BRAIN COMPUTER INTERFACE BASED SMART HOME CONTROL USING EEG SIGNAL

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ABSTRACT:*The paper presents the Brain-Computer Interface (BCI) based home control system. The proposed system isused to facilitate the handicapped and needy persons. Neurosky headset is used to detect Electroencephalogram (EEG) signal from brain activity. Recognizing the brain activity for certain thoughts and eye blinking patterns, we managed to correlate them with the switching and regulation of certain home appliances like fan, bulb, etc. BCI based systems can yield the accuracy from (80 to 100) %.*

Key Words:EEG signals, smart home control

1. INTRODUCTION

Human brain comprises on three major parts; forebrain, midbrain and hindbrain. Forebrain consists of cerebrum and the limbic system. Midbrain comprises of tectum and tegmentum while the hindbrain composed of cerebellum, pons and medulla.Cerebrum performs thinking and problem solving actions.Cerebellum establishescoordination between the body parts (for example, the coordination of legs while walking). Midbrain relates to the auditory and visual activities. Cerebrum being the cortex is the most important part of the brain. It controls all the muscular activities from limbs movement to the eye blinking of a person. Whenever there is a muscular activity or some sort of thoughts provoked by a person, the neurons in the cerebrum gets activated [1].

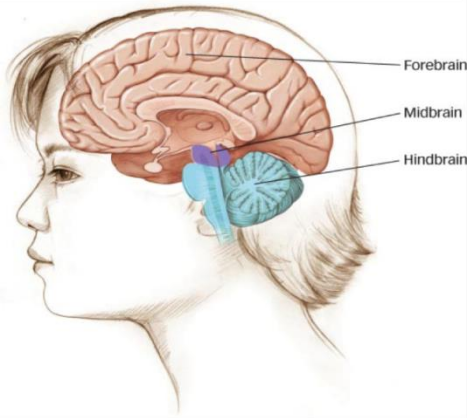

Figure 1: Human Brain [1]

Special people who are unable to move anywhere or unable to perform any muscular activity due to non functioning of their nervecells that carry information to the muscles.In this regard, to facilitatethose people, the concept of Brain Computer Interfaced (BCI) based system was developed. BCI is a communication link between human brain and computer in order to control the external devices. The BCI systems use thoughts as a control mechanism [2]. They can interact with the world and can perform their daily life activities like an operating wheel chair or household appliances.Figure 2 shows the general design of BCI system.

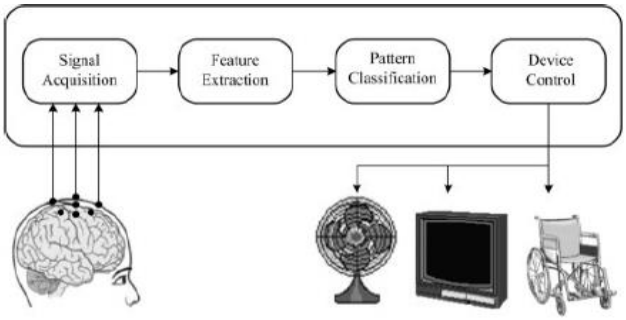

Figure 2: General design of BCI system [3]

Invasive and Non-Invasive are two major types of BCI systems. In invasive BCI based systems, a chip is installed inside the brain which records the brain activity. This is not often practical because this requires a brain surgery. While in non-invasive type, a device (headset) is attached to the scalp (externally) which measures the brain signals [4]. Electroencephalography (EEG) sensors are usedto

Capture the electrical signals generated in the human brain. Non invasiveEEG sensors are cost effective, portable and are widely used in BCI systems [5]. Once the EEG signalis acquired then certain features from these signals areextracted. These features may be amplitude of thoughts evoked, band power, etc. These features are used to generate an event that will control a user (a disabled person) intended device.

The research on BCI based system started in mid 1960s by the US Department of Defence to reduce the mental workload load of fighter pilots.At an initial stage, BCI based systems could not flourished. The prime reason was low processing speed of computer and data acquisition devices (EEG sensors).However, it laid the bases for research programs and nowadays, researchers are taking interest in BCI systems because of technology advancement in processing speed computers and sensors [6]-[7].

The paper presents a smart home control system based on non invasive type brain computer interface for the treatment of handicapped.The system enables them to operate the home appliances without any physical movement.The system uses EEG signal as input signal.

2. LITERATURE REVIEW

Author proposed the hybrid BCI based on P300 evoked potential and steady state visually evoked potential (SSVEP) to control the smart home devices [8]. Real time BCI based TV channel control are discussed in [9]. A novel brain machine interface system (BMI) is developed in [10] with

experimental smart home in which home appliances are controlled. BMI using EEG signal is designed for controlling the 7 degree movement of robotic arm [11].Adaptive learning techniques are discussed in [12] for the feature extraction of time varying EEG signals. The purpose was to discover an effective approach to detect the dynamic variations of brain activities.Region based smart home control system is developed for disabled persons in [13]. The paper claims the accuracy of 95% for controlling the smart home applications.

3. BCI BASED SYSTEM

BCI based system consists of several steps. Typical BCI based systems comprise of Electrode headset connected to a computer via wired or wireless connection. The headset records and transmits the brain signals to the computer. The brain signals are processed in computer and respective algorithms are applied to get the desired results. These steps are briefly explained below:

3.1 MEASUREMENT OF EEG SIGNALS

The aim of this step is to acquire the EEG signals. This is achieved by using Electrodes that are placed on the user's scalp (head) at respective positions.Figure 3 shows NeuroSky headset that fits comfortably on one's head. It consists of two electrodes, one being attached at the forehead right above the left eye and other one is attached to the left ear lobe that works as a ground. It records the brain waves and transmits it to the computer via Bluetooth which is built in feature of Mindwave.

3.2 PRE-PROCESSING OF RAW DATA

EEG signals are very low power signals. Pre-processing and signal conditioningonEEG signal are performed in order to improve the signal quality.

3.3 FEATURE EXTRACTION

The aim is to extract and identify the actual EEG signal from redundant signals which relates to user intention. An event is defined on the bases of some features. For instance eye blinking or raising an eye are the features to establish an event. Whenever these features occur, some task will be performed.

Figure3: Neurosky headset

3.4 CONTROLLING DEVICES

When userblinks his eye, an event is created and certain algorithms are executed to operate and control the home appliances.

4 BCI BASED SMART HOME CONTROL (Setup)

The paper presents BCI based smart home control system.Non-invasive type BCI technique is used to develop this system. The simulation of brain activity for acquiring the desired EEG signals is accomplished by voluntary eye blinking. For every action, the brain emits certain signals. The EEG based sensors record these signals for various activities. The generated signals have different frequencies based on the intensity of the action. Figure.4 depicts the block diagram of data transmission in the system.

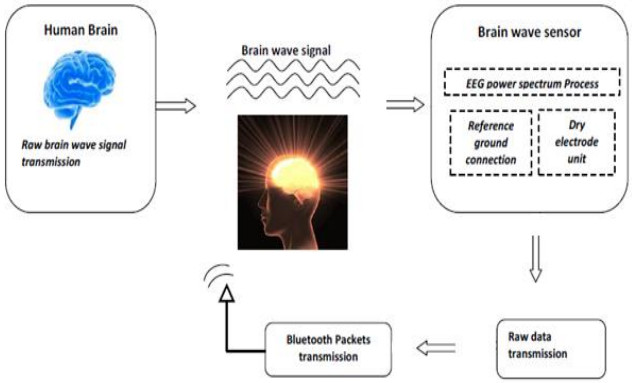

Figure 4: Methodology Involved in Data Transmission

The raw data is extracted and processed. The controller is programmed to operate the home appliances like lights, fan etc based on processed data.Figure 5 shows the data reception in the system.

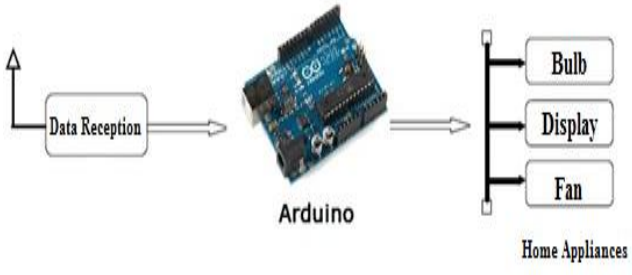

Figure 5: Appliances controlled by Arduino UNOControl system

Figure 6 shows the complete block diagram of smart home.

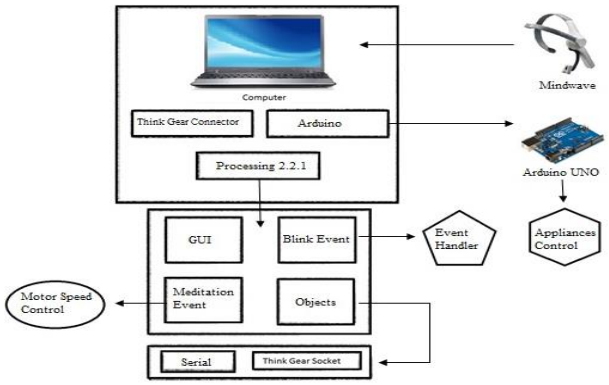

Figure 6: Architecture Overview Diagram

In order to acquire the EEG signal, a connection between computer and the mind wave mobile through the Think Gear Connector is established. To extract the useful data from the redundant data, Think Gear Socket type object is developed which carried all the parameters independently. So, we can access the value of blink strength and meditation using

standardized functions. These parameters are used to operate and regulate the devices. System integrates the Arduino with the relay module and
L298N(full bridge driver).These modulesareinterfaced with devices like light, fan, lock, alarm. The relay module switches at 5V or 0 V while our proposed appliances operate at 12V. To remove this potential deficit, an external source is used through the relays. Figure 7 shows the hardware setup of smart home control system.

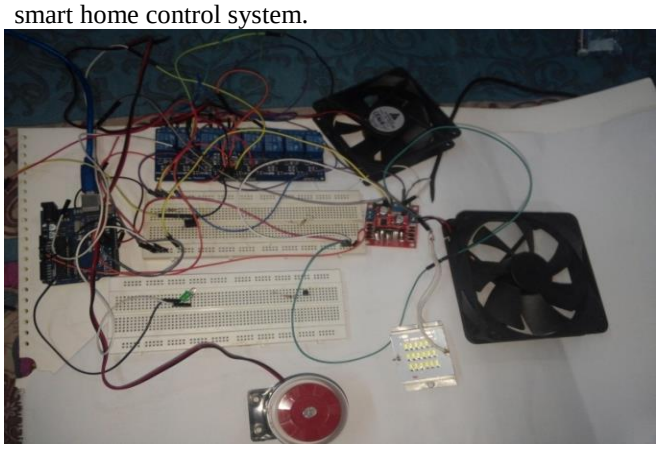

Figure 7: System integration

To facilitate the user, graphical user interface (GUI) is also developed. User is not indulged in the mechanics of the system and can interact with the system through GUI. The system is "Not Active" state by default. At this time data sending from the NeuroSky headset is off. To get the system activate, the user must make three eye blinks up to a certain threshold. Once the system is activated, window is appeared for five seconds as shown in Figure 8in order to turn on the desired appliance.

Figure 8: System in activated state

The cursor will remain under the bulb for five seconds, if user intended to turn on the light; he has to make two eye blinks of certain threshold within that time period. After five seconds, it will moveto next appliance automatically and so on. User has an option to control the speed of a fan. Three levels are defined for fan speed; fast, medium and slow. The selection of speed level depends on the meditation value.Meditation value less than 33 is defined for slow speed; meditation value more than 33 but less than 66 is for medium speed. While meditation value more than 66 is defined for fast level of speed.After passing through all available appliances the cursor will disappear and system will go into non-activated state.

5 CONCLUSION

The paper presented the smart home control system based on BCI using EEG signal.The system used EEG sensors for acquiring brain signals. Using eye blinking feature, user can select and control the desired home appliances like turn on light. This isreal time and fully automated system because the user is not required to perform any physical activity. According to the evaluation of the tests conducted on the system, the proficiency of the system is concluded to 70%. The system can be enhanced by adding more appliances. BCI based systems can facilitate the disabled person and can take the drastic change in their lives.

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