior Control Solution".** The researchers used state of the art machine learning methods to enable these patients to use BCI in six or less sessions. The BCI was used to operate a gaming application. 3 out of 4 severely disabled patients were able to gain significant control via motor imagery.

In the paper , **"An EEG-Based BCI System for 2-D Cursor Control by Combining Mu/Beta Rhythm and P300 Potential"**, Yuanqing Li, Jinyi Long, Tianyou Yu, Zhuliang Yu, Chuanchu Wang, Haihong Zhang, and Cuntai Guan have presented a new BCI and its implementation for 2-D cursor-control by **combining the P300 potential and motor imagery**. Two almost independent signals have been obtained for controlling two degrees of movements of a cursor simultaneously. In particular, a motor imagery detection mechanism and a P300 potential detection mechanism were devised and integrated with a specially designed GUI.

In the study titled **"Quadcopter control in three-dimensional space using a non-invasive motor imagery based brain-computer interface"**, Karl LaFleur, Kaitlin Cassady, Alexander Doud, Kaleb Shades, Eitan Rogin, and Bin He performed an experimental investigation where 5 human subjects were trained to demonstrate their ability to control a robotic AR Drone quadcopter in a three-dimensional physical space by means of a motor imagery EEG brain-computer interface. Through the use of the BCI system, **subjects were able to quickly, accurately, and continuously pursue a series of foam ring targets and pass through them in a real-world environment using only their "thoughts".**

Jason Sleight, Preeti Pillai, Shiwali Mohan performed experiments to show that the using EEG signals to perform classification of executed and imagined motor movements can be performed effectively through the use of **sophisticated machine learning techniques such as ICA and SVM**, despite the close similarities between the two signals. However, they found that results differ significantly across patients, suggesting that **BMI is highly specialized and must be uniquely determined for each individual patient**. Published in **"Classification of Executed and Imagined Motor Movement EEG Signals"**

In **"An ERD/ERS Analysis of the Relation between Human Arm and Robot Manipulator Movements"**, results show that in the case of movement execution and imagination, the ERD in the **contralateral motor area (C3) is more**

intense than in the ipsilateral motor area (C4) as expected. Ernesto Pablo Lana, Bruno Vilhena Adorno, Carlos Julio Tierra-Criollo state that this feature could be used for left and right arm movement discrimination, in the case of an implementation of a BMI using two robotic manipulators.

In their paper- "**Virtual Keyboard Controlled by Spontaneous EEG Activity**",B. Obermaier, G. R. Mueller and G. Pfurtscheller demonstrate another application of motor imagery. They test a virtual keyboard on severely impaired patients. The operation of the VK is based on an application of Graz BCI. The spelling consists of the selection of a letter using successive steps of isolation. Three patients were tested and an error-free letter selection is done in six trials. The experiments showed that **this device can be used as an alternate spelling device because it has a higher spelling rate**.

In their paper titled "**Motor Imagery Based On Wavelet Power Spectrum for a Brain Computer Interface"**, Javier Castillo-Garcia, Eduardo Caicedo , Berthil Borges Longo, Alan Floriano ,and Teodiano Bastos-Filho performed a study where **a BCI based on wavelet power spectrum using motor imagery** is implemented. Four motor tasks were used and the method proposed achieved success rate of 89% and ITR of 11.40 bit/min. The proposed method had statistical significance (p-value<0.05) and the size of effect was very high (>2.0) for sensitivity, specificity, accuracy and Kappa coefficient.

1.5 Existing System

One of the major issues faced by people with LIS is that they cannot use modern technology, especially to communicate with computers. They cannot access the computers through any means at present. While there are a few applications like Graz BCI and Virtual Gaming that allow interactions with computers, these are extremely application specific. They do not focus on the general use of computer systems.

The current systems use multiple stimuli and modes to scale up from one dimension to multiple dimensions. That is, different methods are used in parallel to measure signals in each dimension. This can be resource extensive and expensive.

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1.6 Proposed System

The proposed system aims to help the people in locked-in-state to operate a media player by imagined movement, also known as motor imagery.

Research has shown that the electrical signals produced in the brain upon actual motor function are the same as those produced when the same motor function is imagined. This is the basis of motor imagery.

We use a combination of binary digits, wherein left hand movement maps to a ‘0’ and right hand movement maps to a ‘1’, thereby creating a language. These strings are then mapped to inputs to the computer system. This allows us to scale up to multiple dimensions without the requirement for additional hardware or techniques.

Existing systems use different paradigms such as motor imagery, P300, SSVEP for each dimension when the system is required to scale to more than one dimension. This results in additional cost in terms of hardware and processing. We reduce this cost by allowing scaling up to multiple dimensions using just a single paradigm such as motor imagery.

1.7 Statement of the Problem

Design a system that allows people with severe motor disability to communicate with computers in real time. This system should be able to scale up to multiple dimensions effectively.

1.8 Summary

This chapter gives the details about the existing problem and the purpose of our project. It also contains details about the system and the proposed system. It makes us aware about the different terminologies, definition and abbreviations used in the project.