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BRAIN COMPUTER INTERFACE BASED WHEELCHAIR: A ROBOTIC ARCHITECTURE

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ABSTRACT
People with physical disabilities depend on technology for assistance and physical control. This paper presents non-invasive brain controlled wheelchair. Electroencephalogram (EEG) signals are used for controlling the wheelchair movement. Proposed design includes a novel approach for control wheelchair using Brain Computer Interface (BCI) technology. For validation of design a robotic module has been developed which can move under the control of human thoughts.

KEYWORDS: Electroencephalogram; Brain Computer Interface; Brainwave Sensor; Wheelchair;

INTRODUCTION
A person with physical disabilities can move from one place to another place independently with the help of wheelchair having joystick, touchpad, keyboard etc. But people who lose their muscle control are unable to operate the wheelchairs. Brain computer interface (BCI) is a latest method of communication between computers and human being. It uses a direct way of access to the intentions of a person. The communication towards computer and the will of the person which is fed into the machine gets collected at its source the brain[1].

BCI system is distinguished into two different categories, invasive method and non-invasive method. Invasive method consists direct implantation of electrode into brain for measuring brain signal while in non-invasive method brain signals are measured from scalp of brain. EEG is an example of non-invasive brain signals acquisition system. The EEG signals are of different classes based on their frequency range and occurrence. Delta, Theta, Alpha, Beta, Mu and Lambda wave are the types of EEG waves. Occurrence of these waves depends upon different activities performed by brain[2]. Proposed system utilize Mu signal. These Mu waves exist in frontal position of brain.

Table 1: Different Types of Waves

Sr. No.	Waves	Location	Generation	Frequency
1	Delta	Everywhere	During sleep and coma	< 4 Hz
2	Theta	Temporal and Parietal	Emotional Stress	4 - 7 Hz
3	Alpha	Occipital and Parietal	During mental imagery	8 - 12 Hz
4	Mu	Frontal	During intention for movement	9 - 11 Hz
5	Beta	Parietal and frontal	During intense mental activity	12 - 36 Hz

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LITERATURE SURVEY

EEG has history of more than 100 years Luigi Galvani first demonstrated in his research that the nerves contain an intrinsic form of electrical activity in 1791[3]. Based on this theory many researchers have been done for years. This EEG technique has been used by many of researchers for wheelchair control. Kazno Tanaka developed recursive training algorithm for generation of recognition pattern from EEG signal[4]. Junichi Miyata proposed υ-ϕ coordinates based system with straight and corner movement[5]. Brice Rebasamen developed a wheelchair based on P300 BCI system in which user has to select a destination amongst list of predefine locations[6]. Robert Prueckl proposed BCI based on steady state visual evoked potentials (SSVEP). For stimulation a box equipped with LEDs (for forward, backward, left and right commands) is used that flicker with different frequencies[7]. By using eight electrodes EEG signals are captured and Wavelet Packet Transform is used for feature extraction of relevant frequency[8]. Tom Carlson et al., 2013 showed four healthy subjects were able to control wheelchair using asynchronous motor imagery based BCI protocol[9]. Rajesh Singhla developed a wheelchair based on steady state visual evoked principle in which he found that Support Vector Machine(SVM) shows better accuracy than Artificial Neural Network(ANN)[10]. Tabias Kaufmann et al., 2014 proposed system which is based on tactually evoked event related potentials for controlling wheelchair[12]. Choi and coworkers, also used a BCI based on motor imagery to build a brain-controlled mobile robot.[13].

SYSTEM DEVELOPMENT

EEG is recording of minute electrical potential produced by brain. EEG acquires recording of the brain's spontaneous electrical activity over a short period of time as recorded from multiple electrodes placed on the scalp. Neuron is responsible for generation of EEG signals. Neurons generate potential which travels down and results into neurotransmitter. Receptor is present in dendrite which gets activated by neurotransmitter. Due to the alliance of receptor and neurotransmitter electric signal generated, can be measured at the scalp of brain.[15] This voltage varies from 1uV to 100uV. This generated potential difference is called EEG signal. This may vary according to brain activities of human being. The conceptual diagram of proposed system is shown in figure1.

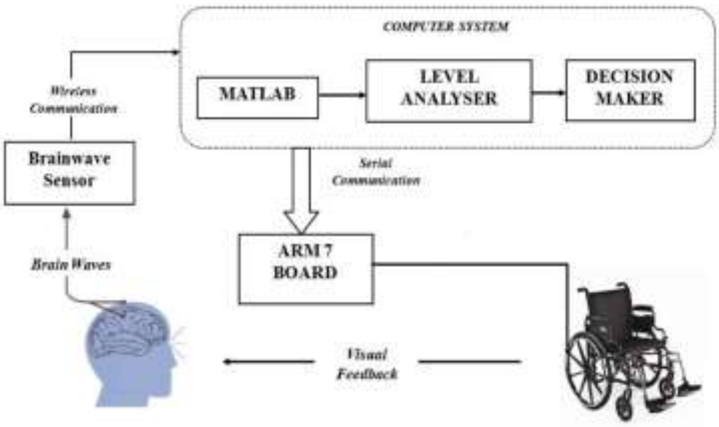

Figure 1: Conceptual Diagram of System

A. Brainwaves Acquiring System

For experimental purpose brainwave sensors is used for collecting EEG signals from scalp of brain. It is single node sensor that uses gold-plated dry electrodes for collecting brainwaves from the scalp of the brain. Sensor consist a single channel having three contacts points i.e. EEG, Reference and Ground. Out of frontal, parietal and occipital lobe Mu waves collects from frontal lobes FP1 node. Collected signals are in time domain and are converted into frequency domain in frequency range of 9 to 11Hz using Fast Fourier transform (FFT). Mu signals are transmitted to computer system via Bluetooth communication. The transmitted data is in digital form of brain concentration [11]. Computer system comprises of Matlab based analysis of data received from sensor. Received signal waveform in figure 2 illustrates brain concentration level of user. Artificial Neural Network (ANN) based classifier is used for decision making. This classifier is used to analyze comparison in between the collected values from sensor and reference level in order to generate a command which is required for movement of wheelchair.

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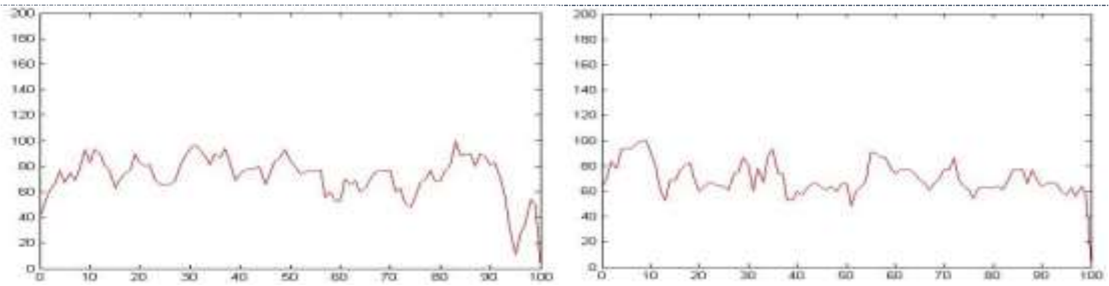

(a) ***(b)***

Figure 2: Mu waves for (a) User1 (b) User2

B. Robotic Module

A wheelchair prototype shown in figure 3 is used for validation of proposed system. L29d motor driver is used for movement of motor M1 (left) and motor M2 (right). ARM7 controller controls the motors by sending interrupt signals. Motors can be moved in forward or backward direction by changing bit combinations provided to motors. A Serial port is used to send data from computer system to robotic module. Bits combinations used to generate control commands and their respective functions are presented in table2. Forward movement of M1 and stop movement of M2 results in turning the wheelchair in right direction. Likewise other movements can be achieved[10].

Table 2: Bit Combinations for Motors

Sr. No.	Motor 1	Motor 2	Function
1	High	Low	Turn Right
2	Low	high	Turn Left
3	Low	Low	Stop Moving
4	High	High	Move Forward

RESULTS AND DISCUSSION

During the experimental setup signal samples from different users for various movements have been taken. For every person 10 samples of concentration level for each movement are taken. It is observed that concentration level of each user is different. Figure 3 illustrates graph of concentration level of users consisting average concentration level of distinct user for different movement.

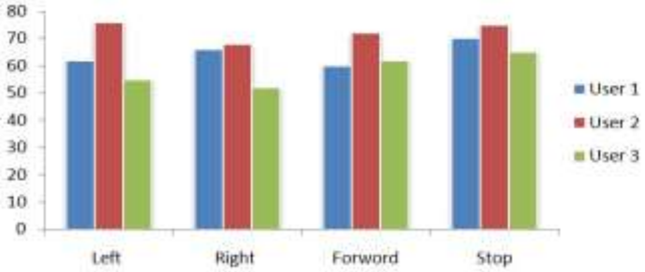

Figure 3: Concentration level of users

From figure 3 it is observed that an average concentration of user 1 is 65, user 2 is 73 and user 3 is 59. So these are the reference values for that respective user. By considering this reference value ANN classifier performs decision making operation for wheelchair for generation of movement command.

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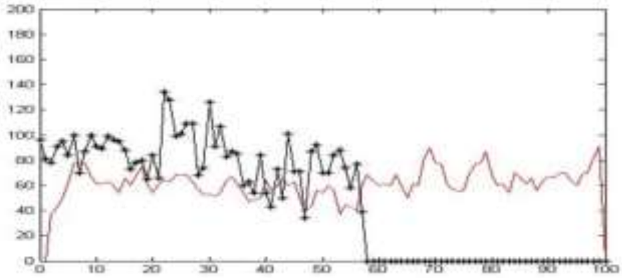

Figure 4: Combine graph for concentration and eye blinking

For examining the effect of performing different tasks together, eye blinking with full strength and thought of a movement are considered together. It is observed that while performing eye blinking, user's brain concentration level decreases. When user stops blinking his brain concentration level increases. This shows that user has to concentrate to perform a wheelchair movement. During performing actual experiment to move wheelchair by using EEG signals a negligible delay has been observed between user thoughts and wheelchair movement.

Accuracy of the system is measured by number of accurate movements performed by system according to user's thought. 10 samples of movement thought of each user are taken. Out of these, the correct movements are measured. Out of 10 samples for each user, 9 correct detections were measured for user1, 7 for both user2 and user3. Accuracy for each user is presented in figure 5 which shows upto 80% average accuracy for proposed system is achieved.

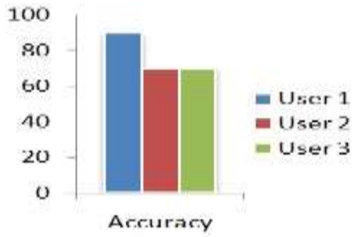

Figure 5: System accuracy

CONCLUSION

Use of BCI technology in human life results a comfort zone to a physically challenged people. Brain controlled wheelchair is one of the examples of it. But important task is to take brain controlled wheelchair from experimental stage to real world life. For this system Mu signals are use for controlling operations which is slow but reliable. Instead of using single node brain wave sensor, a sensor consists more number of nodes can be more effective to achieve better accuracy.

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