Research Article

ELECTROENCEPHALOGRAPHY AND EYE POWER FOR CONTROLLING SHOOTER GAME

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ABSTRACT

Neuromuscular stimulation (NMS) is an improving neuro-degenerative syndrome that impinges on the nervous system of human brain along with the spinal cord. Inspire of a complete and permanent paralysis, the patients are fully conscious and have a deep desire to communicate with others. Brain-Computer Interface facilitates controlling devices using brain signals. This study has been introduced to entertain persons in the midst of relentless motor deficiency by developing a real-time noninvasive BCI system. The users can turn a Computer application ON/OFF, move the cursor right/left/up/down and shoot any target by utilizing the power of their eyes. Based on the Electroencephalography technology, this research uses a MATLAB-based game and utilizes the cost- effective Emotiv EPOC System in extracting and recording the brain signals. As the amplitude of the mu and beta brain signals decrease during are alorimagined Movement; EPOC control panel, EmoKey and mouse emulator are used to translate the change of this amplitude into commands to control the computer cursor movement. Inhabitants with rigorous glide deficiency may possibly utilize human mind indicators for 2D subject movement and objective assortment through sense the object by individual's eyes and their heads.

Key Words: Computer Applications, Information Processing, Industrial Electronics, Brain-Computer Interface

INTRODUCTION

Brian Computer Interaction (BCI) has been utilized to recognize the commands obtained through sensing human eyes and heads. It is also used to process the computerized program by analyzing human brain signals as a nervous communication process. BCI could be classified into three different categories such as non-invasive, invasive and partially- Invasive. Non-invasive BCI, as EEG, is the most accessible method as the device to be adjusted on the façade of the human's scalp and there is no surgery needed. EEGs interface with different computers and imitate the information concerning patients' psychological strengths. Invasive BCI involves implanting an array of microelectrodes during the configuration of motor or illustration cortex giving the clearest and effective brain signals. It is used in many applications as the treatment of blindness. However, it is dangerous, costly and is associated with scar tissue buildup.

A partially-invasive BCI implants the array of microelectrodes contained by the cranium and does not implement in human brain internally. This type of BCI is virtually effectual in a similar way as invasive BCI. It is less complex hazardous, exclusive and less affected by scar tissue buildup. However, as the surgical procedure should be done, the device is still costly and unapproachable to the high proportion of patients. Regrettably, the mainstreams of BCIs are exceptionally valuable, uncomfortable equipment that is unattainable for the individuals belong from underprivileged backgrounds. Conversely, there is less significant, minor declaration EEGs with negligible necessitate of wearable hardware and in the corporation of improvement in wireless access to the host mainframe. Analysis and transformation of the brain signals to control technical device(s)/software(s) exist in the hosts personal computer (PC). This technique provides the security and efficiency through a less costly affiliation of non-invasive BCI (Anupama et al., 2012; Alwasiti et al., 2010). The aspiration for supporting handicapped has been tackled by several researchers via countless ways in diverse applications (O'Connor, 2013; Barea et al., 2002; Wolpaw et al., 2002; Wolpaw et al., 1991; Lievesley et al., 2011; Poor et al., 2011). Amyotrophic lateral sclerosis, ALS, is an advanced neurodegenerative syndrome that influences the nervous system of human brain along with the spinal cord. The motor neuron in NMS revolutionized deterioration ultimately guided to its fatality. Amid the expiry of motor neurons, the capability of the human mind intelligence to commence and manage body organism functioning would vanish. In the midst of deliberate muscular movement gradually altered, the infected people in their last arena of the syndrome might turn out to be completely paralyzed. According to NMS organization, the disease is relatively rare and affects about 400,000 people in the global context and put to death over 100,000 people annually (ALS/MND, 2016; NMS, 2016). This disease attacks motor neurons in the brain resulting in complete and permanent paralysis. Still, these patients are fully conscious, and have needs, feelings and a deep desire to communicate with others.

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Normal human beings are capable of communication using their throats, mouths, and hands, but severely disabled people are unable to use these typical channels for communication. These handicapped people in a desperate need to effective tools assisting them to control the external environment to live without much external help. There are many technologies and related tools for the handicapped people and channels for interaction.

BCI or mind-machine interface, MMI, is the human machine interface, HMI, which is capable of interpreting patient's contemplations into technologically organized indicators exclusive of the utilization of the conversation medium depended on the implementation of verbal communication or several additional neuromuscular movements. In order to help NMS patients and other similar handicap persons to communicate with the world more easily, a real-time inexpensive non-invasive HMI was introduced. The patient would be able to experience the alteration in game and entertainment atmosphere through shooter game (Cho & Lee, 2014). The reflected signals, according to the eye and head movements, are acquired by EEG and processed in a way to control the computer's cursor. The user including the NMS patient can play a Computer application without a need to any muscle except the eye and head movements. Figure 1 shows an ALS-patient is playing the shooter game by his eyes and his head only.

Figure 1: NMS patient is playing shooter game by his eyes and his head

MATERIALS AND METHODS
Materials
Shooter Game is a vertical-scrolling shoot-me-up based MATLAB game. The code is readable; well- commented and is broken down into lots of simple subroutines (Dave's MATLAB Shooter, 2011). The game comprises of 4 basic tasks: shooting, resetting, quitting, and moving the hero's ship left and right.

Many recently available technologies can be used in BCI such as EEG which is economical and uncomplicated to attain via making it the solitary functioning non-invasive mind idealizing the eminence of approach for frequently synchronized human brain responsive psychoanalysis (Zhang et al., 2008). EEG is a complex signal, illustrated in the form of periodic representation. This periodic representational action is alienated into different bands of ranges through regulatory frequency. The magnitude of an EEG stream normally allocated between the frequency bands commencing as regarded from 1 to 100 µV in a common grown-up person. The frequency-range of these potentials is 1 Hz to 30 Hz. There are major different six frequency bands, shown in table 1 (Rangaswamy, 2002).

Table 1: The Major Six Frequency Bands

Types of Waves	Frequency bands	Function
Delta Waves	0.5Hz-3.5Hz	These are the slowest wave but the highest in amplitude. They are normally associated with deep sleep.
Theta waves	3.5Hz-7.5Hz	They are associated with frustration, disappointment, drowsiness, and deep meditation and amplitudes $> 20\mu V$
Alpha waves	7.5Hz-12Hz	They are connected with leisure and disentanglement. Thinking of peaceful thing with closed eyes increases their levels.
Beta waves	12Hz-30Hz	They are small, fast and divided into β1 and β2. They are associated with focused concentration as during solving mathematics.
Gamma waves	31Hz-100 Hz	They are associated with attention, perception, and cognition.
Mu waves	8 Hz-11 Hz	They are strongly connected with motor activities.

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Physical changes observed in patients are particularly analyzed in the form of touch receptor on human body skin as well as a light receptor reflected on human eye's retina. The received signs produce Sodium and Potassium ions in the human mind to initiate motion transversely through the neuron's plasma covering. It in response sources an electrical current transfer from the brain. This flow of current could be utilized to estimate the movement isolated in the human mind and as a result, interpret essentially by the EEG. The people mind conditions evidenced by Electroencephalography (EEG) for the duration of playing on mainframe computer applications movement. The flow of electrical current is calculated with electrodes on the human scalp, which processed within an average range of 7 µvolts/mm.

Electrode placement is based on the International 10-20 International EEG System, generated in 1958 through a committee of the International Federation of Societies for EEG in addition to Clinical Neurophysiology. To give the consistency of electrode positioning among varying individuals, the International 10-20 system applies anatomic landmarks on the human scalp, shown in figure 2. These landmarks are presented as the nasion and the inion. The nasion is the region surrounded in the cranium precisely backward of the human eyes. The inion area is the lowest portion of the skull on the back of the human head. The "10" and "20" correspond to authentic detachment connecting neighboring electrodes which comprise of moreover 10% or 20% of the entire front to backward and rightward to leftward space of the cranium. Every position utilizes a correspondence to recognize the lobe and a figure to categorize the hemisphere position. The calligraphy F, T, C, P and O presented the Frontal, Temporal, Central, Parietal and Occipital, correspondingly. A "z" pointed to the electrode positioned on the central line.

Emotiv Epoc System is found in 2003 by Australian Electronics Company developing BCI based on EEG technology. It is based on a high-tech, affordable EPOC headset, for collecting EEG calculations and implemented a technical software assortment for functioning and examine the general information. The headset is wireless and utilizes a USB medium to commune through the 2.4 GHz band. EPOC headset contains a rechargeable battery of lithium for 12-hour duration, the sensors of 14 saline-based on EEG, and 2 gyroscopes. The Emotiv EPOC congregate information commencing the statistic channels named AF3, AF4, F3, F4, F7, F8, FC5, FC6, P3, P4, P7, P8, T7, T8, O1, and O2, figure 2. The Emotiv system is applying a high pass filter at a cutoff frequency of 0.16 Hz and a low pass filter frequency given as 83 Hz before it has been amplified by a differential amplifier about (1000 – 100,000 times). Followed by, a raw ADC with a rate of 2048 sec/channel. The given statistical information has been processed by a 5th order Sinc filter for indentation of 50 Hz and 60 Hz. The evaluated data has been modeled towards 128 sec/channel to eradicate the major harmonics. On the whole, the effectual bandwidth is 0.16 – 43 Hz with a 16-bit resolution. Figure 3 shows the block diagram describing this preprocessing technique. The preprocessed signal streams are in that case transmitted wirelessly to the host mainframe to perform analysis and transform them into control signals for software applications (Emotiv EPOC, 2014).
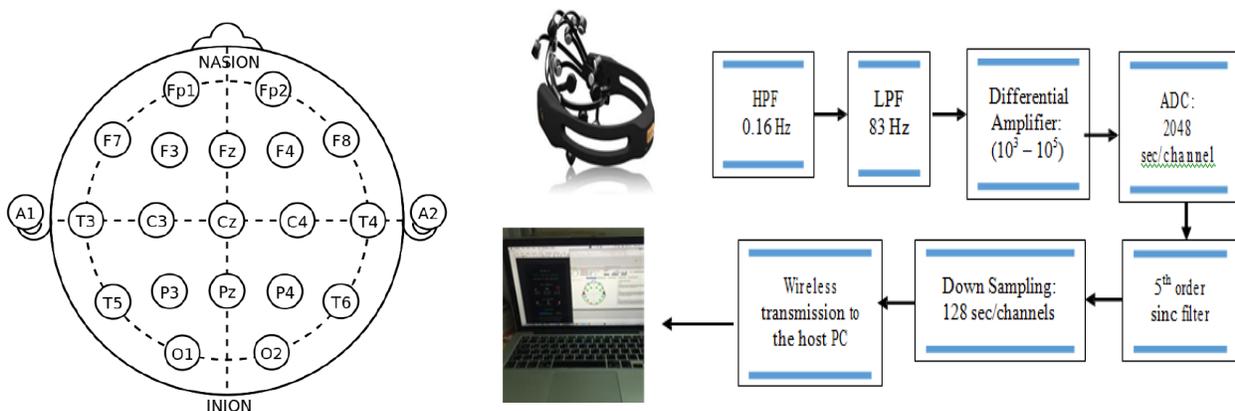
Figures 2 & 3: The electrodes' positions and the channels' names in the 10-20 international system. The block diagram of EEG preprocessing procedures

SDK Software
Emotiv recommended 4 forms of technical software improvement kits for contribution in a variety of controls in excess of the EPOC headset and recognition libraries and appeared in the corporation of up to 5 diverse licenses: Individual, Developer, Research, Enterprise, and Educational. This research used the Development Edition which comes with detection libraries, EPOC Control Panel, EmoKey and Mouse Emulator. Control Panel is a GUI which

establishes a connection with the headset and thus the acquired brain data. The signals' colors: green, yellow, orange, red and orange, red and black show the signals' strengths from the highest to the least respectively, figure 4. Expressive suite measures facial expressions and can distinguish 12 procedures: blink, left-right wink, left/right look, raise/ furrow brow, smile, laugh, clench, and left/right smirk. It includes the avatar which detects and mimics the user's facial expressions. Each facial expression can be converted into a combination of keystrokes, or mouse clicks by activating the EmoKey in a way that each facial expression can be linked to the application(s) running on the host PC, figure 5. Affective suite observes the consumer's sentimental conditions: commitment and dullness, annoyance, deliberation, immediate and long-term enthusiasm. Cognitive suite supervises the consumers' responsive judgments. It could be used to determine 13 types of feelings: left, right, push, pull, lift, drop, rotate left, rotate right, rotate forward, rotate backward, rotate clockwise, rotate counterclockwise and vanish. The movement human thoughts ought to be skilled earlier than bringing into play, and the consumer can narrate diverse judgments to the incorporated procedures (for example during providing the guidance of PUSH-command by idealizing "green"). The software bestows response in the structure of a hovering cube which will take action to the acknowledged opinions. Mouse Emulator uses the gyroscope and allows users to control the mouse with their head movements.

Figures 4 & 5: EPOC Control Panel: Headset Setup and Expressive Suite

Methods
After the Emotiv EPOC headset is equipped, the investigation objective deposit in his/her skull, and embarks on scrutiny the calibration during the response from the incorporated GUI. The entire conversation connecting the headset and the processor transpires during a regular USB dongle. The EPOC transmits the EEG stream of information through the scalp to the processing mainframe wirelessly. The received EEG signals are detected, translated and utilized, replacing the PC cursor's movement, in playing the shooter game. This approach is explained in the flow chart shown in figure 6. The study has utilized the Emotiv technology, Emokey, and mouse emulator to translate the facial expressions and head motion into commands. These commands control the shooter game which was installed on the host PC. Procedures for applying this mapping approach are shown in figure 7.

RESULTS AND DISCUSSION
We implemented our approach with six subjects of different genders and different ages. Screenshots of some of these procedures are shown in figure 8.
Handicap people used their eyes to perform particular movement function for sensors to detect their thoughts. Human eyeball could be considered as an unchanging dipole with a negative pole on the surface of the retina and positive pole on the surface of the cornea. Subsequently, the eye movement generates an electric field, and the cornea-retinal potential can be measured. Looking left creates a positive voltage at F7 and negative voltage at F8 while looking right causes the opposite. Looking-up causes negative potentials at both of F7 and F8 while looking down causes the opposite. When eye blinks, DC potential of high amplitude (mV) is sensed by the electrodes located at FP1/2) relative to F3/4.

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CONCLUSION

The research introduced BCI/HMI as a capable technology for generating the conversation association connecting human nervous structure and peripheral applications. Techniques of the human mind conceptualization and particularly the multichannel electroencephalography (EEG) are presented. The Emotiv software demonstrated the
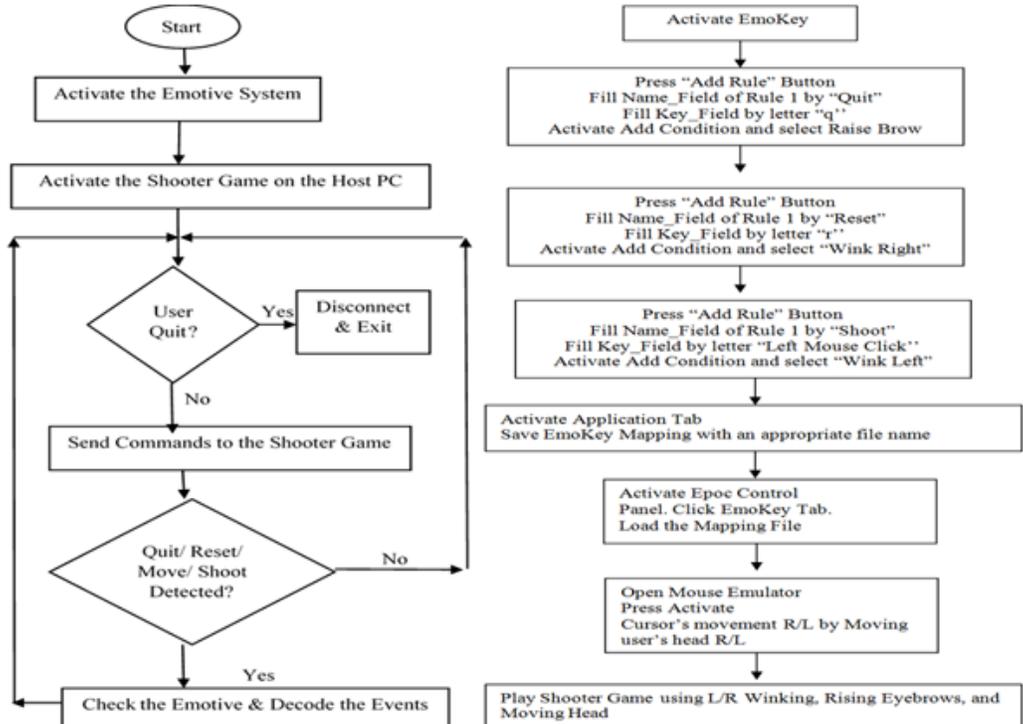
Figures 6 & 7.: Flow Chart of the used approach. Procedures for transferring facial expressions and head's motion into commands
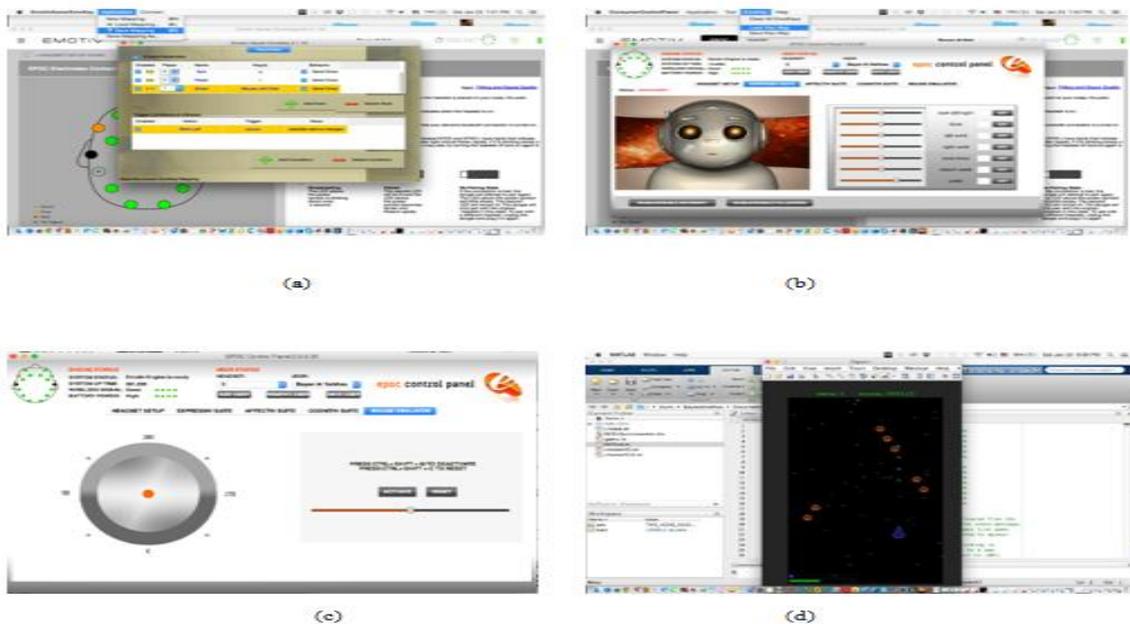

Figure 8: **The mapping approach. (a) & (b) Saving/loading the mapping (c) Activating the mouse emulator (d) controlling the shooter game using facial expressions and head movements**

EEG statistics in instantaneous moment next to the fourteen channels including all of those channels divergence with the consumer's judgments. Furthermore, the Emotiv technology has the ability to pick up facial expressions data. The immersive quality experience of the user can be affected not only by the sensible information but also by the atmosphere that responds the actions of user intelligently such as the agents in the game. When the agent acts irrationally or predictably, the user might feel boring, and a rejection of the immersive experience can be caused. Therefore, the immersion can be enhanced by the intelligent agent in the game system. In this research, the low-cost EEG Emotiv EPOC Neuroheadset was utilized to assemble a channel among the individuals' mind based facial expressions with a shooter game. We only utilized the expressive suite of the EPOC control panel and the mouse emulator as well. Successfully, the users could control the game without using the PC mouse but only by their thoughts, facial expressions, and head movements.

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