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A Mind Operated Computer Mouse using Discrete Wavelet Transforms for Elderly People with Multiple Disabilities

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Abstract

According to a statistical survey made by World Health Organization (WHO) India suffers from highest number of road accidents and out of which more than ten percent of them are prone to head injuries. This scenario leads to patient's death or make the victim to become comatose. Also, many different disorders can disrupt the neuromuscular channels through which the brain communicates with and controls its external environment. Brainstem stroke or spinal cord injury, cerebral palsy, muscular dystrophies, multiple sclerosis and numerous other diseases impair the neural pathways leading to communication and control which make the victims intellectually or physically disabled. Most often, the communication for paralyzed people is established by using a Brain Control Interface (BCI). Most of the existing systems had experimented Brain Computer Interface either with animals or healthy human beings. But, this paper focuses on movements of the mouse cursor controlled by a person with multiple disabilities. The mouse cursor movement would further be used by the disabled person to have a communication with his caretaker by means of the software developed by us. The proposed system uses discrete wavelet transforms for de-noising the muscular and cardiac signals. An independent component analysis is performed in order to extract the beta rhythms from the EEG signal. The mouse control is achieved by interfacing the mouse with a microcontroller which receives the operating voltages from the Data Acquisition System (DAS) which acquires and conditions the EEG signals coming from the user brain. The proposed system is tested on several young and elderly persons and is found to be working with more than 95% accuracy

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1. Introduction

A Brain–Computer Interface (BCI) activates electronic or mechanical devices with brain activity alone. BCIs and BMIs allow direct brain communication in completely paralyzed patients and restoration of movement in paralyzed limbs through the transmission of brain signals to the muscles or to external prosthetic devices. We differentiate invasive from noninvasive BCIs: Invasive BCIs use activity recorded by brain implanted micro- or macro electrodes, whereas noninvasive BCIs use brain signals recorded with sensors outside the body boundaries. Advances in cognitive neuroscience and brain imaging technologies have started to provide us with the ability to interface directly with the human brain. This ability is made possible through the use of sensors that can monitor some of the physical processes that occur within the brain that correspond with certain forms of thought. Researchers have used these technologies to build brain-computer interfaces (BCIs), communication systems that do not depend on the brain's normal output pathways of peripheral nerves and muscles. In these systems, users explicitly manipulate their brain activity instead of using motor movements to produce signals that can be used to control computers or communication devices.

The BCI systems are classified into dependent and independent systems based on the usage of brain activity. A dependent system uses the activity in the brain's normal output path ways. An independent BCI system does not use brain's normal output path ways. Based on the placement of electrodes, the BCI systems are classified into Invasive and Non-Invasive systems.

The invasive systems involve attaching the electrodes directly to the brain tissue. The patient's brain gradually adapts its signals to be sent through the electrodes. The non-invasive systems involve placing the electrodes on the scalp of the patient and taking readings. The non-invasive methods take Electroencephalogram (EEG) readings of the brain. An electroencephalogram is a measure of the brain's voltage fluctuations as detected from scalp electrodes. It is an approximation of the cumulative electrical activity of neurons.

In 1950, Jase Delgado made the first wet brain implant on a living animal. In 1976, DARPA initiated the super BCI research. In the same year, Jacques J. Vidal has coined the term "BCI" and has proved that it can be used for communication. Researchers at Case Western University used 64 electrode EEG skull cap to return limited hand movements to quadriplegic people. In the year 2002, implanted monkeys were trained to move a cursor on a computer screen by researchers at Brown University. Brain gate, a brain implant system was developed by cyber kinetics along with Neuroscience department of Brown University in 2003. A high accuracy BCI controlled wheel chair was developed in Japan in 2005 [7].The work by Lisazyga in 2009 explained the details of the system that can urn brain waves into FM radio signals and decode them into sound [8]. Again in 2009, Dr. Chris James experiment had one person using BCI to transmit thoughts translated as series of binary digits, over the internet to another person whose computer receives the digits and transmits them to the second user's brain through flashing an LED.

In 2010, a team from Singapore has developed an EEG based BCI training program that combines the advantages of traditional computerized programs and the "Neuro Feedback Training (NFT)" [9]. In 2011, the first thought controlled social media network is utilized by the Neurosky. The University of Technology, Sydney, has developed a "Thought controlled wheel chair" [10]. In 2011, Haier electronics developed the world's first BCI technology Smart TV [11]. In their paper "A New Gaze BCI Driven Control of Upper Limb Exo-skeleton for Rehabilitation in Real World Tasks" published in 2012, Antonio Frisoli et. Al., proposed a new multi-modal architecture for gaze independent BCI driven control of upper limb exo-skeleton for stroke rehabilitation to provide assistance in the execution of reaching tasks in a real world scenario [13]. A hybrid BCI to control the direction and speed of simulated or real world wheel chair was developed by Jinyi Long et.al in 2012 [14]. Nethu Robinson et.al from Nanyang University Singapore, used a signal processing technique to extract features from non-invasive EEG recordings for classifying voluntary hand movements in 2013[15].

In 2003, researchers at Duke University taught rhesus monkeys to consciously control the movement of a real time robotic arm using only feedback from a video screen and their thoughts. All the systems discussed above had experimented Brain Computer Interface either with animals or healthy human beings. But, this paper focuses on movements of the mouse cursor controlled by a person with multiple disabilities. The rest of the paper is organized as follows: Section 2 gives the overview of proposed methodology, section 3 discusses the experiments made and results obtained and finally section 4 concludes the paper.