ISSN 2278-3091
Volume 9, No.4, July – August 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse276942020.pdf
https://doi.org/10.30534/ijatcse/2020/276942020

# In situ developmental control of biomedical applications using human brain

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## ABSTRACT

This article describes the development of BCI (Brain computer Interface) that allows individuals to record their brain activity and then utilize it for useful application. A virtual reality system is connected with EEG device for smart home application. It paves way for usual way of control and communication. Its an artificial system that sidesteps the neuromuscular output terminals which are efficient pathways of our body. Different brain states resulting due to neural interactions lead to the development of patterns which are characterized by different amplitudes and frequencies. A minute electrical discharge is observed for every interaction between neurons received by brain which is separated into packets which are transmitted through a remoteway of communication (Bluetooth). The wave measuring unit will receive the immediate first information of the brain wave directly through Arduino Uno Controller. Next the instruction is sent to the home section. Taking a notice of the brain action, certain thoughts and eye squinting pattern, relationship were established between exchanging and regulation of certain home appliances.

**Key words:** Brain computer Interface, Electroencephalogram, Brain wave, neuromuscular output channels, Arduino

## 1. INTRODUCTION

Human brain is separated into three important sections like forebrain, midbrain and the hindbrain. The limbic system and cerebrum forms the part of the forebrain. Midbrain consists of tectum and tegmentum while the hindbrain consists of cerebellum, pons and medulla. Figure 1 shows the structure of human brain. Cerebrum performs thinking and problem solving actions. Cerebellum establishes coordination between the body parts. Midbrain relates to the auditory and visual activity. Cortex being a part of cerebrum is the crucial part of the brain. It regulates all the muscular developments from hands and leg movement to the eye squinting of a human being. Immediately after thoughts are stimulated into a person, the neurons present in the brain get triggered. Special people who are those who are unable to move or unable to perform any muscular activities due to improper functioning of nerve cells which serves in carrying information to the muscles. In this regard to facilitate those people the concept of Brain Computer Interface(BCI) based system was developed. BCI is a correspondence bond between human brain and PC so as to control the outer devices. They can interact with the outer world and can perform their daily life activities.

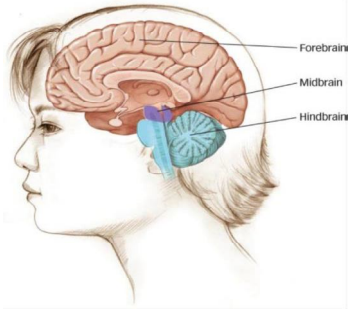


**Figure 1:** Human Brain [12]

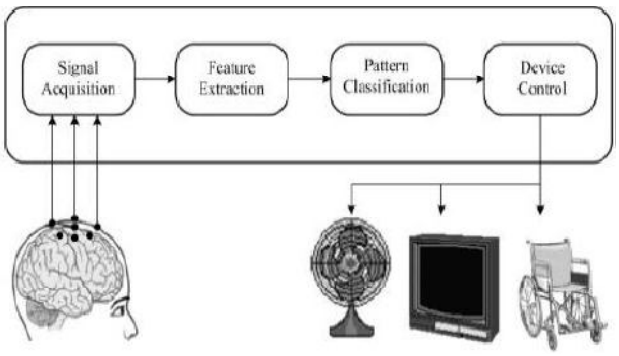


**Figure 2:** General design of BCI system [12]

## 2. BRAIN COMPUTER INTERFACE

Figure 2 shows the general design of a Brain Computer Interface (BCI) system. Invasive BCI and non-invasive BCI are the two types of brain computer interface. A small chip is placed inside the brain which records the brain activity in case of invasive BCI. This is not practical because this requires

brain operation. But in Non-Invasive based BCI system, a device is connected externally (forehead or scalp) which measures the brain signals. The department of defence, US began their research work on BCI based system that helps to decrease the workload of the brain of fighter pilots by collaborating with their plane's computer .The project was terminated at the time because the technology was not sophisticated enough to support the cause. Nevertheless it paved way for the research agendas and even today researchers have done intensive work on many prototypes that archives brain activity like the NeuroSKY, P300, etc.

Several research works have been carried out related to brain computer interface over the years. Aya Khalef [1] etal have developed a novel motor imagery that records electrical brain activity and calculates the mutual information using a linear support machine (SVM) that works based on feature selection and classification. Aydemir et al [2] executed using an effective channel signal selection for brain computer interfaces a technique called robust subject specific sequential forward search method (RSS-SFSM). For validation purpose the developed method was manifested upon two different BCI datasets. Kuhner et al [3] developed framework that allows user to control a mobile robotic device. This setup is suitable for persons with disabilities who constantly rely on human care takers. Brain information throughput based on probability of symbol occurrence was estimated [4] using the general notion of shared information. The outcomeshave got least error with increasing classification accuracy.

A binary class mental task classification is extended to a multi class mental problem by Akshansh Gupta et al [5] wherein a sets of relevant and non-redundant features are selected using a linear regression and a multivariate feature selection. At the last an optimal decision tree based support vector machine classifier was used for multi-mental task classification. Shuailei Zhang et al [6] have developed a pattern based low level commands showing insignificant differences with related to distinctiveness and user centered systems. It was found that by using a novel neural network pattern based on low level commands alone have led to the development of brain signal interface with the system. Research work on quadriplegic patients by Morgan B Lee [7] developed the brain computer interface system that restored the function of quadriplegic patients through virtual prosthetics, FES systems. The outcome was that the motor BCI hardware and software successfully controls the effectors that by using advanced physical prosthetics, FES systems can be able to restore function of the patients own limb. An electroencephalography (EEG) based BCI system [8] was worked and the experimental results of the datasets have shown significant enhancement in the BCI performance in the motor imagery classifications. nRF51822 which is a microprocessor and Bluetooth based BCI system [9] was implemented to collect the brain information which contained a classifier based on neural network.

A BCI system [10] was interfaced with individuals with late stage amyotrophic lateral sclerosis (ACS). Experimental results have shown excellent reception of signals for 36 months. EEG based BCI with neurofeedback [11] targeting sensor motor was implemented to acquire signals from motor skills. Through neurofeedback etiquettere presentation that had streamlined quality signal recordings, signal optimizing techniques the BCI transmitted the signals so as to decrease the symptoms with motor disabilities.

The available systems that are already developed requires human interface or has to be controlled using remote unlike the proposed system. There is no muscle contraction sensing exist in the present systems. Moreover for working in them it requires direct pc interaction. But in the proposed system it is not mandatory to have any such interaction with the pc. The system is designed and interfaced based on graphical user interface(GUI) and it also requires a neuro headset which consists of so many electrode when compared to the proposed system. Moreover the graphical user interface used in this system functions in accordance with the facial expression of the user along with the inputs from the Arduino controller.The accuracy of the existing system depends highly on pc interaction instead of the human brain interference so the proposed system is more user-interactive.

## 3. EXPERIMENTAL ANALYSIS

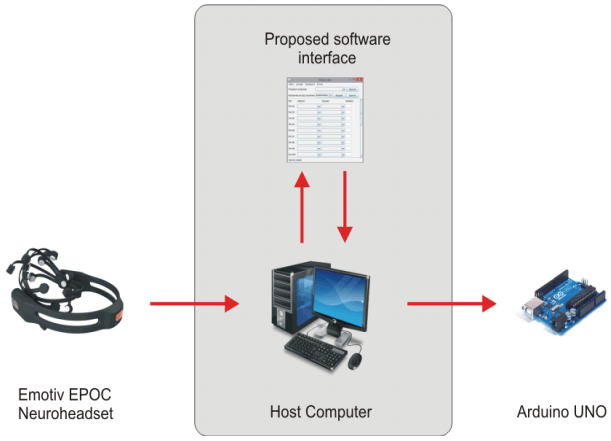


**Figure 3:** Proposed block diagram

The key factor behind the working of modules (bulbs, fans) is given in the brain wave analysis of the proposed system. Here the muscle contraction sensing occurs using the human thoughts. Figure 3 shows the proposed block diagram of the system. Unlike the existing system, this system is self-controlled by the user and the user has the operating facilities. In the preceding systems, the modules are controlled either by using remote control or it requires the interference of individual to operate the module using switch. The main idea behind this system is for the betterment of physically challenged people who face difficulty for moving from one place to another .They generally has to depend on others for performing work such as switching on the light or fan etc. Development of a brain wave interfaced smart home application would help this kind of people to be self-independent and they don't have to depend on others for operating the modules such as light or fan etc.at their home or work place. For the interfacing of brain waves with Arduino bluetooth communication is used. Unlike the existing system which helps in long distance communication, the bluetooth module helps in providing accuracy to the system. This

proposed system can be used for applications such as automotive application, industrial application, home applications, monitoring device applications etc.

The paper represents a research work on a smart home application based on Non-Invasive type BCI based system for the treatment of handicapped people. The system uses EEG(Electroencephalogram) signal as an input signal. The system enables the disabled people to operate the home appliances without any physical movement. Brain computer interface system which is used for this purpose comprises of EEG(electroencephalogram). The EEG based brain computer interface system is used for measuring the net brain activity through voltage measurements by surface electrodes. This system provide direct communication route from the brain to the external device. This system monitors brain wave via network of electrodes and thus it is also known as mind machine interface. A single sensor on the FP1 position of our forehead is considered for the working purpose of a brain computer interface system. The feature of brain computer interface includes the detection of multiple mental states simultaneously. It also provide EMG feature for the detection of eye blink.

## 4. WORKING OF BRAIN WAVE SENSOR & IMPLEMENTATION

For the implementation of BCI a neuro headset is placed on the user's head. This headset consists of a single electrode which is placed at FP1 position of our forehead. This headset is interfaced with the Arduino controller directly using a Bluetooth module(HC05). Figure 4 shows the methodology involved in the data transmission and figure 5 shows the data reception interface. The Arduino controller is programmed for measuring the concentration level, attention level and eye blink. Using the UART serial port rs232 the data is sent to the pc which consists of Arduino UNO software. The software thus exhibits our attention level. Approximately five levels are considered at a time and their average is considered. Based on our level of attention the signal will be sent to the controller and as a result the modules will function accordingly. The modules which work by this system are operated using relay. The main idea behind using this concept is operating the module automatically without any remote control or switches so that it doesn't require any other human interference except the user himself.

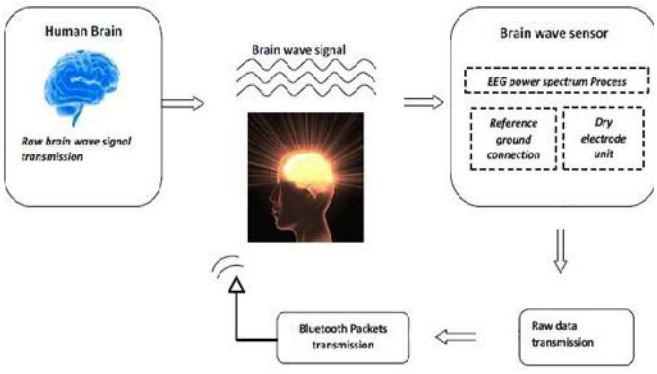


**Figure 4:** Methodology Involved in Data Transmission [12]

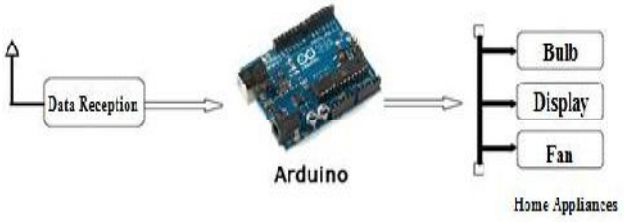


**Figure 5:** Data reception [12]

## 5. RESULTS AND DISCUSSION

The exchanging information route interconnecting brain, computer/processor or peripheral technical device can be intercommunicated by using brain computer interface. Based on the signal acquisition, transformation of signals generated by central nervous system (CNS) and analysis forms the fundamental aspect of the brain computer interface systems. According to this as a result neurohead set was created as a part of the research. The objective was to research the feasibility to regulate the complex application using graphical user interface (GUI) along with brain computer interface. The emotive EPOC neurohead set is used as the part of this application.

We implemented our design using non-invasive technique unlike invasive approach wherein the brain activity is recorded using a small chip placed inside the brain. This is not practical in our case because this requires a brain surgery. At the mean time in non-invasive techniques, the scalp is attached with a device like headset which is capable of measuring brain signals. We used NeuroSky headset for this case.

These are the discrete phases experienced one after the other to recognize the product at a given time.

**Testing Of NeuroSky (Mindwave)**

This was our first phase in which we initiated our project by testing the compatibility and reliability of NeuroSky. We went through several problems during testing. The first and foremost difficulty we faced was the Bluetooth connection of NeuroSky with computer. We tried using Bluetooth module hc-06 and hc-09 and failed badly in doing so. There was no need of Bluetooth module in our case as NeuroSky has built-in Bluetooth feature and your computer can find its connection easily when you set Mindwave available for other devices to connect by using the button on the back of device.

After successful establishment of Mindwave with computer via Bluetooth, there comes a hurdle in recording brain activity. At first, we successfully observed the attention and meditation levels by Brain Wave Visualizer.

**Accessing Mindwave Parameter**

After developing a connection between the computer and the Mindwave Mobile through the ThinkGear Connector, we had to extract the useful data from the raw data. We developed a ThinkGearSocket type object which carried all of the parameter independently. So, we accessed the values of Blink Strength and Meditation using standardized functions. Both these parameters are used to operate and regulate the devices.

**System Integration**

System integration involves the connection of arduino with the relay module and L298N which further are connected to the devices as shown in figure 6. The relay module is

switching at 5V or 0 V. Our appliances are operational at 12V which we apply from an external source to the relay. The neuro headset used for this procedure is shown in figure 7. Appliances like led light, lock, alarm and curtains are connected via relay module while the fan motor is connected via L298N which controls its speed. Varying the duty cycles we were able to control the speed.

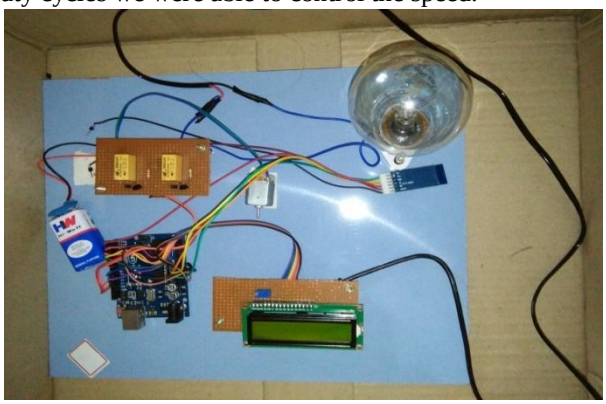

**Figure 6:** Devices integrated

**Figure 7:** Neuro headset used

## 6. CONCLUSION

Thus an artificial system is developed which gives us details of the brain waves known as BCI (Brain computer Interface) that allows individuals to record their brain activity and then utilize it for useful application. The impulse which is produced by the brain was recorded by the brain sensor that will bisect the packets and the packet data is sent through a Bluetooth wireless medium. The raw information is received by the measuring unit which is directly interfaced through Arduino Uno Controller. Then the instruction will be sending to the home section. Recognizing the brain activity of certain thoughts and eye blinking pattern, we managed to correlate them with the switching and regulation of certain home appliances like fan, bulb.

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