ISSN XXXX XXXX © 2019 IJESC

IJESC

Research Article Volume 9 Issue No.3

Brain-Controlled Neuroprosthetic Chair

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Abstract:
This paper presents the future of technological advancements in the wheelchair industry through brain control. The modern world sees a larger percentage of disabilities among the world population. Nearly about 3.6 million are using wheelchairs to overcome their physical disability. Nowadays, the most popular technology that experts provide the disabled with is an electric-powered wheelchair. However, this technology has basic drawbacks since the disabled still are not able to reach the wheelchair if it was placed far from them; and still needs help from somebody. The objective of this project is to create a system that helps the incapacitated to move their wheelchairs to the desired destination. Brainwaves are produced by synchronized electrical pulses from masses of neurons communicating with each other. These pulses are of lower order (mV or μV). Brain waves can be sensed using Electroencephalography methods (EEG). This measurement is of invasive or non-invasive types. Invasive type involves implanting electrodes under the skull. This method has a high sensing tendency but causes severe after-effects and it leads to the formation of permanent scar tissue over the brain surface which in turn reduces the sensing ability. Noninvasive type involves electrodes being placed over the head and forehead. This method has a low sensing tendency but doesn't affect the functioning of the system or brain. Later developments in technology improved the sensing tendency of the noninvasive method.

Keywords: Brain Control, EEG Waves, Human Brain, Interface, Wheelchair

I. INTRODUCTION

Advancements in user interface started its initiation from punch cards and magnetic tapes to today's multi-touch and Gesture controlled devices. The next phenomenal outcome of the user interface would be a brain-computer interface. It acquires the direct input from the brain as signals process, analyze and transmit input to the desired output action. The brain-computer Interface will be a revolutionary technology for people disabled by neuromuscular disorders. This BCI technique can be used for persons with physical ailments to operate the movement of the wheelchair without any dependence on others for help. The direction of the wheelchair can be controlled with forced actions.

II. METHODS OF ACQUIRING BRAINWAVES

1. Traditional Method

The electrode caps consists of electrodes which are placed over the head in an arrangement called the 10-20 system shown in Fig 1. This is a placement scheme devised by the international federation of societies of EEG for electrode caps. It takes several numbers of electrodes to analyze the brain and understand its neural activity. It is mainly used for study purposes. This became outdated as the technology improves in folds by reducing the number of electrodes needed by increasing the sensitivity of the electrodes for capturing the Brainwaves efficiently.

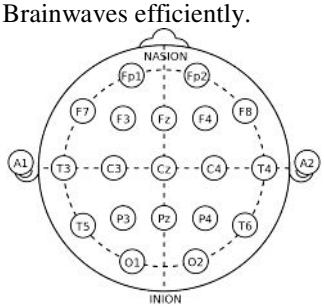

Figure. 1. 10-20 Electrode Cap

2. IMPROVED METHOD

The study using traditional method led to the finding of the area where the activities of the brain are concentrated. This reduced the number of EEG pickup electrodes needed. The parts of the brain where the EEG pickups could serve the purpose are Frontal Lobe, Motor Cortex, Auditory Cortex, Occipital Lobe, Parietal Lobe, Somatosensory Cortex, Visual Cortex, Temporal Lobe. They are depicted better in Fig 2.

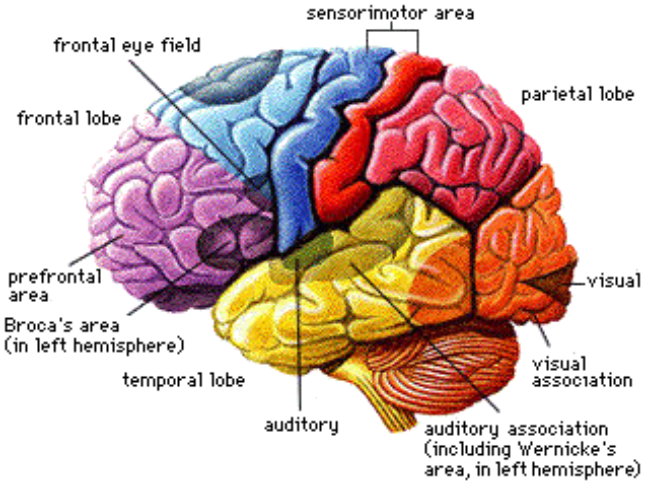

Figure.2. Parts of Brain

a. Frontal Lobe

The frontal lobe performs cognitive skills like motor function, problem-solving, language, judgment, social and sexual behavior. It acts as the "control panel" of our personality and our ability to communicate. It is one of the four paired lobes in the brain's cerebral cortex. The left frontal lobe controls the muscles on the right side of our body and right frontal lobe controls the muscles on the left side of our body. Damage to the frontal lobe causes speech problems, changes in personality and poor coordination.

It is involved in the motor functions. Its role is to generate neural impulses that execution of movement. The motor cortex is the region of the cerebral cortex involved in the planning, control, and execution of voluntary movements.The connection from the primary motor cortex to muscles of the body is so important that any damage leads to an impaired ability to move.

b. Auditory Cortex

It is a part of the temporal lobe, located at the right above the ears. It is that region of the brain which disperses sound and is responsible for the ability to hear. It plays a significant part in the hearing process, by processing sound along with its volume and pitch. Damage to it causes loss of hearing because both the ears are connected to the auditory cortex.

c. Somatosensory Cortex

The function of somatosensory cortex is to receive all the sensory inputs like sense feelings in the skin, pain, visual, or auditory stimuli for processing. It is part of the cerebral cortex and is located exactly in the middle of the brain.

d. PARIETAL lobe

The parietal lobes can be divided into two functional regions. One involves sensation and perception and the other is concerned with integrating sensory input, primarily with the visual system Parietal lobe stroke causes symptoms like Inattentiveness, Apathy, dullness, etc.

e. Occipital Lobe

It is a part of the cerebrum. It makes sense of visual information so that the human brain can understand the vision. If it is impaired, it would result in homogenous loss of vision with same “field cut" in both eyes, loss of visual capability and inability to identify colors.

f. Visual Cortex

It is the primary cortical region of the brain. It receives, integrates and processes the visual information that is relayed from retinas. Most case of the vision loss is not in the eyes, they are due to the damaged visual cortex.

g. Temporal Lobe

The temporal lobe receives sensory information such as sounds and speech from the ears. It is also key to being able to comprehend or understand meaningful speech. Left temporal lesions result in impaired memory for verbal material and right-side lesions result in the recall of non-verbal such as music and drawings.

III. PROPOSED APPROACH

Brainwaves are generally broken down based on frequencies. Not only do they vary in frequency but also in amplitude. These waves can be amplified and digitalized for further processing of data. The block diagram of the proposed approach is shown in Fig 4.

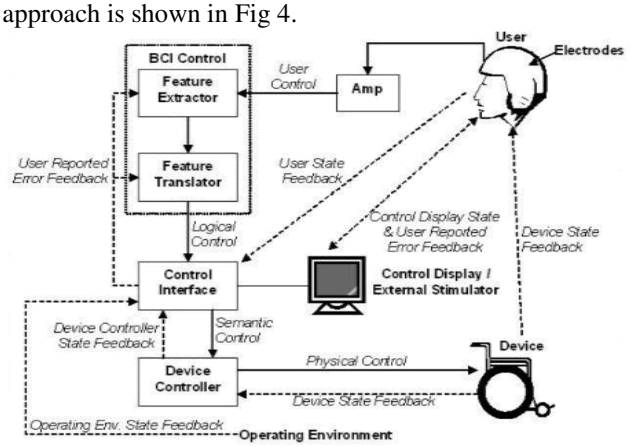

Figure.3. Working of the System

IV. TYPES OF BRAINWAVES

Brainwaves are generally broken down into five main frequencies: Beta waves, Alpha waves, Theta waves, Delta waves and Gamma waves. Not only do brainwaves vary in frequency, they also vary in amplitude. These waves can be amplified and are converted into digital form for further processing of data. Here, the approach is to make use of processing boards to act as actuating medium between EEG device and motors of Wheelchair. This board will convert the brain waves transmitted by the EEG device into digital signals. Based on the processed signal the control actions will be performed. The Brainwaves change according to what activity brain is doing and feeling. When slower brain waves are dominant, we can feel tired, slow, sluggish, or dreamy. The higher frequencies are dominant when we feel wired, or hyper-alert. Gamma waves lie in 38 to 42 Hz and give information about ideas, language, memory processing and various types of learning. Beta waves lie in 13-38 Hz and occur when we are actively thinking, problem-solving, etc. Alpha waves lie in 8-13 Hz and occur when we are relaxed and calm. Theta waves lie in 4-7 Hz and are associated with sleep, deep relaxation, and visualization. Delta waves lie in 4 Hz and occur during sleep. Different types of brain waves are furthermore explained in session from 4.1 to 4.5. Based the difference in frequencies, a specific wave can be easily filtered out using different types of Filters. Change in amplitude depicts the activity of brain and thoughts going in the brain. For example, consider the forced action eyelid blink. The natural blinking of eyes does not create a larger amplitude whereas a forced blink causes larger spikes which are taken as actuating inputs in many applications based on the brain waves.

1. Delta Waves

Delta brainwaves are slow, loud brainwaves. They are generated in deepest meditation and dreamless sleep. They suspend external awareness and are the source of empathy. Healing and regeneration are stimulated in this state, and that is why deep restorative sleep is so essential to the healing process.

Figure. 3.a. Delta waves

2. Theta Waves

Theta brainwaves occur most often in sleep but are also dominant in deep meditation. Theta is our gateway to learning, memory, and intuition. In theta, our senses are withdrawn from the external world and focused on signals originating from within.

Figure. 3.b. Theta waves

In theta, hold our 'stuff', our fears, troubled history, and nightmares.

3. Alpha Waves

Alpha brainwaves are dominant during quietly flowing thoughts and in some meditative states. Alpha is 'the power of now', being here, in the present. Alpha is the resting state of the brain. Alpha waves aid overall mental coordination, calmness, alertness, mind/body integration and learning.

Figure. 3.c. Alpha waves

4. Beta Waves

Beta brainwaves dominate our normal waking state of consciousness when attention is directed towards cognitive tasks and the outside world. Beta is a 'fast' activity, present when we are alert, attentive, engaged in problem-solving, judgment, decision making, or focused mental activity.

Figure.3.d. Beta waves

5. Gamma Waves

Gamma brainwaves are the fastest of brain waves and relate to simultaneous processing of information from different brain areas. Gamma brainwaves pass information rapidly and quietly. The subtlest of the brainwave frequencies, the mind must be quiet to access gamma.

Figure.3.e. Gamma waves

V. CONCLUSION

Forty years ago, the technology was so basic. At present, technological advancements are beyond imagination. Though the advancements are of higher level, they fail to serve their purpose. To make the better outcome of it, we have to bridge the gap between advancements and population. This brain-controlled mobility vehicle could ease the people with physical limitations and constrained abilities. Often disability is considered a curse; why not consider it as a field for advancement? "Your life will become better when you make others life better" **-William Smith**

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VII. ACKNOWLEDGEMENT

We extend our gratitude to our Project Guide, Mr. P. Tamilmani, an Assistant professor, who provided insight and valuable guidance to us in publishing this paper. We would also like to express our gratitude to the Project Supervisor, Mr. K. R. Ganesh, and an Assistant Professor in EIE Department of Valliammai Engineering College.