iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** V **Month of publication:** May 2021

DOI: https://doi.org/10.22214/ijraset.2021.34320

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue V May 2021- Available at www.ijraset.com

Review on Smart Home using BCI Technology

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Abstract: ***Smart home technology allows the inhabitants to monitor their home and any electrical device locally or remotely via computerized central control. But even in this advanced Era disabled people are not able to utilize the currently available technologies. Thus, Brain Computer Interfacing (BCI) based smart home systems are really useful for people with disabilities. Brain Computer Interface is used for the interaction between human brain and digital computer to control/operate the external devices without the use of muscular body part. Developments in BCI really helps to make our lives easier. The study shows that a BCI system can be used for smart home control. Everyone is benefitted from this technology and especially all the disabled people will find this really life changing. This paper discuss about the techniques used to control a device using BCI.***
Keywords: Brain Computer Interface, Smart Home, Central Control, EEG, Device Control

I. INTRODUCTION

In this paper we discuss the different methods for device control using BCI technology. There are many possibilities to control a device such as by measuring eyeblink, eyebrow, thinking etc. We are discussing three main techniques that is using eyeblink pattern, raising of eyebrow and by mind control. Brain-computer interface (BCI) systems helps people to interact with other people and to operate the environment without muscular activation. In the BCI-based smart home system, the user can control home appliances like television, fan, door, light system etc. without any physical movement.

BCIs collects brain signals, analyse them, and translate them into commands that are relayed to output devices that carry out desired actions A BCI records and decodes brain signals. neurons communicate with each other by sending and receiving very small electrical signals. It is really possible to listen to these signals with advanced electrical sensors. A normal healthy person is able to move because the brain sends signals via the central nervous system to the muscles of the body. All interaction of a person requires precise communication between the brain and muscles. Medical conditions such as stroke or neuromuscular diseases can break the communication between the brain and body. However, in many cases the brain is still able to generate the activity for intended movements and a BCI can use the brain activity to control assistive devices. So, all these BCI systems are so useful to the paralysed or physically disabled people. It is also beneficial to a healthy person. A smart home, also called an intelligent building, integrated home system or automated home, is a home environment that consists of electronic devices which is controlled by a central control agent. A wide variety of techniques are available to fulfill a smart home technology. BCI based on Steady-State Visually Evoked Potentials (SSVEPs) can be used as hand-free control device [1]. Also, BCI-based smart home (BSH) system for controlling home doors using two different suites for the Emotiv headset: The Expressive Suite and Cognitive Suite can also be used [6]. In another study we can observe that the Electroencephalographic signals (EEG) recorded from the brain activity using the Emotiv EPOCH headset are interfaced using mouse emulator to a graphical user interface (GUI) on the computer screen. The user will use this GUI to control various devices in a smart home [3]. Eyeblink pattern [2] and voice control [4] can also be used for controlling a device. Wireless BCI technology is a commercial electroencephalogram headset which is used to control home and medical appliances such as a light bulb, a fan, a digital blood pressure monitors and an Infrared deep pain therapeutic belt for dependent people [7].

Smart home technology will definitely improve the quality of life. It allows the inhabitants to monitor their home and any electrical device locally or remotely via computerized central control. The smart home technology is an important concept in research and development, specially utilizing the brain-computer interface technology to control the daily use home appliances.

II. METHODOLOGY

A. Eye Brow

In this method, a non-invasive BCI device called Emotiv EPOC headset having 14 channels which are sampled at 128 Hz is being used to capture EEG signals. It has a built-in low pass filter of order 5 with a bandwidth of 0.2 to 45 Hz, and is wirelessly connected to the computer via 2.4 GHz band [3]. The EEG signals collected during the brain activity are transmitted via Bluetooth to the interface computer. The headset is interfaced with the help of a mouse emulator to the Graphical User Interface (GUI) on the computer screen. The built-in gyro sensor kept in the headset controls the mouse cursor in the mouse emulator.

Hence the obtained electroencephalography (EEG) signals can be trained and used to control the mouse on a graphical user interface of required devices on the computer screen. This application will be very useful especially for people with disabilities. The mouse emulator in Emo Control Panel is used to generate a mouse click whenever the user will raise an eyebrow.

All the required commands are displayed via a graphical user interface (GUI), over the computer screen. The user can select his/her desired application by a raise of an eyebrow which results in a mouse click on the desired control, so that the control will get toggled. This mentioned technology is developing very rapidly as it is having innumerable uses, the most important of which is improving the quality of life of human beings in general and elderly and disabled people in particular. The BCI system can be divided into two types such as non-invasive and invasive type. In the case of invasive type BCI system, in latter an IC is implanted inside the brain by surgery. Hence people choose non-invasive BCI methods which involves only wearing of a headset or cap equipped with an active electrode system.

The main objective of this design is to develop and implement a brain controlled smart home system. In this system, the brain EEG signals are acquired using Emotiv EPOC headset [3]. A single feature like raising an eyebrow along with mouse emulator is used to control a virtual home environment using a graphical user interface (GUI). Each click on the desired home icon by using a raised eye brow signal will activate the control of that device.

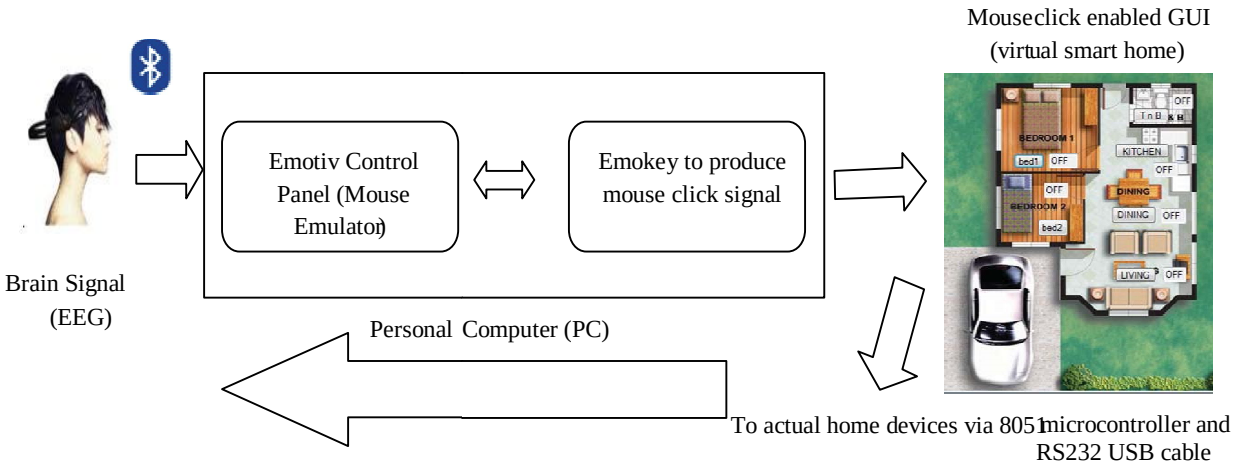

Fig.1 Wheelchair mind control

B. Mind Control

The brain signals use thinking control for controlling the wheelchair using the window platform. EEG signals are captured using Epoc+ Emotiv headset having 14 channels. The four major types of brainwave patterns are delta, theta, alpha, and beta, and they can be detected and interpreted. The signals are sent wirelessly to devices for controlling them. Emotiv EPOC / EPOC+ has the features of 14 EEG channels plus 2 references for providing the optimal positioning for accurate spatial resolution. While the users are concentrating on the desired tasks, the data is being recorded and the activity of the brain over different regions are being measured. Thus, the EEGdata is further classified for various cognitive actions based on the measurements in order to control the wheelchair. The design is based on collaboration of electronics domains and computer science [4].

An Arduino micro controller is used which can convert signals received from the developed software into corresponding actions. Relays are used instead of switches and Bluetooth modules as the selected platform is purely based on Bluetooth communication or else wireless communication. This idea allows a person to communicate with the computer through the brain wave sensor used in Emotiv Epoc+ headset and controls different objects like a wheelchair, a remote control, any home devices. There are many tabs in the control panel. The cognitive panel associates each extracted signal a specific action like moving left, right, etc. each user can login to the control panel with his username and password.

The extracted signals and their associated actions are sent to the main system through a mediatory software called Mind Your OSCs. The main system is thus capable of sending messages to the Arduino where the instructions are converted to real actions. The processing software collects the EEG data from the EEG sensor and then computes the data to its associated action for sending the action to the Arduino microcontroller, which will then send the relative voltage to the digital potentiometer to control the wheelchair.

Few libraries called processing serial are required for the connection between processing and Arduino. The communication between Epoc and Processing is done through a software called OSCp5. The user can control his/her wheelchair by concentrating on specific direction, so that the wheelchair will move on that desired direction. The quality of thinking control depends on the level of concentration.

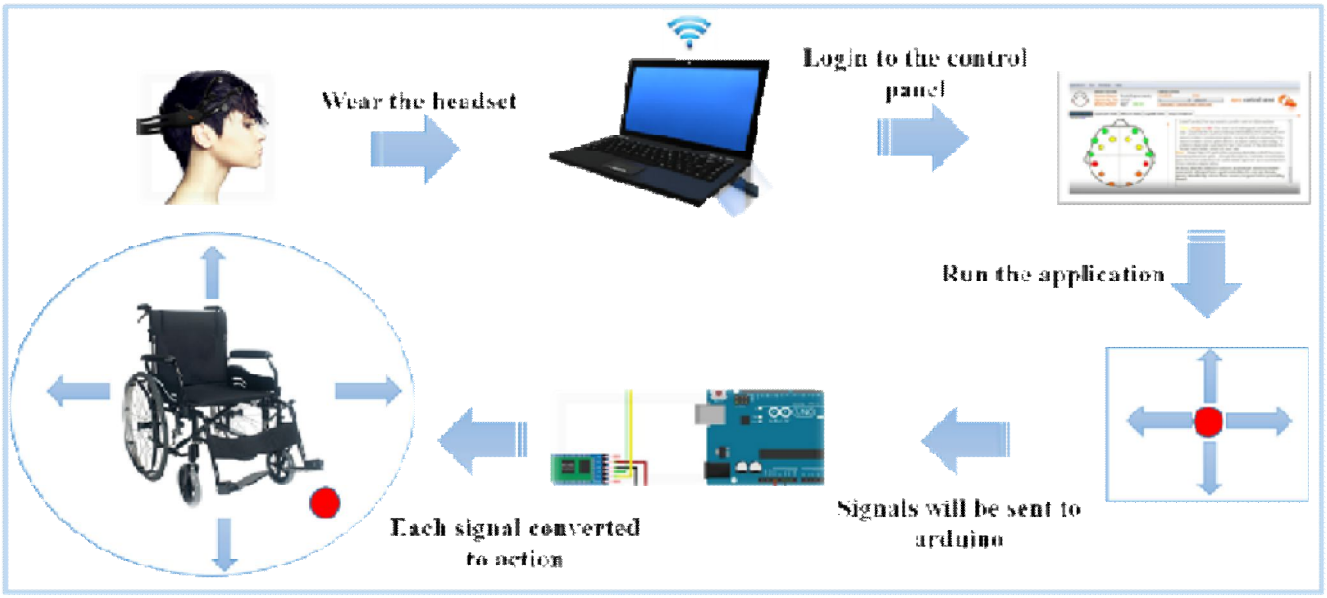

Fig. 2 Block Diagram of Mind Control

C. Eye Blink

The room facilities consist of moving the bed backrest upwards and downwards then switch the fan and light on/off. Four icons representing four commands appear on the screen consecutively. The electroencephalograph (EEG) signals from the patient were acquired from the prefrontal region. The Attention and eye blink is used as input for the decision system. The attention level is acquired from the EEG headset and the eye blink is detected from the filtered raw EEG signal. The low pass filter and peak amplitude is used to detect the eye blink from EEG signal [2]. The decision is made when the eye blink and attention level are higher than the threshold value. The raw EEG signals were filtered using a 5th order Butterworth low pass filter with a cut-off frequency of 5 Hz. Since the eye blink has a very low-frequency less than 5 Hz a low-pass filter is implemented using cut off frequency 5 Hz. For the patient suffering with motor paralysis, though they can't move their body but still can move their eye muscle in order to blink their eye.

People at last stage of ALS, their eye muscles can maintain certain functions. As the eye muscles still preserve its function, then the cues generated by the eye muscles like eye blinks can be used as inputs for assistive device for the patients. While operating, Four icons are displayed over the computer screen. Each figure appears sequentially. When a corresponding icon appears on the screen the patient can then select a particular command just by blinking his/her eyes. The subject must maintain his/her attention at a particular level in order to gain a valid selection.

Based on the EEG signals collected, attention level and blink strength are extracted from the patient's brain waves. A decision is made based on that attention level and blinks strength and it is used to control the patient's room facilities. The Attention level was used in decision system so as to ensure that the subject is focus on that particular task and ensure that the eye blink is voluntary blink. The attention level and the eye blink strength are used as the input for making the decision model. A valid selection is made when, $A_{blink} > Th_{blink}$ and $A_{attention} > Th_{attention}$, D=1 else D=0.

Where A_{blink} and $A_{attention}$ are the eye blink and attention levels similarly Th_{blink} and $Th_{attention}$ are the threshold value for eye blink and attention. D is the decision output with the value is "1" for all valid decisions and "0" for no decision. The selected command is a command represented by the icon that appears when the valid decision is made. For example, if the bed upward icon appeared on the screen and the subject has a high attention and blink his/her eye, the decision would be a valid decision and the selected command is moving the bed backrest upward. The raw EEG signals were filtered using a 5th order Butterworth low pass filter with a cut-off frequency of 5 Hz. Since the eye blink has a very low-frequency less than 5 Hz a low-pass filter is implemented using cut off frequency 5 Hz.

Whenever there is an eye blink, the filtered EEG signal will show its peak or else there is no peak in the filtered EEG signal. By considering all, this approach can be used as an input for controlling the patient's room facilities like moving the bed backrest upward and downward, turn the fan on and off and turn the light on and off. Figure shown below is the block diagram of Patient Room Facilities Control using Eye Blink

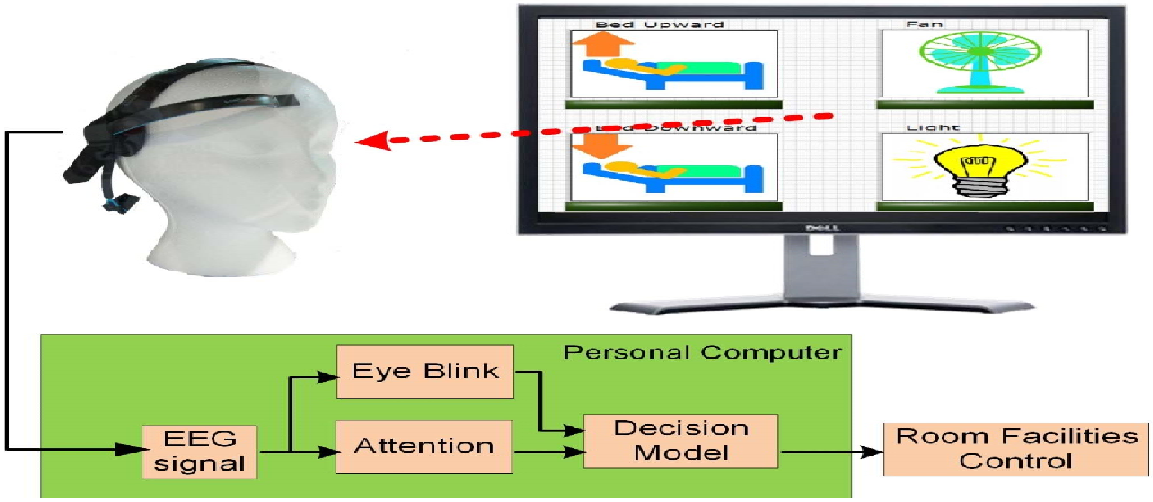

Fig. 1 Design of Patient Room Facilities Control using Eye Blink

III.CONCLUSIONS

In this study, we were able to analyse different types of BCI system. All these methods are designed for people, belonging to all categories but distinctly used to assist who cannot operate the peripheral devices using their normal muscular body parts.

Brain Computer System uses the brain signals in the form of Attention Level through Mind wave Headset, in order to control any of the home appliances say, Bulb/Fan. It is very advantageous to have the headset over the head scalp as there is no harm while using it. Simply place the headset over the scalp and check for connection status to Fitting as provided in Mind Wave Mobile. If the headset is connected properly then further process can be carried out for controlling the required devices. This technology is very expeditiously developing, as it has multifarious uses. Moreover, the most important fact is it plays a vital role is improving the quality of life of human beings in general as well as elderly and disabled people exceptionally.

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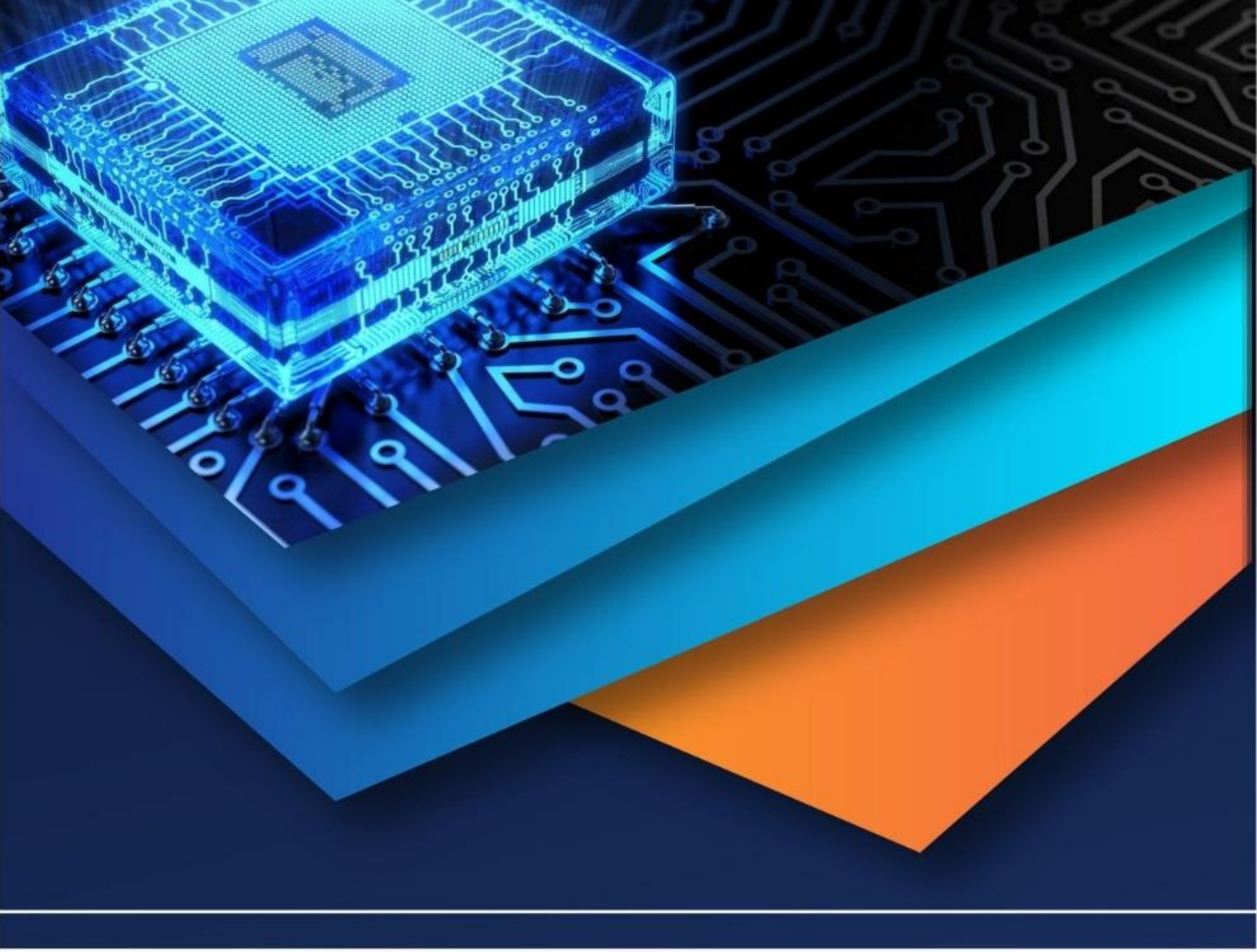

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