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Design and Implementation of Neuro Based Switching System Control for Power Socket

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Biosensor is an analytical device that used to convert a biological response into an electrical signal. While, electroencephalogram (EEG) is a test that measures and records electrical signal from the brain through a metal electrode. Smart home controller using biosensor is a system that allows a communication of human brain and home appliances, microcontroller or computer. The main objective of this project is to design and implement a neuro based switching system control for power socket using biosensor and IoT data visualization, and to analyze system performance in terms of biosensor and IoT performance. To achieve the objective, EEG signal acquired by using a low cost EEG biosensor that is Neurosky Mindflex device. After that, EEG signal was analyzed and classified through Arduino (IDE) serial monitor. Next, classified signal was used to control a real-time home appliance by sending a command to NODEMCU ESP8266. A communication between Neurosky Mindflex device with microcontroller or computer are designed to turn on and off home appliances. Besides biosensor data visualization, home appliances usage can be observed through IoT platform i.e. ThingSpeak via the internet.

Keywords : Home application, brain control, Eeg signal, switching system, biosensor.

I. INTRODUCTION

Biological is an analytical device that used to convert a biological response into an electrical signal. Typically, biosensors must be highly specific, independent of physical parameters such as pH and temperature and should be reusable.

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Production of biosensors, its materials, transducing devices, and immobilization methods requires multidisciplinary research in chemistry, biology, and engineering. EEG bio amplifier is the one of the biosensor applications.

EEG stand for electroencephalogram is a test that measures and records electrical signal from the scalp of the brain through a metal electrode [1]. This electrode connected by wires to a computer. The computer records the brain's electrical activity and display it on the screen. Electrical signal consists of alpha waves, beta waves, theta waves and delta waves. All this have own frequency (in Hz) and mental condition. There are six most common applications for EEG which is neuro marketing, human factors, social interaction, psychology and neuroscience, clinical and psychiatric studies and brain computer interfaces (BCI).

Now, some low cost non-invasive EEG system in the market that provide a new feature to explore human brain with affordable and worth it with the price. Mindflex Duel by Neurosky. Neurosky (founded in 2004) is company that develop in electroencephalogram (EEG) biosensors devices especially in consumer-level brainwave monitoring. Mindflex

Duel is the one of the device made by Neurosky as a game where moving an object with mind [2]. Utilizing EEG technology, the wireless headset reads user brainwave activity and moving and object. The device used a variation of EEG technology to "read" the intensity of these brainwaves via sensors positioned on forehead and ear. The sensors do not generate or interfere with brainwaves, they only read what is already there.

Biosensor is defined as is an analytical device, used for the detection of an analytic that combines a biological component with a physicochemical detector. It is commonly used to refer to an electrical bio signal. Electrical bio signals (bio-electrical signals) are the electrical currents generated by electrical potential differences across a tissue, organ or cell system like the nervous system. Typical bio-electrical signals are ECG (Electrocardiogram), EMG (Electromyogram), EEG (Electroencephalogram) and EOG (Electrooculogram). GSR (Galvanic skin response) and HRV (Heart rate variability) are also thought of as bio-electrical signals, although they are not measured directly from electrical potential differences.

Figure 1 shows a biosensor device that used to capture brain electrical activity. This non-invasive brain-computer interface turns user brainwaves into action, unlocking new worlds of interactivity.

The Mindwave Mobile can support video games, research software or other applications such as home controller for an enhanced user experience.

Figure 1. Biosensor

Brain-computer interface (BCI) also known as brain-machine interface is a hardware and software communication system that allow humans to interact with their surroundings, without the involvement of peripheral nerves and muscles, by using control signals generated from electroencephalographic (EEG) activity [3]. There are three types of BCI which is invasive BCI, partially BCI and non-invasive BCI. In invasive BCI, brainwave sensor chip is implanted into the human brain during neurosurgery. Invasive BCI produce the high quality of signal but this method is not recommended because an injury to scar-tissue. For partially invasive BCI, the brainwave sensor chip is placed inside the skull, but the rests placed of human brain. This method will produce a better resolution signals. The non-invasive is brainwave sensor as shown in Figure 2 is placed outside the skull or more specific is on the scalp. Dry electrode is used to detect the brain signals and a reference electrode ear clip is used for the reference point or ground.

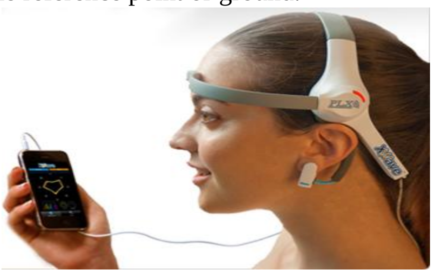

Figure 2. Non-invasive Brainwave Sensor

Development of IoT Smart Home Controller using Biosensor is a system that allows the communication between brain signal with the microcontroller processor to generate commands for controlling home appliances such as light, fan, plug and etc. The aim of this project is to develop a smart home controller using biosensor which able to improve life quality. In addition, this project works on cost savings concept as home appliances can be turn on when needed and turn off when no one use.

II. RESEARCH METHOD

This project was develop with some alterations were made to make the project more agile. The project generally developed based on the interconnection between brain Mindflex headset, NodeMCU ESP8266, Arduino (IDE), IoT ThingSpeak and smart home controller as shown in Figure 3. The most important to make this project is successful and the switching controllers is working by implementing the biosensor. Biosensor used is based on electroencephalogram (EEG) to detect electrical activity of the brain by placing electrode on the forehead. The combination of hardware and software development are applied to ensure this project done successfully.

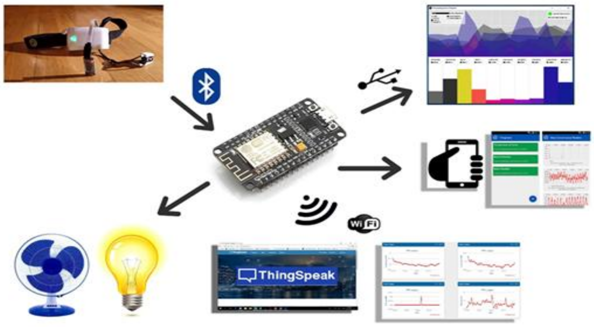

Figure 3. Switching Controller using Biosensor

This project started with microcontroller configuration which NodeMCU ESP8266 is used in this project to perform and execute the command. Next, EEG biosensor which is the Mindflex headset is configured to detect electrical activity of the brain by placing the EEG device on the head. The electrical signal is recorded as data brainwaves to translate into readable command in NodeMCU ESP8266. The command used is high-level language using Arduino (IDE) programming language. Then, attention and meditation waves are detected to control home appliances with specific value range from 0 to 100. Next, the IoT platform is needed for data visualization and data storage to database. ThingSpeak is the best platform to capture sensor data and turns it into useful information.

A. EEG Biosensor Initial Setup

Mindflex EEG Headset as shonw in Figure 4 is used to detect the brain wave signal and detect eye blinking to perform a command.

Figure 4. Mindflex EEG Headset

The procedure of setting up Mindflex headset as below:

1. Add Bluetooth module to Mindflex EEG Headset.
2. Share power and ground with Bluetooth module.
3. Pair and bind two Bluetooth modules with AT command on Arduino (IDE) serial monitor.
4. If the pair and bind between two Bluetooth is successful, turn on the Mindflex and make sure the NodeMCU is connected with personal computer and the brainwaves activity can be seen in serial monitor.

B. Microcontroller Configuration

Several configurations are needed for the first time boot of NodeMCU ESP8266, creating the command using Arduino (IDE) and transmitted the data to cloud (ThingSpeak) through wireless connection (Wifi). Arduino Brain library need to be downloaded and installed.

NodeMCU and Thingspeak configuration as below:

1. Dowload ESP8266 community library from internet.
2. Copy the below code in the Additional Boards Manager

3. Register ThingSpeak account
4. Create new channel for Attention and Meditation value and light and fan usage
5. After that, channel ID is given and also API keys to be inserted in Arduino (IDE) so that the brainwaves activity can be recorded.

As for light and fan controller, API key and variable ID from Thingspeak need to be link with the brainwave signal acquired from the microcontroller.

```
ThingSpeak.setField(1, a);
ThingSpeak.setField(2, m);
ThingSpeak.setField(3, LightState);
ThingSpeak.setField(4, FanState);
ThingSpeak.writeFields(myChannelNumber, writeAPIkey);
```

Figure 5. Coding to send data to ThingSpeak

C. Test and Measurement

Test and measurement is required in order to achieve a targeted result. It will covered the measurement needed in this project. Next, the analysis and test needed to perform to ensure that the project works without errors. The measurement is recorded from brain wave signal activity. In detecting the electrical activity or attention and meditation, subject need to relax to get meditation value high and another subject need to be active to get attention value high. This will be used in controlling the speed of fan. Next is eye blinking detection which to control ON and OFF the light.

Table 1. Type of Brain state and its condition

Type	Value Range	State & Conditions
Attention	0 – 50	Lack of focus
	51 - 100	Concentrate
Meditation	0 - 50	Distractions
	51 - 100	Calmness

Subject Test:

This project needs accuracy of the signal. To get the accuracy of the results and can implements home controller, the measurement results must be compared to prove the signal is correct. The number of subject test is 1 persons with of ages 22 and male. The result maybe different because the subject need to practice using the Mindflex headset.

Controller System:

To control home appliances, for person attention and meditation level will be different. The below values to control light and fan. In proposed system, attention and meditation level are tracked for operating light and fan respectively. That is the operation and controlling of the system using BCI can be done in two ways which is attention and eye blinking. In this project, all can be done by using Mindflex EEG Headset.

Table 2. Controller ways and Home appliance state

Attention	0 - 30	Light on
Attention	75 – 100	Light off
Meditation	0 - 30	Fan on-high speed
Meditation	31 - 100	Fan on-low speed

The value of attention and meditation can be visualised by using ThingSpeak. The result update in real-time and the data will save in ThingSpeak cloud. The light and fan usage also can be seen in the ThingSpeak to observe how many time user used to control light and fan.

III. Result And Analysis

The Processing software in Figure 6 displayed the real-time data of the brain activity. But it's not shows the values of the brain attention, meditation and brain frequency such as delta, theta, low alpha, high alpha, low beta, high beta, low gamma and high gamma. The Figure 7 shows the Brain Grapher after execute using Processing software. The connection quality between transmitter and receiver must be good means the green colour circle as shows in Figure 7 and the packets received indicates the data received by Processing software from Mindflex mindset. Otherwise, if the connection quality is poor, the connection quality the red colour circle is shown.

Figure 6. Model of the project

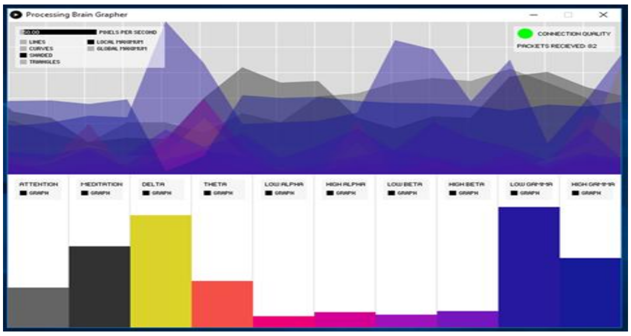

Figure 7. Real-time Brain Grapher Processing

To get the real-time brain activity, the connection quality between transmitter and receiver must be good means the green colour circle as shows in Figure 4.2 and the packets received indicates the data received by Processing software from Mindflex headset. Otherwise, if the connection quality is poor, the connection quality the red colour circle is shown. The Table 3 shows the values from serial monitor. The readCSV() function returns a string (well, char*) listing the most recent brain data, in the following form signal strength, attention, meditation, delta, theta, low alpha, high alpha, low beta, high beta, low gamma and high gamma.

Table 3: The values from serial monitor

Signal strength	Attention	Meditation	Delta	Theta	
0	20	50	566281	116435	
Low Alpha	High Alpha	Low Beta	High Beta	Low Gamma	High Gamma
19795	30007	4449	7956	4224	647415

Table 4 shows the value to switch on the light, brain attention used is greater than 75% out of 100%. At this range, user at high level of focusing. To switch off the light, user brain attention must be lower than 30%.

Table 4: Attention value to control the light

Attention value	Light State
> 75%	ON (1)
< 30%	OFF (0)

The attention value is measured from 0 to 100 which is the more user focusing, the higher the attention value.

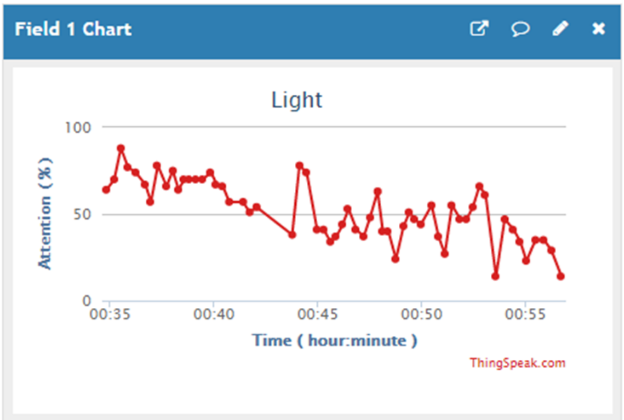

Figure 8. Attention value against time

The attention values show in Figure 8 is not consistent along 30 minutes depend on user brain, user activity either active or passive. The point on the graph shows the attention value recorded and after 15 seconds delay, and next attention value recorded since ThingSpeak only record the data every 15 seconds. User can set how many data to be displayed on the chart. As above, 150 data or attention value displayed.

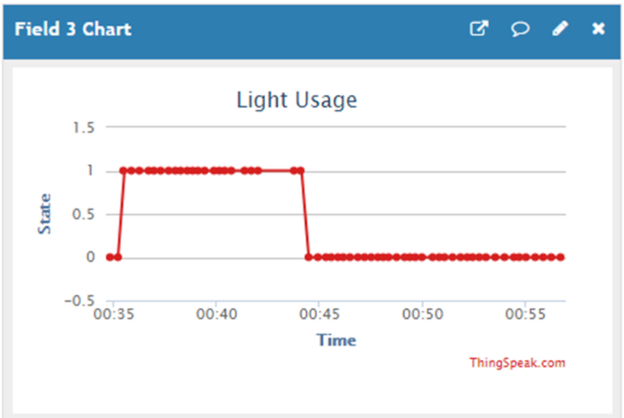

Figure 9. Light state either ON (1) or OFF (0)

The meditation value also measured from 0 to 100 which is higher the level of calmness or relaxation, higher the meditation value. The 150 meditation values are recorded in Figure 10 and it is not consistent along 30 minutes. The meditation value recorded is plotted and after 15 seconds delay, and next meditation value recorded since ThingSpeak only record the data every 15 seconds. Figure 11 shows the fan state either ON or OFF. The "1" in the graph means the fan is ON and "0" means the fan is OFF. From the graph, the fan turns ON means the meditation less than 30% and the fan is turn off when the meditation value also less than 30%.

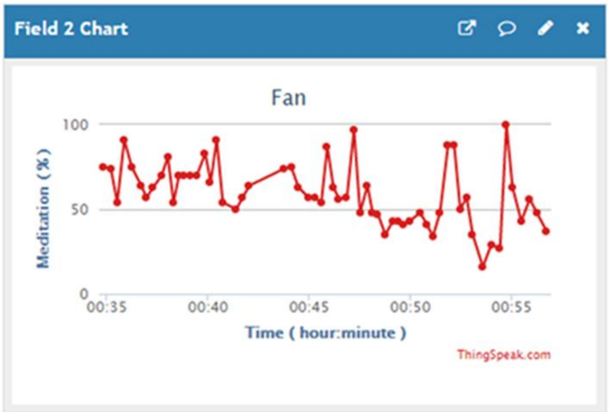

Figure 10. Meditation value against time

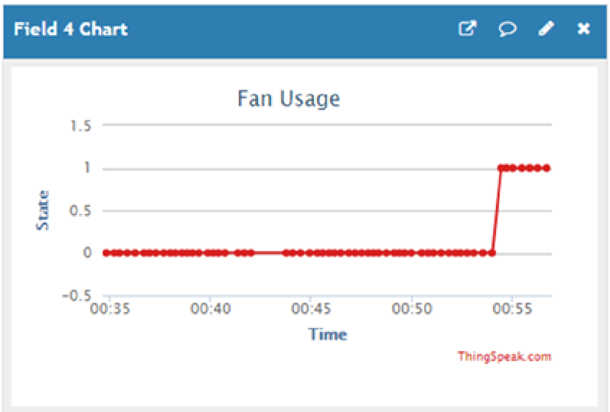

Figure 11. Fan state either ON (1) or OFF (0)

The Processing software also shows the graph depend on packets or data received from Mindflex headset and being process by NodeMCU microcontroller.

The data received and recorded in the ThingSpeak every 15 seconds. While running the brain grapher, make sure only one serial port is used, if not the grapher cannot be displayed because of interception between serial port and the connection quality is poor.

The most common cause of ERROR: Checksum is faulty batter.Other than that, maybe due to NodeMCU board not get enough CPU frequency not get enough power from universal serial bus port on personal computer. The attention and meditation values are used to control light and fan because human brain frequency is not fix. The value of brain wave value i.e. delta, theta, low alpha, high alpha, low beta, high beta, low gamma and high gamma of brain changing every seconds. So, to control light and fan using brain frequency maybe harder than using attention and meditation of brain.

IV. CONCLUSION

In this paper, the design and implementation of a neuro based switching system control for power socket using IoT is possible to build where the system can control light and fan with brain signal wirelessly. This was accomplished using Mindflex EEG headset equipment containing only one electrode on the forehead.

EEG signals from the user brain are sent to the NodeMCU ESP8266 (microcontroller) via Bluetooth and sent to ThingSpeak to store and retrieve data that can be visualize through ThingSpeak website or ThingView apps on mobile phone. In project development of IoT smart home controller, the aim is to help disabilities people to control their home appliance. They need more home appliances to be control such as remote control for television, air conditioner and others. Adding various smart home controller maybe can help them to do more rather than control the light and fan only.

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