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Home Automation Using Brain Signals

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ABSTRACT

In this time of digitization and computerization, the life of individuals is getting more straightforward as nearly everything is programmed. This interconnection of the things can be used to help people with physical disabilities including paralysis. The brain signals of such people can be harnessed to create a home automation system. In this work, the concentration levels of such individuals// are extracted using the EEG signals. These signals are then used to control the electronic devices. The designed system has been tested to operate the switching of an electric bulb using brain signals. This system can also be extended to assist a physically impaired individual to have effective control over electrical and electronic appliances and devices within a home.

Keywords: Brain Computer Interface, EEG signals, home automation.

I. INTRODUCTION

There is a huge amount of money spent yearly on the care of physically disabled people [1]. Many a times, not only the monetary factors but also the emotional well-being of the disabled person also must be considered. Many disabled people do not like to be dependent on the care- givers or any other family members to perform even simple operations like switching on the lights or fans. Technologies to help the physically disabled people is the call of the day. These technologies use the Internet of things combined with some other signals from the person to perform these simple tasks.

An important point to note is that while these people may be physically disabled, their brains and minds work just fine. Hence the signals from the brain can be harnessed to control the surrounding electrical and electronic devices.

Brain Computer Interface (BCI) is such technology that allows communication between the human brain and an external device, such as a computer or a home automation system, using brain signals. For this technology to work the sensors have to be placed near the brain and the sensors should be sensitive enough to pick up the brain signals. The signals captured by these sensors are then processed to control the lights and fans in a house. The range of control of the devices using this technology is a matter of design. In a home atmosphere, the Bluetooth can be used effectively. In cases where the range of operation needs to be more, internet may have to be used.

Before the EEG signal can be harnessed for further applications, a thorough investigation of the signal and their components is very much mandatory. EEG waveforms are generally characterized depending on the frequency. Although the classification can also be done on the basis od amplitude, morphology and continuity also, BCI related applications generally depend on the frequency parameter. Table 1 shows the classification of the EEG signals based on the frequency, and in what state of mind these signals can be captured.

TABLE 1: EEG SIGNAL CLASSIFICATION

Component	Frequency	State
Delta	< 4Hz	Sleep
Theta	4 – 8 Hz	Meditation
Alpha	9-13 Hz	Relaxed
Beta	14-30 Hz	Alert
Gamma	>30	Concentration

II. LITERATURE SURVEY

The literature survey required for this work is divided into 3 phases. In the first phase, the potential applications of BCI are explored. In the second phase, the part of the EEG signal which can be exploited for the proposed work is explored. The study in the third phase relates to the hardware implementation requirements. There are various technologies which can help the physically disabled people. One among them is the Morse-code detector using the eye- blinks [1]. This can be used when a person is physically incapable of sending messages to the outside world. BCI based applications are generally used in cases where the human being is physically incapable of achieving simple day-to-day activities. BCI has been used to control a robotic arm [2]. In this work, the EEG signals are collected using a gel-based sensor, filtered, and processed. They are then fed to a motor which controls a robotic arm with six degrees of freedom. A correction mechanism to improve the grasping of the robots is implemented by [3]. BCI can also be used to control a wheelchair [4]. Along with the EEG signal, eye- blinks are also extracted in this work. This is a GUI based work which moves the wheelchair without an ON-OFF button. The robotic movement can be implemented using Recurrent neural Networks as shown by the authors in [5]. Though the efficiency of such a system is very good, user training is mandatory which may not be desirable in some cases. In another system, an online BCI system has been designed using the steady state visually evoked potential [6]. The main advantage of such a method is that no user training is required. Different parts of the EEG signals can be utilized for the BCI applications. Six types of data or components which are of particular interest are the Beta, Alpha, Beta, Gamma, Theta, Delta and Mu. Alpha brain waves have been utilized [7] to control the devices. Beta and Mu rhythms have been used to control the prosthetic arms by the authors in [8]. The forward and the inverse kinematic behaviour of the indigenously developed robotic arm is also tested in this work. The authors in [9] have used Supervised learning techniques to achieve the control of the robotic arm. A headset paired with a computer- based software 'Emotiv' have been used to control the robotic arm [10]. The main drawback of this system is that a computer and the related software needs to be setup. The use of Arduino is feasible where setting up a system with the required software becomes tedious [11]. The surveyed literature has shown that the concentration levels of the human brain signal have not been harnessed for any of the application. Hence, in this work, the concentration levels will be used for home automation.

III.METHODOLOGY

The methodology used to implement the proposed work is shown in Figure 1a and Figure 1b. Figure 1a shows the transmitter block diagram and Figure 1b shows the receiver block diagram. The brain signals captured here are the electroencephalogram (EEG) signals. Rather than using electrodes to capture those signals which is a messy process (because of the use of gels), here we use a head band mounted sensors which capture the signals.

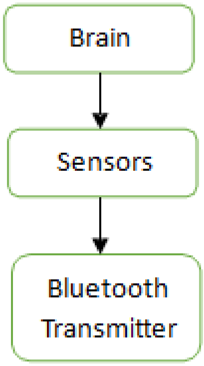

FIGURE 1A: TRANSMITTER

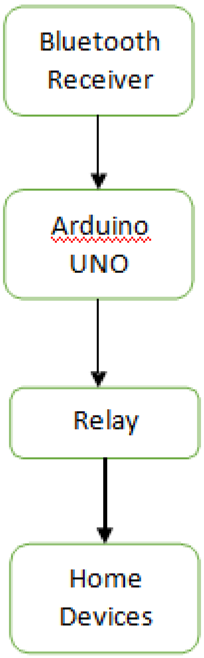

FIGURE 1B: RECEIVER

Using a gel-based EEG sensor may get messy, hence a headband sensor based on dry electrodes is used in this work. The headband (transmitter) used for this work is the NeuroSky Mobile 2, shown in Figure 2. As can be seen from the diagram, the headband has a battery holder which is required for the operation of the headband. There is a main electrode which captures the brain signals. There is also a reference electrode which must be clipped to the ear. Although the ear clip can be attached anywhere on the ear, literature suggests, that the auricle (outer portion of the ear) is the beast placement option, since there is no nearby brain activity. There is a ThinkGear AM (TGAM) module (which is a primary brainwave sensor), along with a Bluetooth module. The main characteristic of this component is that it senses the signals from the brain while filtering out the external noise and electrical interferences. The sensing is done with zero latency.

FIGURE 2: HEAD BAND.

The captured signal is then transmitted to the Arduino Uno using a Bluetooth HC-05 module. The signal current generated by the brain waves and received by the Arduino is very less in amplitude. When a small amount of electric current must drive a high current load, a relay must be used. The electric values will change depending on concentration levels. The lights turn ON-OFF depending on these levels.

IV. RESULTS

The complete setup of the receiver is shown in Figure 3. To make the entire system portable, all the required components are mounted on a single board. For testing purposes 3 LEDs (Red, Yellow, and Green) are initially interfaced on the board. When the system is first switched on, the user has to mount the headband on his head and clip the secondary or the reference electrode to the ear. The user then has to concentrate on a particular object or think about something or try to solve a puzzle in the mind. Depending on the brain activity, the brain signals are captured and their values can be seen on the serial monitor of the Arduino Uno.

The Arduino is programmed in such a way that, when concentration level ranges between 10-30, Red LED will be turned ON. As an extension to home automation, it is seen that the actual 9-watt bulb is OFF. This level of concentration is seen when the person is not concentrating on anything in particular. This scenario is shown in Figure 4.

FIGURE 3: INITIAL SETUP.

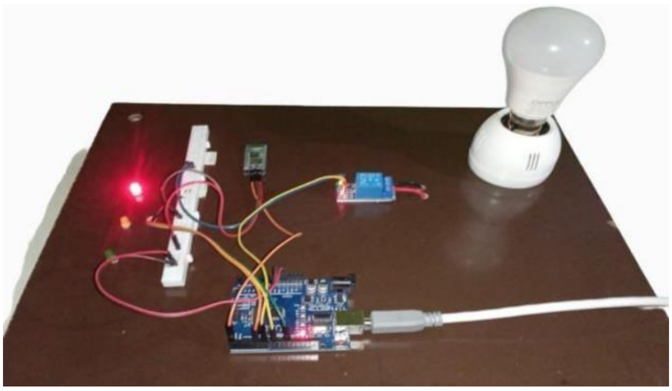

FIGURE 4: AT LOW LEVEL CONCENTRATION.

When concentration level ranges between 40-60, yellow led is turned ON and indicates that the person has medium concentration, The Arduino has been programmed to turn the bulb ON. This is shown in Figure 5. Also, care is taken that the lights remain on till a next higher level of concentration by the user. This ensures that, once the lights are turned ON, they do not automatically turn OFF when the user relaxes. If the user wants to turn the lights OFF, then the next level of concentration is required.

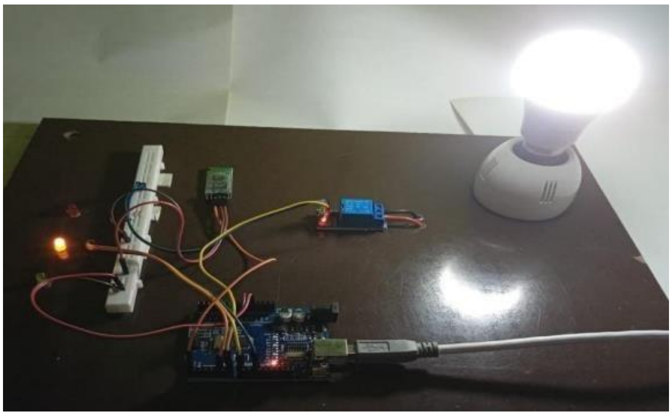

FIGURE 5: AT MEDIUM LEVEL CONCENTRATION.

When concentration level raises to the range between 70-90, Green LED is turned ON and indicate the person has HIGH concentration we are made the bulb OFF.

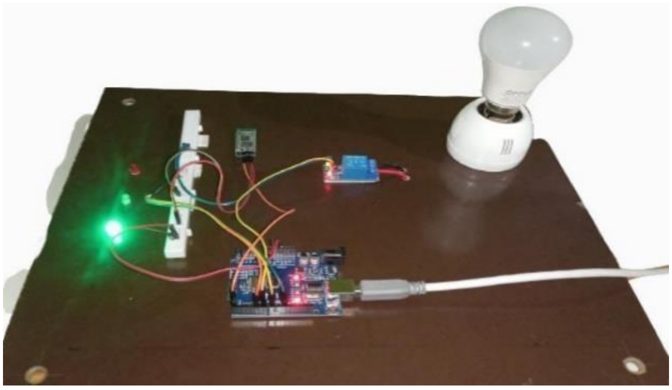

FIGURE 6:AT HIGH CONCENTRATION.

V. CONCLUSION

The main objective of the proposed work is to harness the concentration level (electrical energy of the brain signals) for home automation. This project is particularly useful for physically disabled people. This is achieved by using the EEG signals from the brain and interfacing it with the Arduino UNO, which controls the home devices. The proposed project is implemented and tested on a physically handicapped person and the results are found to be satisfactory. As a future work, this project can be extended to includes some more devices such as fans. The authors have also started to work on converting the prototype to a wearable device.

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