VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, Belgaum – 590014

Project Report
On

"PROSTHETIC ARM AND HOME APPLIANCES CONTROLLED BY MIND-THOUGHTS AND EYE-BLINKS"

Submitted in Partial fulfillment of the Requirement for the VIII Semester

Bachelor of Engineering
In
Computer Science and Engineering

Submitted By

Afrid Pasha H P (1CE19CS003)
Amith Singh M (1CE19CS007)
B M Puneeth (1CE19CS013)
Kruttika Kirankumar Bhomkar (1CE19CS046)

Under the Guidance of
Mrs. Sangeetha Rao S
Asst. Professor, Dept. of CSE

CITY ENGINEERING COLLEGE

Doddakallasandra, Kanakapura Road, Bengaluru – 560 061
2022 – 2023

CITY ENGINEERING COLLEGE

Doddakallasandra, Kanakapura Road, Bengaluru-560061

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

CERTIFICATE

This is to certify that the Project work entitled **"PROSTHETIC ARM AND HOME APPLIANCES CONTROLLED BY MIND-THOUGHTS AND EYE-BLINKS"** has been successfully carried out by Afrid Pasha H P (1CE19CS003), Amith Singh M (1CE19CS007), B M Puneeth (1CE19CS013) and Kruttika Kirankumar Bhomkar (1CE19CS046), students of City Engineering College in partial fulfillment for the award of the **Bachelor of Engineering in Computer Science and Engineering** from Visvesvaraya Technological University, Belgaum during the year **2022-2023**. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the departmental library. The Project Report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said Degree.

Mrs. Sangeetha Rao S	Dr. Sowmya Naik	Dr. Thippeswamy H. N
Asst. Professor	HOD	Principal, CEC
Dept. of CSE	Dept. of CSE	

External Viva

Name of Examiners	Signature with date
1. Emmanuel Raj M.C	23/05/23
2. P. Prasad	23/05

ABSTRACT

The field of prosthetics has showed a significant improvement over last few years, due to advancement in technologies. However, they have certain problems either with being really expensive, does not provide full motor functions, may require surgical approach or does not look like an arm. This project describes how the Brain waves can be used to control a prosthetic arm using Brain Computer Interface (BCI). The BCI system consist of Electroencephalogram (EEG) sensors placed on the headset to capture the brain waves, which will be extracted using Think Gear. The Brain signal act as command signals and transmitted to microcontroller. This command signal is based on concentration level and eye blink strength of the subject. The prosthetic arm consists of microcontroller coupled with servo motors to perform flexion and extension of fingers. The Brain Computer Interface (BCI) system will administer the disabled people to control their prosthetic arm using their Brain. Level analyzer unit (LAU) will receive the brain wave raw data and it will extract and process the signal. Then the instructions will be sending to the home section to operate the modules (bulb, fan). The project operated with human brain assumption and the On/Off condition of home appliance is based on changing the muscle movement with blinking.

ACKNOWLEDGEMENT

Firstly, we are grateful to our institution **"CITY ENGINEERING COLLEGE"** for providing us a congenial atmosphere to carry out the project successfully.

We would like to express our heartfelt gratitude to**, Dr. THIPPESWAMY H. N,** Principal, City Engineering College, Bengaluru for extending his support.

We would also like to express our gratitude to **Dr. SOWMYA NAIK,** Head, Department of Computer Science and Engineering whose guidance and support was truly invaluable.

We are very grateful to our guide, **Mrs. SANGEETHA RAO S,** Asst. Professor, Department of Computer Science and Engineering, for her able guidance and valuable advice till date.

We would also be indebted to our Parents and Friends for their continued moral and material support throughout the course of project.

Our hearty thanks to all those have contributed bits, bytes and words to select and proceed this project.

AFRID PASHA H P (1CE19CS003)

AMITH SINGH M (1CE19CS007)

B M PUNEETH (1CE19CS013)

KRUTTIKA K BHOMKAR (1CE19CS046)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

In India, there are about 5 million disabled people (in movement/motor functions). The disabled people affected with neuromuscular disorders such as multiple sclerosis (MS) or amyotrophic lateral sclerosis (ALS), brain or spinal cord injury, Myasthenia gravis, brainstem stroke, cerebral palsy, etc. In order to express themselves one must provide them with augmentative and alternative communication. There are over 10 million amputees worldwide, out of which 30% are arm amputees. The only solution that is there is prosthetic arms. Early prosthetics were simple. They were immovable prosthesis like wooden shaft, pegs and metal hooks. Later advances facilitate the movement of the prosthesis, but they looked very different from a human hand.

In recent years, there has been a growing interest in the development of prosthetic devices that can be controlled by brain waves and eye blink signals. Such devices have the potential to greatly improve the quality of life for individuals with physical disabilities, allowing them to perform daily tasks more easily and efficiently. Additionally, the integration of home automation technology into such devices can provide users with greater independence and control over their environment. The aim is to design and develop a prosthetic arm and home automation system that can be controlled by the user's brain waves and eye blink signals. The system will consist of a wearable prosthetic arm that can be controlled using signals generated by the user's brain waves and eye blinks, and a home automation system that can be controlled using the same signals. The system will be designed to be safe, reliable, and easy to use, with a focus on user comfort and accessibility.

The technology involves in the development of signal processing algorithms that can accurately and precisely detect and interpret the user's brain waves and eye blink signals. The system will also incorporate a Bluetooth module to enable wireless communication between the prosthetic arm, home automation system, and control device. The project will culminate in a functional prototype of the system, which will be tested and evaluated for its safety, reliability, and ease of use. The modern world is rapidly moving towards smart homes that offer convenience, comfort, and energy efficiency to their occupants. Home automation systems are designed to achieve these objectives by integrating various devices and systems in the home, such as lighting, temperature control, security, and entertainment, into a centralized control system that can be accessed and managed remotely.

Focus is to design and develop a home automation system that is easy to use, energy efficient, and provides greater comfort and convenience to the occupants of the home. The system will be designed to integrate various devices and systems in the home, such as lighting, temperature control, security, and entertainment, into a centralized control system that can be accessed and managed remotely using a smartphone or other mobile device. The system will incorporate various sensors and control devices to enable intelligent control of the home environment. For example, temperature sensors will be used to detect changes in temperature and adjust the thermostat accordingly, while motion sensors will be used to detect the presence of occupants in the home and adjust the lighting and security settings accordingly.

Emphasis was given on the improvement in both the function and appearance of prosthesis. As technology advanced, the hands became more natural. But the problem is they are unable to control or move as desired. Myoelectric prostheses were developed, which provided greater range of motion and freedom. But myoelectric prostheses are very expensive and need to undergo a critical nerve surgery. And if nerves get damaged its useless.

Fig. 1.1: Laboratory Trials

1.1 BACKGROUND

In 1875, Richard Caton (1842–1926), a physician practicing in Liverpool, presented his findings about electrical phenomena of the exposed cerebral hemispheres of rabbits and monkeys in the British Medical Journal. In 1890, Polish physiologist Adolf Beck published an investigation of spontaneous electrical activity of the brain of rabbits and dogs that included rhythmic oscillations altered by light. Development of human arm prosthetics, which are improved to regain lost functions of amputated limbs, encounters critical and challenging problems to carry out various dexterous tasks. To date, many of revolutionizing design of human arm prosthetics including Boston Arm (Mann & Reimers, 1970), Deka Arm (Resnik, 2010), Otto Bock trans carpal hand (Otto Bock Health Care, Minneapolis, MN), and Shanghai Kesheng Hands (Shanghai Kesheng Prosthese Corporation Ltd.) have been developed.

Imitation of the fundamental patterns of human arm motion depends highly upon the transformation of the neuromuscular activities of residual limbs to a specific control signal for controlling the artificial arm. In this respect, myoelectric signals provide a base of intuitive control, unlike the conventional or direct control. The dexterous control of such myoelectric-based prostheses requires a clear extraction of features from recorded surface electromyography (SEMG) signals and pattern recognition to discriminate the motion and force intentions of the prosthetics users. The progress of feature extraction from SEMG signals has an extensive coverage of myoelectric controlled prostheses studies due to the features in both time and frequency domains have the great potential on representing clear and meaningful information.

Fig. 1.2: SEMG Signals and Pattern Recognition

1.2 BRAIN COMPUTER INTERFACE

The communication of human with the machines can be done using BCI (Brain Computer Interface) technology. Recent advancements in BCI have presented new opportunities for development of new prosthetic arm interface for such people based on thought or brain signals. The basic idea of BCI is to translate user produced patterns of brain activity into corresponding commands. BCI's systems elude the conventional channels of communication which is muscles and speech instead they provide direct communication and control between human brain and physical devices by translating the brain activity into commands in real time. The BCI uses non-invasive EEG sensors to acquire signal from the brain, being a relatively low-cost solution and also avoids dangerous surgery for invasive method where electrodes are placed inside of brain called implants. The EEG technique assumes brainwaves recording by electrodes attached to the subject's scalp. This system comprises of four distinct stages; which are extracting the raw brainwaves, processing the signal, classifying them into different command signals and interfacing them to the prosthetic arm.

EEG-based BCI system can be implemented to overcome the problem of prosthetic arm. EEG-based brain controlled prosthetic arm is a BCI system that controls the actions of the prosthetic arm using brainwaves as command signal. This BCI system implemented is same as how a regular human control the movements of his/her hand. The system will detect the brain waves that can be used as command signals to control the movement of prosthetic arm that is flexion and extension. The Flexion and Extension depends on the concentration levels and eye blink of the subject. The control of the prosthesis is determined by the ability of one's mind to focus and to concentrate. This can be achieved with a few days of training. The project presented in this paper aims to develop a low-cost and versatile human-like prosthetic arm controllable via brain activity using EEG neuro-feedback technology. In this present world many people are coming across many problems, one of those problems is physically handicapped and aged people depending on others to complete their tasks. Technology can be used to reduce this problem to maximum extant using BCI (Brain-computer interface). Brain-computer interface is nothing but the interaction between the human neural system and machines; it is a control system which enables the people to communicate and control a device by mere thinking.

The ultimate goal of the project is to create a system that can provide greater comfort, convenience, and energy efficiency to the occupants of the home, while reducing the environmental impact of home automation.

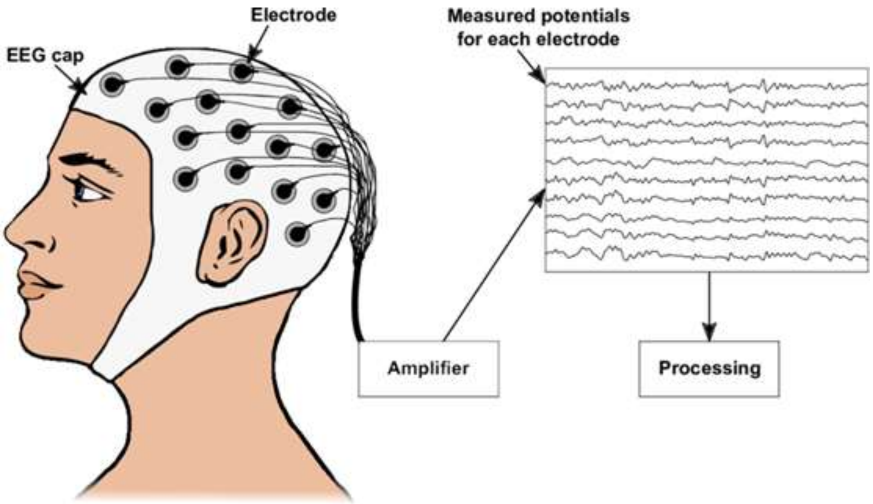


Fig. 1.3: EEG Signal Processing

The BCI system employs the user's brain activity signals as a medium for communication between the person and the computer, translated into the required output. It enables users to operate external devices that are not controlled by peripheral nerves or muscles via brain activity.

The first step in EEG signal processing is preprocessing, which focuses on removing noise and artifacts from the raw EEG signals. Techniques such as filtering, which eliminates high-frequency noise and power line interference, and artifact removal algorithms that target eye blinks and muscle artifacts, are commonly employed. Once the signals are preprocessed, the next step is feature extraction. Relevant features are extracted from the EEG signals, such as power spectral density, frequency bands, or event-related potentials (ERPs) that capture specific brain responses to stimuli or events. These features provide insights into the underlying brain activity.

1.3 OBJECTIVES

- Designing a method for real time collection of different types of data from the headset.
- To analyze different waveforms of Brain.
- To make device Economical.
- Self-controlled and operating facility.
- Controlling the Prosthetic Arm.
- Controlling the Home Automation.

CHAPTER 2

LITERATURE SURVEY

[1] TITLE: "Wearable, Wireless EEG Solutions in Daily Life Applications"

AUTHORS: Vojkan Mihajlovic, Bernard Grundlehner and Ruud Vullers

YEAR: 2015

DESCRIPTION

Brain computer interface (BCI) is a communication pathway between the brain and the external peripheral devices like computers. Besides the numerous benefits that the technological inventions brought to the healthcare domain, especially in surgical and monitoring applications within hospitals, they also facilitated raised awareness of people about their own health. Promoting health is crucial not only for the younger generation if they would like to have a prosperous and long life, but also for elderly if they would like to live independently and to stay mentally fit for a longer period.

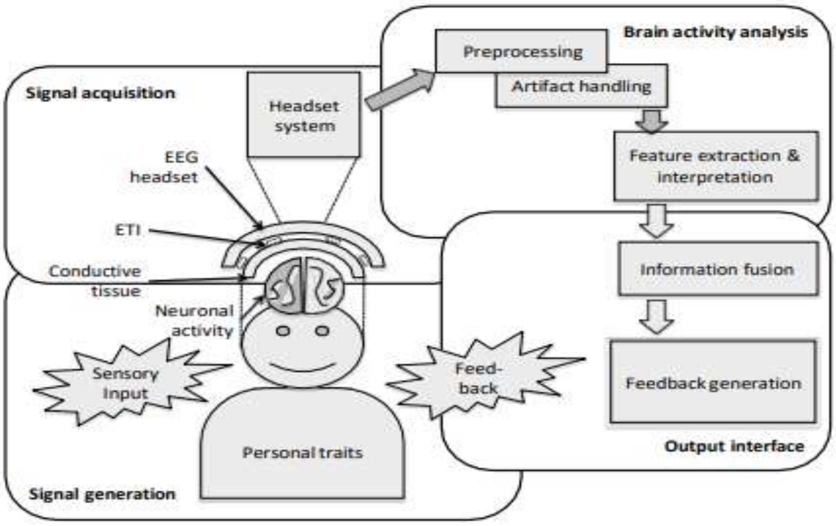


Fig 2.1: Aspects that should be considered when Designing and Developing Intelligent Wireless, Wearable EEG Solutions for Daily Life Applications.

DRAWBACKS

- Has very low accuracy.
- May cost expensive.
- Ethical issues may prevent its development.

[2] TITLE: "Speed Control of Festo Robotino Mobile Robot Using Neurosky Mind Wave EEG Headset-Based Brain-Computer Interface"

AUTHORS: Jozsef Katona, Tibor Ujbanyi and Gergely Sziladi.

YEAR: 2016

DESCRIPTION

Brain-Computer Interface (BCI) is an emergent technology to build a direct communication channel between human brain and the computer. BCI reads the waves produced by the brain and translates these signals into actions and commands, which can control the computer. The BCI can be used in many applications for example playing games, social interactions by detecting emotions, or to help disabled persons. EEG system has been widely used in the field of BCI. The developed BCI system facilitates a relatively accurate andrapid control. Detection and evaluation of encephalic frequencies are performed by an EEG helmet worn by the user using the electric wheelchair, on which several EEG sensors can be found. Evaluation and processing of received signals are performed by a notebook,which can transmit the right-left-forward commands to the wheelchair. For performing 'stop' procedure, a complementary detector was used, which was not based on detectingbrain waves**.** The ASIMO (Advanced Step in Innovative Mobility) robot is a humanoid (similar to humans), which looks like a boy, and can be controlled by brain waves, this device also uses EEG technology.

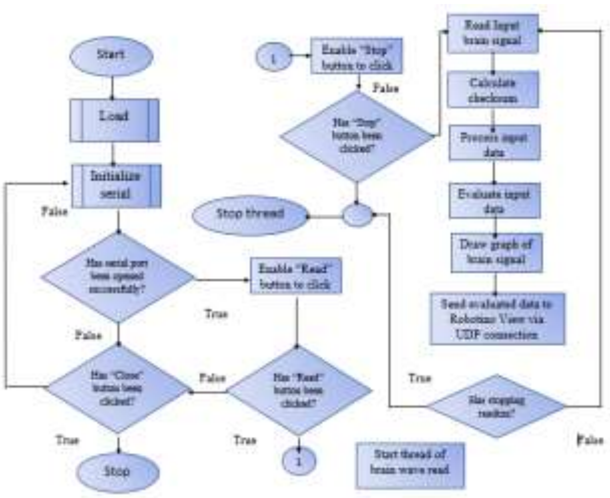


Fig 2.2: **Logical Design**

DRAWBACKS

- Has low accuracy.
- It costs expensive.
- Not much reliable.

[3] TITLE: “Evaluation of E-Learning Activities with Neurosky Mind Wave EEG”

AUTHORS: Diana Janeth Lancheros-Cuesta and Yudi Yirley Forero

YEAR: 2018

DESCRIPTION

The use of e-learning educational platforms is increasing activities (OVA virtual objects of learning). However, Forero states that “Some students may have difficulties in the process learning related to certain medical conditions” such as people who have disorders in the development have problems with perception, attention, memory,thinking, language, learning and psychomotor development.

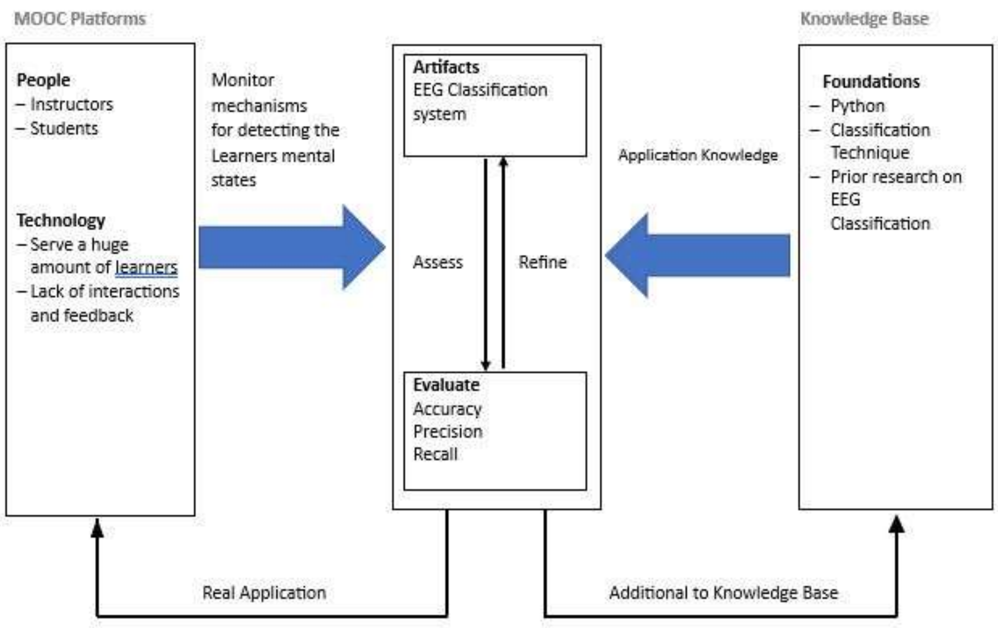


Fig 2.3: Mental Effort Detection using EEG Data in E-Learning Contexts

DRAWBACKS

- Discomfort was experienced when wearing the headset.
- Needs improvement in the performance based on the feedback.

[4] TITLE: "Dry-Contact Electrode Ear-EEG"

AUTHORS: Simon L. Kappel, Hans Olaf Toft and Preben Kidmose.

YEAR: 2018

DESCRIPTION

For decades, researchers and clinicians have been interested in measuring EEG outside the laboratory. In recent years, this interest has gained momentum due to significant technological advancements of wearable devices, and demands for better and more efficient health care technology. Ambulatory EEG systems exist and enable long term real-life recordings, but they are typically bulky and obtrusive for the user's everyday life activities, and must be mounted by trained personnel. Wearable EEG systems try to overcome the limitations of ambulatory systems, aiming at user friendly systems which are easy to mount and which enable long-term recordings in the everyday life.

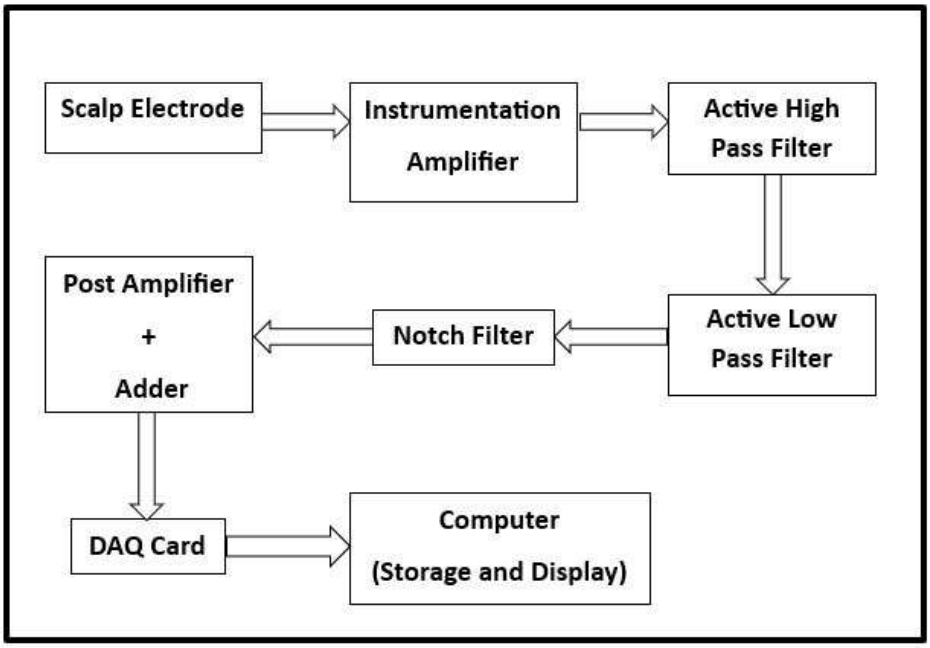


Fig. 2.4: Dry-Contact Electrode Flow Diagram

DRAWBACKS

- Not able to detect neural activity.
- Can't be used to identify the location of neurotransmitters.
- EEG feedback was affected by participant's stress.

[5] TITLE: "Sensitive Brain-Computer Interface to Help Maneuver a MiniatureWheelchair Using Electroencephalography"

AUTHORS: Prashant Kumar, Saurabh Gupta, and Prasenjit Chanak

YEAR: 2020

DESCRIPTION

The Human brain consists of billions of neurons which are interconnected. It generates electrical charges during its working. These charges sum up together to generatean electric field having varying potentials of the order of microvolts. The electrical activityof the brain can be recorded from the scalp. These recordings are known as Electroencephalogram (EEG). The classification of EEG signals is done in the following bands: α, β, δ, θ, and γ. controlling various devices with the help of brain is a wide field of research in the present scenario. In order to interact with computers or other devices using brainwaveswe require an interface between brain and computer which is referred to as Brain- Computer Interface (BCI).

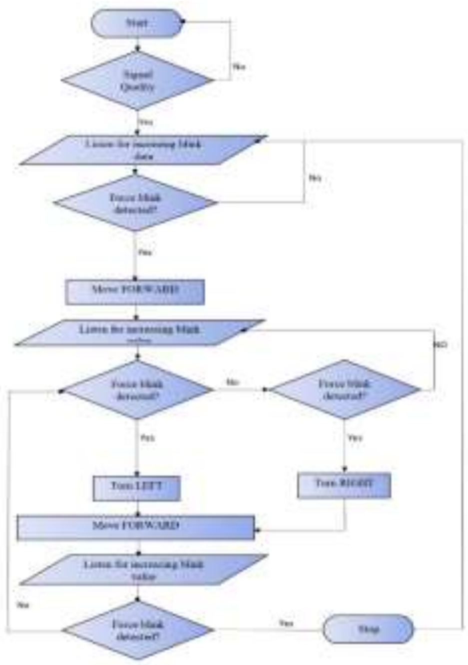


Fig. 2.5: Experimental Setup Flow

DRAWBACKS

- EEG/ERP is hard to figure out.
- Biggest limitation in accuracy in reading the signals.

- May be potentially dangerous. Especially in a situation where the user is crossing the street.

[6] TITLE: "Real-Time Human-Like Robot Control Based on Brain Computer Interface"

AUTHORS: Abdelkader Nasreddine Belkacem

YEAR: 2020

DESCRIPTION

A brain computer interface provides the possibility of communicating with environment by controlling any external device (e.g., artificial robotic arm) for patients with severe motor dysfunction using their brainwaves only. To provide multidimensional control, Belkacem have described the first reported decoding of bilateral hand movements by using single-trial magnetoencephalography (MEG) signals as a new approach to enhance a user's ability tointeract with a complex environment through a multidimensional BMI.

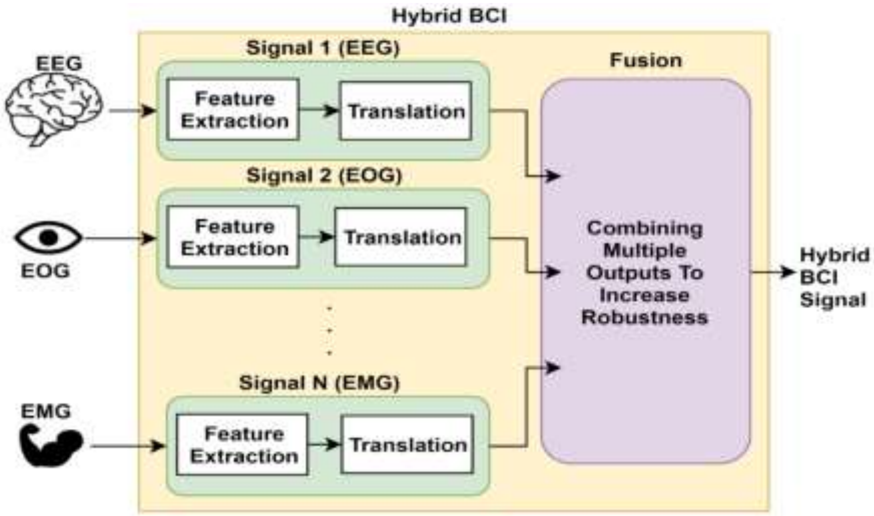


Fig. 2.6: Hybrid BCI

DRAWBACKS

- Less accurate as controlled through brain wave.
- May cost more.
- Need constant monitoring.
- EEG/ERP is hard to figure out.

CHAPTER 3

PROBLEM STATEMENT

In this project, we decided to design a unique elbow adjustable prosthetic arm for people from ages from eighteen to fifty. This product will be created for low to middle income consumers. In addition, this product will have an attached hand that let our customers to easily perform their daily task. In our act of re-design, an ideal prosthetic arm with modifications to best fit the preferences of the consumers will be produced. According to our research result, most of the customers preferred a low-cost prosthetic arm with high efficiency and reliability. The developed a prosthetic arm is high cost, and restricted in the movement. The proposed system can be controlled by signals from Mind wave (i.e., EEG signals) and will have a functional elbow and hand with independent functionality. More over the arm will be lightweight and strong enough for daily activities.

3.1 EXISTING SYSTEM

EMG Controlled Prosthetic Arm

Control signals stimulate the muscles that control the movement of hand. The prosthetic arm is controlled using those brain signals and those signals can be captured by several ways. One of the better techniques is to capture signals from the muscle surface. Electromyography (EMG) is an electro-diagnostic medicine system for assessing and recording of electrical activities formed by skeletal muscle. The EMG signals can be analyzed to detect medical deformities, stimulation level and enrolment order. It also analyzes the biomechanics of human or animal movement. In addition to these, EMG signals are recommended by researchers as a control signal for prosthetic devices. Prosthetic limbs need to be measured and fitted to the patient for his needs.

Brain Wave Controlled Robot Using MATLAB

The Brainwave Controlled robot could be a robot that uses EEG-based BCIs to receive human control. Two main categories of Brainwave controlled robots to help disabilities are brain- controlled manipulators and mobile robots. One representative work of brain-controlled manipulators is that the manipulator used at intervals the FRIEND system developed by Graseretal that is in a position to indicate the brain-controlled capabilities of robots out of a controlled laboratory situation. The developed brain-controlled Arm is controlled by the servo motors and those motors are controlled by brain waves are processed in the MATLAB, then the respective action takes place. These types of models are very difficult for the patients to control. And the patient needs the continuous access to the MATLAB for processing which makes it difficult to use.

Non-Functional 3D Model

Some people born with missing hands, and cannot grab things since they were little. Some people who faced some accident and have to face the fate of amputation, and cannot use their hands normally. The prosthetic hands are the best option for them. But some prosthetic hands can only be a kind of decoration, they do not have any function to make the user’s life easier. There have some functional prosthetic hands, electric-powered (i.e., myoelectric) and body- powered (i.e., mechanical) devices have been developed, but the cost of maintenance and replacement represents an obstacle for many families. Due to the complexity and high cost of these prosthetic hands, they are not accessible to those from low income, uninsured families or to children from developing countries.

Thus, many patients are still using the hooks or clamps. In recent years, advancements in computer-aided design (CAD) programs, additive manufacturing, and image editing software offer the possibility of designing, printing, and fitting prosthetic hands devices at a distance and at very low cost. Using 3D printing can make the prosthetic hand according to the patient’s size.

3.1.1 Drawbacks of Existing System

- Using EMG sensor Accuracy is low. The amplitude of EMG is random in nature. EMG signal is affected by the firing rate of the motor units, which in most conditions, fire in the frequency region of 0 to 20 Hz. Factors affecting EMG signal falls into three basic categories, namely:
  Caustic Factors, Intermediate Factors and Deterministic Factors
  1. **Causative Factors:** This is the direct effect on signals. Causative factors can be divided into two classes:
     A. Extrinsic: This is due to electrode structure and placement.
     B. Intrinsic: Physiological, anatomical, biochemical factors take place due to number of active motor units.

2. **Intermediate Factors:** Intermediate factors are physical and physiological phenomena influenced by one or more causative factors.

3. **Deterministic Factors:** These are influenced by Intermediate Factors. The number of active motor units, motor firing rate, and mechanical interaction between muscle fibers have a direct bearing on the information in the EMG signal and the recorded force.

- The price of parts may fluctuate depending on their availability. Some may become more expensive or be discontinued and classified as obsolete. Although a new machine is an investment, the lowered risk of downtime and increased production generally offsets the price tag.

3.2 PROPOSED SYSTEM

An artificial arm is a man-made device that is integrated into a human to replace a natural organ, for the purpose of duplicating a specific function so that the patient may return to normal life as soon as possible. New plastics and other materials, such as carbon fiber have allowed artificial arm to become stronger and lighter, limiting the amount of extra energy necessary to operate the arm. This technology has been used in both animals and humans. This artificial arm having servo motors each individually connected to the five fingers. These servo motors will help in controlling function such as extension and flexion. These movements will be controlled by the command signal generated from Arduino Uno according to the brainwaves value received. Hence, the arm is controlled by using the command signal on a real time basis. Home device control using Brainwave signals. With the rapid development of IoT home automation framework accomplished incredible prominence in the most recent decades and it builds the solace and personal satisfaction. Home automation using brain waves has been designed, tested, and implemented in this project. It will be helpful for physically challenged people to control electronic devices. This system will also assist a physically impaired individual to have effective control.

3.2.1 Advantages of Proposed System

- Easy to install: Proposed model is very easy to install on the patient’s body compared to other models. One can install it by himself without the consultation of any doctor and train the brain just by seeing the guidelines of the Model.

- Changeable battery: Batteries can be easily changed when ever needed and can be charged fast by the external chargers.
- It provides better living, more features, more advancement in technologies etc.
- Linking people via chip implants to super intelligent machines seems, to a natural progression- creating in effect, super humans.
- By these humans get gradual co-evolution with computers.

Fig 3.1: Brain Controlled arm

Calibration and training are crucial components of the system, allowing users to establish a connection between their brain signals and the desired arm movements. This phase enables the system to learn and adapt to the unique brain patterns of each user, enhancing the accuracy and responsiveness of the control.

CHAPTER 4

SYSTEM REQUIREMENTS SPECIFICATIONS

4.1 HARDWARE REQUIREMENTS

- RAM 4GB - 8GB
- Hard Disk 500GB – 1TB
- Arduino Uno
- HC-05 Bluetooth Module
- Regulated Power Supply
- Brainwave Sensor
- Prosthetic Arm
- Relay
- Servo Motor
- LCD Screen

4.2 SOFTWARE REQUIREMENTS

- **Operating system:** Windows 10
- **IDE:** Arduino IDE
- **Language:** Embedded C

4.3 HARDWARE DISCRIPTION

4.3.1 Arduino

Arduino/Genuino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connecting a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong, worst-case scenario you can replace the chip for a few dollars and start over again. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards. The first in a series of USB Arduino boards, and the reference model for the Arduino platform for an extensive list of current, past or outdated boards see the Arduino index of boards.

Fig 4.1: Arduino

Arduino Specification:

Microcontroller	**ATmega328P**
Operating Voltage	**5v**
Input voltage	**7-12v**
Input voltage limit	**6-20v**
Digital I/O Pins	**6**
Analogue input Pins	**6**
DC current per I/O pins	**20 mA**
DC current for 3.3v Pin	**50 mA**
Flash Memory	**Of which 0.5KB is used**
SRAM	**2 KB**
EEPROM	**1KB**
Clock Speed	**16MHz**
Length	**68.6mm**
Width	**53.4nm**
Weight	**25g**

Table 4.1: Arduino Specifications

- **Arduino Programming**

The Arduino/GenuinoUno can be programmed with the (Arduino Software (IDE)). Select "Arduino/GenuinoUno from the Tools>Board menu (according to the microcontroller on your board). The ATmega328 on the Arduino/GenuinoUno comes pre-programmed with a boot loader that allows us to upload new code to it without the use of an external hardware programmer. We can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP or similar.

The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:

- On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then rese ingthe8U2.
- On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

Warnings

The Arduino/GenuinoUno has a resettable poly fuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Differences With Other Boards

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Power

The Arduino/GenuinoUno board can be powered via the USB connection or with an external power supply. The power source is selected automatically External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and VIN pin headers of the POWER connector. The board can operate on an external supply from 6 to 20 volts. If supplied with less than7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12volts. The power pins are as follows:

- VIN. The input voltage to the Arduino/Genuino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). One can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- GND. Ground pins.

- 3V3. A 3.3volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- IOREF. This pin on the Arduino/Genuino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or 3.3V.

Memory

The ATmega328 has 32 KB (with 0.5 KB occupied by the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Input & Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pin mode(), digital write (),_and digital read () functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull- up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach interrupt () function for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog write () function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- LED: 13. There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e.,1024 different values). By default, they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog reference function( ). There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with analog Reference ().
- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

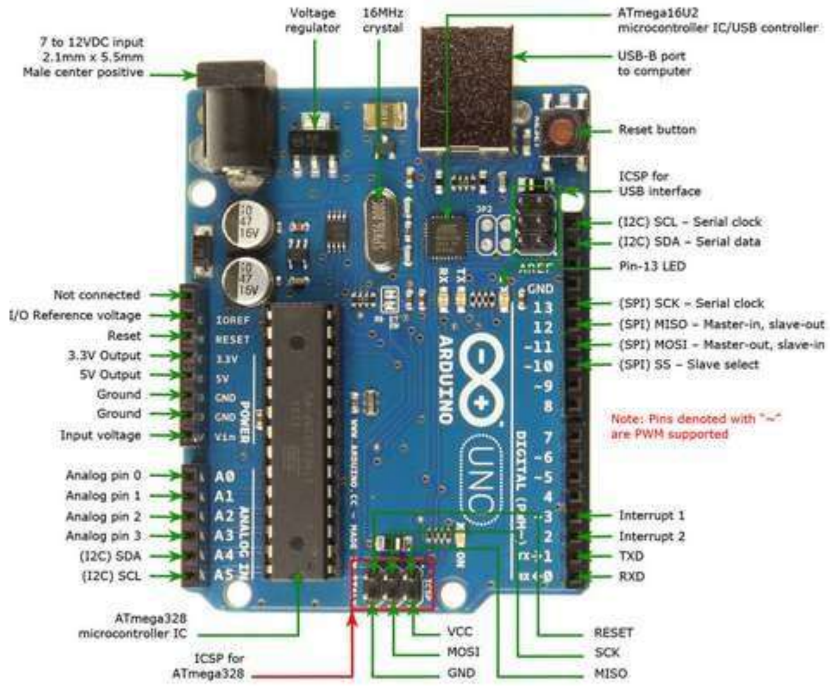


Fig. 4.2: Pin Specification

Communication

Arduino/GenuinoUno has a number of facilities for communicating with a computer, another Arduino/Genuino board, or other microcontrollers. The ATmega328provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The 16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an in file is required. The Arduino Software (IDE) includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and1). A Software serial library allows serial communication on any of the Uno's digital pins.

Automatic (Software)Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino/GenuinoUno board is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nano farad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino Software (IDE) uses this capability to allow you to upload code by simply pressing the upload button in the interface toolbar. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the boot loader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data. The Uno board contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN".

4.3.2 Bluetooth

- Serial Bluetooth module for Arduino and other microcontrollers
- Operating Voltage: 4V to 6V (Typically +5V)
- Operating Current: 30mA
- Range: <100m
- Works with Serial communication (USART) and TTL compatible
- Follows IEEE 802.15.1 standardized protocol
- Uses Frequency-Hopping Spread spectrum (FHSS)
- Can operate in Master, Slave or Master/Slave mode
- Can be easily interfaced with Laptop or Mobile phones with Bluetooth
- Supported baud rate: 9600, 19200, 38400, 57600, 115200, 230400, 460800.

HC-05

Other Bluetooth Modules:

HC-04, HC-06, HM-11, ESP32, CSR8645

✦ **HC-05 Bluetooth Module**

The HC-05 is a very cool module which can add two-way (full-duplex) wireless functionality to our project. One can use this module to communicate between two microcontrollers like Arduino or communicate with any device with Bluetooth functionality like a Phone or Laptop. There are many android applications that are already available which makes this process a lot easier. The module communicates with the help of USART at 9600 baud rates hence it is easy to interface with any microcontroller that supports USART. So, if you looking for a Wireless module that could transfer data from your computer or mobile phone to microcontroller or vice versa then this module might be the right choice for you.

✦ Usage of HC-05 Bluetooth Module

The HC-05 has two operating modes, one is the Data mode in which it can send and receive data from other Bluetooth devices and the other is the AT Command mode where the default device settings can be changed. We can operate the device in either of these two modes by using the key pin as explained in the pin description. It is very easy to pair the HC-05 module with microcontrollers because it operates using the Serial Port Protocol (SPP). Simply power the module with +5V and connect the Rx pin of the module to the Tx of MCU and Tx pin of module to Rx of MCU as shown in the figure below. The HC-05 module is also favored in wearable technology, such as fitness trackers or smartwatches. By incorporating the module, wearable devices can establish wireless connectivity with smartphones or other devices. This functionality enables data synchronization, notifications, and remote-control capabilities. The HC-05 module is commonly used in educational projects to teach wireless communication and Bluetooth technology. Its ease of use and availability make it a popular choice for students and hobbyists exploring electronics and programming.

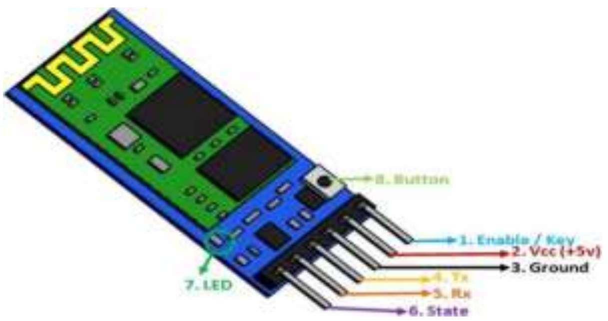


Fig 4.3: Pins Specification of HC-05

During power up the key pin can be grounded to enter into Command mode, if left free it will by default enter into the data mode. As soon as the module is powered you should be able to discover the Bluetooth device as “HC-05” then connect with it using the default password 1234 and start communicating with it.

Applications

1. Wireless communication between two microcontrollers
2. Communicate with Laptop, Desktops and mobile phones
3. Data Logging application
4. Consumer applications
5. Wireless Robots
6. Home Automation

4.3.3 Regulated Power Supply

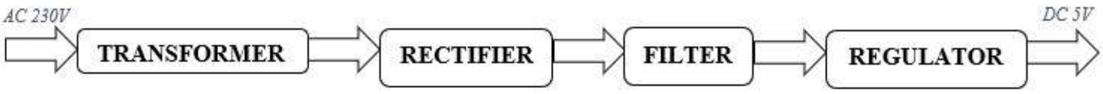


Fig 4.5: Regulated Power Supply

Transformer

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors without changing its frequency. A varying current in the first or primary winding creates a varying magnetic flux in the transformer's core, and thus a varying magnetic field through the secondary winding. This varying magnetic field induces a varying electromotive force (EMF) or "voltage" in the secondary winding. This effect is called mutual induction. If a load is connected to the secondary, an electric current will flow in the secondary winding and electrical energy will be transferred from the primary circuit through the transformer to the load. This field is made up from lines of force and has the same shape as a bar magnet. If the current is increased, the lines of force move outwards from the coil. If the current is reduced, the lines of force move inwards. If another coil is placed adjacent to the first coil, then, as the field moves out or in, the moving lines of force will "cut" the turns of the second coil. As it does this, a voltage is induced in the second coil. With the 50 Hz AC mains supply, this will happen 50 times a second. This is called MUTUAL INDUCTION and forms the basis of the transformer.

- **Rectifier**

A rectifier is an electrical device that converts alternating current (AC) to direct current (DC), a process known as rectification. Rectifiers have many uses including as components of power supplies and as detectors of radio signals. Rectifiers may be made of solid-state diodes, vacuum tube diodes, mercury arc valves, and other components. A device that it can perform the opposite function (converting DC to AC) is known as an inverter. When only one diode is used to rectify AC (by blocking the negative or positive portion of the waveform), the difference between the term diode and the term rectifier is merely one of usage, i.e., the term rectifier describes a diode that is being used to convert AC to DC. Almost all rectifiers comprise a number of diodes in a specific arrangement for more efficiently converting AC to DC than is possible with only one diode. Before the development of silicon semiconductor rectifiers, vacuum tube diodes and copper (I) oxide or selenium rectifier stacks were used.

- **Filter**

The process of converting a pulsating direct current to a pure direct current using filters is called as filtration. Electronic filters are electronic circuits, which perform signal-processing functions, specifically to remove unwanted frequency components from the signal, to enhance wanted ones.

- **Regulator**

A voltage regulator (also called a ‗regulator) with only three terminals appears to be a simple device, but it is in fact a very complex integrated circuit. It converts a varying input voltage into a constant ‗regulated ‘output voltage. Voltage Regulators are available in a variety of outputs like 5V, 6V, 9V, 12V and 15V. The LM78XX series of voltage regulators are designed for positive input. For applications requiring negative input, the LM79XX series is used. Using a pair of ‗voltage-divider resistors can increase the output voltage of a regulator circuit. It is not possible to obtain a voltage lower than the stated rating. You cannot use a 12V regulator to make a 5V power supply. Voltage regulators are very robust. These can withstand over-current draw due to short circuits and also over-heating. In both cases, the regulator will cut off before any damage occurs. The only way to destroy a regulator is to apply reverse voltage to its input.

4.3.4 Brainwave Sensor

In 1924, Hans Berger, a German psychiatrist, performed the first electroencephalographic (EEG) recording in humans (Berger, 1929), a discovery that was initially greeted with great skepticism by the scientific community. By recording from one electrode placed over the forehead and one over the occipital cortex, Berger discovered the existence of rhythmic activity oscillating at approximately 10 Hz, particularly during relaxed wakefulness and in the absence of sensory stimulation or mental activity. In this landmark discovery, Berger described for the first time what would become known as alpha waves. As a result, Berger was among the first to suggest that the periodic fluctuations of the human EEG may be associated with mental processes, including arousal, memory, and consciousness. Over the years, developments in data collection and analyses transformed EEG into one of the prime techniques for studying the human brain.

The past two decades in particular have witnessed unparalleled progress in our ability to image human brain function non-invasively. Different imaging techniques are available to investigate brain function based on hemodynamic(fMRI), metabolic (PET), electromagnetic (EEG, MEG) measurements. In order to investigate Spatio-temporal dynamics of brain activity, methods that directly assess neural activity are required. By measuring electrical activity of neuronal assemblies with millisecond temporal resolution, EEG and MEG, unlike hemodynamic techniques, offer the possibility of studying brain function in real time. Unfortunately, as will be discussed in this chapter, the spatial resolution afforded by EEG/ MEG is constrained by several factors. The most important of these factors are the distorting effects of the head volume conductor, imperfect signal-to-noise ratios, and limited spatial sampling due to practical limits on the numbers of electrodes that can be utilized. More importantly, it soon became evident that the neuromagnetic “inverse problem” (the attempt to identify generating sources of measured, scalp-recorded EEG signals) is fundamentally ill- posed. As first described in 1853 by Helmholtz, there are an infinite number of source configurations that can explain a given set of scalp-recorded potentials. Thus, at a first glance, the quest for the development of methods combining millisecond temporal resolution with millimeter spatial resolution appears to be a lost cause. Fortunately, solutions to the inverse problem can be found by postulating physiologically and anatomically sound assumptions about putative EEG sources and by mathematically implementing established laws of electrodynamics.

The main purpose of the present chapter is to review recent advances in the EEG field. To understand these developments, it will first be necessary to detail the physiological basis of the EEG signal. Subsequently, important issues associated with data acquisition, signal processing, and quantitative analyses will be discussed (see Davidson, Jackson, & Larson, 2000; Pivik et al., 1993; Gasser & Molinari, 1996; Nuwer et al., 1999; Thakor & Tong, 2004 for more comprehensive reviews of these topics). The largest portion of the chapter will be devoted to reviewing emerging source localization techniques that have been shown to localize EEG activity without postulating a priori assumptions about the number of underlying sources (Baillet et al., 2001; Michel et al., 2004). The picture emerging in light of these achievements reveals that the spatial resolution of the EEG may be substantially higher than previously thought, thus opening exciting and new opportunities for investigating spatiotemporal dynamics of brain mechanisms underlying mental processes and dysfunctions in psychopathology, bringing us closer to fulfillment of Berger's dream that EEG will open a "window to the mind".

Key Features of Brainwave Starter Kit

- Uses the TGAM1 module
- Automatic wireless pairing
- Single AAA Battery
- 8-hours battery run time
- Bluetooth v2.1 Class 2 (10 meters range)
- Static Headset ID (headsets have a unique ID for pairing purposes)
- UART Baud rate: 57,600 Baud

Interfacing Neurosky Headset

The Neurosky EEG Headset has to be placed on the patient's head. Different parts of the headset:

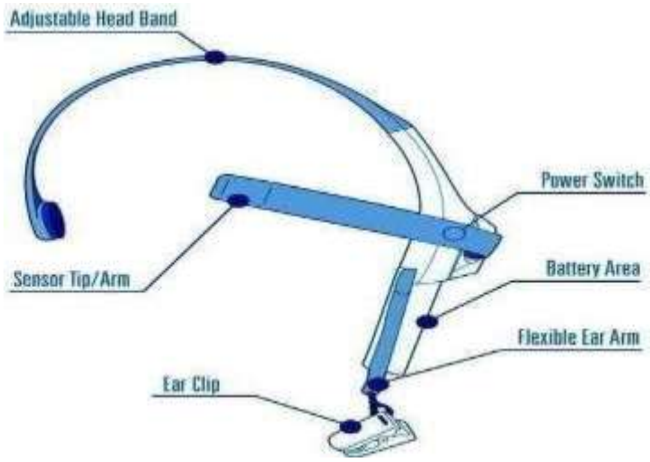
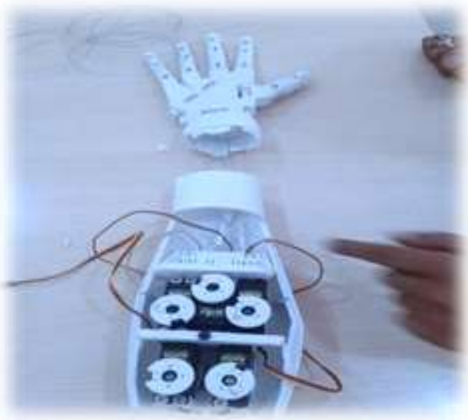


Fig. 4.6: Neurosky EEG Headset

This non-invasive BCI system implemented here collects the brain waves using dry electrodes placed on the forehead of the patient, exactly at the FP1 location of the 10-20 electrode system.

4.3.5 Prosthetic Arm

The project presented in this paper aims to develop a low-cost and versatile human-like prosthetic arm controlled by brain activity using EEG neuro-feedback technology. The arm is equipped with a network of smart sensors and actuators that give the patient intelligent feedback about the surrounding environment and the object in contact. The arm is created using a 3-D printer in order for it to be cost efficient. The prosthetic arm structure can be 3D printed or built using metal. 3D printed arm will be cheaper than the metallic arm. Each finger will be individually connected to a servo motor. These 5 servo motors will help to control the movements i.e., flexion, extension and pinch. These three movements will be controlled by the command signal generated from Arduino Uno according to the brain waves values received. This prototype focuses on the arm environment interaction.



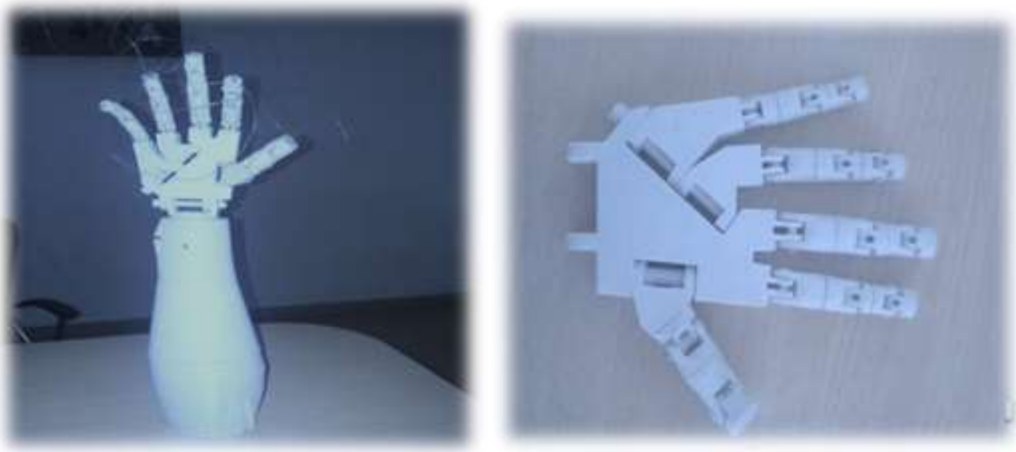


Fig. 4.7: Printed Prosthetic Arm

4.3.6 Servo Motor

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

Fig 4.8: Servo Motor

- **Wire Configuration**

Wire Number	Wire Color	Description
1	Brown	Ground wire connected to the ground of system.
2	Red	Powers the motor typically +5V is used.
3	Orange	PWM signal is given in through this wire to drive the motor.

Table 3.2: Wire configurations

Tower Pro SG-90 Features

- Operating Voltage is +5V typically
- Torque: 2.5kg/cm
- Operating speed is 0.1s/60°
- Rotation: 0°-180°
- Weight of motor: 9gm
- Package includes gear horns and screws

SG-90 Servo Motor Equivalent

MG90S Metal Gear, MG995 High Torque Metal Gear, VTS-08A Analog Servo. The SG-90 servo motor is a commonly used micro servo motor that offers precise control and is suitable for a wide range of applications. If you're looking for an equivalent alternative to the SG-90 servo motor, you can consider the TowerPro MG90S servo motor. The TowerPro MG90S servo motor is quite similar to the SG-90 in terms of size, weight, and performance. It is a micro-sized servo motor that provides reliable and accurate angular control.

Selecting Our Servo Moto

There are lots of servo motors available in the market and each one has its own specialty and applications. The following two paragraphs will help to identify the right type of servo motor for our project/system. Most of the hobby Servo motors operates from 4.8V to 6.5V, the higher the voltage higher the torque we can achieve, but most commonly they are operated at +5V. Almost all hobby servo motors can rotate only from 0° to 180° due to their gear arrangement so make sure you project can live with the half circle if no, you can prefer for a 0° to 360° motor or modify the motor to make a full circle. The gears in the motors are easily subjected to wear and tear, so if your application requires stronger and long running motors you can go with metal gears or just stick with normal plastic gear. Next comes the most important parameter, which is the torque at which the motor operates. This 2.5kg/cm torque means that the motor can pull a weight of 2.5kg when it is suspended at a distance of 1cm. So, if you suspend the load at 0.5cm then the motor can pull a load of 5kg similarly if you suspend the load at 2cm then can pull only 1.25. Based on the load which you use in the project you can select the motor with proper torque. The below picture will illustrate the same.

4.4 SOFTWARE REQUIREMENTS

4.4.1 Arduino IDE

A program for Arduino may be written in any programming language for a compiler that produces binary machine code for the target processor. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio. The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for commonfunctions and a hierarchy of operation menus. A program written with the IDE for Arduino is called a sketch. Sketches are saved on the development computer as text files with the file extension.ino. Arduino Software (IDE) pre-1.0 saved sketches with the extension.pde.

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, whichprovides many common input and output procedures. User-written code only requires twobasic functions, for starting the sketch and the main program loop, that are compiled andlinked with a program stub main () into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. A minimal Arduino C/C++ sketch, as seen by the Arduino IDE programmer, consist of only two functions:

- **Setup ():** This function is called once when a sketch starts after power-up or reset. Itis used to initialize variables, input and output pin modes, and other libraries needed inthe sketch.
- **Loop ():** After setup () has been called, function loop () is executed repeatedly in themain program. It controls the board until the board is powered off or is reset.

Fig. 4.9: An Arduino Sketch

4.5 APPLICATIONS

- The proposed arm hosts state-of-the art technological advancement, communication protocols, control systems, and human interfacing. This gives its incredible potential in numerous applications related to the health care field as well as other fields.
- As long as health care is considered, the thought may be expanded to other body parts as well as to patients having other dysfunctions as nerve damage.
- On the other hand, numerous industrial and commercial applications can utilize many features of the proposed arm.
- Within the health care field, there exists a class of patients who require extra help with their daily lives. This includes elderly people, people under rehabilitation, and people with limited mobility, etc.
- The proposed arm may be interfaced to a robotic structure and work as a helper or caregiver to this group of people. It can be programmed to do various functions according to specific patient needs. This may vary from cooking to assistance with bathing or dressing.
- Another illustration in the medical field is remote high precision surgical procedures, where surgeons can undergo operations remotely with the aid of the robotic arm many industries utilize robots in the manufacturing process, many of which can make use of a modified version of the proposed arm.
- Based on a specific application, this smart arm can be programmed to execute a

series of predefined actions, and customized with dedicated sensors, actuators and customized algorithms (such as image and signal processing, gesture and voice recognition etc.).

- In addition, connecting the arm to the Internet, and making it part of an Internet of Things network (IOT) will increase the performance and productivity of many industry applications.

4.6 TECHNOLOGY USED

Embedded C

- When designing software for a smaller embedded system with the 8051, it is very common place to develop the entire product using assembly code. With many projects, this is a feasible approach since the amount of code that must be generated is typically less than 8 kilobytes and is relatively simple in nature.If a hardware engineer is tasked with designing both the hardware and the software, he or she will frequently be tempted to write the software in assemblylanguage.
- Additionally, the amount of code reusable from a typical assembly language project is usually very low. Use of a higher-level language like C can directly address these issues. A program written in C is easier to read than an assemblyprogram.
- Since a C program possesses greater structure, it is easier to understand and maintain. Because of its modularity, a C program can better lend itself to reuseof code from project to project. The division of code into functions will force better structure of the software and lead to functions that can be taken from one project and used in another, thus reducing overall development time.
- A high order language such as C allows a developer to write code, which resembles ahuman's thought process more closely than does the equivalent assembly code. The developer can focus more time on designing the algorithms of the system rather than having to concentrate on their individual implementation. This willgreatly reduce development time and lower debugging time since the code is more understandable.
- By using a language like C, the programmer does not have to be intimately

familiar with the architecture of the processor. This means that someone new to a given processor can get a project up and running quicker, since the internalsand organization of the target processor do not have to be learned.

- Code developed in C will be more portable to other systems than code developed in assembly. Many target processors have C compilers available, which support ANSI C.
- Real-time responsiveness and deterministic behavior are often required in embedded systems, and Embedded C provides mechanisms for handling interrupts, timers, and scheduling tasks to meet these requirements.
- Embedded C code can be written in a portable manner to ensure compatibility across different microcontrollers and platforms. Memory management is crucial in Embedded C due to the limited resources available in embedded systems.
- Various development tools and IDE’s support Embedded C, providing features like code editors, compilers, and debuggers. Knowledge of hardware architecture and understanding of data sheets and datasheets is important when working with Embedded C.
- Embedded C is widely used in various applications, including consumer electronics, automotive systems, industrial automation, medical devices, and more.

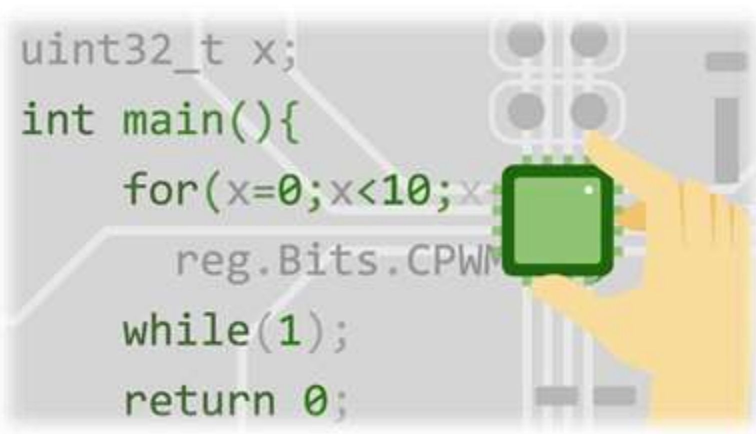


Fig. 4.10: **Embedded C Programming**

CHAPTER 5

SYSTEM ANALYSIS AND DESIGN

5.1 DESIGN CONSIDERATION

- **User Safety:** Safety should be the foremost consideration in the design of the system. The prosthetic arm should be designed to prevent any accidental harm to the user or others. The home automation system should also be designed to prevent any accidents, such as electrical hazards, due to the user's control signals.
- **Accuracy and Precision:** The system should be designed to accurately and precisely detect and interpret the user's brain waves and eye blink signals. This would require high-quality sensors and signal processing algorithms.
- **Reliability:** The system should be designed to be reliable and robust, with a low failure rate. The hardware and software components should be thoroughly tested and validated to ensure that they work as intended.
- **Scalability:** The system should be designed to be scalable, so that it can be easily adapted and modified as needed. This could involve using modular components that can be easily replaced or upgraded, or designing the system to be compatible with other technologies.
- **Accessibility:** The system should be designed to be accessible to a wide range of users, including those with physical disabilities. This could involve designing the user interface to be easy to use and intuitive, or incorporating assistive technologies such as eye tracking allowing them to control the system using eye movements.
- **Cost:** The system should be designed to be cost-effective, using off-the-shelf components where possible to minimize the cost of development and production. The design should also take into account the cost of maintenance and repair, as well as the cost of training users to use the system.

5.2 SYSTEM ARCHITECTURE

The system architecture presented above is a layered architecture for a home automation system. It consists of four main layers: User Interface Layer, Control Layer, Communication Layer, and Device Layer.

- **User Interface Layer:** It provides the interface for the user to interact with the home automation system. It allows the user to control various devices and appliances in the home such as lighting, temperature, security, and entertainment systems. The user interface can be a web-based interface, mobile application, or voice-based interface.

- **Control Layer:** It is responsible for receiving and processing user commands and translating them into actions that can be performed by the devices and appliances in the home. This layer comprises a central controller that receives and processes user commands and a set of smart devices and appliances that can be controlled by the central controller.

- **Communication Layer:** It provides the necessary connectivity for the system to function. It includes various communication protocols such as Wi-Fi, Bluetooth, and ZigBee that allow the devices and appliances to communicate with each other and with the central controller.

- **Device Layer:** It comprises various smart devices and appliances that are integrated into the home automation system. These devices can include smart thermostats, smart lighting, smart locks, and smart entertainment systems. These devices are responsible for carrying out the actions specified by the control layer and communicating back to the control layer regarding their status and feedback.

The system architecture is designed to be scalable and expandable, allowing for the addition of new devices and appliances as needed. Additionally, the system is designed to be modular, with each layer functioning independently and able to be upgraded or replaced as necessary. This system architecture provides a robust and flexible home automation system that can provide greater comfort, convenience, and energy efficiency to the occupants of the home.

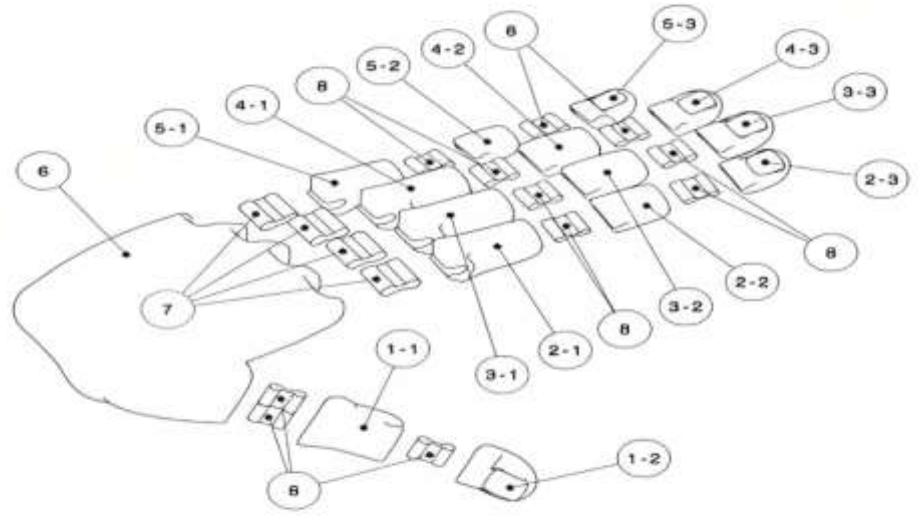


Fig. 5.1: Exploded View of Prosthetic Arm

BILL OF MATERIALS		
ITEM NUMBER	DESCRIPTION	NUMBER OFF
1-1	Thumb Proximal Phalanx	1
1-2	Thumb Distal Phalanx	1
2-1	Index Proximal Phalanx	1
2-2	Index Middle Phalanx	1
2-3	Index Distal Phalanx	1
3-1	Long Proximal Phalanx	1
3-2	Long Middle Phalanx	1
3-3	Long Distal Phalanx	1
4-1	Ring Proximal Phalanx	1
4-2	Ring Middle Phalanx	1
4-3	Ring Distal Phalanx	1
5-1	Small Proximal Phalanx	1
5-2	Small Middle Phalanx	1
5-3	Small Distal Phalanx	1
6	Hand Body	1
7	Palmar Digital	4
8	Proximal And Distal Interphalangeal	1 1

Table 5.1: Prosthetic Arm Joints Positions

Development of the system requires tools like:

- Brain Wave headset with NeuroSky sensor.
- Arduino C

We have used an EEG headset called Neuro Sky Mobile 2. The headset is Bluetooth capable and transmits brainwave data with negligible latency. The EEG data is transmitted to a processor which uses neural networks to determine intent of thought and sends the command to the prosthetic arm to perform the required hand movement.

Fig. 5.2: EEG Headset

The model consists of 3 modules out of which one is software module, one is a mechanical module and one is an electric module. This is a generalized architecture which can be modified according to required use case.

5.2.1 EG Module

Consists of the BCI headset and is responsible for detecting the P300 waves and sending the serial data to the processing unit. Any opensource headset can be used as long as the latency and accuracy are limited to reasonable amounts. Numerous raw materials are used in the construction of an EEG machine. The internal printed circuit boards are flat, resin-coated sheets. Connected to them are electronic components such as resistors, capacitors, and integrated circuits made from various types of metals, plastic, and silicon. The electrodes are generally constructed from German silver. German silver is an alloy made up of copper, nickel, and zinc. It is particularly useful because it is soft enough to grind and polish easily. Stainless steel (which has a higher concentration of nickel) can also be used. It tends to be more corrosion resistant but is harder to drill and machine. An adhesive tape is used to attach surface electrodes to the patient. Since the electric signals are weakly transmitted through the skin to the electrodes, an electrolyte pastes or gel is typically needed. This material is applied directly to the skin. It may be composed of a cosmetic ingredient like lanolin and chloride ions that help form a conductive bridge between the skin and the electrode allowing better signal transmission. Polytetrafluoroethylene (Teflon) is used as a coating for the wires and various kinds of electrodes.

5.2.2 Control Module

The software-based processing unit which translates the raw EEG serial data pertaining to a particular thought to the physical action like lifting of arm, gripping an object etc. This is done using a Long Short-Term Memory Neural Network which, in our implementation, we have trained using a custom prepared dataset.

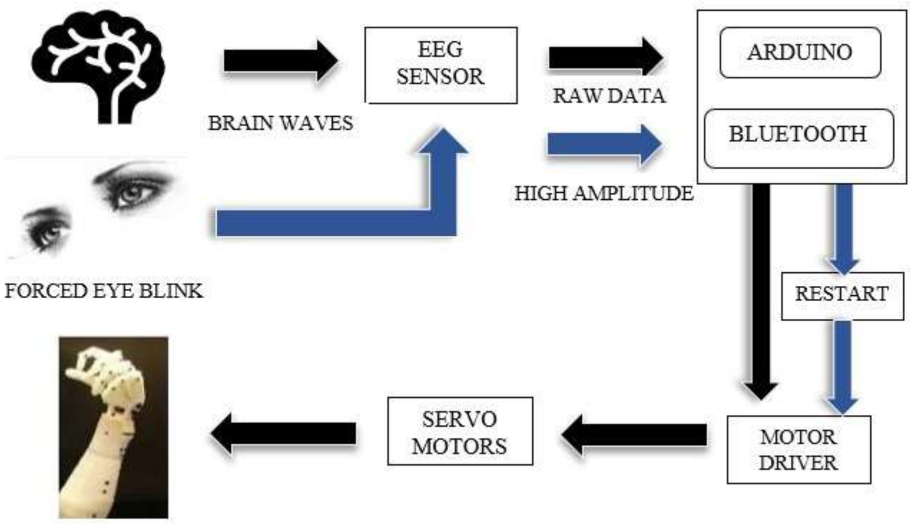


Fig 5.3: Control Module Block Diagram

5.2.3: Robotic Arm

This is the physical motorized robotic arm which will contain the exoskeleton and the actuators required to move the various parts of the arm to emulate real arm movements. Actuators may include various servo motors for precise movement. A microcontroller is used to control all the motors in the arm. Robotic arms can be used to automate the process of placing goods or products onto pallets. By automating the process, palletizing becomes more accurate, cost-effective, and predictable. The use of robotic arms also frees human workers from performing tasks that present a risk of bodily injury. The links of the manipulator can be considered to form a kinematic chain. The terminus of the kinematic chain of the manipulator is called the end effector and it is analogous to the human hand. However, the term "robotic hand" as a synonym of the robotic arm is often proscribed.

5.2.4: Bluetooth module

The Bluetooth technology manages the communication channel of the wireless part. The Bluetooth modules can transmit and receives the data wirelessly by using two devices. The Bluetooth module can receive and transmits the data from a host system with the help of the host controller interface (HCI). It is used for many applications like wireless headset, game controllers, wireless mouse, wireless keyboard, and many more consumer applications. It has range up to <100m which depends upon transmitter and receiver, atmosphere, geographic & urban conditions. It is IEEE 802.15.1 standardized protocol, through which one can build wireless Personal Area Network (PAN). It uses frequency-hopping spread spectrum (FHSS) radio technology to send data over air. It uses serial communication to communicate with devices. It communicates with microcontroller using serial port (USART). A Bluetooth module is an electronic device that allows wireless communication between devices over short distances using Bluetooth technology. Bluetooth modules are widely used in a variety of applications, including wireless data transfer, remote control, and wireless sensing.

5.3 CIRCUIT DIAGRAM

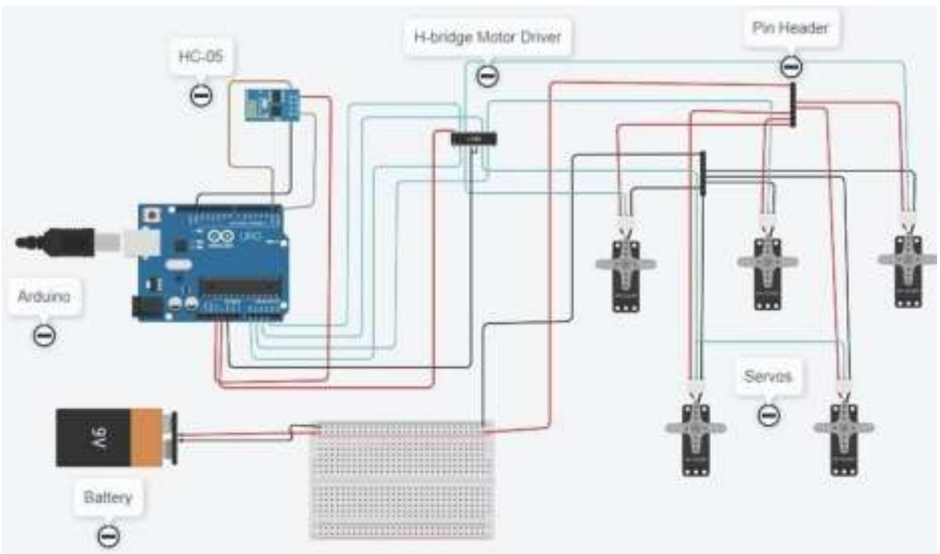


Fig 5.4: Circuit Diagram

The various components which we have used are Arduino, Battery, Servo motors, Bluetooth module HC-05, Motor driver and Pin Header. Pin header is a connector which is used to connect pins of Servo motors and Arduino. All grounds are connected to common ground of Arduino. Power supply is provided by 9 volts battery which is not enough so we are using Arduino power pin to give power to Bluetooth. We are providing power to Servo motors separately because it needs more power. Signal wires are connected to output of H-bridge. Inputs of H-bridge are called to analog inputs in Arduino. Bluetooth HC-05 is connected to Tx, Rx & to power supply.

5.3.1 Pin Used

ARDUINO PINS
Analog pins—A0, A1, A2, A3,
GND-2, 3.3V, 5V, Tx->1, Rx->0
H-BRIDGE MOTOR DRIVER PINS
Input 1 ,Input 2, Input 3, Input 4, Output 1, Output 2, Output 3, Output 4
Power 1, GND
BLUETOOTH (HC-05) PINS
Tx, Rx, GND, Power

Table 5.2: Pins Used

5.4 DATA FLOW DIAGRAM

1. A data flow diagram (DFD) is graphic representation of the "flow" of data through an information system. A data flow diagram can also be used for the visualization of data processing (structured design). It is common practice for a designer to draw a context level DFD first which shows the interaction between the system and outside entities. DFD’s show the flow of data from external entities into the system, how the data moves from one process to another, as well as its logical storage. There are only four symbols:
2. Squares representing external entities, which are sources and destinations of information entering and leaving the system.
3. Rounded rectangles representing processes, in other methodologies, may be called 'Activities', 'Actions', 'Procedures', 'Subsystems' etc. which take data as input, do processing to it, and output it.

4. Arrows representing the data flows, which can either, be electronic data or physical items. It is impossible for data to flow from data store to data store except via a process, and external entities are not allowed to access data stores directly.
5. The flat three-sided rectangle is representing data stores should both receive information for storing and provide it for further processing.

5.4.1 Level 0 Data Flow Diagram

The Level0 DFD shows how the system is divided into sub-systems (processes), each of which deals with one or more of the data flows to or from an external agent, and which together provide all of the functionality of the system as a whole. Figure shows the level 0 DFD. It also identifies internal data stores that must be present in order for the system to do its job, and shows the flow of data between the various parts of the system.

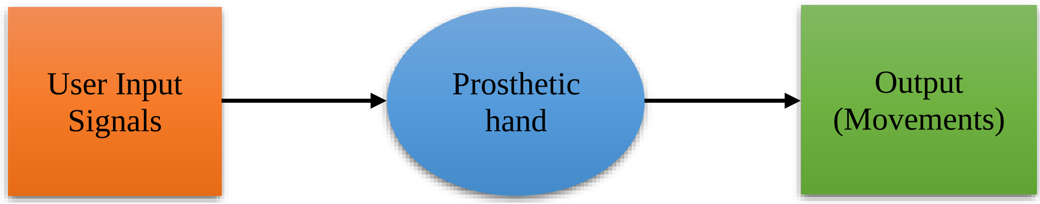


Fig. 5.5: DFD level 0

5.4.2 Level 1 Data Flow Diagram

The level 1 DFD helps to break down the processes involved in your project into smaller, more manageable sub-processes, and shows how they are connected to one another through data flows. This can help in understanding the system better and identifying potential areas for improvement or optimization. The level 1 DFD shows the major processes involved in controlling the prosthetic hand and home automation system, and how they are interconnected. The User Inputs and Sensors layer receives user inputs such as brain waves and eye blink signals, as well as data from sensors. The layer then processes and validates the inputs and data and translates them into commands for the Processor layer. The Processor layer is responsible for interpreting the user inputs and sensor data and translating them into commands for the Motor Control layer. The Control Prosthetic Hand sub-process in the Motor Control layer validates the commands received from the Processor and controls the prosthetic hand based on those commands.

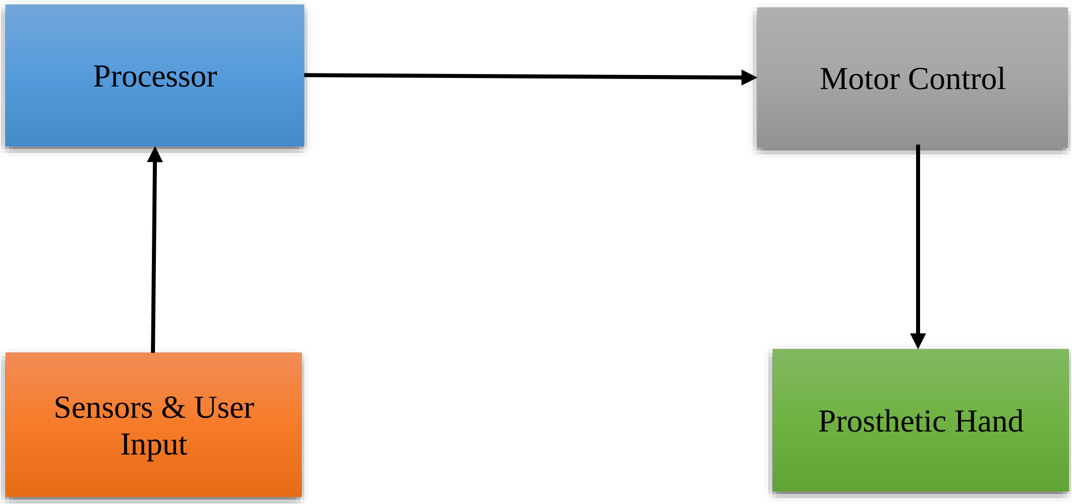


Fig 5.6: DFD level 1

5.5 FLOWCHART

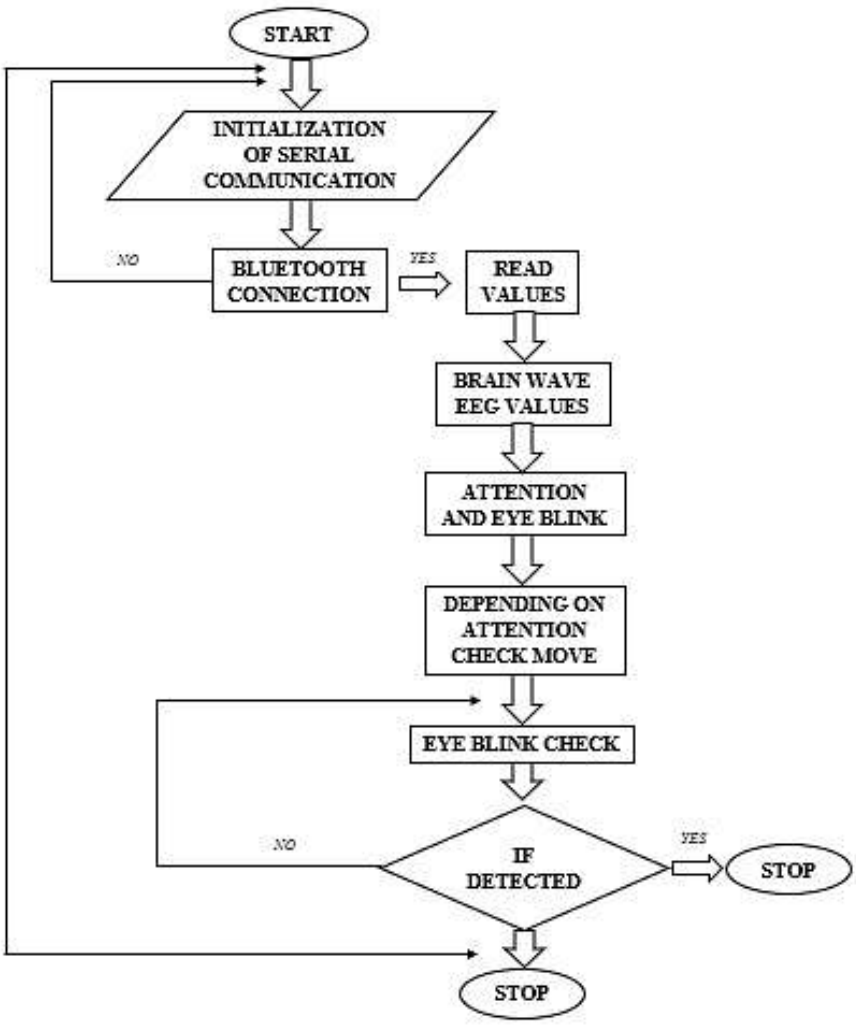


Fig 5.7: Flowchart

- The fig above shows the Flowchart of Brain Controlled Prosthetic ARM.
- First step here is the initialization of serial communication and Bluetooth connection.
- Once the connection is established it continues to read values. If connection fails it again starts with the initialization process.
- After reading Brain waves EEG values it checks the attention and Eye-blink.
- Depending on the attention it checks the movements.
- If Eye-blink is detected it stops, if not then it continues to make the movements.

5.6 CLASS DIAGRAM

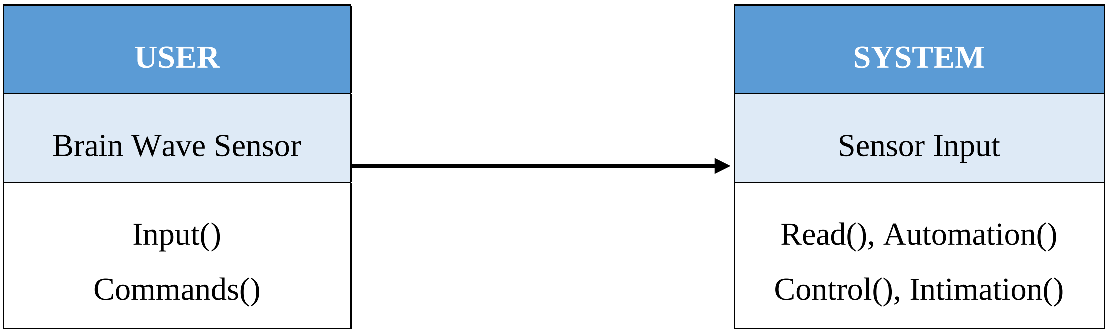


Fig 5.8: Class Diagram

The above class diagram represents the various classes and their relationships in the home automation and prosthetic arm project. The "User" class represents the user of the system and is associated with the "User Interface" class. The "User Interface" class provides the interface for the user to interact with the home automation and prosthetic arm system. The "Sensor" and "Motor Control" classes are associated with the "Processor" class. The "Processor" class is responsible for receiving data from the sensors, processing it and then sending commands to the motor control to control the prosthetic arm and to the home automation devices to control the various appliances.

The "System" class are associated with the Communication, which is responsible for providing connectivity to the system. The "Bluetooth" allows for the communication between the user's device and the home automation and prosthetic arm system, system class provides connectivity between the various devices and appliances in the system.

The "Prosthetic Arm" and "Home Automation are the main in the system class and are associated with the "Motor Control". The "Motor Control" controls the movement of the prosthetic arm and the various appliances in the home automation system.

5.7 SEQUENCE DIAGRAM

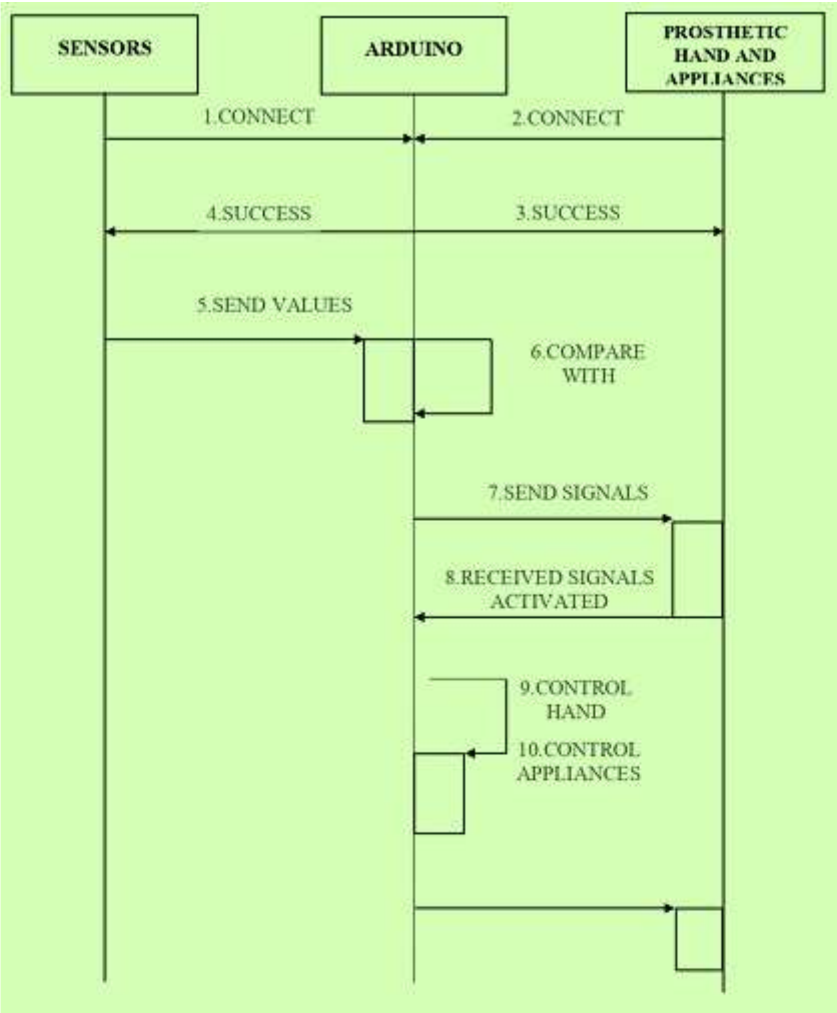


Fig. 5.9: Sequence Diagram

The sequence diagram for home automation and prosthetic arm controlled by brain waves would illustrate the sequence of events and messages exchanged between the different components of the system. For home automation, the sequence diagram might show sensors detecting environmental conditions and transmitting the information to the Arduino board. The Arduino board would then process the input and send messages to the appropriate actuators, such as turning on the air conditioning or opening a door. For the prosthetic arm, the sequence diagram might show sensors detecting brain waves and transmitting the information to the Arduino board. The Arduino board would then process the input and send messages to the motors and servos in the prosthetic arm, adjusting its position or movement based on the user's intention. The sequence diagram would also show feedback mechanisms to ensure proper operation. For example, if the sensors detect a change in environmental conditions or brain waves, the Arduino board would send messages to update the user or homeowner on the system's current status. Similarly, if the response leads to a change in the system's state, such as turning on a light or adjusting the position of the prosthetic arm, the feedback mechanisms would update the user or homeowner on the system's current status. Overall, the sequence diagram would provide a visual representation of the system's operation, showing how the different components work together to achieve the desired outcome of home automation or prosthetic arm control through brain waves. The sequence diagram for home automation and prosthetic arm controlled by brain waves would illustrate the interactions between the different components of the system, showing the sequence of messages exchanged and the order in which they occur. Here is a more detailed description of the sequence diagram:

For home automation, the sensors detect environmental conditions, such as temperature, humidity, and motion. They transmit this information to the Arduino board. The Arduino board processes the input and determines the appropriate response. For example, if the temperature rises above a certain threshold, the Arduino board might turn on the air conditioning. The Arduino board sends messages to the appropriate actuators, such as the air conditioning unit, telling them what action to take. The actuators execute the action, for example, turning on the air conditioning. For the prosthetic arm, the sensors detect brain waves and transmit the information to the Arduino board. The Arduino board processes the input and determines the appropriate response. The Arduino board sends messages to the motors and servos in the prosthetic arm, telling them what action to take. The motors and servos execute the action, adjusting the position or movement of the prosthetic arm. If the sensors detect a change in environmental conditions or brain waves, the Arduino board repeats the decision-making process to determine the appropriate response. If the response leads to a change in the system's state, such as turning on a light or adjusting the position of the prosthetic arm, the feedback mechanisms update the user or homeowner on the system's current status. The sequence diagram would provide a clear visual representation of the system's operation, showing how the different components work together to achieve the desired outcome of home automation or prosthetic arm control through brain waves.

5.8 ACTIVITY DIAGRAM

An activity diagram portrays the control flow from a start point to a finish point showing the various decision paths that exist while the activity is being executed. In this state diagram, the system begins in the start state. Once activated, the prosthetic arm will perform the desired task, such as picking up an object or moving an arm. Similarly, the home automation system will perform the desired task, such as turning on a light or adjusting the temperature. After completing the task, the system returns to the start state, ready to detect the next brain wave signal and activate the appropriate system. It's important to note that this is a simplified state diagram and the actual implementation of a brain wave controlled prosthetic arm and home automation system will likely be more complex.

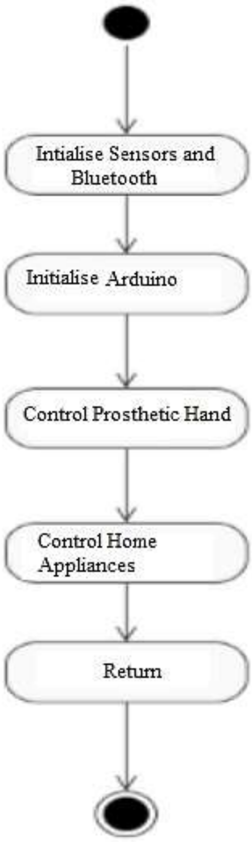


Fig. 5.10: Activity Diagram

5.9 USE CASE DIAGRAM

The use case diagram for home automation and prosthetic arm controlled by brain waves would illustrate the different actors and use cases involved in the system's operation. The actors might include the homeowner, the user of the prosthetic arm, and the sensors and actuators used in the system. For home automation, the use cases might include turning on lights, adjusting the temperature, and opening or closing doors. These use cases would be initiated by the homeowner or by the sensors detecting changes in environmental conditions. For the prosthetic arm, the use cases might include moving the arm in a certain direction or grasping an object. These use cases would be initiated by the user's intention, detected by the sensors and processed by the Arduino board.

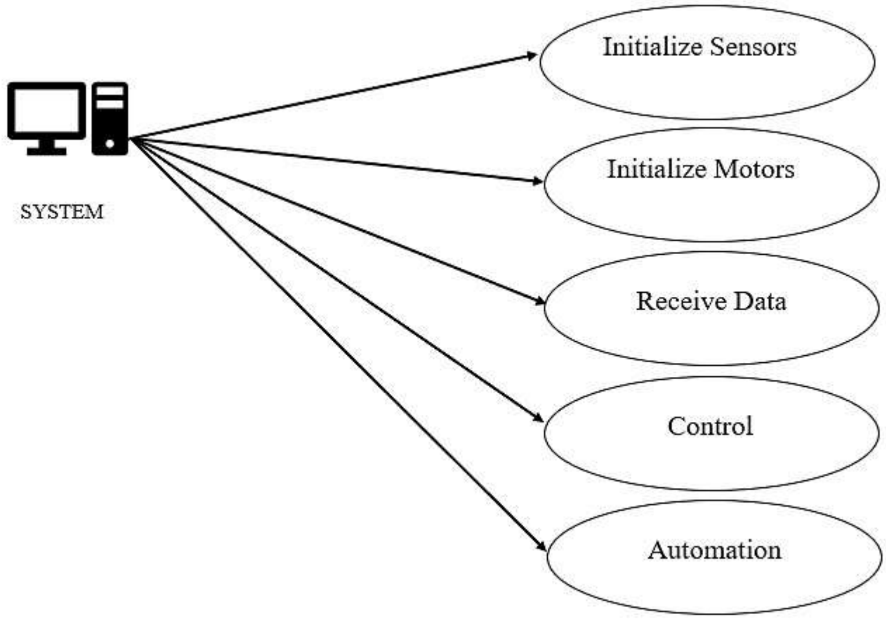


Fig 5.11: Use Case Diagram of System

The use cases would be executed by the motors and servos in the prosthetic arm. The use case diagram would also show the relationships between the different actors and use cases, with arrows indicating the flow of information and control.

The homeowner or user would initiate the use case, the sensors would detect the input, the Arduino board would process the input, and the actuators or prosthetic arm would execute the use case. Overall, the use case diagram would provide a visual representation of the system's operation, showing how the different actors and use cases work together to achieve the desired outcome of home automation or prosthetic arm control through brain waves.

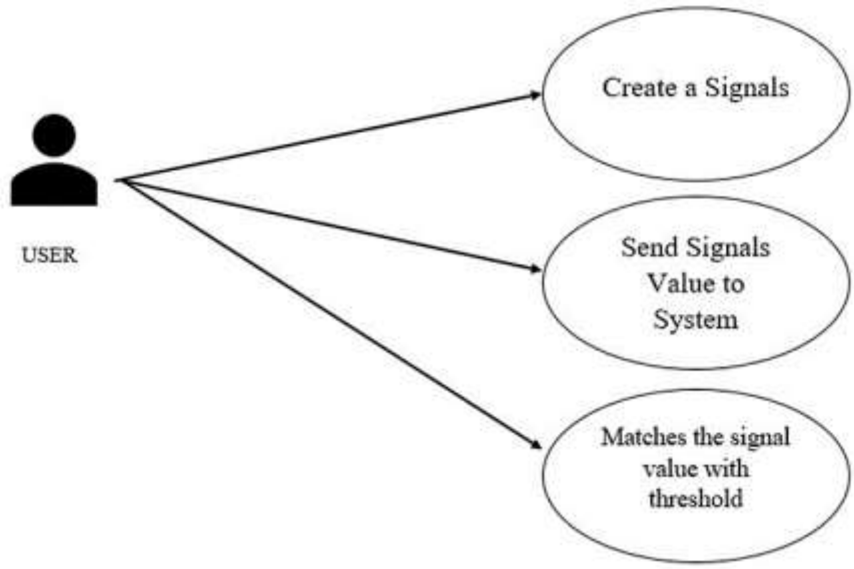


Fig. 5.12: Use Case Diagram of User

5.10 FUNCTIONAL MODULES

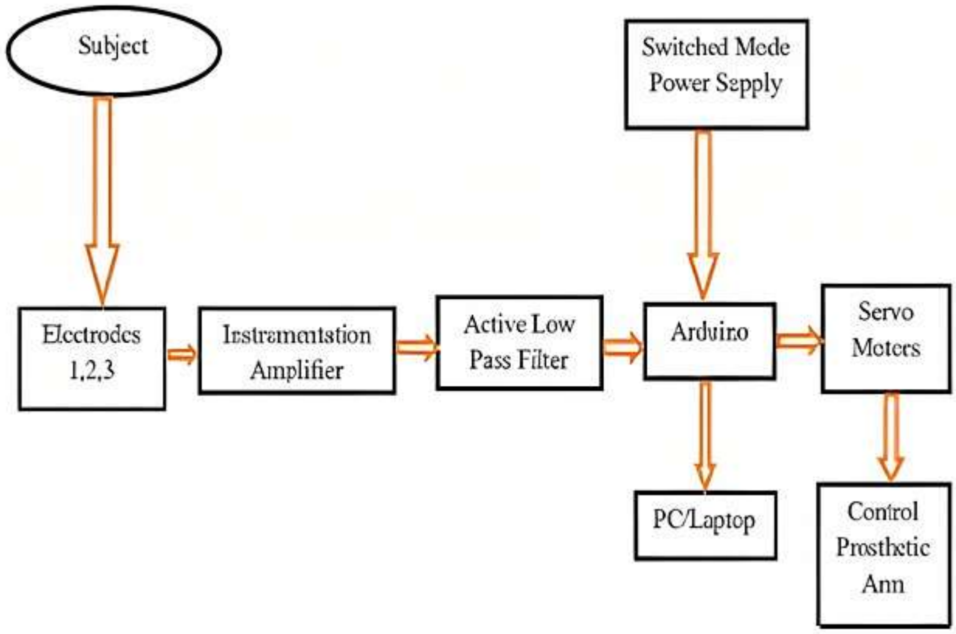


Fig. 5.13: Functional Module

- **Signal Acquisition:** The signal acquisition module involves acquiring the signals generated by the user's brain waves and eye blinks. It utilizes sensors like electroencephalogram (EEG) sensors, electrooculogram (EOG) sensors, or other suitable sensors capable of detecting these signals. The module captures the signals and prepares them for further processing.

- **Signal Processing:** The signal acquisition module involves acquiring the signals generated by the user's brain waves and eye blinks. It utilizes sensors like electroencephalogram (EEG) sensors, electrooculogram (EOG) sensors, or other suitable sensors capable of detecting these signals. The module captures the signals and prepares them for further processing.

- **Prosthetic Arm Control:** The signal acquisition module involves acquiring the signals generated by the user's brain waves and eye blinks. It utilizes sensors like electroencephalogram (EEG) sensors, electrooculogram (EOG) sensors, or other suitable sensors capable of detecting these signals. The module captures the signals and prepares them for further processing.

- **Home Automation Control:** The signal acquisition module involves acquiring the signals generated by the user's brain waves and eye blinks. It utilizes sensors like electroencephalogram (EEG) sensors, electrooculogram (EOG) sensors, or other suitable sensors capable of detecting these signals. The module captures the signals and prepares them for further processing.

- **User Interface:** The signal acquisition module involves acquiring the signals generated by the user's brain waves and eye blinks. It utilizes sensors like electroencephalogram (EEG) sensors, electrooculogram (EOG) sensors, or other suitable sensors capable of detecting these signals. The module captures the signals and prepares them for further processing.

- **System Integration:** The signal acquisition module involves acquiring the signals generated by the user's brain waves and eye blinks. It utilizes sensors like electroencephalogram (EEG) sensors, electrooculogram (EOG) sensors, or other suitable sensors capable of detecting these signals. The module captures the signals and prepares them for further processing.

CHAPTER 6

REAL LIFE IMPLEMENTATION

It is basically a Brain Computer Interface (BCI) System. A BCI is a non-muscular communication channel that enables a person to send commands and messages to an automated system such as a prosthetic arm, by means of his/her brain activity. The basic idea of BCI is to translate user produced patterns of brain activity into corresponding commands. One of the most important features in a BCI system is represented by acquisition. The most spread acquisition technique is EEG, and it represents a cheap and portable solution for acquisition. The EEG technique assumes brainwaves recording by electrodes attached to the subject’s scalp. EEG signals present low-level amplitudes in the order of microvolt and frequency range from 1 Hz up to 100 Hz. Specific features are extracted and associated with different states of patient brain activity, and further with commands for developed applications.

Using EEG one more drawback can be eliminated (i.e., dangerous surgery can be avoided for invasive method where electrodes are placed inside of brain called implants). The EEG Headset or the Brainwave Sensor detects the electrical signals from the brain and sends them in the form of data packets to a Bluetooth. This received data is processed and the control commands are then transmitted to the Arduino via RF. Based on the data received by the Microcontroller it performs certain predefined actions based on the level of concentration.

Real-life implementation of a prosthetic arm and home automation system controlled by brain signals and eye-blink signals requires a detailed and iterative approach that involves a range of technical and non-technical considerations. In this article, we will discuss the different aspects of the real-life implementation of our project and the challenges and opportunities associated with it.

6.1 Designing the System:

The first step in implementing our project in the real world is to design the overall architecture and the hardware and software components. The system should be designed in a modular and scalable manner to allow for flexibility and customization. The design should include sensors that can record brain signals and eye-blink signals, a microcontroller or processor to process the signals and send commands to the prosthetic arm and home automation system, and communication interfaces to transmit and receive data between the system components.

6.2 Prototyping the System:

Once the design is finalized, the next step is to build a prototype of the system. This involves integrating the sensors, actuators, and communication interfaces into a working prototype and testing the system's functionality and performance. The prototype should be designed to be easy to modify and update based on the results of testing and user feedback. The system is designed to be modular and scalable, with sensors, microcontrollers, actuators, and communication interfaces selected for their performance, compatibility, and cost-effectiveness.

6.3 Refining the System:

Based on the test results, the system may need to be refined and improved to address any issues or limitations. This may involve tweaking the software algorithms, improving the hardware components, or optimizing the communication interfaces. Refining the system is an iterative process that involves ongoing testing, evaluation, and modification. Refining the system ensures that it is safe, reliable, and effective in the real world, and that it meets the specific needs of users with disabilities.

The use of BCI technology to control prosthetic arms is still in its early stages of development, but there have been some promising advancements in recent years. One of the most significant breakthroughs was the development of the DEKA Arm System, also known as the LUKE Arm. The DEKA Arm System uses a variety of sensors, including BCI technology, to allow users to control the device using their thoughts. The BCI component of the system uses electrodes placed on the user's scalp to pick up signals from the brain. The signals are then analyzed and translated into movement commands that are sent to the prosthetic arm. The device is capable of performing complex movements, such as grasping and holding objects, with a high degree of accuracy and precision.

Another example of real-life implementation of prosthetic arms controlled by BCI technology is the Modular Prosthetic Limb (MPL) developed by Johns Hopkins University Applied Physics Laboratory. The MPL is a highly advanced prosthetic arm that uses a combination of sensors, including BCI technology, to allow users to control the device with their thoughts. The system uses a combination of implanted electrodes and electrodes placed on the scalp to pick up signals from the brain. The signals are then analyzed and translated into movement commands that are sent to the prosthetic arm. The MPL is capable of performing a wide range of movements, including grasping and manipulating objects, with a high degree of accuracy and precision.

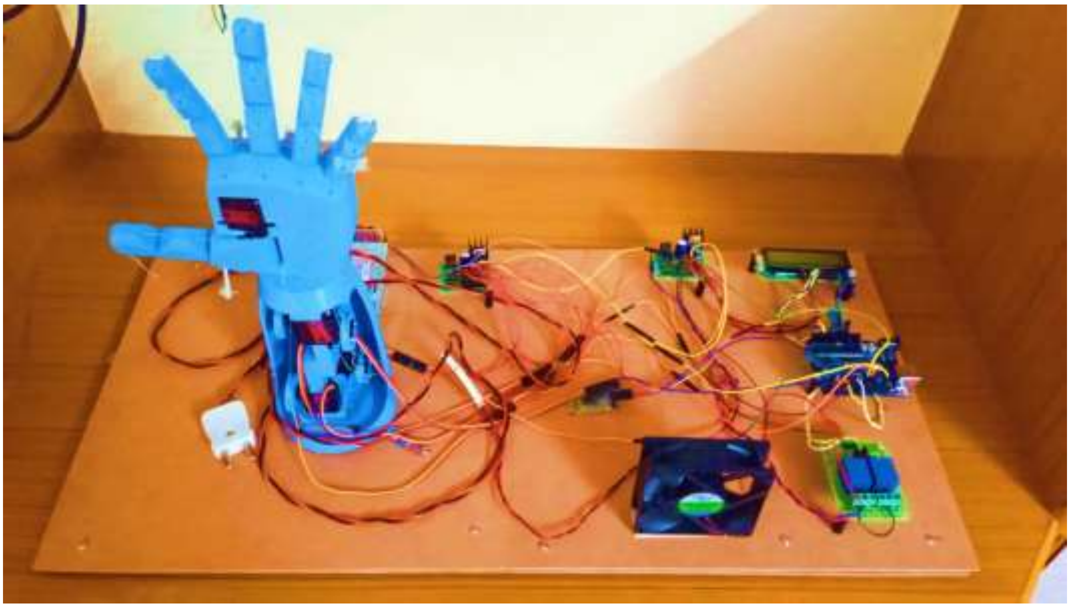


Fig 6.1: Implemented Project

CHAPTER 7

TESTING AND VALIDATION

7.1 INTRODUCTION

Testing of any product comprise of giving the product an arrangement of test information and watching if the product carries on not surprisingly, if the product neglects to carry on obviously, then the conditions under which of disappointment happens are noted for investigating and amendment. At last, the framework in general is tried to guarantee that blunder in past countenances is revealed and the venture acts as determined.

7.2 BASICS OF SOFTWARE TESTING

BLACK BOX TESTING

Black box testing is done to find the following:

- Incorrect or missing functions
- Interface errors and performance errors
- Initialization and termination error

WHITE BOX TESTING

This allows the tests to check whether all independent paths within a module have been:

- Exercised at least once.
- Exercise all logical decisions on their false sides.
- Execute all loops and their boundaries and within their boundaries.
- Exercise the internal data structure to ensure their validity.

7.3 TYPES OF TESTING

Following are the different types of testing

- Unit Testing
- Integration Testing
- System Testing
- Performance Testing
- Validation Testing
- Acceptance Testing

Let us consider each testing and discuss on it in detail. Firstly, we move the first testing and give its detail description.

Unit Testing

Singular part is tried to guarantee that they work accurately. Every part is tried freely. Framework was tried with the arrangement of legitimate test information for every module and the outcomes were checked with the normal yield. This testing is done amid stages, every module is observed to work agreeable as respects to the normal yield from the module.

Integration Testing

Mix testing is another part of testing that is for the most part done keeping in mind the end goal to reveal mistakes related with stream of information crosswise over interfaces. The unit-tried modules are assembled together and tried in little section, which make it less demanding to seclude and revise mistakes.

System Testing

Framework testing is really a progression of various tests whose basic role is to completely practice the PC based framework. Framework testing guarantees that the whole incorporated programming framework meets prerequisites. It tests a design to guarantee known and unsurprising outcomes.

Performance Testing

The execution testing guarantee that the yield being delivered inside as far as possible and time taken for the framework aggregating, offering reaction to the clients and demand being send to the framework so as to recover the outcomes.

Validation Testing

The approval testing can be characterized from multiple points of view. However, a straightforward definition is that. Approval succeeds when the product capacities in a way that can be sensibly expected by the end client.

Acceptance Testing

This is the final stage of testing process before the system is accepted for operational use. The system is tested within the data supplied from the system procurer rather than simulated data.

Table 1 Unit Test Case 1

SI # Test Case	**UTC-1**
Name of Test	Connect sensors with Arduino
Expected Result	We have connected all sensors with Arduino, we have used both Analog pin and digital pin.
Actual output	Same as expected.
Remarks	**Successful**

Table 7.1: Unit Test Case 1

Table 2 Unit Test Case 2

S2 # Test Case	**UTC-2**
Name of Test	Upload the code on Arduino board
Expected Result	We are using here embedded c. We uploaded the code on Arduino board. All sensors are working well.
Actual Output	Same as expected.
Remarks	**Successful**

Table 7.2: Unit Test Case 2

Table 3 Integration Test Case 1

S3# Test Case	**ITC-1**
Name of Test	Arduino with Brainwave sensor
Item being tested	Different attention values should be read
Sample Input	Brainwave sensor input
Expected Result	0 to 100 digital values should be read
Actual output	Digital values read successfully
Remarks	**Successful**

Table 7.3: Integration Test Case 1

Table 4 Integration Test Case 2

S4# Test Case	**ITC-2**
Name of Test	Arduino with Prosthetic hand
Item being tested	Different Movement of fingers
Sample Input	Input to hand
Expected output	Different hand movement should be achieved
Actual output	Functioned Properly
Remarks	**Pass.**

Table 7.4: Integration Test Case 2

Table 5 System Test Case 1

S5# Test Case	**STC-1**
Name of Test	System testing
Item being tested	Prosthetic hand movement with sensor input
Sample Input	Brainwave sensor input
Expected output	Hand should work as per sensor input
Actual output	Same as Expected
Remarks	**Pass**

Table 7.5: System Test Case 1

Table 6 System Test Case 2

S6# Test Case	**STC-2**
Name of Test	System testing
Item being tested	Home automation through sensor input
Sample Input	Brainwave sensor input
Expected output	Device should operate as per sensor input
Actual output	Same as Expected
Remarks	**Pass**

Table 7.6: System Test Case 2

CHAPTER 8

RESULTS

Our project utilizes a headset to capture brain signals and eye movements for controlling a prosthetic arm and home automation system. By focusing their thoughts, users generate brain signals that are translated into attention values, activating specific functions. Blink detection is incorporated to pause or deactivate all functions when the user blinks. This intuitive control mechanism enhances convenience and independence for individuals with disabilities. The system eliminates the need for physical inputs or external devices, allowing users to seamlessly interact with their environment using mental focus. This innovative technology empowers individuals to effortlessly control the prosthetic arm's movements and interact with home automation devices, enhancing their ability to perform daily tasks with increased autonomy.

FIG 8.1: FAN TURNS ON AND ARM SIGNS ONE

FIG 8.2: LIGHTS TURNS ON AND ARM SIGNS TWO

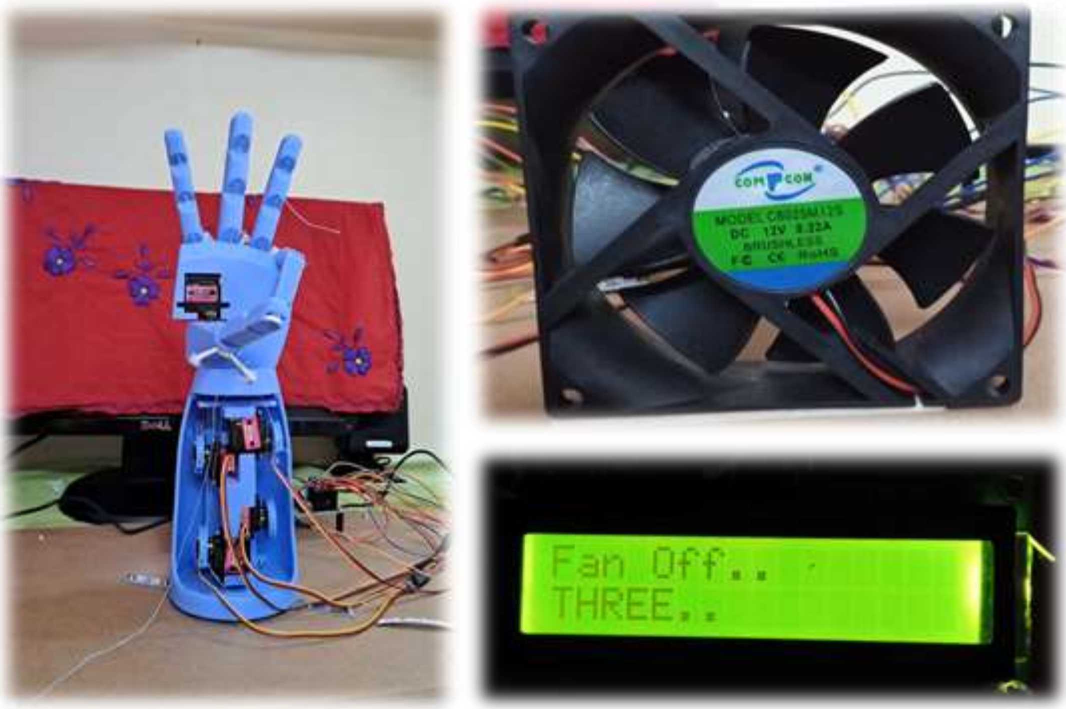


FIG 8.3: FAN TURNS OFF AND ARM SIGNS THREE

FIG 8.4: ARM SIGNS FOUR

FIG 8.5: ARM SIGNS FIVE

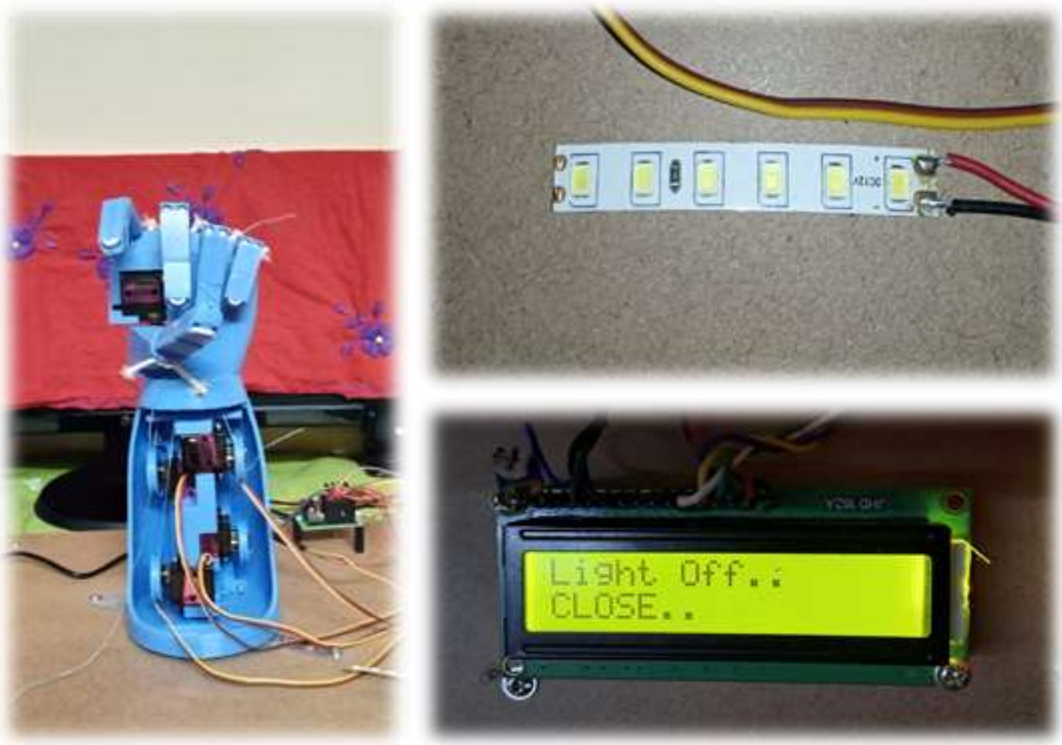


FIG 8.6: LIGHT TURNS OFF AND ARM CLOSES

By capturing brain signals through a headset and translating them into attention values, the system activates specific functions based on the user's focused thoughts. This empowers users to perform tasks and control their surroundings with ease, promoting independence and convenience. Moreover, blink detection is employed to pause or deactivate functions when the user blinks. This intuitive control mechanism ensures a seamless user experience, allowing individuals to interrupt or halt system operations as needed.

Our project offers an intuitive and efficient control mechanism for the prosthetic arm and home automation system. By leveraging brain signal capture, attention values, and blink detection, users can seamlessly interact with the system using their thoughts and natural eye movements. This groundbreaking technology transforms the lives of individuals with disabilities, providing them with increased autonomy and an improved quality of life.

FUTURE ENHANCEMENT AND CONCLUSION

Future Enhancement

1. Enhanced accuracy and reliability of brain signal detection and interpretation.
2. Improved user training and calibration for better control.
3. Reduced costs to increase accessibility.
4. Development of more user-friendly interfaces.
5. Increasing the number of brain signals detected and interpreted for more precise control.
6. Improvement in prosthetic arm design for increased functionality and sensory feedback.
7. Development of more lightweight and flexible prosthetic materials for better comfort.
8. Integration of voice commands for added control and convenience.
9. Addition of haptic feedback for improved user experience.
10. Improvement in battery life and power efficiency for longer use.
11. Integration of other assistive technologies for a more comprehensive solution.
12. Collaboration with healthcare providers to better understand and meet user needs.
13. Development of better algorithms to predict user intent based on brain signals.
14. Integration with smart home technology for a more seamless and integrated experience.

CONCLUSION

The proposed system demonstrates the use of EEG to control the prosthetic arm and promises a feasible solution for amputee disability without undergoing any surgery. This gives it great potential in many applications whether related to the health care field or not. This idea could be expanded to other body parts as well. This is major upgrade form existing prosthetics. The system is cost efficient as compare to myoelectric prosthetics. All this can be archived without any health issues.

The signal generated by brain was received by the brain sensor and it will divide into packets and the packet data transmitted to wireless medium (blue tooth).the wave measuring unit will receive the brain wave raw data and it will convert into signal. Then the instructions will be sending to the home section to operate the modules (bulb, fan). The project operated with human brain assumption and the on off condition of home appliance is based on changing the muscle movement with blinking. The Brain Computer Interface has proved to be boon to the disabled persons by providing them independent environment not by manual control but by mere “thinking”.

REFERENCES

1. Vojkan Mihajlovic, Bernard Grundlehner, Ruud Vullers, Julien Penders, “Wearable, Wireless EEG Solutions in Daily Life Applications: What Are We Missing?”, Journal of Biomedical and Health Informatics, Vol.19, Issue 1, January 2014.
2. Jozsef Katona, Tibor Ujbanyi, Gergely Sziladi, Attila Kovari, “Speed Control of Festo Robotic Mobile Robot Using Neurosky Mind Wave EEG Headset Based Brain Computer Interface”, 7th IEEE International Conference on Cognitive Info Communications, Issue 18, October 2015.
3. Diana Janeth Lancheros-Cuesta, José Luis Ramirez Arias, Yudi Yirley Forero, Adriana Carolina Duran, “Evaluation of E learning activities With Neurosky Mind Wave EEG”, 13th Iberian Conference on Information Systems and Technologies (CISTI), Issue 16, June 2016.
4. Simon L. Kappel, Mike L. Rank, Hans Olaf Toft, Mikael Andersen, Preben Kidmose, “Dry-Contact Electrode Ear-EEG”, IEEE Transactions on Biomedical Engineering, Vol.66, Issue 1, January 2017.
5. Prashant Kumar Tiwari, Abhishek Choudhary, Saurabh Gupta, Joydip Dhar, Prasenjit Chanak, “Sensitive Brain computer Interface to Help Manoeuvre a Miniature Wheelchair Using Electroencephalography”, IEEE International Students' Conference on Electrical, Electronics and Computer Science, Issue 29, May 2018.
6. Abdelkader Nasreddine Belkacem, “Real Time Human Like Robot Control Based on Brain Computer Interface”, 2nd International Workshop on Human-Centric Smart Environments for Health and Well-Being (IHSH), Issue 10, February 2019.
7. Sadat Hasan Shehab, Md. Lizur Rahman, Md. Hasibul Hasan, Md. Iftekhar Uddin, Syed Abrab Mahmood, Azm Ehtesham Chowdhury, “Home Automation System Using Gesture Pattern & Voice Recognition for Paralyzed People”, 11th International Conference on Electrical and Computer Engineering (ICECE), Issue 19, December 2020.
8. Ravi Rahul B M, V.R. Balaji, Ram Balaji K A, Gowtham S, Surya S, “Mind Wave Controlled Assistive Robot”, 7th International Conference on Advanced Computing & Communication Systems (ICACCS), Issue 20, March 2021.

APPENDIX

```
void setup()
{
  pinMode(IN1,OUTPUT);
  pinMode(IN2,OUTPUT);
  pinMode(Relay1,OUTPUT);
  pinMode(Relay2,OUTPUT);
  digitalWrite(IN1,LOW);
  digitalWrite(IN2,LOW);
  digitalWrite(Relay1,LOW);
  digitalWrite(Relay2,LOW);
  Serial.begin(BAUDRATE);
  Serial.println("Prosthetic Hand");
  lcd.begin(16, 2);
  lcd.print("EEG Prosthetic" );
  lcd.setCursor(0,1);
  lcd.print("Hand Home Automation");
  servo1.attach(3);
  servo2.attach(5);
  servo3.attach(6);
  servo4.attach(9);
  servo5.attach(10);
 servo1.write(150);
 delay(1000);
 servo2.write(180);
 delay(1000);
 servo3.write(180);
 delay(1000);
 servo4.write(0);
delay(1000);
servo5.write(180);
delay(2000);
}
```

```
void loop()
{
Brainwave_Signal();
}

void Brainwave_Signal()
{
   Serial.println("Brainwave ....");
  while (1)
  {
    if(ReadOneByte() == 170)
    {
      if(ReadOneByte() == 170)
      {
        Plength = ReadOneByte();
        if(Plength == 32)   // Big Packet
        {
          generatedchecksum = 0;
          for(int i = 0; i < Plength; i++)
          {
            payloadData[i]   = ReadOneByte();
            generatedchecksum  += payloadData[i] ;
          }
          generatedchecksum = 255 - generatedchecksum;
          checksum  = ReadOneByte();
           if(checksum == generatedchecksum)
          {
            Poorquality  = payloadData[1];
            Attention    = payloadData[29];
            Serial.print(Attention);
            lcd.clear();
            lcd.print(Attention);
            Serial.print("\n");
            Attention_Fun(Attention);
           }
```

```
            }
          }
        }
      }
    }

    void Attention_Fun(byte data1)
      {
          if (Poorquality == 0)
            {
              if (j<3)
                {
                    Temp += data1;
                    j++;
                }

              else
                {
                     Temp += data1;
                     Att_Avg = Temp/4;
                     Serial.print("Att_Avg");
                     Serial.print(Att_Avg);
                     Serial.print("\n");

                       if (Att_Avg >= 70)
                           {
                             digitalWrite(Relay1, HIGH);
                             Serial.println("ONE...");
                             lcd.clear();
                             lcd.print("Fan On..");
                             lcd.setCursor(0,1);
                             lcd.print("ONE..");
                           ONE();
                           delay(1000);
                            }
```

```
else if (Att_Avg >= 60)
        {
            digitalWrite(Relay2, HIGH);
            Serial.println("TWO...");
            lcd.clear();
            lcd.print("Light On..");
            lcd.setCursor(0,1);
            lcd.print("TWO..");
            TWO();
            delay(1000);
        }

else if (Att_Avg >= 50)
        {
             digitalWrite(Relay1, LOW);
             Serial.println("THREE...");
             lcd.clear();
             lcd.print("Fan Off..");
             lcd.setCursor(0,1);
             lcd.print("THREE..");
            THREE();
            delay(1000);
         }

else if (Att_Avg >= 45)
        {
            digitalWrite(Relay2, LOW);
            Serial.println("CLOSE...");
            lcd.clear();
            lcd.print("Light Off..");
            lcd.setCursor(0,1);
            lcd.print("CLOSE..");
           CLOSE();
        delay(1000);
```

```
          }

else if (Att_Avg >= 40)
          {
                Serial.println("FOUR...");
                digitalWrite(Relay2, LOW);
                lcd.setCursor(0,1);
                lcd.print("FOUR...");
                FOUR();
                delay(1000);
          }

else if (Att_Avg < 40)
          {
            Serial.println("FIVE...");
            lcd.setCursor(0,1);
            lcd.print("FIVE...");
            FIVE();
            delay(1000);
         }
            j=0;
           Temp=0;
         }
    }
    else
     {
          digitalWrite(Relay1, LOW);
          digitalWrite(Relay2, LOW);
          Serial.print("Signal Poor Quality");
          Serial.print("\n");
     }
 }

void INITIAL()
{
```

```
    servo1.write(150);
    delay(1000);
    servo2.write(180);
    delay(1000);
    servo3.write(180);
    delay(1000);
    servo4.write(0);
    delay(1000);
    servo5.write(180);
    delay(1000);
}

void ONE()
{
      servo1.write(0);
      delay(1000);
      servo2.write(180);
      delay(1000);
      servo3.write(0);
      delay(1000);
      servo4.write(180);
      delay(1000);
      servo5.write(0);
      delay(2000);
      INITIAL();
}

void TWO()
{
      servo1.write(0);
      delay(1000);
      servo2.write(180);
      delay(1000);
      servo3.write(180);
      delay(1000);
```

```
      servo4.write(180);
      delay(1000);
      servo5.write(0);
      delay(2000);
     INITIAL();
  }

void THREE()
{
        servo1.write(0);
      delay(1000);
      servo2.write(180);
      delay(1000);
      servo3.write(180);
      delay(1000);
      servo4.write(0);
      delay(1000);
      servo5.write(0);
      delay(2000);
      INITIAL();
}

void FOUR()
{
        servo1.write(0);
      delay(1000);
      servo2.write(180);
      delay(1000);
      servo3.write(180);
      delay(1000);
      servo4.write(0);
      delay(1000);
      servo5.write(180);
      delay(2000);
     INITIAL();
```

```
}

void FIVE()
{
    servo1.write(150);
    delay(1000);
    servo2.write(180);
    delay(1000);
    servo3.write(180);
    delay(1000);
    servo4.write(0);
    delay(1000);
    servo5.write(180);
    delay(2000);
    INITIAL();
}

void CLOSE()
{
    servo1.write(0);
    delay(1000);
    servo2.write(0);
    delay(1000);
    servo3.write(0);
    delay(1000);
    servo4.write(180);
    delay(1000);
    servo5.write(0);
    delay(2000);
    INITIAL();
}
```

ACHIEVEMENTS AND AWARDS

CITY ENGINEERING COLLEGE

Affiliated to VTU, Approved by AICTE, Accredited by NAAC, Doddakallasandra, Bangalore-62

Certificate Of Appreciation

This is to Certify that ...AFRID PASHA H.P.........of City Engineering College, with project entitled

"Prosthetic arm & home Appliances controlled by brain waves & Eye blink signals"

has been awarded **First** prize in college level project exhibition "Tech Tarang-23" organized by the department of CSE,ISE,AI&ML,ECE,MECH & CIVIL, **City Engineering College** held on May 9th 2023

Dr. Sowmya
HOD, Dept. of CSE

Dr. Thippeswamy H.N
Principal

CITY ENGINEERING COLLEGE

Affiliated to VTU, Approved by AICTE, Accredited by NAAC, Doddakallasandra, Bangalore-62

Certificate Of Appreciation

This is to Certify that ....B. M. PUNEETH.........of City Engineering College ,with project entitled

"Prosthetic arm & home Appliances controlled by brain waves & eye blink signals"

has been awarded **First** prize in college level project exhibition "**Tech Tarang-23**" organized by the department of CSE,ISE,AI&ML,ECE,MECH & CIVIL, **City Engineering College** held on **May 9th 2023**

Dr. Sowmya
HOD, Dept. of CSE

Dr. Thippeswamy H. N
Principal

CITY ENGINEERING COLLEGE

Affiliated to VTU, Approved by AICTE, Accredited by NAAC, Doddakallasandra, Bangalore-62

Certificate Of Appreciation

This is to Certify that ....KRUTTIKA BHOMKAR of City Engineering College ,with project entitled

"Prosthetic arm & home Appliances controlled by brain waves & eye blink signals"

has been awarded **First** prize in college level project exhibition "Tech Tarang-23" organized by the department of CSE,ISE,AI&ML,ECE,MECH & CIVIL, **City Engineering College** held on May 9th 2023

Dr. Sowmya
HOD, Dept. of CSE

Dr. Thippeswamy H. N
Principal

CITY ENGINEERING COLLEGE

Affiliated to VTU, Approved by AICTE, Accredited by NAAC, Doddakallasandra, Bangalore-62

Certificate Of Appreciation

This is to Certify that ...AMITH SINGH.........of City Engineering College ,with project entitled

"Prosthetic arm & home Appliances controlled by brain waves & eye blink signals."

has been awarded **First** prize in college level project exhibition "Tech Tarang-23" organized by the department of CSE,ISE,AI&ML,ECE,MECH & CIVIL, **City Engineering College** held on May 9th 2023

Dr. Sowmya
HOD, Dept. of CSE

Dr. Thippeswamy H. N
Principal

Karnataka State Council for Science and Technology

(An autonomous organisation under the Dept. of Science & Technology, Govt. of Karnataka)
Indian Institute of Science Campus, Bengaluru – 560 012
Telephone: 080-23341652, 23348848, 23348849, 23348840
Email: office.kscst@iisc.ac.in, office@kscst.org.in • **Website:** www.kscst.iisc.ernet.in, www.kscst.org.in

KSCST

Dr. U T Vijay
Executive Secretary

24th April, 2023

Ref: 7.1.01/SPP/33

To,
The Principal,
City Engineering College,
Doddakallasandra, Kanakapura Main Road, Vasanthapura,
Bengaluru – 560 062.

Dear Sir/Madam,

Sub : Sanction of Student Project - 46th Series: Year 2022-2023

Project Proposal Reference No. : **465_BE_4387**
Ref : Project Proposal entitled **PROSTHETIC ARM AND HOME APPLIANCES CONTROLLED BY MIND-THOUGHTS AND EYE-BLINKS**

Congratulations,

We are pleased to inform that your student project proposal referred above, has been approved by the Council under "Student Project Programme - 46th Series". The project details are as below:

Student(s)	Mr. B. M. PUNEETH	**Department**	COMPUTER SCIENCE AND ENGINEERING
	Mr. AMITH SINGH M		
	Ms. KRUTTIKA KIRANKUMAR BHOMKAR		
	Mr. AFRID PASHA H P	**Sanctioned Amount (in Rs.)**	4,000.00
Guide(s)	Mrs. SANGEETHA RAO S		
	Mrs. TEGASWINI B N		

Thanking you and with best regards,

Yours sincerely,

(U T Vijay)

Copy to:
1) The HoD
   COMPUTER SCIENCE AND ENGINEERING
   CITY ENGINEERING COLLEGE, BENGALURU

2) Mrs. SANGEETHA RAO S   Mrs. TEGASWINI B N
   COMPUTER SCIENCE AND ENGINEERING
   CITY ENGINEERING COLLEGE, BENGALURU

3) THE ACCOUNTS OFFICER
   KSCST, BENGALURU

DECLARATION

We students of 8^{th} semester BE, Computer Science and Engineering from City Engineering College hereby declare that Project work entitled "Prosthetic Arm and Home appliances Controlled by Mind-Thoughts and Eye-Blinks" has been carried out by us at City Engineering College, Bangalore and submitted in partial fulfilment of the course requirement for the award of the degree of Bachelor of Engineering in Computer Science and Engineering of Visvesvaraya Technological University, Belgaum, during the academic year 2022-2023.

We also declare that, to the best of our knowledge and belief, the work reported here does not form the part of dissertation based on which degree or award was conferred on an earlier occasion on this by any other student.

Date: 23-05-2023

Place: Bangalore

Afrid Pasha

AFRID PASHA HP (1CE19CS003)

Amithsgh.

AMITH SINGH M (1CE19CS007)

B.M.Puneeth

B. M. PUNEETH (1CE19CS013)

KBP

KRUTTIKA K BHOMKAR (1CE19CS046)