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An approach towards automation in human machine interaction through emotions using Brain Wave Sensor by EEG

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Abstract*—This project presents brain controlled applications based on Brain–computer interface (BCI). BCI is becoming increasingly studied as the way users interact with computers because recent technological developments have led to low priced, high precision BCI devices. These systems that can bypass conventional channels of communication (i.e., muscles and thoughts) between human brain and physical devices, to provide direct communication and control, by translating different patterns of brain activity into commands in real time.*

The device tested in this paper is called NeuroSky MindWave Mobile, which is an electroencephalograph (EEG) measuring device and enables the measuring of brain activity using 2 strategically placed sensors.

*With the help of this, we are analyzing the brain wave signals. Human brain have millions of interconnected neurons. The interaction pattern between these neurons is represented as emotional states and thoughts. This pattern will be changing as the human thoughts changes, which in turn produce different electrical waves. These electrical waves will be sensed by the brain wave sensor and it will convert the data into packets and transmit via Bluetooth medium***)**

Keywords—Brain Computer Interface(BCI), Neurons, brain wave sensor, EEG.

I. INTRODUCTION

BCI measures the brain activity of a user and then identifying the thought pattern or desired action using brain waves of the user. BCI have been investigated in many applications like medical and commercial, such as physiotherapy [1], [10] and measuring brain activity of individuals to stimuli [2-3]. Typical BCI equipment that utilize EEG [4] to measure brain activity is expensive and require expert knowledge to setup and use. The signals generated by brain are received by the brain sensor and they will divide into packets and the packet data transmitted to wireless medium (bluetooth) [5]. The wave measuring unit will receive the brain wave in raw data format and it will convert into signal using MATLAB GUI platform. Brain-computer interface is nothing but the interaction between the human brain system and machines; it is a control system which enables the people to communicate and control a device by mere thinking. BCI collects the information from the brain and give commands to computer interface at the same time and operate different appliances. This is an electrical activity that records brain waves from scalp of the brain. The use of sensors make it possible to monitor brains neuron process activities that can relate to certain form of thoughts such as how much focused we are in certain objects from an interview to interviewer to get

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out the thoughts as an analogue value and convert it to digital signals output produced by human brain.

From the past few years, the advancement in Information Technology (IT), cognitive neuroscience and brain signals capturing technologies by external devices both in non/or invasive allow us to interact with human brain directly. For decades, human have been fantasizing to communicate and interact with machines via thoughts itself and moreover expectation was always that the devices will be able to reveal human brains, feelings, meditation as well as attention. Neurosky MindWave [6] logs the wearers mental state in the form of NeuroSky's embedded properties like Attention and Meditation with the help of eSense algorithms not an open source platform. People with cerebral palsy, who have their cognitive function preserved, but are unable to communicate or move, or both, require technological learning aids.

II. L MATHEMATICAL MODEL ITERATURE SURVEY

A. Under the case study of this review, the paper [7], illustrated the BCI Framework using the Emotiv EPOC [8] and the Hardware Setup.

Framework Of BCI proposed:

It consists two vital components- Emotiv SDK and Lego NXT SDK. The GUI was particularly based on C++ programming which merged the computerized (processed) signals from Emotiv SDK and output to the agent. The process starts with a training that has to be implemented in the current GUI. After the training is complete the Emotiv SDK is ready to determine the action that the user has intended. For the robotic application, 4 basic actions are used – Neutral, Left, Right and Forward.

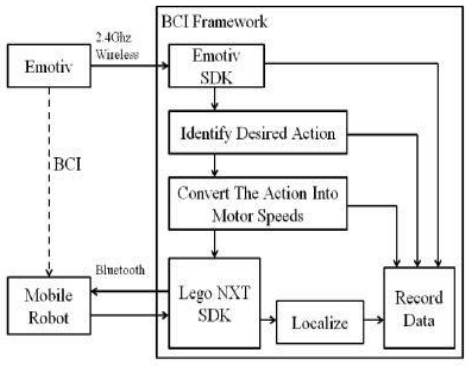

Fig 1. BCI Framework

The advantage of using this BCI Framework is that multiple users can be added as a different 'Profile' to the system. For each user, a different training data set has to be maintained. For better aided training the concept of controlling a 3D-Object is done on the GUI. Once the training is completed, it is saved and kept for future retrieval.

Hardware Setup:

- *Emotiv EPOC Neuroheadset*

This head-mounted device, comprising of 14 channels, each of which is hydrated by a saline solution. The reason here for using the saline solution is to increase the conduction power of the contact-pad. This will in return improve the sensitivity and the readings.

International 10-20 system is used to place the sensor locations. Fig 2. Shows the sensor locations of Emotiv EPOC.

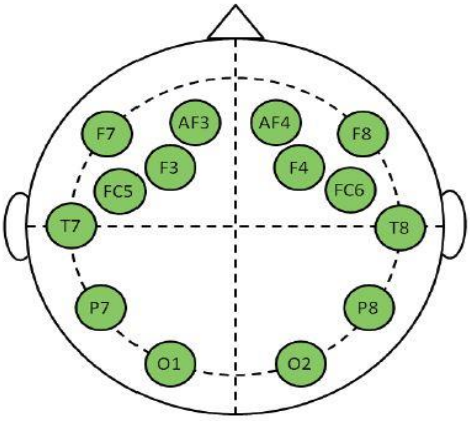

Fig 2. Sensor Locations

EPOC's general specification for rate of sampling is 2048 Hz and 14 bit resolution. Due to this high rate, it enables precise detection and accuracy. Also, to detect the alignment of the EPOC Headset, Gyroscopic sensor is used.

A trivial weakness of this hardware is that, it is used for advanced system where high accuracy is must. For low-scale home automation purpose, a low duty Headset (Like NeuroSky Mindwave) can be used. Also this paper explains the use of EPOC only with the Emotiv SDK and LEGO NXT SDK. Usage of intermediate Microprocessor/Microcontroller is not discussed.

B. In [9], special focus is made on economic device "NeuroSky MindWave Mobile" and complete path of the signal – right from the brain waves to the end-device.

- Components Of the System:

I. ARM-based Processor/Controller:

Here in this paper, 32-bit Embedded RISC ARM Microprocessor is used. It is low power, high performance and small in size. This ARM Processor is used to receive the Bluetooth Serial Signals, process these signals and forward them to Driver Circuit. Now according to the signals from the driver circuit, the Home Appliances functioning is done. Driver Circuit will be connected to Port 1 of the Processor.

II. NeuroSky Technology:

By placing a sensor on the scalp, the pattern and the frequencies of the electrical signals can be measured. Neurosky ThinkGear Technology quatifies the analog electric signals and converts them into digital signals. After this, Neurosky transfers these signals to required application or games.

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eSense is Neurosky's proprietary algorithm to determine and compute the mental states. To calculate eSense, the NeuroSky Think Gear technology strengthens the raw brainwave signal and eliminates the ambient noise and muscle movement. This eSense meter values do not construe an exact number, but instead designate ranges of activity. The eSense meters shows how effectively the user is entrancing Attention (concentration) or Meditation (relaxation).

The eSense meter indicates the level of a user's mental "calmness" or "relaxation". Its value ranges from 0 to 100. Please Note that the Meditation is a measure of a person's mental states, not physical levels, so simply relaxing all the body muscles may not instantly result in an exaggerated effect meditation level.

III. EEG Signals:

Electrodes play the key role to collect EEG signals from the surface of the scalp. The most widely used electrodes are silver/silver chloride (Ag/AgCl) due to low cost, low contact impedance, and relatively good stability. These operations lengthy and are uncomfortable to users. To meet-up these limitations of "wet" electrodes, some researchers have been discovering dehydrated electrodes, which don't require gel and also skin cleaning. The main disadvantage of present dry electrodes is that the acquired EEG signals are worse than those acquired with conventional electrodes due to the increased contact impedance.

The following figure shows the basic block of working Home Appliance system.

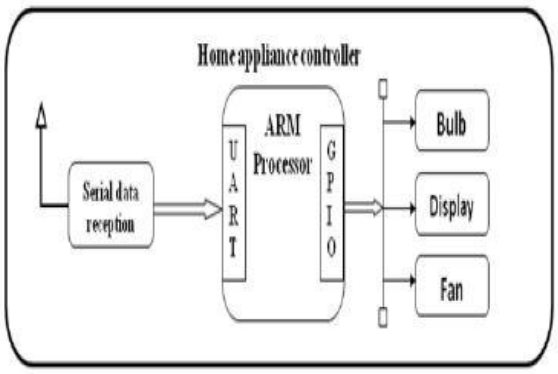

Fig. 3 Home Section

- Flow And Design:

After the BrainWave headset is switched ON, it will start sensing the neuroal signals and via the Bluetooth, it will send the Serial data to interconnected Processor. There the programming language module like MATLAB/Python will check the attention and Eye Blinking Levels.

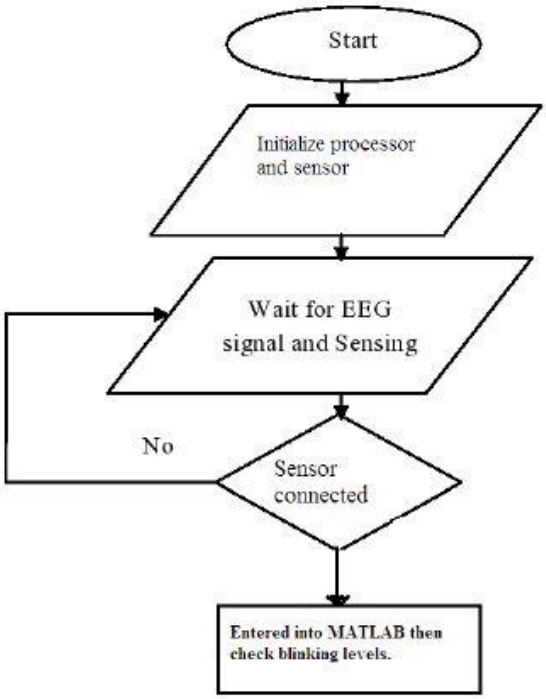

Fig. 4 Design Flow

The results obtained with NeuroSky headset doesn't give the 100% accuracy of brainwaves but it is too good for its price and it can give up to 80 % accuracy of brainwaves. After installing all the Neurosky software's in PC, and connecting the Headset with PC through PC using Bluetooth, we need to wear the headset to the head and then we needed to open the Matlab/Python Code and run the program, after clicking run the program in the command window, it will display the brainwave is connected, blink is detected and after that it will show the attention values and Blink values.

III. Determining Attention

Neural bio-recorder used as input which measures and interprets brain activities. The application of a single electrode measures the change in field potential over time arising from synaptic current and forms the basis for EEG. Readings will be inferred from processing beta and alpha waveform activity. Provides two 100-scale outputs operating at 0.5 Hz described by the Emotiv EPOC chip as "Attention" and "Meditation".

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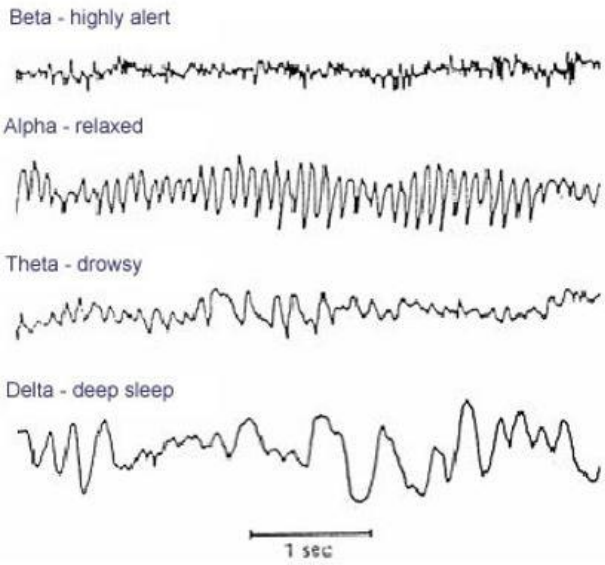

Fig. 5 Waveform and its activities

Alpha Rhythm

- 8~13 Hz
- Indication of physical relaxation and relative mental inactivity

Beta Rhythm

- 13~35 Hz
- Indication of mental activity

IV. Mathematical Model

The active and reference electrodes in the EEG headset measure electrical potential. Electrical potential is supplied directly to the embedded chipset for filtering as well as separation. The relative power of the alpha and beta waves in relation to the total EEG signal can be used to determine the cognitive state of person.

The equations used for analysis are as follows:

$$\alpha_i = \sum_{k=1}^{n} P\alpha_k$$

$$\beta_i = 5\sum_{k=1}^{n} P\beta_k$$

N is the number of electrodes (one in this case), $P\alpha_k$ is the power in the alpha band for signal k and α_i is the total power in alpha band for all N signals at time window i. These variables are same for the beta band. The power of the beta wave is multiplied by five because beta waves are usually smaller than alpha waves by a factor of five.

If $\alpha_i > \beta_i$, then the state is relaxed, otherwise, the state is attentive.

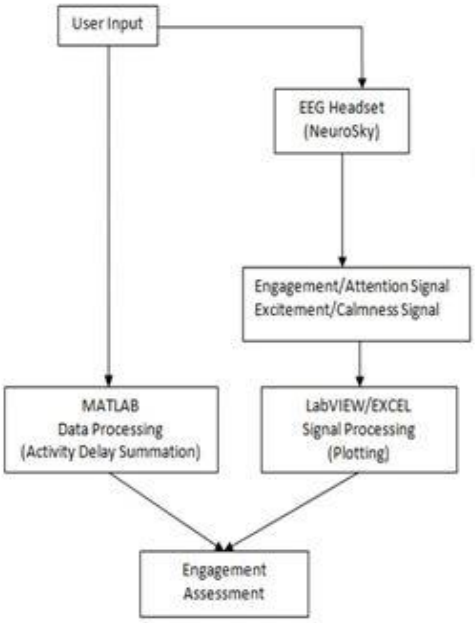

Fig. 6 Flow Diagram

V. Conclusion

The signals generated by brain were received by the brainwave sensing device and it will divide into packets and the packet data transmitted to wireless medium (bluetooth). The wave measuring unit will receive the brain wave raw data and it will convert into signal using MATLAB/Python Programming Platform. Then the instructions will be sending to the home section to operate the appliances (bulb, fan).

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