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A Novel Approach on Electroencephalogram (EEG) Based Common Application to Control Devices and Appliances for Paralyzed Personal

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ABSTRACT

This paper discusses about the conceptual idea on creating computer applications to control IoT devices through EEG based signals for people suffering from Paralysis and Motor Neuron disease which includes Amyotrophic Lateral Sclerosis, Primary Lateral Sclerosis , Progressive Bulbar Palsy , etc. Motor Neuron Diseases are group of rare Neuron Disorder or Degenerative disease that kills the motor neurons responsible for the Human's Motor activities. This disease affects either the Upper Motor Neurons or Lower Motor Neurons or both. The proposed conceptual idea provides a promising solution to the physically challenged or people suffering from Motor Neuron disease to control the smart phone, computers and other domestic appliances like digital TV, climate control, etc through their EEG signals. The EEG signal from the human subject are received, analysis of the type of emotion is carried out / facial activity such as smile, blink, brows up, etc depending upon the frequency received from the sensor and the same will be used to control any electronic device like Smart phone and domestic appliances such as security system, climate control system, etc. through wireless communication like infrared, WIFI and bluetooth.

Keywords

Brain Machine Interface, Brain Computer Interface, Electroencephalography, Smart Phone, Appliances, Computer.

1. Introduction

Motor Neutron Diseases is a nomenclature used for group of diseases that affects human motor neuron or motor nerve. Motor neuron are the nerve cells responsible to activate, control and information interchange between the brain and the voluntary muscles in arms, legs, back, neck, etc. Motor Neurons are of two kinds Upper Motor Neurons (UMN) and Lower Motor Neurons (LMN). UMN responsible for the information interchange between Brain and Spinal cord and LMN responsible for the information interchange between Brain and the muscles. MND is a global disease; it does not discriminate on any geography basis. Statistics says [1] & [2] over 420,000 people are living with MND worldwide. Approximately 140,000 cases are diagnosed worldwide each year i.e. 384 new cases every day.

MND affects the human slowly and get worse over the period of more than three months. Multiple patterns of muscle weakness are seen in the infected individuals, and muscle cramps and spasms are also seen. The affected individuals will face difficulty in breathing with climbing stairs (exertion), lying down (orthopnea), or even respiratory failure if breathing muscles become involved. Stephen Hawking is one of the most well-known people with MND. This disease starts with people aged between 40 to 60 years. Most of the people live for 3 to 5 years with this disease after their symptoms start, some people lived more than that or longer.

The people affected with this disease are people who already lived in this world for 30 -40 years

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before affected by MND. They use to roam around do their day to day work independent of anybody. Once they are affected by MND, they became dependent on someone else for everything. They will be isolated from the external world, they cannot use the domestic appliances which they were using and they cannot communicate with their family members, relatives and friends. This develops increase of stress in the patient.

Brain-computer interfaces system provides rehabilitation or replacement to disorder people [3]. BCI technology is used not only to interact with others and communicate but also gives the opportunity to disorder people to operate and control home appliances, computers and more devices [4]. Emotiv headset is interfaced to the computer screen with the help of mouse emulator. Brain activity is recorded and smart devices in home are controlled using GUI of Emotiv headset [5]. The Brain Computer Interfaces was designed to harness P300 and N200 components of event-related potentials to control home appliances [6]. The patients who affected with amyotrophic lateral sclerosis or spinal cord injury can communicate with the external world using an electroencephalography-based brain–computer interface [7]. The BCI platform has been developed to control home systems by thoughts over the Internet of things (IoT) [8]. The real time brain wave-controlled interface system has used LCD display for the patients to control their electric wheel chair [9].

This "Electroencephalogram (EEG) Based Universal Application to Control Devices and Appliances for Paralyzed Personal" proposes a Universal Brain Machine Interface (BMI) computer application which can receive the patient's EEG Signal, analyze the type of emotion or facial expression, get the control signal mapped to the analyzed EEG signal and send it to the device which the patient wishes to control. The application of Brain Computer Interfaces (BCI) has been extended its usage for normal users in non-medical fields such as cognitive training, entertainment, and others [10]. Many clinical studies reported about BCI interfaces as a real-time communication between the external world and the user [11].

The main objectives of this paper are,

i. To develop a Universal BMI Computer Application for a Commercial Of The Shelf (COTS) Wireless EEG Sensor Kit for controlling any domestic appliance product or devices like PC, smart phones, security system, lighting system, etc.
ii. To develop the computer application logic to collate and analyze the type of data EEG signal received from the COTS EEG Sensor.
iii. To develop the computer application logic to send the control signal to the products or devices to be controlled.
iv. To develop a universal computer application to control different products or devices from different verticals.

2. Materials and Method

This section discusses about the high level block diagram proposed, the hardware materials and software application to be used. The Figure 1 shows the block diagram of the common EEG based device control application

COTS EEG Sensor Kit

This is a third party COTS EEG Sensor Kit, which detects the EEG signal from the patients and send the raw data to the computer in which the Common Application to Control Devices is available through a Bluetooth (BT) receiver connected to the PC. The raw data will contain the

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Beta, Alpha, Theta and Delta frequency details of the EEG signal detected from the patient which provides the consciousness level of the patient. The consciousness level can be whether the patient is on alert state, sleep state, drowsy state and meditation state. Along with the consciousness level the sensor kit can send the Facial Expression state also. The Facial Expression state can be single eye blink, double eye blink, browses up, etc.

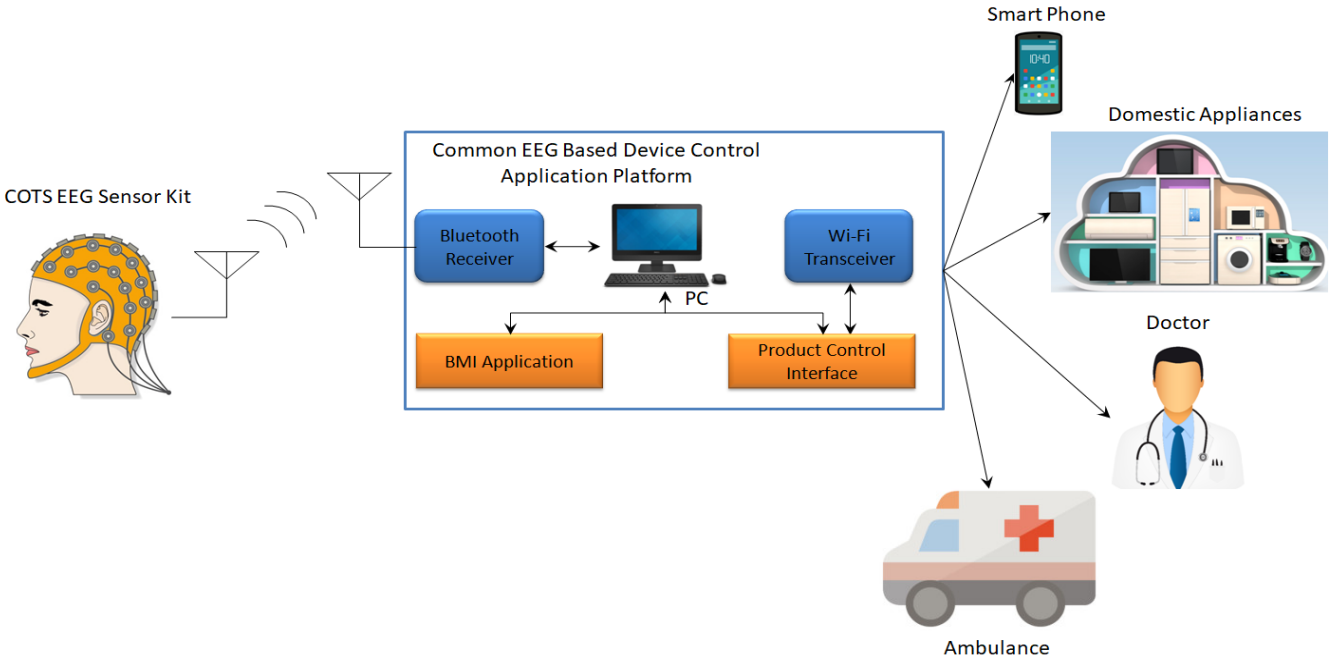

Figure 1. Block diagram of the common EEG based device control application

BMI Application

Figure 2 shows the BMI application Graphical User Interface (GUI) which is the heart of this proposed system, this BMI application developed on .NET C# platform will be connected to EEG Sensor Kit's Application Programmable Interfaces (APIs). These APIs will receive the raw EEG data from the EEG Sensor kit through the Bluetooth (BT) receiver and store it in the local file for processing. While the raw data is being filled in the file, the BMI application will analyze the raw data and provide the results in which the received signal falls in frequency band. Once the raw data is analyzed and the type of frequency, the BMI application will look in the mapped frequency with the corresponding device control signal and send control signal along with the device to control to the product control interface block for controlling the devices. The Table 1 shows the sample physiological state of the patient or subject along with the frequency band and the sample device control signals.

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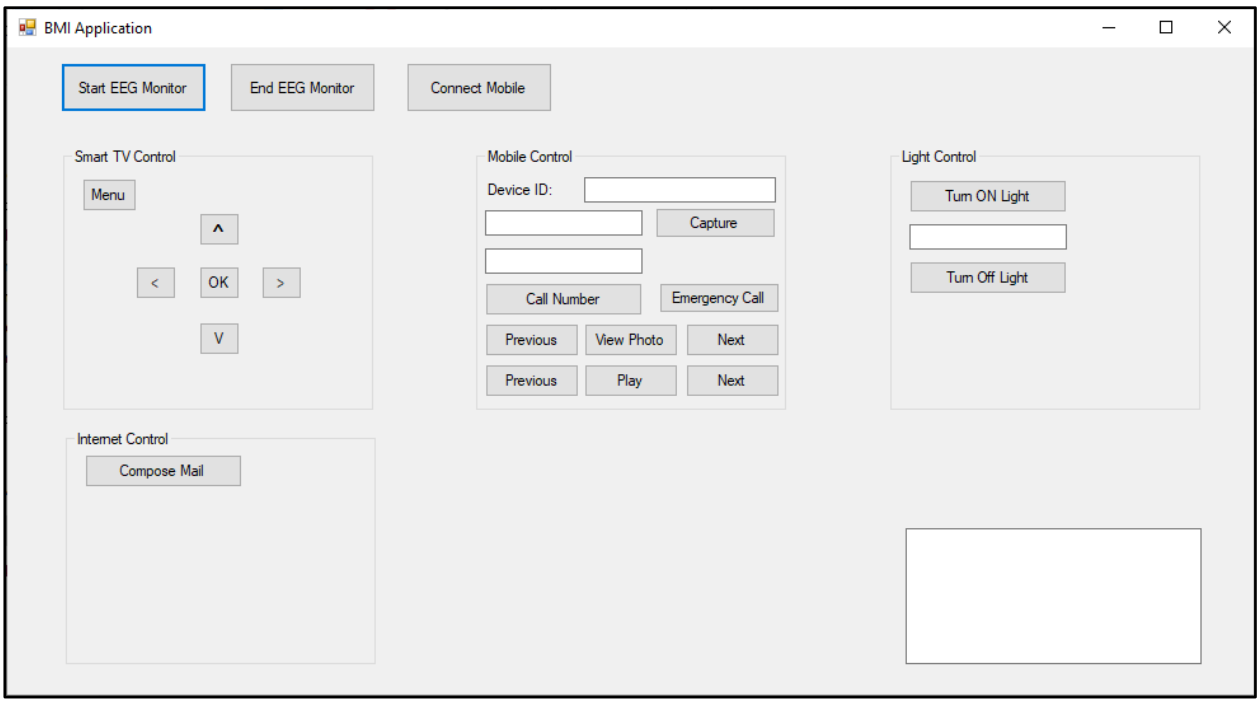

Figure 2. BMI Application GUI

Table 1. Frequency Band Vs Physiological State Mapping

#	Name of the Frequency	Frequency Band	Physiological / Consciousness State	Sample Control Signal
1	Beta	14 Hz – 30Hz	Awake, attentive and alert state	Move Left / Turn ON
2	Alpha	7Hz – 13Hz	Relaxed, calm and lucid state	Move Right / Turn OFF
3	Theta	4Hz – 7Hz	Hyperventilation	Move Up / Increase Volume / Temperature
4	Delta	< 4Hz	Deep Sleep, Between Seizures	Move Down / Decrease Volume / Temperature

Product Control Interface

The Product Control Interface (PCI) block receives the device to be controlled and the control signal from the BMI Application. Depending upon the target device for e.g. Smart Phone, Digital TV and the PCI sends the control signal to the device to be controlled. When the device to be tested is mobile, then the control signals are sent through the Universal Serial Bus (USB) communication to operate the mobile. The control signal will be used to operate the Mobile Application, send a message, make a ECall, etc. If a PC is selected a device to control, sending mail, operating the PC are the functionalities for which the keyboard and mouse control signals will be used. If the device to be controlled is a climate control system, then the infrared control signal will be sent to increase or decrease the temperature of the room. Likewise, any electronic

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device can be added to the Product database and can be controlled using the wired and wireless communication.

Results and Conclusion

The expected result for this proposed idea relies on the approach of reading the EEG signal or frequency from the Senor points from the patient. Figure 3 show the frequency read from the EEG sensor points. Differentiate between the normal mental condition and the expected mental or facial condition changes like Active, Calm, Meditating, Sleeping, Eye-Blink, etc., and the control the devices and make the physically challenged people to be connected with the external world, friends and relatives. Figure 4 shows the normal facial condition and Figure 5 shows the left eye wink facial change condition. This solution provides the ease of devices and appliances control with promptness, reduces the dependency of the care takers. The BMI Application acts as the single universal platform for all the digital and electrical devices of different verticals. This solution greatly reduces the stress of the paralyzed people, also helps in monitoring the health condition and trigger ECall during any emergency. This leads to provide better and prompt services to the MND affected person.

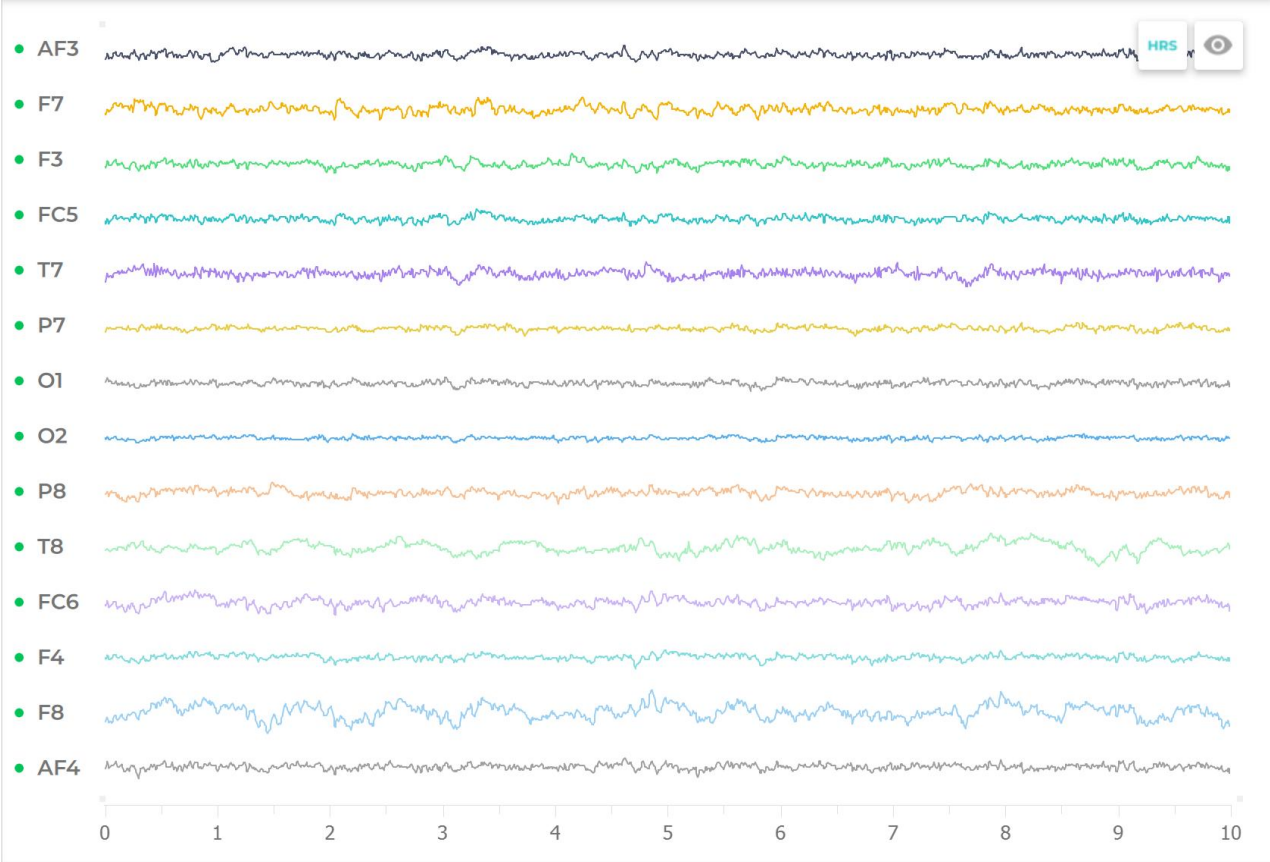

Figure 3. 14-Channel EEG sensor point frequency

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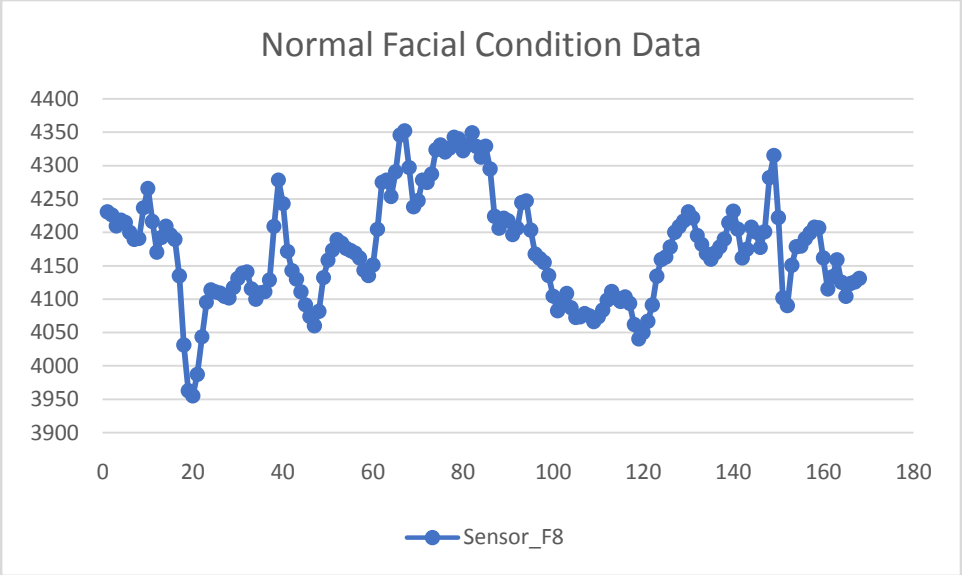

Figure 4. Normal facial condition data

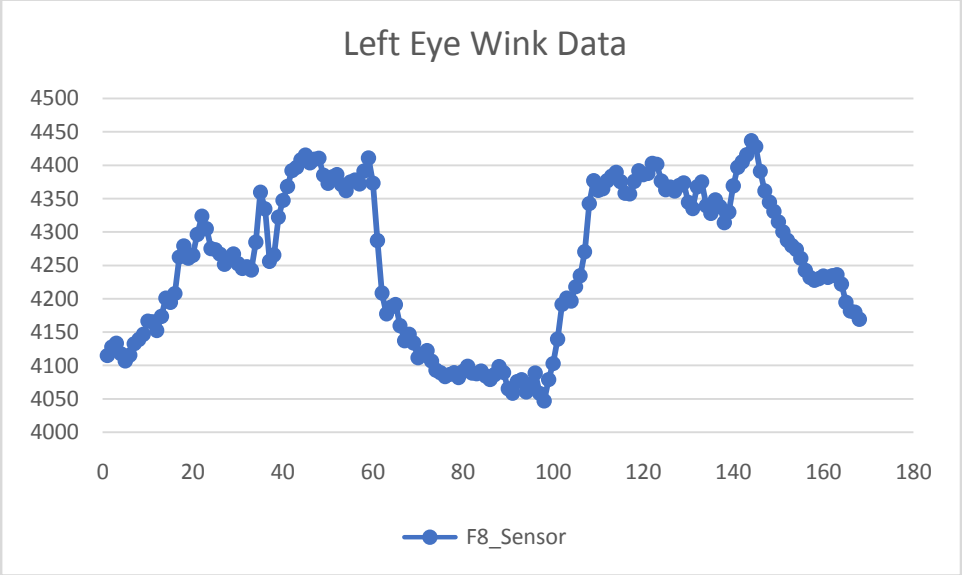

Figure 5. Left eye wink data

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