Electroencephalography (EEG) for Control the Luminaire System with Arduino UNO

Intisar Mohsin Saadoon and Qabas Abdal Zarhaa Jabbar
Department of Computer Science, College of Education, Mustansiriyah University, Baghdad, Iraq
dr.intisar_muhson@uomustansiriyah.edu.iq

Abstract: Electroencephalography (EEG) is a technique of reading the nerve electrical activity of the human brain by placing the EEG sensors into the scalp for the direct connection between the human brain and the computer. The main objective of this project was to read brain waves and generate control signals that used to control the luminaire system.

Key words: Electroencephalography (EEG), Graphical User Interfaces (GUI), brain wave, electrodes, Arduino, luminaire system

INTRODUCTION

The EEG signal obtained from the anterior lobe, when converted from the time domain to the frequency domain using the fast Fourier transform, reproduces different frequencies associated with different mental and emotional states (Fig. 1).

The main objective of this project was to read brain waves and generate control signals that used to control the luminaire system to build an initial model to assist real-time communication to alleviate the lives of the disabled (Myung and Yoo, 2013).

Graphical User Interfaces (GUI) are developed in two parts in this project. The first is part read the real-time brain signals the second part control the luminaire system with the help of Arduino UNO.

MATERIALS AND METHODS

Electroencephalography (EEG): One can get these days some of EEG systems at low cost prices from the market. Electrodes which installed on EEG systems can be connected to the computer wirelessly using Bluetooth bandwidth is 2.4 GHz.

The Arduino is open-source board have ARM processor can be configured by using software in development environment and used to gather and analyse the data to use it in real-time or stored for future analysis Fig. 2.

Electroencephalography (EEG) is the measurement of the electrical activity generated by neurons in the brain. A group of electrical signals generated by nerve cells in the brain are read by placing electrodes and analyzing that information that relates to the current emotional and emotional state of the brain (Fig. 3).

Hardware required
- Arduino UNO
- NeuroSky headset (Slave)
- HC-05 Bluetooth module (Master)
- USB cable for Arduino
- Breadboard
- Jumper wires
- LEDs

The TX pin from the Arduino to the RXD pin on the HC-05 removed becouse we are only interested in the data transmitted from the HC-05 module to the Arduino Fig. 4.

EEG signal analysis: EEG signals vary by frequency band capacity (Lakshmi *et al.*, 2014). Delta waves are high-frequency waves within the range 0-4 Hz occur during the deep sleep. Theta waves within the frequency range 4-8 Hz occur while meditating, inactivity or drowsiness. Alpha waves within the range 8-14 Hz and occurs during relaxation or meditation or close the eyes. Mu waves occur within the frequency band 8-13 Hz while the motor neurons are at rest. Mu suppression occurs when the user imagines moving or actually moving parts of his body. Beta waves within the frequency band 13-30 Hz and occur during the focus, alarm or activity status. Gamma waves within the frequency band 30-100 Hz during sensory processing of sound and sight (Fig. 5).

Brain-Computer Interface (BCI): Brain-Computer Interface (BCI) is a system that measures brain activity and transforms this activity into artificial outputs (Sathurappan and Potty, 2013), thus, changing the interaction of outputs between the computer system and

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Corresponding Author: Intisar Mohsin Saadoon, Department of Computer Science, College of Education,
Mustansiriyah University, Baghdad, Iraq dr.intisar_muhson@uomustansiriyah.edu.iq
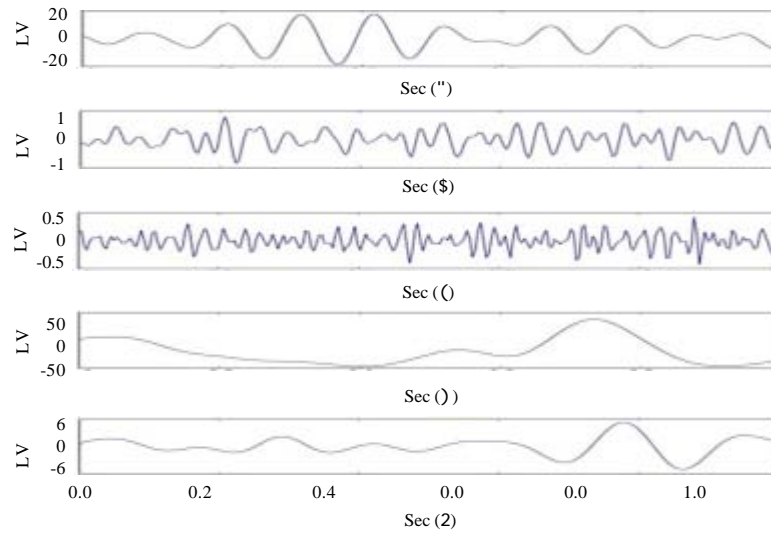
Fig. 1: Brain waves

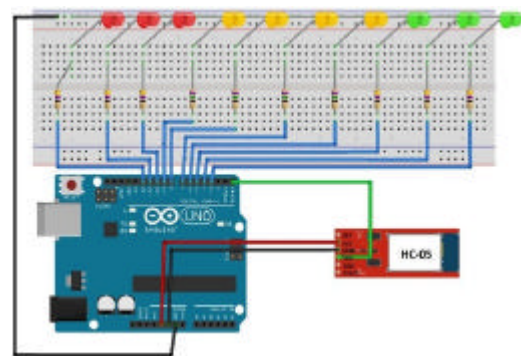Fig. 2: Arduino UNO

Fig. 3: NeuroSky headset

Fig. 4: HC-05 Bluetooth with Arduino

its external or internal environment (Wang, 2012) as show in Fig. 6. The computer interface system must contain four components:

- Activity must be recorded directly from the human brain using a specific sensor
- User feedback must be provided
- It should work in real time
- It must rely on intentional control

EEG signals taken by sensors within the frequency band from 1-100 Hz, including noise signals (Almejrad, 2010). The active range pass filter for bandwidth from 0.1-100 Hz is designed to eliminate other frequency signals. The signal also contains 50-60 Hz noise resulting from the interference of the power line which can be reduced by protecting the wires. The signal picked up by the sensor is amplified for the first time by the amplifier (Azim *et al.*, 2012). Active band pass filter
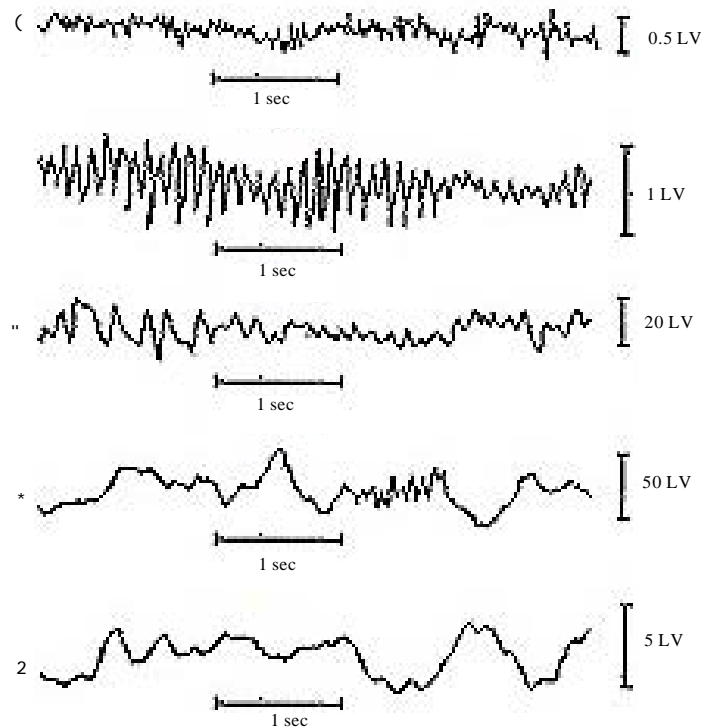
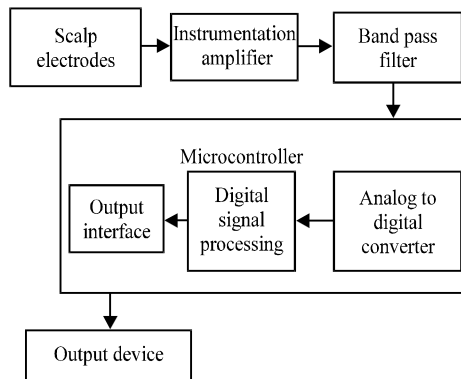Fig. 5: Brain waves frequency band

Fig. 6: Brain-computer interface

removes unwanted frequencies from the amplified signal. This analog signal is converted to a digital signal using an analog to digital converter in the ATmega 328P microcontroller. Digital signal is processed in the micro controller, thus, controls the LED input.

NeuroSky visualization: Reading the result of brain signals by NeuroSky visualization Fig. 7 after connect with specific port com to get results of attention, Meditation and Blink St:

- Attention: 69 4.044
- Meditation: 47 3.524
- Blink St: 57 3.648

Main coding:
```
if(brain.update()) {
Serial.println(brain.readSignal());
if(brain.readSignal()==0){
if(brain.readAttention()≤47 )
{
digitalWrite(lid1, HIGH);
digitalWrite(lid2, HIGH);
digitalWrite(lid3, HIGH);
digitalWrite(lid4, LOW);
digitalWrite(lid5, LOW);
digitalWrite(lid6, LOW);
digitalWrite(lid7, LOW);
digitalWrite(lid8, LOW);
digitalWrite(lid9, LOW);
digitalWrite(lid10, LOW);
}
else if(brain.readAttention()≥47 && brain.readAttention()≥69)
{
digitalWrite(lid1, LOW);
digitalWrite(lid2, LOW);
digitalWrite(lid3, LOW);
digitalWrite(lid4, HIGH);
digitalWrite(lid5, HIGH);
digitalWrite(lid6, HIGH);
digitalWrite(lid7, HIGH);
digitalWrite(lid8, LOW);
digitalWrite(lid9, LOW);
digitalWrite(lid10, LOW);
}
else if(brain.readAttention()≥69)
```
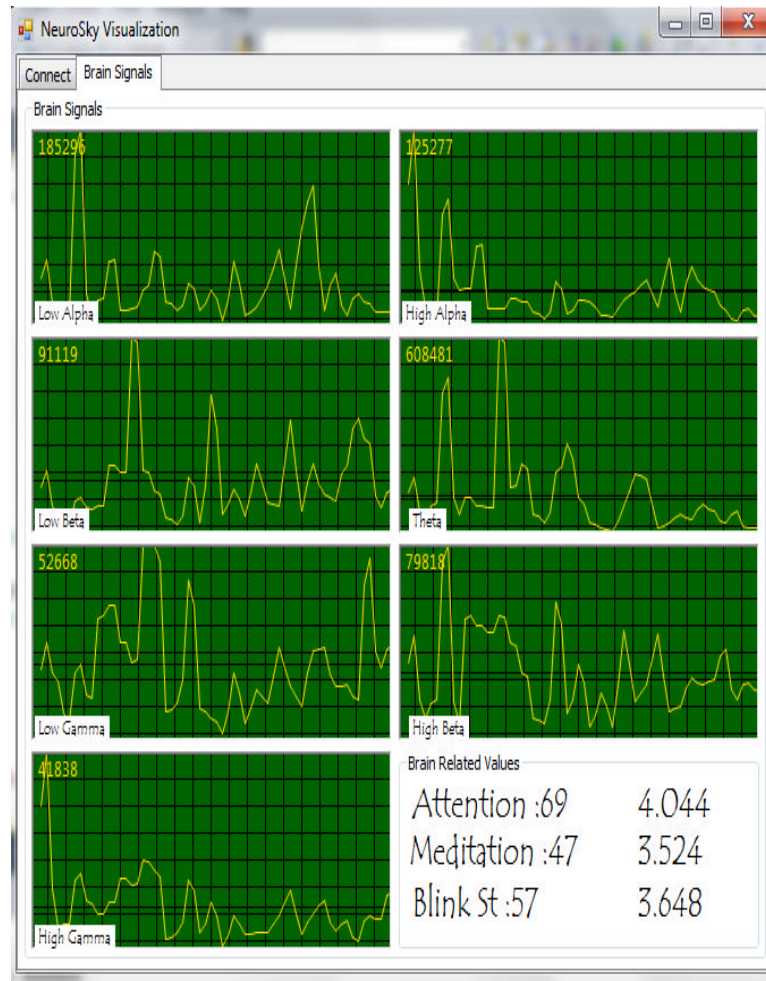
Fig. 7: NeuroSky visualization interface results

```
{
digitalWrite(lid1, LOW);
digitalWrite(lid2, LOW);
digitalWrite(lid3, LOW);
digitalWrite(lid4, LOW);
digitalWrite(lid5, LOW);
digitalWrite(lid6, LOW);
digitalWrite(lid7, LOW);
digitalWrite(lid8, HIGH);
digitalWrite(lid9, HIGH);
digitalWrite(lid10, HIGH);
}
else if(brain.readSignal()>0 && brain.readSignal()<200)
{
digitalWrite(lid1, LOW);
digitalWrite(lid2, LOW);
digitalWrite(lid3, LOW);
digitalWrite(lid4, LOW);
digitalWrite(lid5, LOW);
digitalWrite(lid6, LOW);
digitalWrite(lid7, LOW);
digitalWrite(lid8, LOW);
digitalWrite(lid9, LOW);
digitalWrite(lid10, LOW);
}
```

CONCLUSION

The main objective of this project was to read brain waves and generate control signals that used to control the luminaire system to build an initial model to assist real-time communication to alleviate the lives of the disabled. Graphical User Interfaces (GUI) are developed in two parts in this project. The first is part read the real-time brain signals the second part control the luminaire system with the help of Arduino UNO.

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