BCI Framework Based Mind-Wave Game Controller

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Abstract

Human-Computer Interaction (HCI) systems may not be suitable for disabled or paralyzed peoples. Brain-Computer Interface (BCI) is an alternative method of communication for disabled or paralyzed peoples. Electroencephalography (EEG) is the non-invasive method of signal acquisition to measure the electrical activity of the brain. This neural oscillations is popularly called brain waves. To make a wireless transmission, the Bluetooth transmitter is integrated with EEG device. The EEG recognized signal may contain the artifacts and noise. To remove this artifacts by using filters and amplifiers is used to amplify the EEG signal. Then the processed EEG signal is transmitted to Bluetooth receiver, which is integrated with microcontroller. Microcontroller sends the control command to the computer system for corresponding EEG signal. Based upon the control command the direction of game is takeover. This device can act as like as the following keys, which is present in the keyboard. The keys are W, A, S and D. This device gives high end user experience of gaming.

Keyword- BCI, Electroencephalography, Computer interface

I. INTRODUCTION

Brain Computer Interface (BCI) is the new emerging interfacing technology to interface brain to external world devices such as, computer, mobile and other applicable devices. BCI is the technology is started in 1920's. Initially it was thought that this concept is not possible, but later on various researcher's involvement has been taken this field into higher growth. Initially BCI is consider only in medical field for manufacturing the assistive devices for disability peoples. Later on the development turn into healthy peoples also. The assistive devices for disability peoples enhance the quality of life. The BCI devices is cheap and easy to use. BCI is help the peoples to restore and regain the motor abilities and motor functionalities. Brain computer interface is an alternate method of communication for disabled peoples, who are fighting each day with their disability. Modern technology peoples is always willing and depending to use smart devices and expect innovative alternate communication devices. The main focus of the BCI is paralysed peoples, but paralysed and non-paralysed peoples is considered in today. The recent development makes enormous impact in BCI technology. Various companies and research group still give their bigger contribution of development of BCI technology.

II. BCI GENERAL FRAMEWORK

There are five basic stages in Brain Computer Interface (BCI). The following figure 1 shows the various stages in Brain Computer Interface system.

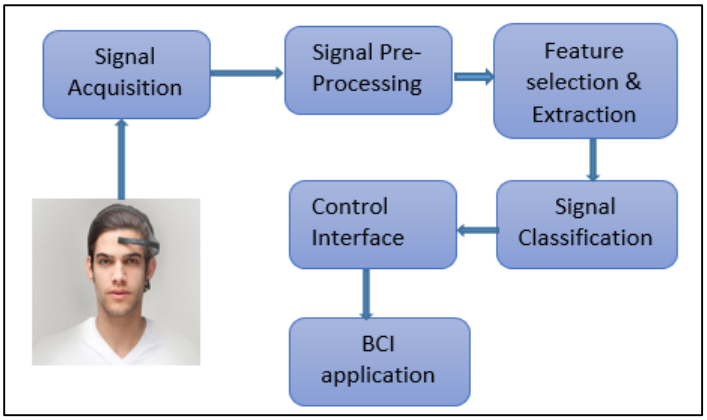

Fig.1: General BCI Framework

A. Signal Acquisition

Signal acquisition is the first stage in brain computer interface system. The acquisition may be Invasive or Non-invasive. The electrode directly placed in the scalp in using EEG method of acquisition. International 10-20 system is the standard internationally recognised method for applying the electrode in the scalp for EEG experiments. The acquisition may done by using single electrode or array of electrodes. In recent improvement of technology various companies provide the EEG device with single electrode. A single electrode is enough for getting all kind of bio-signal. The signal is get from sensorimotor areas.

B. Signal Pre-processing

After getting the digitized Bio-signal from signal acquisition method the signal is to be pre-processed for removing artifacts. Artifacts means the acquired bio-signal is corrupted by eye movement or muscle intervention. To remove this artifacts by using several methods, such as blind source separation technique called Independent Component Analysis (ICA) method, regression method. The following are the possibilities of occurring artifacts they are:

1) The frequency is known to be limited range. The frequency cross the limit may contain artifacts, to remove the artifacts by using frequency filtering.
2) Power supply may create a 50HZ power line noise. To remove this noise by using notch filtering.
3) The artifact is limited to a certain time range.

Amplification and filtering is the general method in pre-processing. The digitized acquired signal having a minute range in volts. To convert this minute bio-signal into recognised format, the amplification process is needed.

C. Feature Selection and Extraction

Feature selection is the process of finding the best subset of the input feature set. Feature extraction is the process of creating a new features based on combination or transformation of the original feature set. Both selection and extraction process is leading to dimensionality reduction. Feature selection is difficult and important task. Some characteristics of the features may varies time to time for the same user and differ from different users. Many methods used in feature selection they are, simple ranking methods (t-statistics, k-fisher coefficients). Non-ranking methods (genetic algorithms (GA), sequence forward selection (SFS), Principle Component Analysis (PCA), Linear Discriminant Analysis (LDA)). Some of the feature extraction techniques are: Discrete Fourier Transform (DFT), spectrum density (PSD), Discrete Wavelet Transform (DWT) of Higher Order Statistics (HOS), Autoregressive models (AR), Principal Component Analysis (PCA). Feature extraction are meant to minimize the loss of the important information contained in the signal. Feature extraction process is needs whenever there is a larger inputs set is available. Now a days we can use single electrode enough to acquire brain signal. So there is no need of feature extraction.

1) Discrete Wavelet Transform (DWT)

Wavelet transform is the process of expressing any general function into infinite series of wavelets. The important idea in wavelet analysis is expressing a signal as a linear combination of particular set of functions by shifting and expanding the original wavelet. This decomposition gives a set of coefficient called wavelet coefficient.

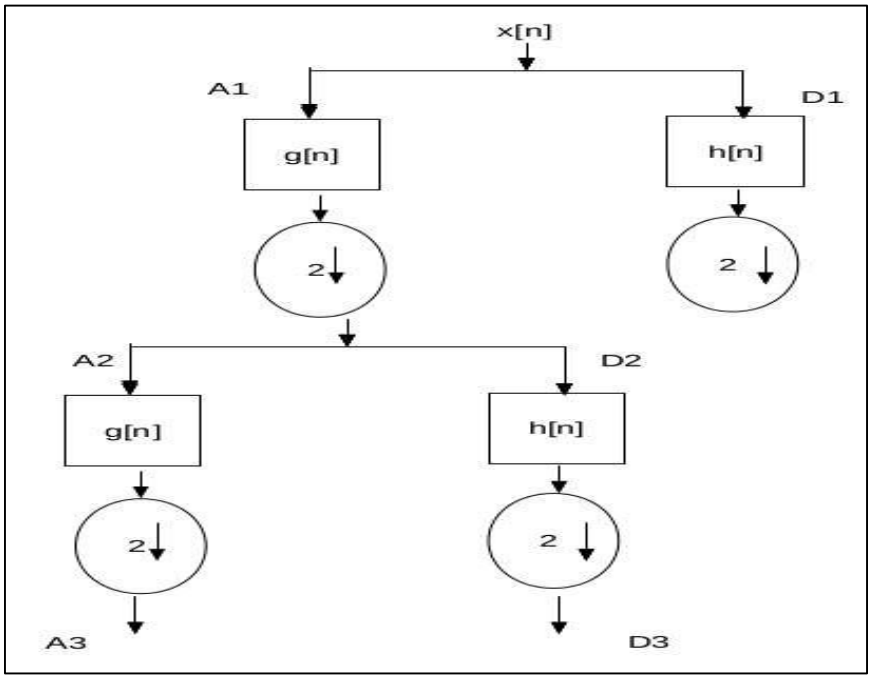

Fig. 2: Decomposition of signal using DWT

D. Signal Classification

After the signals are pre-processed and cleaned, they will be classified to find out which kind of mental task the subject is performing. Various classifier method is used for signal classification. Classification can be done for both eye blink and mental task. Some of the classification methods are: MLP neural networks, Support Vector Machines (SVM), Linear Discriminant Analysis (LDA), Bayesian Classifier (NBC), nearest neighbour classifier (KNN), K-means, Hidden Markov Models (HMM), Decision Tree (DT) and clustering (C).

E. Control Interface

Control interface is the final stage to complete the interface between the brain and the device. The appropriate chosen device for BCI interfacing is complete the user intended task through the way of signal is converted into command. Based upon the command the function is to be performed by control device. The interfacing may wired or wireless transmission. To convert the user brain signal into command for user intended task is difficult one.

III. ELECTROENCEPHALOGRAPHY

Electroencephalography (EEG) is a Non-invasive method of acquisition. EEG measures the voltage fluctuations resulting from the ionic current within the neurons in the brain. This project using EEG device for signal acquisition. The advantage of this EEG device is portable, easy to use and non-invasive. In recent BCI applications are all using this EEG device for not causing any problem to their users. And also dry electrodes is used in EEG, no need of conductive gel is to be used. Now a days a single electrode is enough for getting all kind of signals. The following figure 3 shows the single electrode EEG device.

Fig. 3: EEG Device

IV. OBJECTIVE OF THE PROJECT

The goal of the Project is to develop a fast and reliable connection between the brain and a personal computer. The 'Brain-Computer Interface' device can provide Paralysed or motor-impaired patients a mode of communication through the translation of thought into direct computer control. In this project Using EEG to acquisition of brain signal and make a wireless transmission by integrating Bluetooth modules to both user and system side. The signal is Pre-processed and transmitted to microcontroller. Microcontroller can emulate a signal to the key and to control a direction of game.

V. SYSTEM ANALYSIS

A. Existing System

In the existing system, the entertainment world today has become very popular in using video games. The growth of technology, graphical field and processing speed, the global gaming sector has been revolutionized. Various gaming mediums are used to play a video games such as Computer/Mac gaming, dedicated TV consoles, handheld gaming consoles, mobile and tablet based gaming. The global gaming market has been showing a growing trend in forecast years too. In the existing system, hand using games are quite interesting in the beginning, but as time goes, it gets bored.

1) Drawbacks of Existing System

- Not more realistic.
- Disabled peoples cannot able to play games.
- The existing, hand using games are quite interesting only a small period of time.
- Gaming affects human eye

B. Proposed System

This project, the device can detect your focus level, your meditation level, and blinks. The more focused you are the higher the "attention" level becomes, the more relaxed you are, the higher the "meditation" level becomes. The core concept is that using different brainwaves will be able to control a game by the user. Alpha is the frequency range from 7 Hz to 14 Hz, is the frequency range at the time of Relaxation or Meditation. Beta is the frequency range from 15 Hz to about 30 Hz, is the frequency range at the time of busy or active thinking and active concentration. Based upon the above two frequency ranges is used to control a game by using the mind-wave game controller.

1) Purpose

- It's give back an ability for people who are fighting each day with their disability.
- Play real games with our thoughts.
- Today's generation need all things are virtualization based, mind-wave gaming control device gives high end user experience of gaming.
- It increases the user brain functioning.

VI. SYSTEM DESIGN

A. Use Case Diagram

UML has a common modelling tool have many types of diagrams. One of the most important UML diagrams is use case diagram. The following figure 4 is the use case diagram of BCI system for game controller:

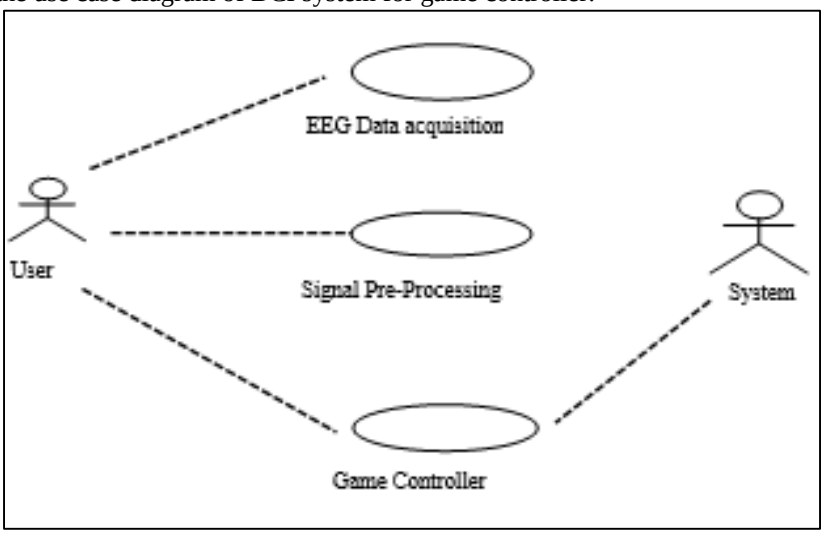

Fig. 4: Use Case Diagram for Mind-Wave Gaming

As figure 4 shows, there are three main use cases, signal acquisition, signal Pre-processing and game controller. The Signal acquisition use case is responsible for reading EEG data packets from EEG acquisition device by Bluetooth port, and then send to signal Pre-processing module after data formatting. Signal Pre-processing use case is responsible for analysis and processing EEG data from the signal analysis modules, the last results will be sent to the game controller. Finally, the game controller produces control signals to control the direction of the gaming. The two roles in the figure are the user and system.

VII. SYSTEM ARCHITECTURE DIAGRAM

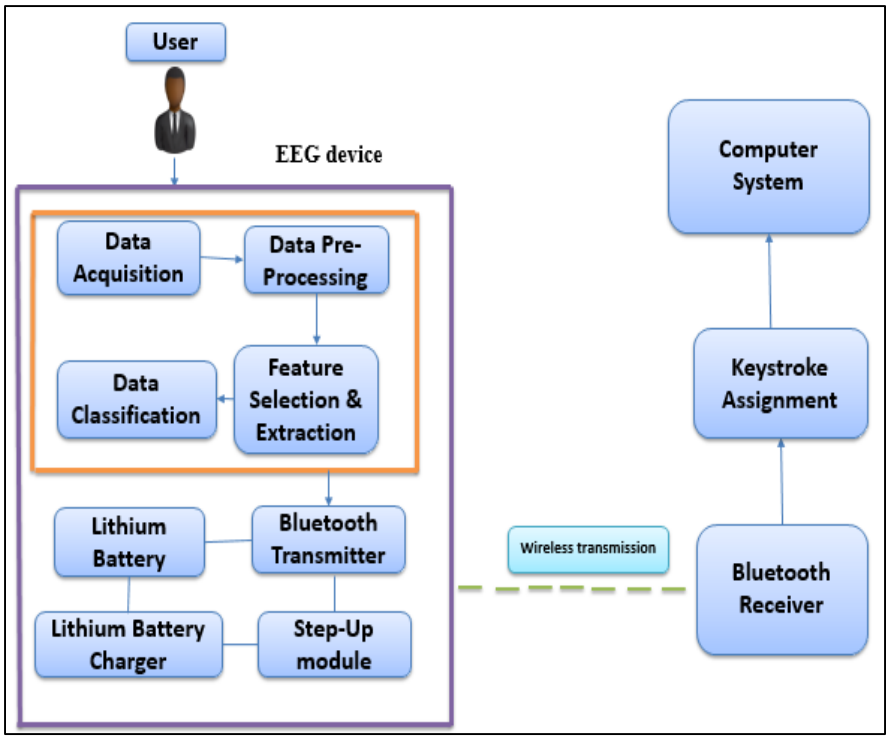

Fig. 5: System Architecture Diagram

VIII. SYSTEM MODULES

The system is sub-divided into four modules they are:

- EEG Data Acquisition Module
- Data Pre-Processing Module
- Configuring Bluetooth Module
- Keystroke Assignment

A. EEG Data Acquisition Module

EEG (Electroencephalography) acquisition device is used to measure the electrical signal by using dry electrodes from the sensorimotor area. For wireless communication, the chargeable lithium battery is associated with EEG device.

Based upon the user's concentration and relaxation different brainwaves are produced. It has one dry sensor that can be placed on the forehead, left side (approximately equal to Fp1 in the 10-20 system).

B. Data Pre-Processing Module

In this module, EEG device consists of a pre-amplifier unit, a microcontroller unit and a Bluetooth transmission unit. The microcontroller unit is used for reduce the noise and regulate the sampling rate. Signals were pre-processed to remove artifacts.

A notch filter was used to remove 50Hz power line noise. Differential amplifiers with band-pass filters were used to minimize the effects of high-frequency noise and low-frequency artifacts.

C. Configuring Bluetooth Module

The Bluetooth transmitter is associated with the EEG device, which is used to provide a wireless transmission. Using a 500mAh Li-Ion battery, a USB charger circuit, a 5v step up circuit and two resistors (100 ohm and 200 ohm) is used to perfect power supply for the chip and for the Bluetooth module.

Then, the processed EEG signal is transmitted to the computer using Bluetooth transmitter. The EEG data value is receive by Bluetooth receiver and the value is used for control a game.

D. Keystroke Assignment

Keystroke assignment is the process of assigning a corresponding EEG signal to a key. The chip board (Arduino Leonardo) is able to emulate keyboard or mouse. Using this feature, the software code that emulates W, A, S, D and control a game.

The eSense values: If the eSense value reaches the limit (70 for meditation and 65 for attention) or detects blinks emulates a pressed key.

In keystroke assignment process, the limit value is to be set. If the signal value falls under any limit range the corresponding command associated with that is triggered and the direction of the game is controlled.

IX. EXPERIMENTS AND METHODS APPLIED

A. Hc-05 Bluetooth Module

Hc-05 Bluetooth module is Bluetooth serial port protocol module. This Bluetooth can be used in both master and slave configuration and give a best solution in wireless communication. This Bluetooth module is having a following features:

- Bluetooth V2.0+Enhanced Data Rate (EDR).
- 2.4 GHz radio transceiver and baseband
- CMOS technology and Adaptive Frequency Hopping Features.

The role of the module (Master/Slave) can be changed by using AT commands. Master module is always initiate connection to another Bluetooth devices. Slave is only accept the connection from master.

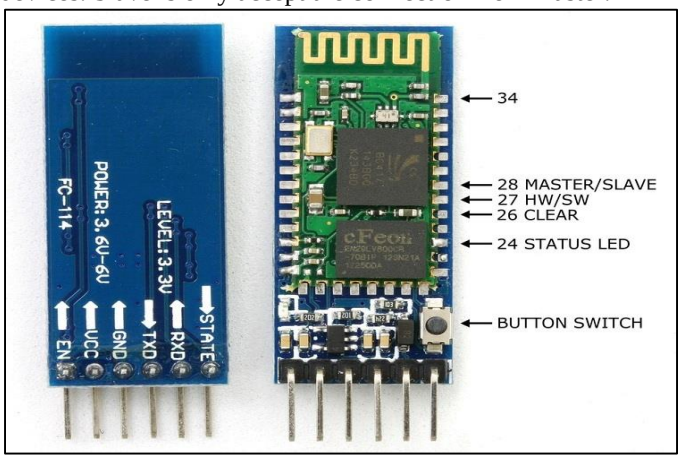

Fig.6: (a) HC-05 Bluetooth Module

Fig 6(a) and 6(b) shows the sample view of HC-05 Bluetooth module and pin diagram respectively.

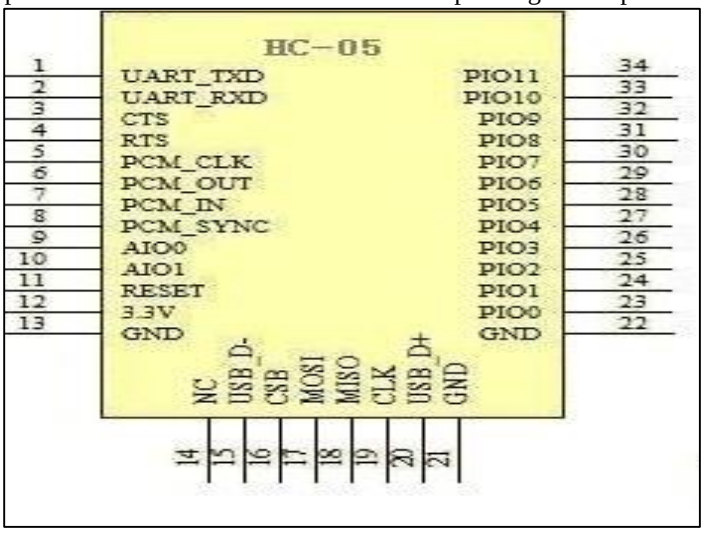

Fig. 6: (b) HC-05 Bluetooth Pin Diagram

B. Hc-06 Bluetooth Module

The following figure 7(a) and 7(b) shows the sample view of HC-06 Bluetooth module and pin diagram respectively.

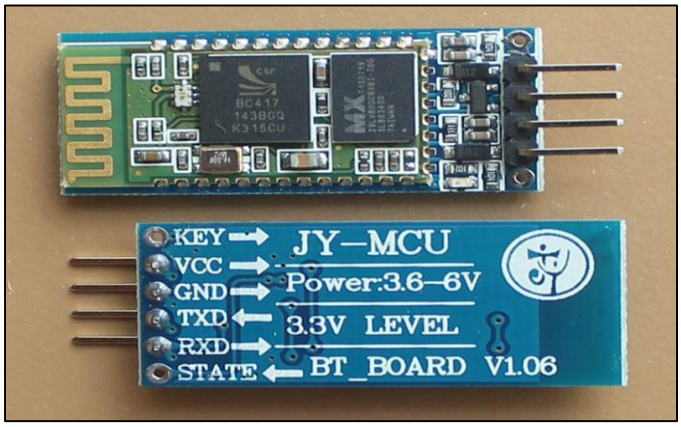

Fig. 7: (a) HC-06 Bluetooth Pin Diagram

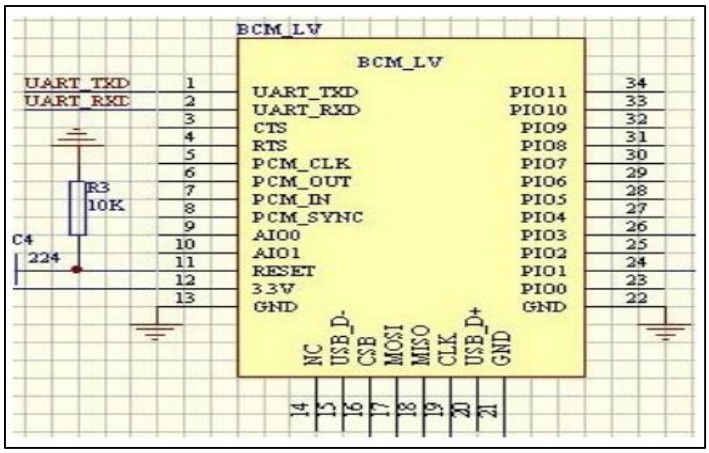

Fig. 7: (b) HC-06 Bluetooth Pin Diagram

C. 500 MAH Lithium Ion Battery

Lithium ion batteries are light weight, thin and powerful. The battery is chargeable one. The battery has a capacity of 500 mAh. It has a 2-pin JST-PH connector and protection circuitry. The following figure 8 shows the clear view of 500 mAh lithium Ion Battery.

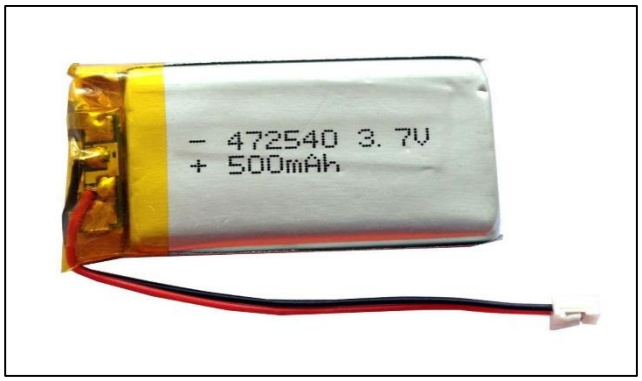

Fig. 8: 500 mAh Lithium Ion Battery

D. 5V Step-Up Module

It is a regulator module is used to regulate a DC output of 5V at 1A continuous current. The following figure 9 shows the 5V step-up module.

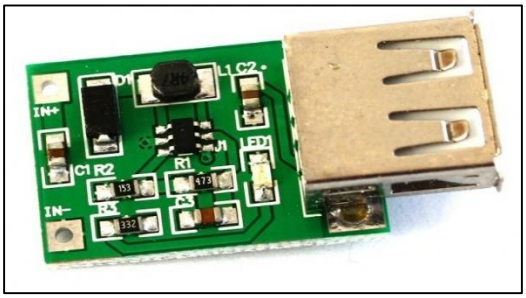

Fig. 9: 5V Step-Up Module

E. Lithium Ion Battery Charger

Lithium ion battery charger for the purpose of charging the lithium ion battery. The following figure 10 (a) and 10(b) shows the lithium ion battery charger module and its circuit diagram respectively.

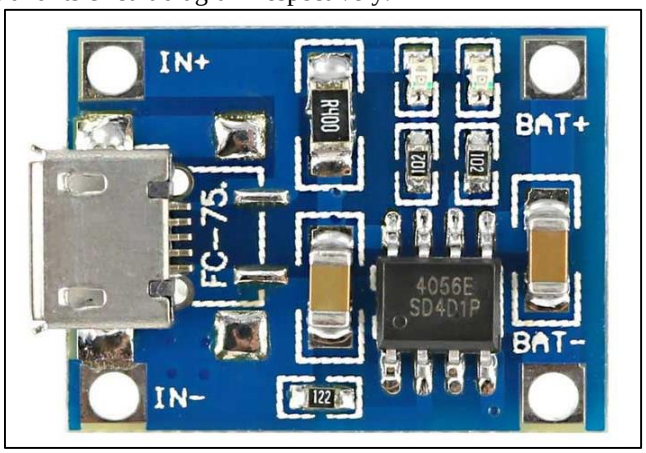

Fig. 10: (a) Lithium Ion Battery Charger Module

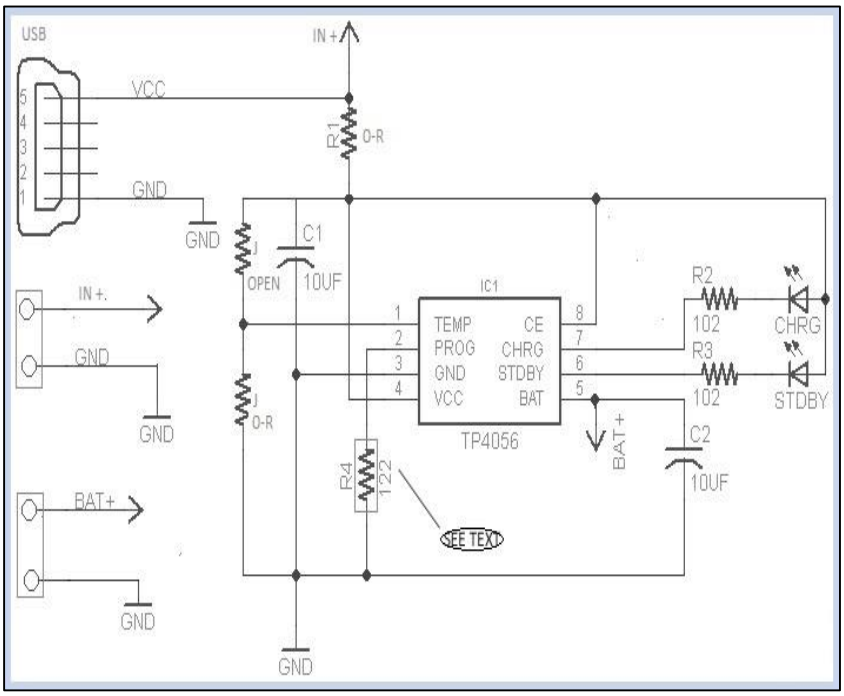

Fig. 10: (a) Lithium Ion Battery Charger Circuit Diagram

F. Arduino Leonardo

Arduino Uno R3 allows for faster transfer rate and having more memory. No drivers is needed for Mac or Linux. Arduino is used to develop a stand–alone interactive objects. The following figure 10 shows the pin diagram of Arduino.

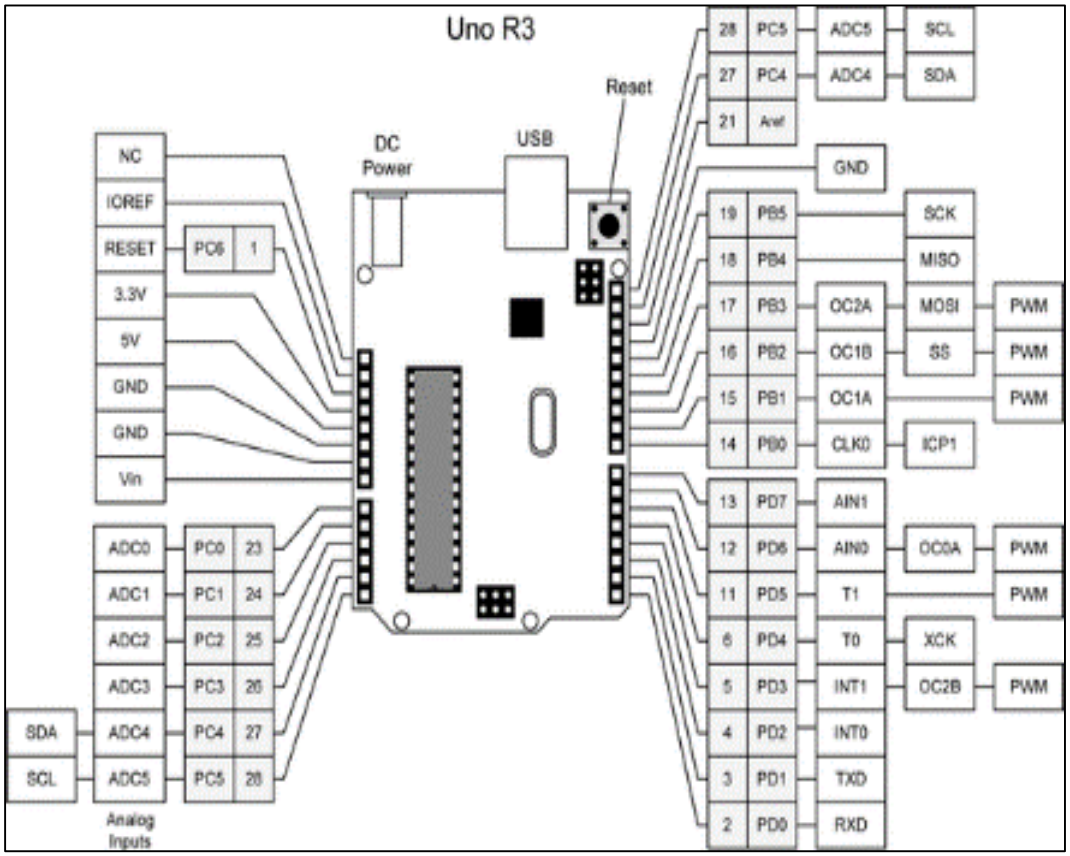

Fig. 11: Arduino Leonardo Pin Diagram

X. IMPLEMENTATION AND RESULT

Initially program the HC-05 and HC-06 Bluetooth module by load up into Arduino UNO. Using the Arduino IDE to configure the Bluetooth modules. HC-05 act has a master and HC-06 act has a slave. After that using "EN" pin to connect each other. EEG is a device which is used to measure the brain signal. For make a wireless transmission the EEG device is hacked for the purpose of integrating chargeable lithium battery and step-up modules. The signal is pre-processed for removing artifacts and this signal is transmit to the Arduino by using Bluetooth modules. The microcontroller (Arduino Leonardo) is able to act as like as keyboard or mouse. Using this facility it emulates the following keys of W, A, S and D. Based upon the user emotion and feelings, the brain signal is to be changed.


Fig. 12: Mind-wave game controller

XI. CONCLUSION AND FUTURE WORK

This project investigates to control a game by EEG signals. The goal is to control the direction (left or right) of the game by EEG signals. Using our brain signal to control a game, there is need for a little training to every user. This project investigates control of a car racing game by EEG signals is little difficult in the beginning. In future using our brain signal to control and operate all machines and also it will help to remote access of internet in future.

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