VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnanasangama, Macche, Santibastwada Road
Belagavi-590018, Karnataka

A
UG PROJECT REPORT
on

Design and Implementation of Smart Prosthetic Hand using Artificial Intelligence

Submitted in partial fulfillment of the requirement for the degree of

Bachelor of Engineering
in
Electronics & Communications Engineering - ECE
by

1DS19EC060	**Kavyanjali R**
1DS19EC080	**Mo Imran**
1DS19EC085	**Nalliboyina Yuva Raja Phani Kumar**
1DS20EC420	**Maria Dayana L N**

Under the guidance
of
Dr. T. C. Manjunath
Internal Project Guide
Professor & Head, ECE Dept., DSCE, Bengaluru

Department of Electronics & Communication Engineering
(An Autonomous College affiliated to VTU Belgaum, accredited by NBA & NAAC, Ranked by NIRF)
Shavige Malleshwara Hills, Kumaraswamy Layout,
Bengaluru-560078, Karnataka, India

2022-23

Certificate

Certified that the project work entitled "Design and Implementation of Smart Prosthetic Hand using Artificial Intelligence" carried out by **Kavyanjali R** (USN-1DS19EC060), **Mo Imran** (USN-1DS19EC080), **Nalliboyina Yuva Raja Phani Kumar** (USN-1DS19EC085), **Maria Dayana L N** (USN-1DS20EC420) are bonafide students of the ECE Dept. of Dayananda Sagar College of Engineering, Bangalore, Karnataka, India in partial fulfillment for the award of Bachelor of Engineering in Electronics & Communication Engineering of the Visvesvaraya Technological University, Belagavi, Karnataka during the academic year 2022-23. It is certified that all corrections / suggestions indicated for project work have been incorporated in the report deposited to the ECE department, the college central library & to the university. This final year project report **(Course Code : 19EC8ICPR2)** has been approved as it satisfies the academic requirement in respect of project work prescribed for the said degree.

Dept. Project Coordinators (Section incharges)
Abhishek - Suma / Manasa / Srividya / Bindu

Project Guide
Name of the Guide

Head of the Department
Dr. T.C.Manjunath, Ph.D. (IIT Bombay)

Dr. B.G. Prasad
Principal, DSCE

External Project Viva-Voce

Name of the project examiners (int & ext) with date :

1 : Signature : ______________________

2 : Signature : ______________________

Declaration

Certified that the project work entitled, "Design and Implementation of Smart Prosthetic Hand using Artificial Intelligence" with the project work course code **19EC8ICPR2** is a bonafide work that was carried out by ourselves in partial fulfillment for the award of degree of Bachelor of Engineering in Electronics & Communication Engg. of the Visvesvaraya Technological University, Belagavi, Karnataka during the academic year 2022-23. We, the students of the project group/batch no. R-02 do hereby declare that the entire project work has been done on our own & we have not copied or duplicated any other's work or may be the extension of the works done by the earlier students. The results embedded in this UG project report has not been submitted elsewhere for the award of any type of undergraduate degree.

Student Name-1 : Ms. Kavyanjali R.
USN : 1DS19EC060

Sign : ____________________

Student Name-2 : Mr. Mo Imran
USN : 1DS19EC080

Sign : ____________________

Student Name-3 : Mr. Nalliboyina Yuva Raja Phani Kumar
USN : 1DS19EC085

Sign : ____________________

Student Name-4 : Ms. Maria Dayana L N
USN : 1DS20EC420

Sign : ____________________

Date : 20 / 06 /2023

Place : Bengaluru - 78

Acknowledgement

We would like to express our gratitude to our college management committee for their continuous support and encouragement: **Dr. Hemachandra Sagar, Chairman, Dr. Premchandra Sagar, Vice Chairman, Galiswamy, Secretary, Tintisha Sagar, Joint Secretary and Dr. B.G. Prasad, Principle, DSCE**

We like to thank **Dr T.C. Manjunath, HOD of ECE Department**, our project guide who has supported in all means to travel in the right path to complete this project.

We would also like to thank our project coordinators **Dr. Abhishek M.B, Suma MR. Manasa R K, Bindhu HM, Professors, ECE Dept., DSCE,** for their careful monitoring throughout the project. We would also extend our gratitude to all our teaching and non-teaching staff for their continuous support

We are grateful to our parents and our relatives for their kind cooperation and encouragement which helped us in completion of this project. We would like to express our gratitude and appreciation to our friends for supporting us during this project.

We would also thank the supreme power, the Almighty God who is always the one to guide us to work on the right path of our life.

Table of Contents

Title Sheet		i
Certificate		ii
Declaration		iii
Acknowledgement		iv
Table of Contents		v
List of Figures		vi-vii
List of Tables		viii
Nomenclature and Acronyms		ix
Abstract		1
Chapter 1	Introduction	2-7
	1.1 Overview of the project work	
	1.2 Background information about the project work	
	1.3 Motivation obtained to take up the project work	
	1.4 Problem statement of the project work	
	1.5 Objectives of the project work	
	1.6 Scope of the project work	
	1.7 Organization of the project report	
Chapter 2	Literature Survey	8-9
Chapter 3	Project Details	10-32
Chapter 4	Simulation or Experimental Results & Discussions	33-36
Chapter 5	Conclusions, Future Work & Outcome of the project work	37
References.		38-39
Appendix		40-55
Papers presented		56
Awards, Certificates Recognitions & Photographs		57-66
Hard copy of the presented conference paper / published journal paper		67-80
Plagiarism reports		81-85
CO-PO Mapping Justification Sheets		86-88
Budget Estimation Sheets		89

List of Figures

Fig. 1 : Solider who lost his hand in war 1

Fig. 2 : Child with hand amputee 2

Fig. 3 : Block diagram 3

Fig. 4 : Data Flow Diagram 4

Fig. 5 : Flow Chart 5

Fig. 6 : The attached sensors in the 10 – 20 system 6

Fig. 7 : TGAM module connection circuit 7

Fig. 8 : Data packet structure 8

Fig. 9 : Packet Header 9

Fig. 10 : Data payload structure 10

Fig. 11 : Example packet 11

Fig. 12 : Robotic Hand 12

Fig. 13 : Arduino Mega 13

Fig. 14 : Brainsense Headset 14

Fig. 15 : TGAM Module 15

Fig. 16 : Flex sensor 16

Fig. 17 : Servo Motor 17

Fig. 18 : HC-05 Bluetooth Module 18

Fig. 19 : 30rpm DC Motor 19

Fig. 20 : Jumper wires 20

Fig. 21 : 4 Channel Relay Module 21

Fig. 22 : L293D Motor Driver 22

Fig. 23 : Power supply module 5v 23

Fig. 24 : Arduino IDE 24

Fig. 25 : Proposed model 25

Fig. 26 : Hand picking a paper ball 26

Fig. 27 : Operating LED with flex sensors 27

Fig. 28 : EEG Sensor setup 28

Fig. 29 : EEG signals 29

Fig. 30 : Different positions of Hand based on the captured signals 30

Fig. 31 : Simulation Results 31

Fig. 31 : Board Topology 32

Fig. 32 : PCB Layout of TGAM 33

Fig. 34 : B0,B1 Configurations 34

List of Tables

Table 1 : Attention values 1

Nomenclature and Acronyms

Abbreviations (Alphabetical Order):

BCI	Brain Computer Interface
EEG	Electroencephalogram
HCI	Human Computer Interface
IEEE	Institute of Electrical & Electronics Engineers
TGAM	ThinkGear Asic Module

Abstract

This project revolves around a multi-model approach to guide the robotic arm that is controlled by brain, gesture and voice signals. The human brain consists of hundreds of millions of neurons. The utilization of an Electroencephalogram (EEG) based Brain-Computer Interface (BCI) prosthetic arm offers a promising non-invasive approach to support individuals with significant disabilities in their daily lives. This innovative technology has the capability to empower users by facilitating voluntary movements of the prosthetic arm, enhancing their ability to engage in various activities with greater independence and control. The EEG signals from the brain are captured in Brainsense headset and are processed by a microcontroller (Arduino Mega) to control servo motors and move the Prosthetic hand accordingly. It also involves a glove equipped with flex sensors that mimics the gestures. The technique involves the control of the arm motion with the aid of flex sensors. The voice control system is developed in order to control prosthetic arm by giving voice signals via Bluetooth. All operations can be monitored by a user interface with the support of a microcontroller. Individuals who have undergone amputation below the elbow can find significant advantages in utilizing this prosthetic arm. This prosthetic arm empowers physically disabled individuals to regain their independence and reduces their reliance on others to accomplish their daily tasks. This model would be highly useful inpractice, especially, for arm amputees and paralyzed patients.

Keywords—*Brain-Computer Interface, Brainsense headset, Voice control, Robotic arm, Bluetooth, flex sensors.*

Chapter -1

Introduction

Smart prosthetic hands, controlled through a combination of voice commands, gestures, and EEG signals, have emerged as ground breaking solutions in the field of assistive technology. The need for such advanced prosthetic devices is underscored by the staggering statistics surrounding limb loss and the challenges faced by individuals with limb dysfunction.

It is estimated that over 5 million people in India alone are living with some form of disability, including limb loss or dysfunction from the recent report of World Health Organization (WHO). Globally, the number of amputees exceeds 10 million, with approximately 30% of them experiencing arm amputations. These individuals often face significant challenges in performing daily tasks and achieving a sense of independence.

Traditional prosthetic hands, while helpful, have limitations in terms of their natural operation and interaction with the environment. However, advancements in technology have paved the way for innovative solutions that offer greater functionality and control. The integration of voice recognition, gesture recognition, and EEG-based control methods in smart prosthetic hands holds immense promise in addressing these limitations and transforming the lives of individuals with limb loss or dysfunction.

By incorporating voice control into prosthetic hands, users can interact with their devices effortlessly. Voice commands, such as "open hand" or "close fingers," provide precise control over the hand's movements, enabling users to perform a wide range of tasks more intuitively. This form of control eliminates the need for physical buttons or switches and enhances the overall user experience.

Gesture recognition, another key feature of smart prosthetic hands, enables users to manipulate their devices through natural hand movements. This advancement, coupled with the analysis of residual limb muscle activity, allows for accurate interpretation of gestures like pointing or making a fist. Such precise control empowers users to engage in complex activities and enhances their ability to interact with the world around them.

Additionally, the integration of EEG-based control in smart prosthetic hands offers a revolutionary approach. By capturing and interpreting brain signals, users can trigger desired movements of the prosthetic hand simply through their thoughts. This level of control not only enhances functionality but also provides individuals with a greater sense of autonomy and independence.

The combination of voice, gesture, and EEG control mechanisms in smart prosthetic hands marks a significant advancement in assistive technology. These devices offer improved dexterity, natural interaction, and a range of control options tailored to individual preferences and capabilities. With these innovations, individuals with limb loss or dysfunction can regain a sense of empowerment and significantly improve their quality of life.

Fig 1: Solider who lost his hand in war

Fig 2: Child with hand amputee

1.1 Overview of the project work

The project deals with designing a Smart Prosthetic Hand to assist the physically challenged people by analyzing the EEG signals. In addition to the EEG signals, voice-controlled operation and gestures-controlled operation is also included to enhance the user experience. Here we use a non-invasive type of electrode which is just placed on the frontal lobe of our brain, unlike invasive method which is inserted inside the body of the user. There is also a reference electrode which helps is cancelling the environmental or external noise. The reference electrode is clipped to our ears. The EEG Sensor, which is put on our scalp would collect the brain waves from the brain which is signal acquisition. The acquired signal is then sent to laptop which will be processed and then the control commands from the laptop will be transmitted to Arduino. Whereas the voice-controlled operation is achieved with the help of an android app, to which the user would give the input as voice command. The gestures mode of control is realized by the aid of flex sensors attached to each finger. The gestures made using these flex sensors would be replicated by the prosthetic hand.

1.2 Background information of the project work

Advancements in robotics and biomedical engineering have led to significant progress in the field of prosthetics, with prosthetic limbs evolving from simple mechanical devices to sophisticated systems capable of providing enhanced functionality and natural movement. However, traditional prosthetic hands still face challenges in terms of intuitive control and seamless interaction with the user. To address these limitations, the project focuses on the design and implementation of a smart prosthetic hand that leverages the combined power of gestures, voice commands, and electroencephalogram (EEG) signals.

Gestures have gained popularity as a natural means of communication between humans and machines. By capturing hand movements and translating them into control commands, gesture recognition systems provide an intuitive and direct method for controlling prosthetic devices. By identifying a range of predefined hand gestures, the smart prosthetic hand can activate specific hand movements and grasping actions, improving the user's ability to manipulate objects and perform daily tasks.

Voice commands offer an additional input modality that can enhance the control capabilities of the prosthetic hand. By integrating voice recognition technology, users can execute various commands and switch between different modes of operation effortlessly. Voice commands enable actions such as opening or closing the hand, switching between grasp patterns, and adjusting the grip strength, providing users with a convenient and efficient control mechanism.

Furthermore, the project incorporates EEG signals to enable users to control the prosthetic hand using their brain activity. EEG is a non-invasive technique that measures electrical activity in the brain, providing a direct interface between the user's intentions and the movements of the prosthetic hand. By analyzing specific patterns in the EEG signals, the system can interpret the user's desired hand movements and execute them accordingly. This EEG-based control mechanism holds great potential for individuals with limited mobility or those with spinal cord injuries.

The design and implementation of the smart prosthetic hand involve the integration of various components, including sensors for capturing hand gestures, microphones for voice input, EEG electrodes for brain signal acquisition, and an intelligent control algorithm that interprets and translates the collected data into specific hand movements. The integration of these technologies aims to create a prosthetic hand system that is more intuitive, adaptive, and responsive to the user's intentions.

The successful realization of this project could significantly improve the functionality and usability of prosthetic hands, providing individuals with limb loss a greater degree of control and independence in their daily lives. By combining gesture recognition, voice commands, and EEG signals, the smart prosthetic hand aims to bridge the gap between humans and machines, offering a more seamless integration of technology into the lives of individuals with limb loss. Additionally, this research may have broader applications beyond prosthetics, contributing to the advancement of assistive technologies and human-machine interfaces in various fields.

1.3 Motivation obtained to take up the project work

The motivation behind undertaking the project stems from the desire to address the limitations of current prosthetic hand technologies and improve the quality of life for individuals with limb loss. Traditional prosthetic hands often lack intuitive control mechanisms, making it challenging for users to perform daily tasks with ease and precision. By integrating gestures, voice commands, and EEG signals into a smart prosthetic hand system, we aim to provide a more natural and efficient control interface, allowing users to regain dexterity, independence, and a sense of normalcy in their daily lives. The project's ultimate goal is to advance the field of prosthetics by developing an intelligent and adaptive prosthetic hand that seamlessly responds to the user's intentions, enhancing their overall well-being and integration into society.

1.4 Problem Statement of the project work

Arm amputees must be dependent on others for daily activities. To overcome such difficulties, our project aims in designing a Smart Prosthetic hand. Individuals, such as soldiers who have lost their arms in war or those who have experienced limb impairment, face significant challenges in meeting their daily needs and often endure lifelong difficulties. So, taking all these snags into consideration, we have come up with a solution to build a prosthetic arm to overcome the difficulties faced by the individuals. The proposed model uses voice and gesture commands to operate and perform the activities as instructed by the user. Adding to voice and gesture, the prosthetic arm can be controlled by the EEG signals extracted from the individual’s brain. And this can be achieved by a brainwave headset. With solution to the difficulties planned to be tackled with Artificial Intelligence, we define the problem statement as “Design and Implementation of Smart Prosthetic Hand using Artificial Intelligence”.

1.5 Objectives

- ✓ To design a smart prosthetic arm, that utilizes captured EEG signals from the brain and processes them to control the robotic arm.
- ✓ To accomplish complex navigational tasks (pick and place objects).
- ✓ To design a hand that mimics the gestures and act accordingly.
- ✓ To control the hand by voice commands.
- ✓ To executive home automation.

- ✓ To send an alarming message to the family members in case of any emergency.

1.6 Scope of the Project

Our project aims to enhance the quality of life for individuals with disabilities, enabling them to achieve a sense of normalcy and independence in their daily activities. By providing efficient and effective support, our focus is on empowering those who have experienced limb loss due to war, paralysis, or other circumstances. Additionally, our project seeks to assist individuals who have lost control over their limbs, offering them the opportunity to regain functionality and improve their overall well-being. Brain-computer interfaces (BCIs) enables the transmission of a subject's thoughts, decoded from their brain's electrical activity into control signals for external applications all without the need for invasive brain surgery. This technology provides support to individuals in need of assistance transforming them from fully dependent individuals to partially independent ones. As a result, their physical and mental well-being can improve significantly. When designing a prosthetic hand, it is more practical and necessary to focus on accurately replicating a few motions achievable by the human hand rather than attempting to mimic the vast array of gestures it is capable of. Designing an excessively complex prosthesis to mimic every possible hand gesture would be challenging and unnecessary.

1.7 Organization of the Project Report

The project work undertaken by us is organized in the following sequence as follows. A brief introduction to the work is presented in the introductory chapter i.e., Chapter 1 and Literature survey in Chapter 2. In Chapter 3 project details including explanation about the Block diagram, flow chart, data flow diagram and working principle of the project work undertaken by us is presented. Chapter 4 explains the results and discussions and the simulation results along with Applications, Advantages, Outcome and Limitations. Overall Conclusion and future works are discussed in Chapter 5. The papers that were referred while doing this project are also mentioned.

Chapter -2

Literature Survey

Many works have been proposed on Smart prosthetic arm using different technologies. This section presents information on the current technologies, highlighting their advantages and disadvantages, as well as summarizing the work conducted by other researchers in the field to date. The following paragraphs elucidate the contributions made by the researchers in the development of robotic hands. The initial phase involved gathering project papers from diverse sources and conducting a thorough analysis to begin the research. The problem statement was subsequently formulated and defined, with a significant number of papers being referenced throughout the process.

[1]. Maryappan, Prashanth, Riyas Dheen, "A Brain Controlled Robotic Hand by using Brain Computer Interface (BCI) Technology" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181, 2020.

The objective of this brain-controlled based robot implementation incorporates mobility to patients suffering from debilitating degenerative muscular diseases. This paper proposes and implements a holistic methodology to acquire EEG signal with simple electrode,hardware implementation of robot efficient EEG feature extractions scheme to derive driving signal. The proposed scheme maneuvering ability can be improved to navigate in uneven and obstacle ridden.

[2]. Priyank Garg, Mansi Patel, Harshit Verma, "Gesture Controlled Robot with Robotic Arm" International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; Volume 10 Issue V May 2022.

This study accomplished its goal of constructing the hardware and software for a gesture-basedrobot with a robotic arm. Based on the observations gathered, it is obvious that its movement is precise, accurate, easy to handle, and user pleasant. The robotic hand has been created effectively because the robot's movement can be precisely controlled. This robotic hand controlapproach is anticipated to solve problems such as placing or picking things.

[3]. Ujwal, Rakshith Narun, Harshell Surana, "Voice Control Based Prosthetic Human Arm" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 07, July 2019.

In this paper, a medically inclined issue was taken up and was solved. This study involves intricate mechanical design of the arm as well as electronic control. A low-cost, yet functional prosthetic arm was designed and tested to take human vocal commands as inputs. The arm can potentially do all essential tasks done by a human arm on a daily basis.

[4]. Prutha Atre, Sahil Bhagat, Nevil Pooniwala, "Efficient and Feasible Gesture Controlled Robotic Arm" Second International Conference on Intelligent Computing and Control Systems (ICICCS) ISBN:978-1-5386-2842-3, 2020.

It uses Open CV to analyze different types of gestures and act accordingly. Slightest of the gestures is also recognized and extracted. The proposed method uses economic and compact components. Only 30% precision is achieved and uses 70Mb of RAM.

[5]. Dr. R. V. Dharaskar, S. A. Chhabria, Sandeep Ganorkar, "Robotic Arm Control Using Gesture and Voice" International Journal of Computer, Information Technology & Bioinformatics (IJCITB) ISSN:2278-7593, Volume-1, Issue-1,2020

This paper discusses the hand gesture recognition module design for analyzing and classifying hand gestures for HCI including glove-based techniques. It is used to find the way to map a set of angular measurements as delivered by the data glove to a set of predefined hand gestures. This project presented a glove-based approach to hand-gesture understanding that shifts the focus from traditional and potentially complex syntactical analysis toward understanding hand gestures and using their underlying meaning.

Chapter -3

Project Details

3.1 Block diagram of the proposed system

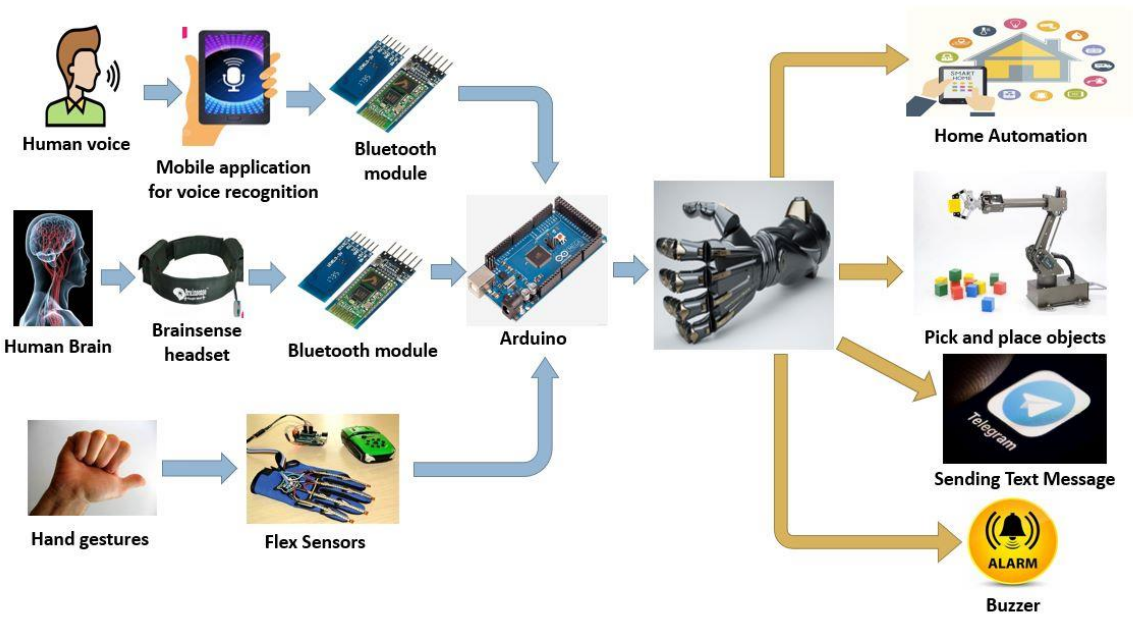


Fig 3: Block diagram

The Brain Signals utilized in this study are Spontaneous EEG signals, which are linked to different facets of brain function associated with voluntary mental tasks performed by the subject. The mental tasks encompass attention, eye blinks, and eye movement, which correspond to forward, reverse, and stop actions, respectively. Instead of using an electrode cap, a headgear is employed in this application for signal acquisition. The headgear or brainwave starter kit utilizes dry sensors, eliminating the need for a conductive gel to be applied between the sensors and the scalp. Furthermore, this device is significantly lighter and more convenient to use in comparison to conventional EEG sensors, as it only requires a single electrode for sensing. The Signal Processing Unit employed in this application is a laptop/PC. The brain signals are wirelessly transmitted from the headgear to the laptop using Bluetooth technology. Once digitized, these values are then transmitted via the USB port to a suitable microcontroller for mapping the brain signal values to control signals for the motors. The block diagram shows the voice recognition process as the first step, which is executed with the help of an android application named voice bot. The communication between the voice bot and the Arduino mega is done using HC-05 bluetooth module as shown above. And the respective outcomes are mapped to the prosthetic hand. Flex sensors, which supports the intuitive functioning are utilized to mimic the gestures of one normally functioning user's hand. This works on the principle of flex sensor's variable resistance capability. Using this technology, user can be able to pick and place the suitable objects. The system is designed to send messages to the closed ones of the user through telegram along with a buzzer sound in case of any emergency situations.

A power supply module is an electronic circuit designed to provide a controlled voltage to a load and establish a ground supply for the servo motors. These circuits are commonly utilized in robotics and various other applications to facilitate the operation of DC motors in both forward and reverse directions. The servo motors integrated into the Robotic Hand are responsible for executing hand movements based on the attention values. The Robotic Hand itself is constructed using 3D printing materials and features attached servo motors. The control signals determine the specific action required, causing the motors to rotate in either a clockwise or anticlockwise direction, or to come to a stop, depending on the desired outcome.

3.2 Data Flow diagram

In executing this project, we have made several valuable contributions, particularly in the area of voice control. Our focus is on enabling users to control the prosthetic arm using voice commands as input. This innovative approach allows for seamless interaction, as the commands are transmitted to the Bluetooth module and processed by the Arduino voice control app on a mobile device, serving as an intuitive interface between the user and the prosthetic arm. To achieve this functionality, we utilize voice commands as the primary input method. The speech recognizer component i.e., Voicebot (android application) plays a crucial role in this process by capturing and converting the spoken commands into text format. The converted text is then passed to the Arduino, where it is parsed and checked against a built-in library of pre-coded instructions. This library includes various commands such as "open all fingers" or "close," enabling the prosthetic hand to respond accordingly to the recognized command. In gestures mode of operation, flex sensors do the magic of moving the fingers of the robotic hand with the aid of flex sensors. One flex sensor is allotted for each finger of the prosthetic hand. Flex sensor which is also called as bend sensor, varies the resistance based on the degree of bend of the sensor.

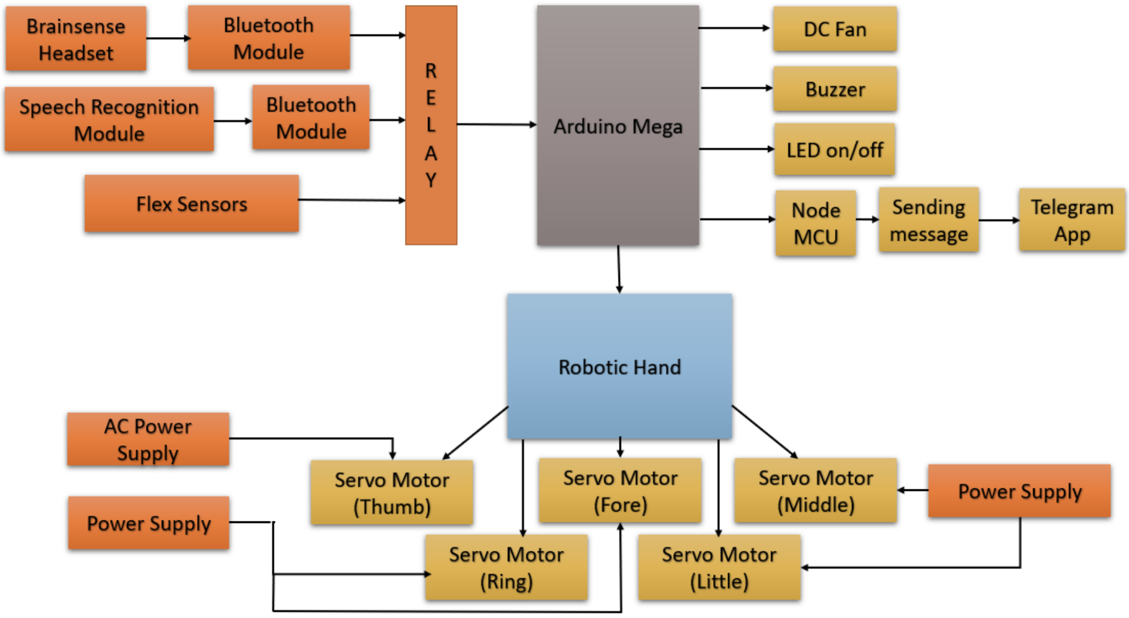


Fig. 4: Data Flow Diagram

The nature of bend is read by analog pins of the Arduino Mega. The analog values are then converted by the ADC converter of the microcontroller. Since the Arduino Mega has 10-bit resolution ADC converter, the digitized values ranges from 0-1023. When there is no bend in the sensor, the value would be near to 1023 and 0 when completely bent. So, depending on the extent of bending, different values are produced. The values thus generated are used to map any particular activity of the robotic hand. For example, in this project, flex sensor allotted to thumb finger is meant for LED ON/OFF. When the value goes less than 200 the LED glows. And for the index finger to operate, the digitized value of the respective flex sensor has to be less than 200. It's user choice to decide the respective threshold value. Such precise control empowers users to engage in complex activities and enhances their ability to interact with the world around them. The third mode of control is EEG mode. The Brainsense Headset employed to do this operation has a signal acquisition point, reference electrode point and a TGAM (ThinkGear ASIC module). The signals are detected by a dry Ag/Agcl electrode. The process of signal acquisition involves the capture and recording of brain signals, while signal processing encompasses multiple stages including pre-processing, feature extraction, and classification. These stages are essential for transforming the raw brain signals into meaningful and actionable information that can be utilized for further analysis and interpretation. To ensure correct placement, position the headset in a manner where the electrode aligns with the FP1 position of the 10-20 electrode global system which corresponds to the human brain. The detected signals are then transmitted to the TGAM chip, which processes the signals and communicates them to the microcontroller through a serial connection. The code uploaded on the Arduino checks and compares the received data. If the data transmitted matches with the respective code, then executes the necessary action. Headset has the capabilities to detect RAW signals as well as the attention and meditation values of the user's mental activity. The values after all the calculations are used to control the hand with coded commands as shown in the table below.

Commands	Extracted Signal
ONE	Attention: More than 70
TWO	Attention: 60-69
THREE	Attention: 50-59
CLOSE	Attention: 45-49
FOUR	Attention: 40-44
FIVE	Meditation: Less than 40

Table 1. Attention values

3.3 Flow chart

The proposed system is a multi-method integrated system that needs to follow certain steps in systematic flow for proper execution of the system. After considering and checking every possible path to execute the multi-model system, the correct and the most efficient path is chosen. Initially when the circuit is switched on, the system by default goes into voice mode of operation. It waits to collect the user input and matches the commands with code written. If the user command is "close", the prosthetic hand fingers would be closed. Likewise, depending on the nature of command, the activities are carried out. If the command is "brainwave", the entire system steps into brainwave mode of operation. As a next step, the EEG brainwave headset starts to record the EEG signals which are processed and the respective outcome is mapped to prosthetic hand to do a particular activity. And if the user input is "sensor" the whole system shifts to gestures mode of operation. Flex sensors are employed to execute this mode. Whatever the input is read would be transmitted to the Arduino mega and then they are mapped to the robotic hand.

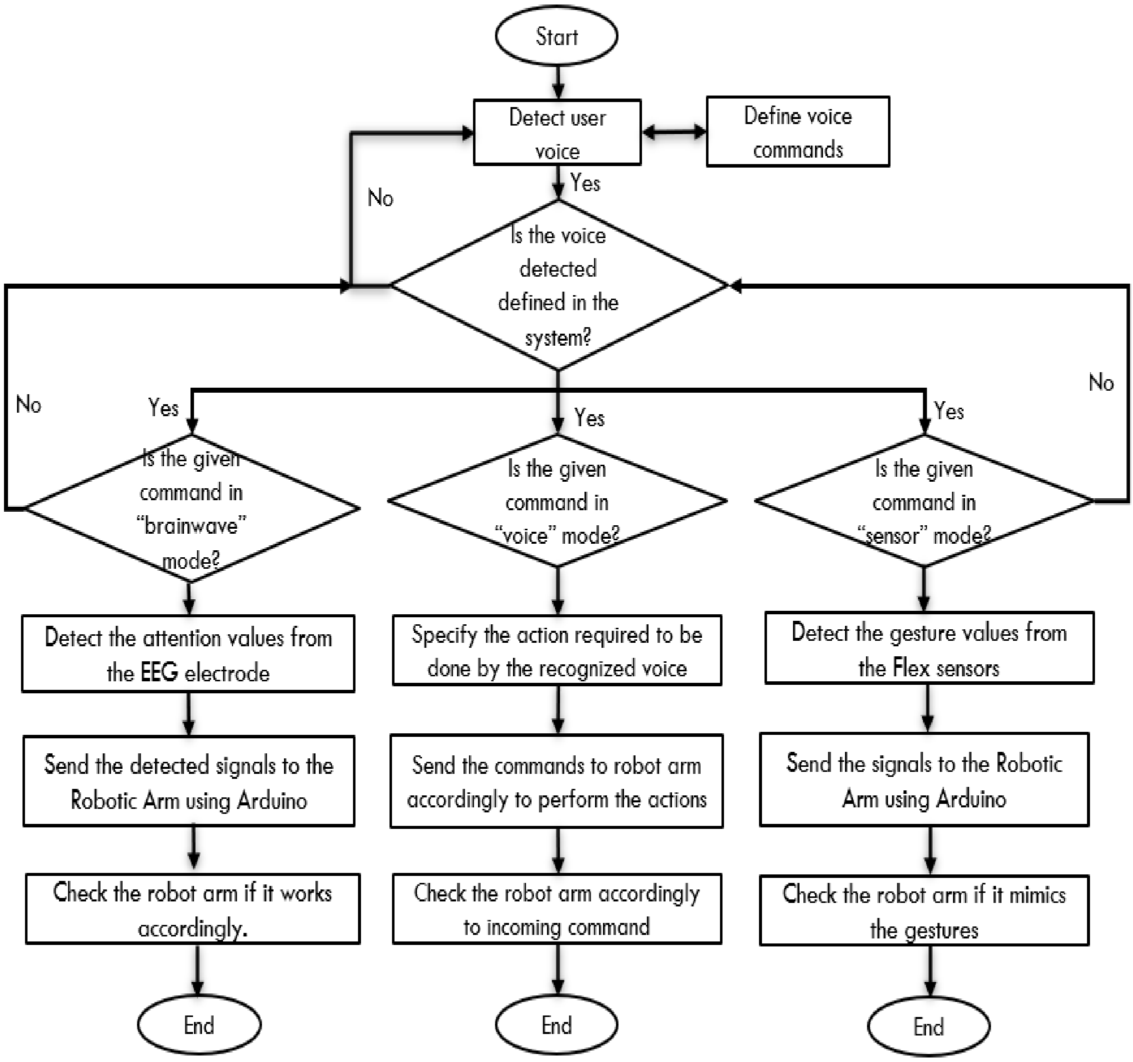


Fig 5: Flow chart

3.4 EEG Signals detection and Classification

3.4.1 Electrode placement:

The EEG signal primarily originates from the summation of postsynaptic potentials in numerous neurons located within the cortex. These electrical potentials collectively contribute to the measurable brainwave activity that can be detected and analyzed through EEG recordings. The electrical potentials accumulate within the cerebral cortex and propagate throughout the brain, eventually reaching the scalp where they can be detected and processed by the Brain-Computer Interface (BCI) system. This allows for the translation of brain activity into meaningful signals that can be utilized for various applications and interactions. In this implemented non-invasive BCI system, brain waves are collected using dry electrodes positioned on the patient's forehead, precisely at the FP1 (frontal polar) location based on the 10-20 electrode system, as illustrated in the accompanying figure.

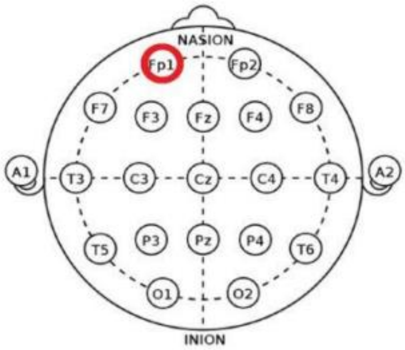


Fig.6: The attached sensors in the 10 – 20 system

3.4.2 EEG signal acquisition method based on TGAM

The TGAM-based EEG signal acquisition method utilizes a compact and integrated single-chip EEG sensor. This device seamlessly integrates multiple functionalities, including signal acquisition, filtering, amplification, analog-to-digital conversion, and computational processing. By combining these essential components into a single chip, the TGAM device provides a comprehensive solution for acquiring EEG signals with high accuracy and efficiency. When it comes to connecting electrodes, there are two commonly used methods. The first approach is known as the unipolar lead method, where one electrode is designated as the reference potential. In many cases, this reference electrode is positioned on the patient's earlobe. This configuration allows for accurate measurement and analysis of the electrical activity in the brain, enabling reliable EEG signal acquisition. In the bipolar lead method, the reference electrode has a default potential of zero, while the active electrode is distinct from the other electrode. This approach is called bipolar because it involves measuring the EEG signal directly from the potential difference between the two adjustable electrodes, without the need for a separate reference electrode. This technique allows for accurate and precise acquisition of EEG signals for analysis and interpretation. EEG (EEG acquisition point), REF (reference point), and GND (ground point) are the three contact points on the TGAM sensor. The ear clips 1 and 2 serve as the reference point connected to the tester's ear. The tester's forehead should be the location of the EEG collecting site. In other words, the unipolar lead technique is used by the TGAM sensor. This TGAM module's serial standard output interface has three output baud rates—1200, 9600, and 57600—and each one affects the output's content differently. It contains A/C noise filters with programmable choices that are separated into 50Hz and 60Hz. The limitations of wired communication in the conventional collection mode can be lifted by the Bluetooth module, enabling EEG collection to take place whenever and wherever is convenient. The connection circuit of the TGAM module is shown in figure below.

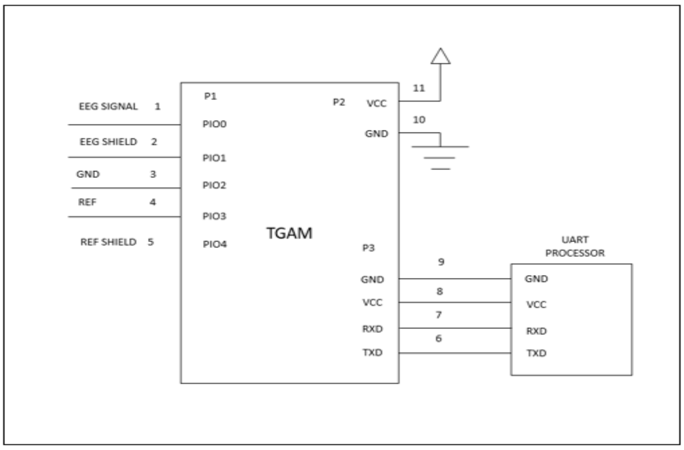


Fig. 7: TGAM module connection circuit

Every NeuroSky product or partner product has ThinkGearTM technology, which enables a gadget to communicate with the brainwaves of the wearer. It consists of the forehead-touching sensor, the contact and reference points on the ear pad, and the onboard chip that analyses all of the data and sends it in digital form to the software and applications. Raw brainwaves (alpha, theta, delta, gamma) and the eSense Metres (Attention and Meditation) are evaluated by the ThinkGear ASIC module.

3.4.3 ThinkGear Data Values

POOR_SIGNAL Quality

The signal quality as measured by the ThinkGear is shown by this unsigned one-byte integer number. It has a value between 0 and 255. Any value that is not zero means that noise contamination of some kind has been identified. The more noise that is detected, the higher the number. A number of 200 indicates explicitly that a person's skin is not being touched by the ThinkGear electrodes. This is statistic, which is normally generated every second, shows how inaccurate the most recent measurements were and numerous factors could be to blame for a poor signal. They are, in order of severity:

- When a person is not wearing ThinkGear, the ground/reference electrode or the sensor electrodes are not worn on their heads.
- Insufficient contact between the sensor, ground, or reference electrodes and the user's skin.
- Excessive head or body movement while wearing the device, such as shaking the headset.

To address the presence of various non-EEG noises, NeuroSky has developed filtering technology and the eSenseTM algorithm. These advancements aim to identify, correct, compensate for, account for, and tolerate different types of noise that can be encountered during the normal use of ThinkGear. However, it is important to note that despite these measures, a certain level of noise is still expected when using the NeuroSky headset. For the majority of regular users who focus on utilizing eSense values such as Attention and Meditation, the POOR_SIGNAL Quality value can often be disregarded. It is worth noting that during periods of poor signal quality, the Attention and Meditation values may not be updated. Hence, individuals who are primarily focused on utilizing the eSense values can generally pay less attention to monitoring the POOR_SIGNAL Quality value. However, certain applications such as medical or research applications that require higher sensitivity to noise or immediate alerts for even minor disturbances, may find the POOR_SIGNAL Quality value more valuable. The output of this Data Value is enabled by default and is usually generated once per second.

3.4.4 eSense(tm) Meters

The eSense meters of NeuroSky headsets offer relative measurements for various mental states, including Attention and Meditation, on a scale ranging from 1 to 100. A value between 40 and 60 is considered the "neutral" or baseline range, comparable to conventional EEG measurements. When the eSense meter readings range from 60 to 80, it is considered "slightly elevated," indicating higher levels of the respective mental state compared to the baseline. On the other hand, readings from 80 to 100 are classified as "elevated," indicating significantly heightened levels of that particular mental state. When the eSense meter readings range from 20 to 40, it indicates reduced levels of the respective mental state compared to the baseline. Similarly, readings from 1 to 20 indicate significantly lowered levels of that particular mental state. These lower levels can suggest states of distraction, agitation, or abnormality. EEG signals in the human brain naturally vary and fluctuate within certain ranges.

3.4.5 Attention eSense

The eSense Attention meter, represented by an unsigned one-byte value, indicates the user's current level of mental focus and attention. Ranging from 0 to 100, higher values indicate greater concentration and stable mental activity. The levels of the Attention meter can decrease due to factors such as distractions, wandering thoughts, lack of focus, or feelings of anxiety. By default, this value is enabled and typically updated once per second.

3.4.6 Meditation eSense

It is an unsigned one-byte value that describes the instant eSense Meditation meter of the respective user. It tells the mental calmness and relaxation levels. The meter ranges from 0 to 100. It's important to note that Meditation measures mental levels, not physical ones, so simply relaxing the body may not immediately result in a higher Meditation level. However, in most cases, relaxing the body can contribute to relaxing the mind as well. Meditation is associated with reduced activity in the active mental processes of the brain. The levels of the Attention meter can decrease due to distractions, wandering thoughts, lack of focus, or feelings of anxiety. By default, this value is enabled and typically provided once per second.

3.4.7 ThinkGear Packets

To process the digital data from ThinkGear components, it is necessary to parse and interpret the incoming bytes as ThinkGear Packets. These packets have three main components:

- Packet Header
- Packet Payload
- Payload Checksum

ThinkGear Packets are employed to transmit Data Values from a ThinkGear module to a receiving device that can process a serial stream of bytes, such as a PC or microprocessor. The design of the Packet format prioritizes resilience and adaptability. The Header and Checksum components play a crucial role in maintaining synchronization and ensuring the integrity of the transmitted data. Additionally, the structure of the Data Payload is designed to accommodate future modifications without causing any disruptions to existing Packet parsers in applications or devices. This means that properly implemented ThinkGear Packet parsers can seamlessly handle newer ThinkGear modules, including any new data fields they may introduce without requiring modifications to the parsers or applications themselves.

3.4.8 Packet Structure

Packets are sent through different transport mediums, including USB, serial COM, Bluetooth, UART. Each Packet comprises a Header, Data Payload, and a Checksum Byte. The Header denotes the start of the Packet while the Data Payload contains the actual data being transmitted. The Packet concludes with the Checksum Byte which serves as a verification mechanism for the Payload's integrity.

```
[SYNC] [SYNC] [PLENGTH]  [PAYLOAD...]    [CHKSUM]
_______________________  _____________  ____________
^^^^^^^^(Header)^^^^^^^  ^^(Payload)^^  ^(Checksum)^
```

Fig. 8: Data packet structure

Generally, the extreme length that [PAYLOAD] has is 169 bytes. While every [SYNC], [PLENGTH], and [CHEKSUM] occupies one byte. In the context of a Packet, the minimum length is 4 bytes when the Data Payload is empty and while the maximum length is 173 bytes when the Data Payload reaches its maximum size of 169 bytes. Two synchronization [SYNC] bytes (0xAA 0xAA) which are followed by a [PLENGTH] byte, that describes the length of the Payload together constitutes the Header of a Packet.

```
[SYNC] [SYNC] [PLENGTH]
_______________________
^^^^^^^^(Header)^^^^^^^
```

Fig. 9: Packet Header

The two [SYNC] bytes, with a value of 0xAA (decimal 170), serve as a signal for the start of a new Packet. Using two synchronization bytes reduces the possibility of mistaking internal [SYNC] bytes within the Packet as the beginning of a new Packet. While it is still possible for consecutive [SYNC] bytes to occur within a Packet, the combined presence of [PLENGTH] and [CHEKSUM] ensures that such "mis-sync'd Packets" are not mistakenly interpreted as valid Packets. The [PLENGTH] byte specifies the length, in bytes, of the Data Payload [PAYLOAD...] section of the Packet. Its value can range from 0 to 169. The total length of the Packet is always [PLENGTH] + 4.

3.4.9 Data Payload

The Data Payload of a Packet is a series of bytes, and its size is specified by the [PLENGTH] byte in the Packet Header. The interpretation of these Data Payload bytes as ThinkGear Data Values is described in the Data Payload Structure section. It is crucial to defer parsing of the Data Payload until the Payload Checksum Byte [CHEKSUM] is confirmed, as explained in the following section.

```
([EXCODE]...) [CODE] ([VLENGTH]) [VALUE...]
____________________ ___________ ___________
^^^^(Value Type)^^^^ ^^(length)^^ ^^(value)^^
```

Fig. 10: Data payload structure

3.4.10 Payload Checksum

The most crucial step in validating a ThinkGear data packet is to verify the checksum byte.

The steps involved in the process are as follows:

1. Take the summation of all the bytes of the data payload.
2. Now, consider the lowest 8 bits of the summation result.
3. The last step is to perform a bit inverse that is also known as 1's compliment inverse of the lowest 8 bits of the summation result.

The received [CHEKSUM] Checksum Byte should be compared with the calculated checksum. If the two-checksum values match, the receiver can proceed to parse the Data Payload. In case the checksum values do not match, it indicates that the entire Packet is invalid and should be discarded.

Example Packet

The example provided represents a standard Packet structure. It is important to note that the data from 3rd byte to 10th byte is only considered for parsing.

```
byte: value // Explanation

[ 0]: 0xAA  // [SYNC]
[ 1]: 0xAA  // [SYNC]
[ 2]: 0x08  // [PLENGTH] (payload length) of 8 bytes
[ 3]: 0x02  // [CODE] POOR_SIGNAL Quality
[ 4]: 0x20  // Some poor signal detected (32/255)
[ 5]: 0x01  // [CODE] BATTERY Level
[ 6]: 0x7E  // Almost full 3V of battery (126/127)
[ 7]: 0x04  // [CODE] ATTENTION eSense
[ 8]: 0x12  // eSense Attention level of 18%
[ 9]: 0x05  // [CODE] MEDITATION eSense
[10]: 0x60  // eSense Meditation level of 96%
[11]: 0xE3  // [CHKSUM] (1's comp inverse of 8-bit Payload sum of 0x1C)
```

Fig. 11: Example packet

3.4.11 Step-By-Step Guide to Parsing a Packet

1. First step is to look out for a [SYNC] byte that is 0xAA.It indicates the beginning of a new packet.
2. Immediate next step is to make sure that second byte is also 0xAA.If not repeat step1.

3. If the third byte read is greater than AA (170) discard the packet and read the next byte.
4. If the third byte read is less than or equal to 170 proceed with further calculation.
5. Store that as PLENGTH (an unsigned char [256] array). Now calculate the checksum as described in the previous section.

3.5 Hardware tools

The project implemented required various hardware and software components. The components used are listed below and their specifications are given in brief in the following sessions.

The components used are:

1. Robotic Arm
2. Arduino Mega
3. Brainsense Headset
4. TGAM
5. Flex Sensors
6. Servo motor
7. HC-05 Bluetooth module
8. 30 rpm DC motor
9. Jumper wires
10. Relay (4 channel)
11. L293 motor driver
12. 5v power supply

The specifications of the Hardware tools used in the project are given below.

3.5.1 Robotic Arm

Fig. 12: Robotic Hand

The physical robotic arm is equipped with an exoskeleton and servo motors to replicate the movements of a human arm. The actuators, such as servo motors, enable precise motion control of different arm components. A microcontroller (Arduino Mega) is employed to manage and coordinate the motor operations within the arm.

3.5.2 Arduino Mega

The Arduino Mega is a microcontroller board that utilizes the ATmega2560 chip. It serves as an enhanced version of the widely used Arduino Uno board, providing additional input/output (I/O) pins, expanded memory, and extra features. Designed to cater to more complex projects requiring a greater number of sensors, actuators, or connections, the Arduino Mega offers increased capabilities and scalability.

Here are the key aspects of the Arduino Mega:

1. Microcontroller: At the core of the board lies the ATmega2560 microcontroller, responsible for processing tasks and controlling connected devices.
2. Digital and Analog I/O: With a total of 54 digital I/O pins, including 15 PWM-capable pins, the Arduino Mega enables versatile digital connectivity. It also features 16 analog input pins, broadening the range of compatible devices.
3. Memory: Equipped with 256 KB of flash memory for program storage, 8 KB of SRAM for data handling, and 4 KB of EEPROM for non-volatile data storage, the ATmega2560 microcontroller provides ample memory resources.
4. Communication: The board supports various communication interfaces, including UART, SPI, and I2C, facilitating seamless interaction with other devices.

Additionally, it incorporates a USB interface for connection to a compute

5. Power: The Arduino Mega can be powered through a USB connection or an external power supply. Operating at 5V, it incorporates a built-in voltage regulator to ensure stable power distribution to connected devices.
6. Compatibility: Utilizing the Arduino programming language and development environment, the Arduino Mega simplifies code writing and uploading. It also offers compatibility with different programming languages and integrated development environments (IDEs).

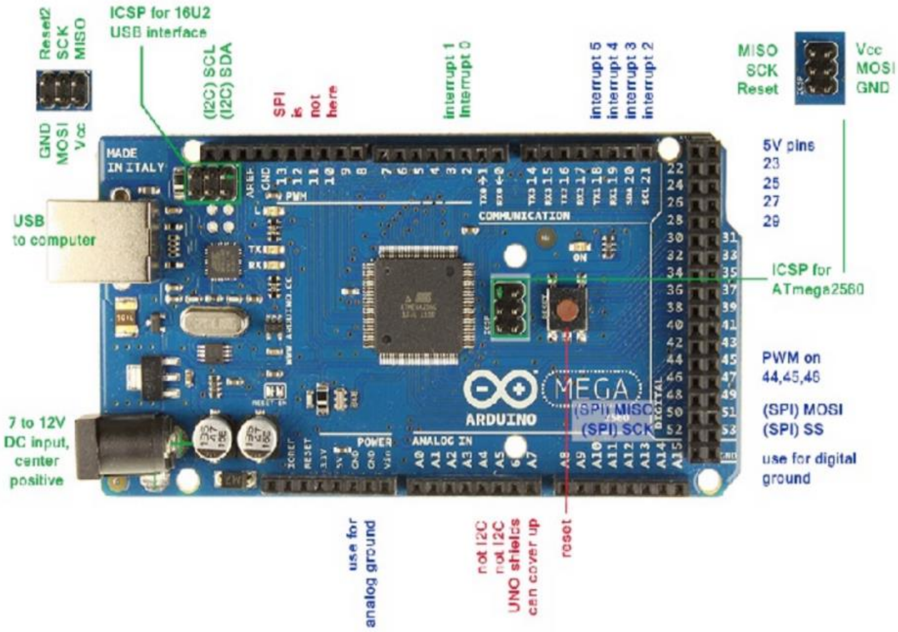


Fig. 13: Arduino Mega

3.5.3 Brainsense Headset

Electroencephalography (EEG) is a technique used to detect and record electrical activity occurring on the scalp. This process involves capturing and measuring voltage changes that arise from the movement of charged particles within the neurons of the brain. The first human EEG was recorded in 1924 by Hans Berger, a German physiologist and psychiatrist. Activities like blinking and paying attention involve significant neuron activity, which can be analyzed and recorded through EEG. In EEG sensor technology, electrodes are commonly used as conductors to transfer electrical current into nonmetallic substances like solids, liquids, gases, plasmas, or vacuums. Examples of electrode materials commonly used include AgCl (Silver Chloride). By using electrodes, information about neuron activity can be collected in the form of raw signals. EEG systems often incorporate a think gear module that converts raw EEG data into data pack

Fig 14: Brainsense Headset

3.5.4 TGAM (ThinkGear ASIC Module)

The TGAM is a brainwave sensor ASIC module developed by Neurosky for widespread applications. It is designed to process and provide outputs for EEG frequency spectrums, EEG signal quality, raw EEG data, and three Neurosky eSense measurements: attention, meditation, and eyeblinks. The module is compatible with simple dry electrodes, making it highly convenient for use. One of its notable features is its low power consumption, making it well-suited for portable devices powered by batteries.

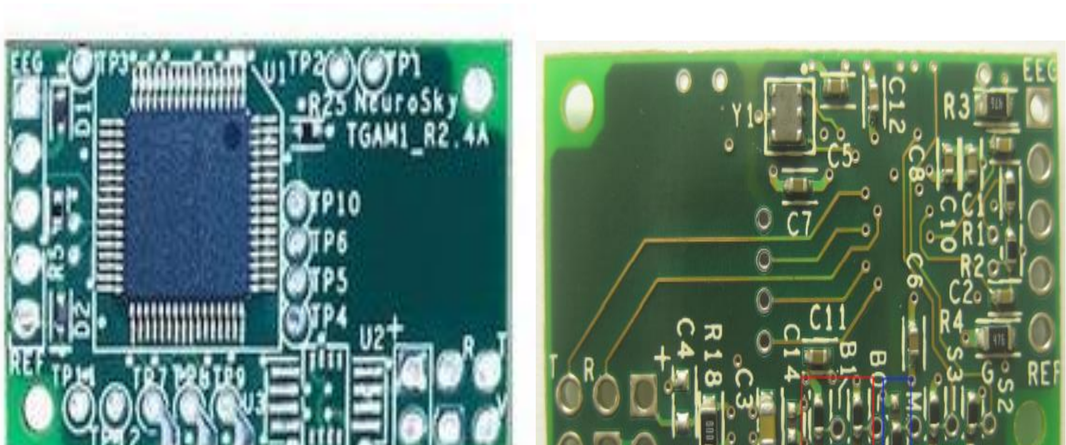


Fig. 15: TGAM Module

3.5.5 Flex Sensors

Flex sensors are electronic devices that detect and measure the degree of bending or flexing. They utilize a flexible substrate material with conductive elements that change resistance as the sensor is bent. This allows for accurate measurement of flexing angle or position. Flex sensors have diverse applications in robotics, prosthetics, gaming, and wearable technology. They enable robotic limbs to mimic human hand movements, enhance the realism of artificial limbs, capture hand gestures in gaming, and track body movements in wearable devices. By translating mechanical deformations into electrical signals, flex sensors provide valuable functionality in various industries and applications that require precise detection of bending or flexing.

Fig. 16: Flex sensor

Specifications & Features

The flex sensor has the following specifications and features:

- It can operate within a voltage range of 0V to 5V.
- It is designed to work efficiently with low voltages.
- The power rating is 1 Watt for peak usage and 0.5 Watt for continuous usage.
- It can operate in temperatures ranging from -45ºC to +80ºC.
- The flat resistance of the sensor is 25K Ω.
- The resistance tolerance is within ±30%
- The resistance range varies from 45K to 125K Ohm when the sensor is bent.

3.5.6 Servo Motor

The MG90S servo motor is a commonly used micro servo motor in robotics and hobbyist projects. It is known for its compact size, lightweight design, and relatively affordable price. The MG90S is a digital servo motor, meaning it uses a digital control signal for precise positioning and control. It operates on a voltage range of typically 4.8V to 6V and provides a torque output of around 1.8 kg/cm. The MG90S servo motor is popular for applications that require small-scale motion control, such as RC vehicles, robotic arms, and model airplanes.

Fig. 17: Servo Motor

3.5.7 HC-05 Bluetooth Module

The HC-05 is a widely used Bluetooth module known for its versatility and ease of use. It is commonly employed in various projects to enable wireless communication between devices. The HC-05 module operates as a slave device, allowing it to connect to other Bluetooth-enabled devices such as smartphones, tablets, or computers. It can be easily integrated into projects as it communicates with the host microcontroller or other devices through a simple serial UART interface. The operating voltage of this is in between 3.3V and 5V. It offers a decent wireless range of around 10 meters (depending on the environment). The HC-05 module features various modes, including a data mode for transparent serial data transmission and a command mode for configuring settings such as device name, pairing code, and baud rate. It can be configured and controlled using AT commands sent over the UART interface. Overall, the HC-05 Bluetooth module is a popular choice for wireless communication projects due to its simplicity, compatibility, and cost-effectiveness. It is commonly used in applications such as home automation, robotics, wireless sensor networks, and remote-control systems.

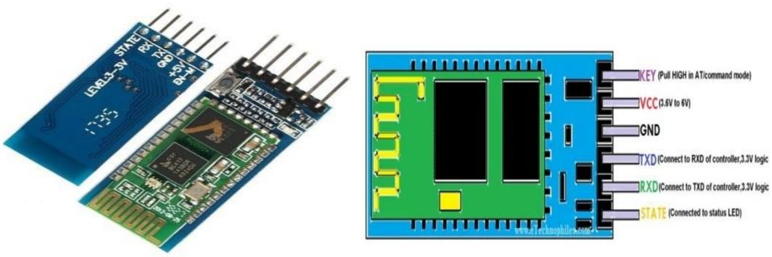


Fig. 18: HC-05 Bluetooth Module

3.5.8 30rpm DC Motor

A 30rpm DC motor refers to a direct current motor that operates at a speed of 30 revolutions per minute. DC motors are widely used in various applications, ranging from robotics and automation to automotive systems and household appliances.

The basic construction of a DC motor consists of two main parts: the stator and the rotor. The stator is the stationary part of the motor that houses the field windings, which generate a magnetic field. The rotor, on the other hand, is the rotating part of the motor that contains the armature windings. When an electric current is supplied to the motor, the interaction between the magnetic field produced by the stator and the armature windings causes the rotor to rotate.

Fig. 19: 30rpm DC Motor

3.5.9 Jumper Wires

A jumper wire is an electrical wire used for connecting circuits on printed circuit boards. It serves various functions such as short-circuiting or creating shortcuts within the circuit. Jumper wires are available in three variations: male-to-female, male-to-male, and female-to-female. The distinction between these wires lies in their end points. Female ends are designed for plugging into connectors, whereas the male ends have protruding pins meant for plugging into other components.

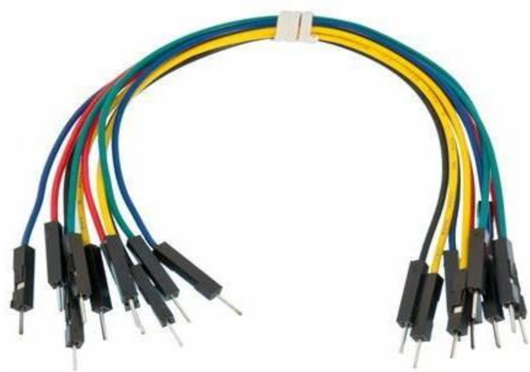


Fig 20: Jumper wires

3.5.10 Four Channel Relay Module

A 4-channel relay module is an electronic device used to control multiple electrical circuits or devices using a microcontroller or other digital control signals. Each channel on the relay module is capable of independently controlling the state (on/off) of a connected circuit.

The relay module consists of four individual relays, each with its own input control signal and output terminals. A relay is an electromagnetic switch that uses a small control signal to activate a larger current-carrying circuit. It essentially acts as a bridge between the low-power control circuit and the high-power load circuit.

The input control signals for each channel are typically connected to a microcontroller or a digital output pin of another device. When the control signal is applied, the corresponding relay is activated, and its output terminals, commonly referred to as the normally open (NO) and the normally closed (NC) terminals, change their states accordingly.

Fig. 21: 4 Channel Relay Module

3.5.11 L293D Motor Driver

The L293D is a popular motor driver integrated circuit (IC) used for driving small to medium-sized DC motors. It is commonly employed in robotics, automation, and other electronic projects that require motor control. The L293D provides an easy and efficient way to control the direction and speed of a motor using digital signals from a microcontroller or other control circuitry.

The L293D motor driver IC can drive two separate DC motors or a single stepper motor. It consists of two H-bridge circuits, each capable of driving a motor in forward or reverse direction. The H-bridge configuration allows the motor to be controlled by applying appropriate signals to the input pins of the IC.

The L293D has multiple input pins, including two control pins for each motor (IN1, IN2 for Motor 1 and IN3, IN4 for Motor 2) and enable pins (ENA and ENB) to activate or deactivate the motor outputs. By providing different combinations of signals to the control pins, the direction and speed of the motors can be controlled.

Fig 22: L293D Motor Driver

3.5.12 Power Supply Module 5V

A 5V power supply module is a device used to provide a stable and regulated 5-volt direct current (DC) output voltage. It is commonly used to power electronic circuits, microcontrollers, sensors, and other low-power devices that require a 5V power source. The power supply module typically accepts an input voltage from an AC wall adapter or a DC power source and converts it to a regulated 5V DC output. It employs various electronic components and voltage regulation techniques to ensure a consistent and reliable output voltage.

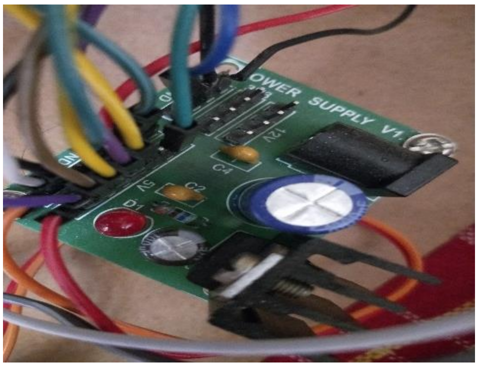


Fig. 23: Power Supply Module 5V

One common type of 5V power supply module is a linear regulator. Linear regulators use a series pass transistor to regulate the voltage. They are simple and inexpensive but are less efficient compared to other types of voltage regulators. Linear regulators are suitable for low-power applications where efficiency is not a major concern.

3.6 Software tools

The specifications of the Software tools used in the project are given below.

3.6.1 Arduino IDE

The coding language used in the project is Embedded C. For writing and uploading code efficiently, we utilize the open-source Arduino Software (IDE), which is compatible with all Arduino Boards. This software includes various components such as a code editor, message area, text console, toolbar with commonly used functions, and a range of options. It establishes a link with Arduino hardware, allowing for program uploads and facilitating smooth communication.

Fig 24: Arduino IDE

3.7 Working Principle of the proposed system

The smart prosthetic hand system utilizes a combination of gestures, voice commands, and EEG signals to provide intuitive and efficient control. The working principle involves the following steps:

1. Gesture Recognition: The system captures hand movements using flex sensors. These sensors detect and analyze the position, orientation, and motion of the user's hand to recognize specific gestures. Predefined hand gestures are associated with corresponding hand movements and grasping actions.

2. Voice Command Recognition: The system incorporates voice recognition technology, enabling users to control the prosthetic hand through spoken commands. Microphones capture the user's voice, which is processed and interpreted to identify specific commands. These voice commands can include actions such as opening or closing the hand, switching between the different modes of operations.

3. EEG Signal Analysis: Electroencephalogram (EEG) electrodes are placed on the user's scalp to detect and record electrical brain activity. The EEG signals are processed and analyzed to identify patterns and extract meaningful information related to the user's intended hand movements.

4. Prosthetic Hand Actuation: The control signals generated by the intelligent control algorithm are transmitted to the actuators embedded in the prosthetic hand. These actuators, such as servo motors, mimic the natural movement and functionality of a human hand. They respond to the control signals by activating the corresponding hand movements, allowing the user to grasp objects, manipulate them, and perform various tasks.

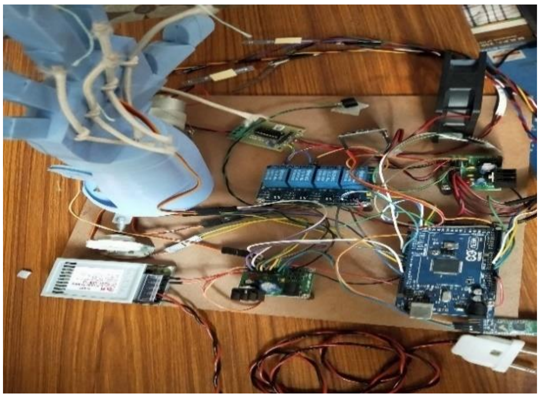
By integrating the working principles of gesture recognition, voice command recognition, and EEG signal analysis, the smart prosthetic hand system provides a seamless and intuitive control interface. It enables individuals with limb loss to control the prosthetic hand with ease, precision, and responsiveness, ultimately enhancing their independence and quality of life.

Chapter-4

Results and Discussions

The hardware setup of the Robotic Hand is done by connecting the Servo motors. The servo motors help in moving the hand efficiently. For the software part, we will get the signal pattern recognized from the EEG sensor for one, two, three, four, five, open and stop commands that willbe equated with Arduino code and it will lead to corresponding movement of the Robotic Hand. The attention and meditation signals can be analyzed. The hardware results of the project will define the movement of the arm that are shown in figure.

4.1 Experimental results



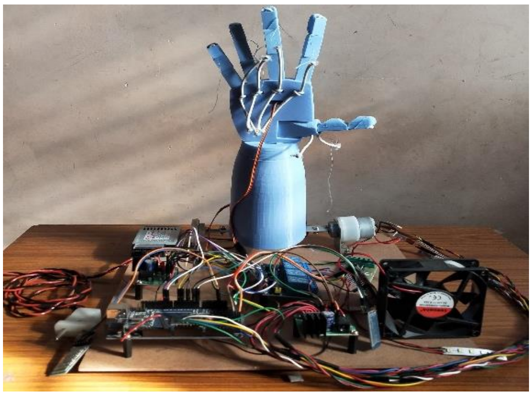


Fig.25: Proposed model

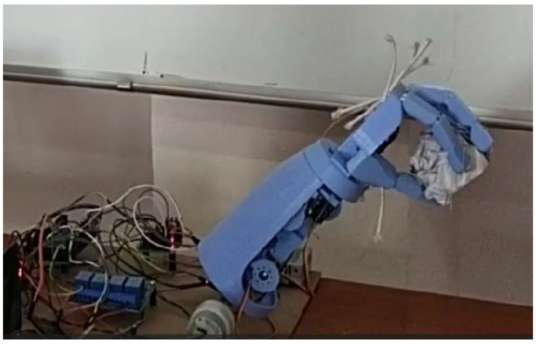


Fig. 26 : Hand picking a paper ball

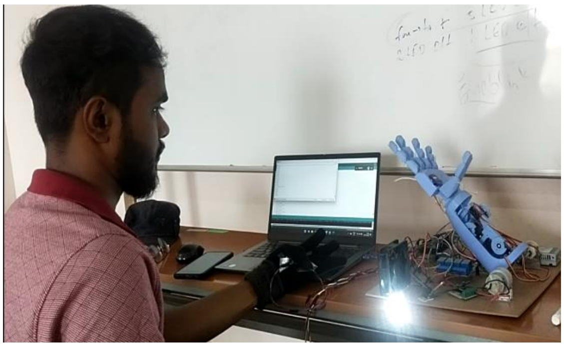


Fig. 27 : Operating LED with flex sensors

Fig 28: EEG Sensor setup

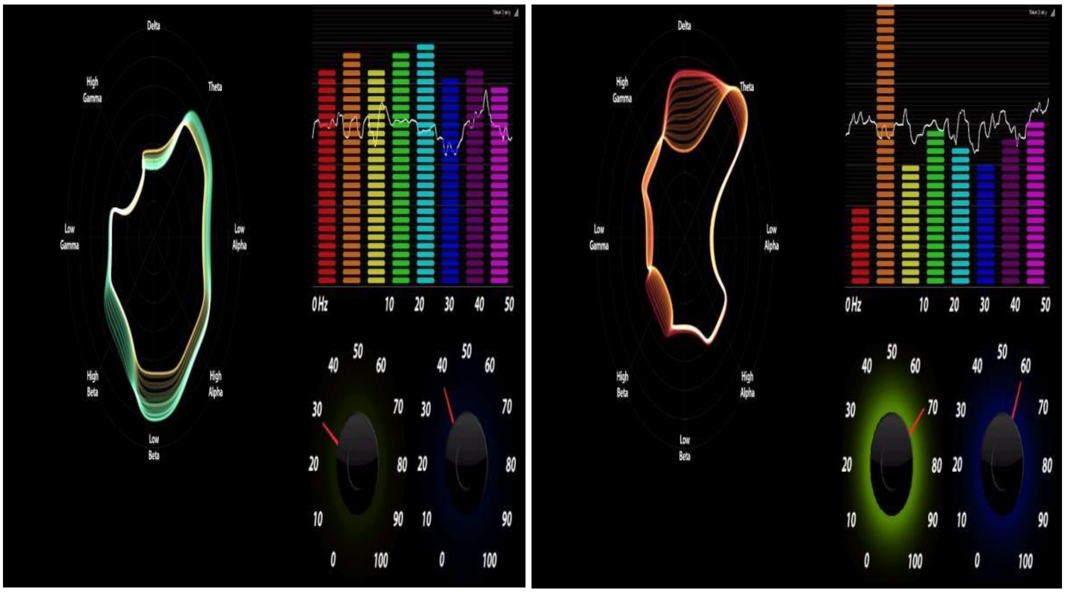


Fig 29: EEG signals

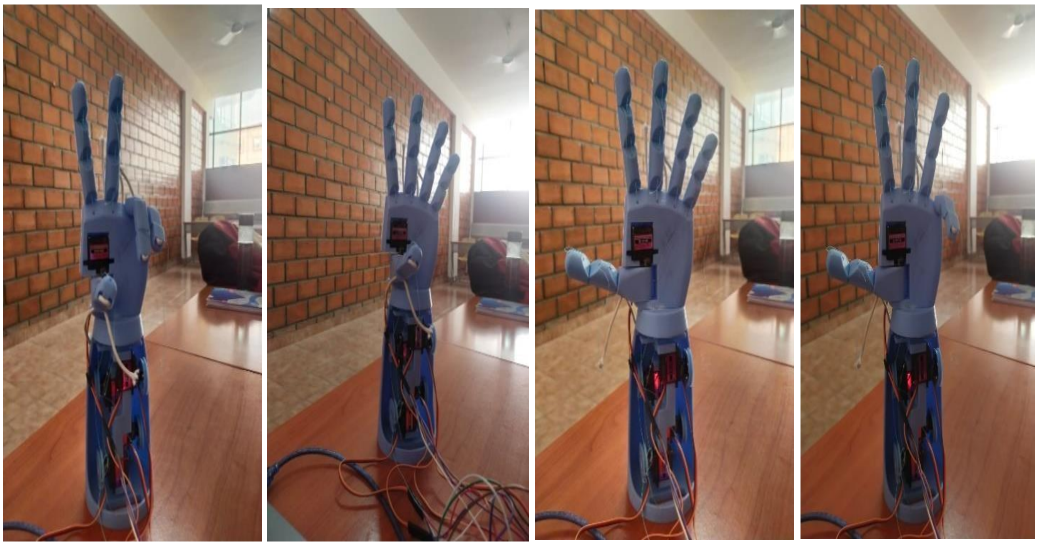


Fig 30: Different positions of Hand based on the captured signals

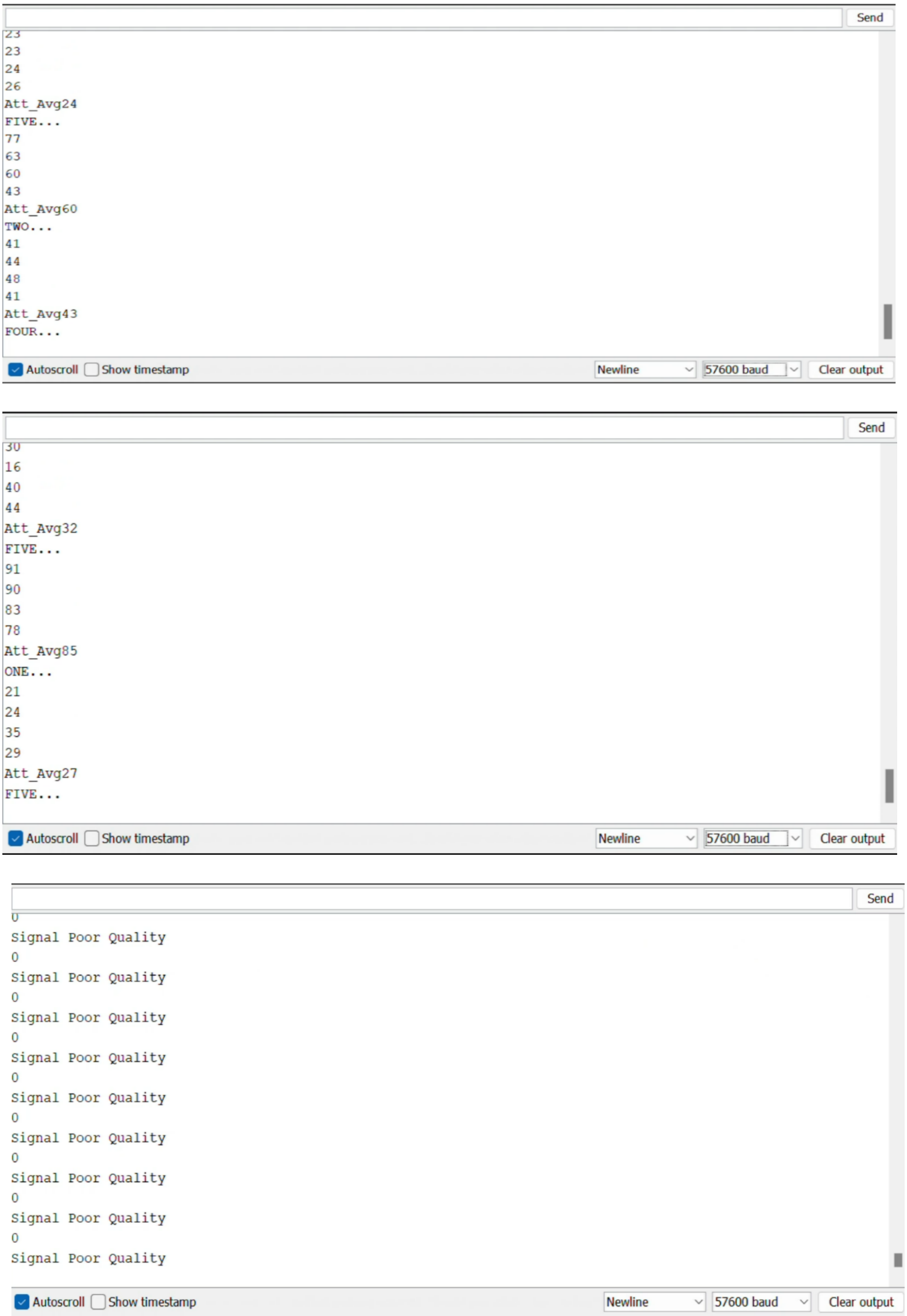


Fig. 31: Simulation Results

4.2 Advantages

- Enhanced User Experience: By combining multiple control modalities, such as voice commands, gestures, and EEG signals, the prosthetic hand provides a more natural and intuitive interaction for the user.
- Improved Independence: The smart prosthetic hand enables users to regain a sense of independence by providing them with the ability to control the hand using their own voice, gestures, or brain signals.
- Flexibility and Adaptability: Users can choose the control mode that suits them best or switch between modes based on their specific needs or the task at hand.

4.3 Applications

- Assistive Technology: The prosthetic hand can serve as an assistive device for individuals with disabilities, allowing them to perform tasks and activities that would otherwise be challenging or impossible.
- Personal Care: The prosthetic hand can assist individuals with limited hand mobility in performing personal care tasks, such as grooming, dressing, and feeding. Its advanced control capabilities make it easier for users to manipulate objects and carry out these activities independently.
- Human-Machine Interaction: The smart prosthetic hand can be integrated into human-machine interaction systems, enabling individuals to control robotic devices or interact with computers and technology using natural hand gestures, voice commands, or even their brain signals.

4.4 Limitations

- The designed arm can with hold only a considerable amount of weight.
- Objects cannot be handled with different pressure. The arm holds every object with thesame pressure and force.
- There is a little delay between the detected signal and movement of the Prosthetic Hand.

Chapter-5

Conclusion and Future Work

5.1 Conclusion

Human-Robot Interaction (HRI) encompasses a broad spectrum of applications, wherein prosthetics holds a prominent position. In this project, a comprehensive approach is proposed and implemented to capture EEG signals from the human brain utilizing specialized brain electrodes. The captured brain signals based on the attention of the user are dumped on to Arduino board via Bluetooth which then controls the Robotic Hand perform actions accordingly. This multi-modal approach opens up new possibilities for intuitive control and seamless integration with the user's natural movements and intentions, improving the overall quality of life for amputees.

5.2 Future work

Future work includes executing the very same project using wireless communication. Also, in the voice mode of control, a special algorithm can be built which has the capability to detect voices that are different from the respective user of the prosthetic hand. This actually enhances the model in security aspect of the user. Instead of relying on flex sensors and gloves, an alternative approach involves the implementation of an AI algorithm or AI chip with advanced computational capabilities and programming. This innovative solution enables the prosthetic hand to respond directly to the user's thoughts, as well as head movements, by utilizing sophisticated mathematical models and processing techniques. By leveraging the power of artificial intelligence, the system can provide a more intuitive and seamless control interface for the user.

References

[1] Maryappan, Prashanth, Riyas Dheen, "A Brain Controlled Robotic Hand by using Brain-Computer Interface (BCI) Technology" *International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181*, 2020.

[2] Priyank Garg , Mansi Patel , Harshit Verma, "Gesture Controlled Robot with Robotic Arm" *International Journal for Research in Applied Science & Engineering Technology (IJRASET)ISSN: 2321-9653*; Volume 10 Issue V May 2022.

[3] Ujwal, Rakshith Narun, Harshell Surana, "Voice Control Based Prosthetic Human Arm" *International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056* Volume: 05 Issue: 07, July 2019.

[4] Prutha Atre, Sahil Bhagat, Nevil Pooniwala, "Efficient and Feasible Gesture Controlled Robotic Arm" *Second International Conference on Intelligent Computing and ControlSystems (ICICCS) ISBN:978-1-5386-2842-3*, 2020.

[5] CP Shantala, CR Rashmi, "Mind Controlled Wireless Robotic Arm Using Brain Computer Interface" *IEEE*, November 2019.

[6] Rashed S. Kanash, Seyed E. Alavi, "Design and Implementation of Voice Controlled Robotic Arm" *IEEE*,2021.

[7] Vignesh T, Nivetha R, Mowneka G, Selvakumar D, "Design and Fabrication of 6-axis Gesture Controlled Robot" *International Conference on Advanced Computing & Communication Systems (ICACCS)*, 2019.

[8] Chinbat, "Prosthetic Arm Control by Human Brain," *IEEE International Symposium on Computer, Consumer and Control (IS3C),* 2018.

[9] T. Beyrouthy, "EEG Mind Controlled Smart Prosthetic Arm,"*A Comprehensive Study Advances in Science, Technology and Engineering Systems,* 2017.

[10] Andrews, "Low-Cost Robotic Arm for differently abled using Voice Recognition,"*Proceedings of the Third IEEE International Conference on Trends in Electronics and Informatics (ICOEI 2019),* 2019.

[11] Juan Pablo, "Voice Controlled Prosthetic Hand with Predefined Grasps and Movements," *VII Latin American Congress on Biomedical Engineering CLAIB,* 2016.

[12] Dr.Sandeep, "ROBOTIC ARM CONTROL USING GESTURE AND VOICE", *IEEE International Journal of Computer, Information Technology & Bioinformatics (IJCITB).*

[13] Guoxin, "The Prosthetic Arm: A Dramatic Improvement For The Limb Amputation From The Humerus," *IEEE 4th International Conference on advanced Robotics and Mechatronics* ,2019.

[14] D. sharma, "Enhanced Framework for Active Prosthetic Arm," *IEEE InternationalConference om Advanced communication and applied informatics.,* 2022.

[15] A. P. Naik, "Arduino based Voice controlled Robotic Arm," *IEEE International Conferenceon advanced Robotics,* 2017.

Appendix

1. Arduino Mega Data Sheet

1.1 Functional Overview

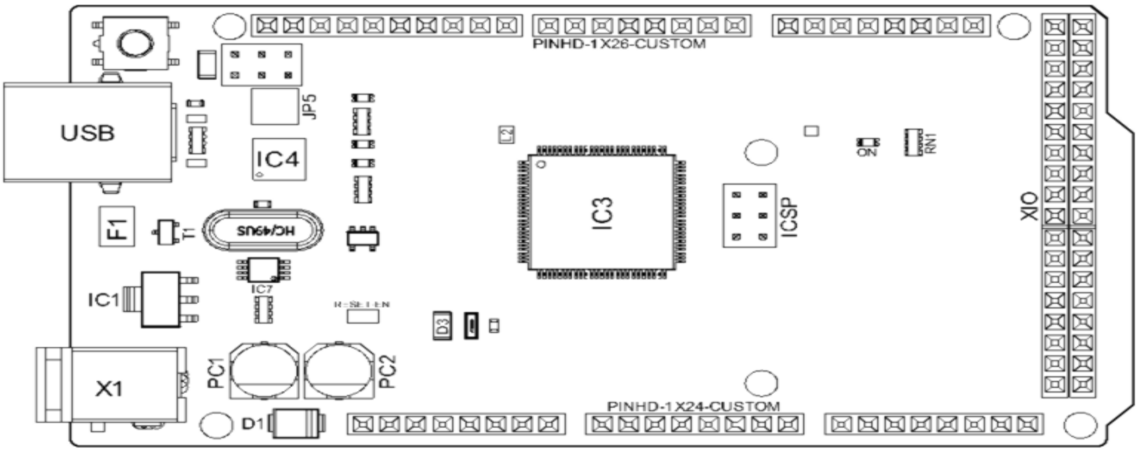


Fig. 32: Board Topology

Primary processor of Arduino Mega 2560 Rev3 board is ATmega2560 chip which operates at a frequency of 16 MHz. It accommodates a large number of input and output lines which gives the provision of interfacing many external devices. At the same time the operations and processing is not slowed due to its significantly larger RAM than the other processors. The board also features a USB serial processor ATmega16U2 which acts an interface between the USB input signals and the main processor. This increases the flexibility of interfacing and connecting peripherals to the Arduino Mega 2560 Rev 3 board.

1.2 Analog Pins

Pin	Function	Type	Description
1	NC	NC	Not Connected
2	IOREF	IOREF	Reference for digital logic V - connected to 5V
3	Reset	Reset	Reset
4	+3V3	Power	+3V3 Power Rail
5	+5V	Power	+5V Power Rail
6	GND	Power	Ground
7	GND	Power	Ground
8	VIN	Power	Voltage Input
9	A0	Analog	Analog input 0 /GPIO
10	A1	Analog	Analog input 1 /GPIO
11	A2	Analog	Analog input 2 /GPIO
12	A3	Analog	Analog input 3 /GPIO
13	A4	Analog	Analog input 4 /GPIO
14	A5	Analog	Analog input 5 /GPIO
15	A6	Analog	Analog input 6 /GPIO
16	A7	Analog	Analog input 7 /GPIO
17	A8	Analog	Analog input 8 /GPIO
18	A9	Analog	Analog input 9 /GPIO
19	A10	Analog	Analog input 10 /GPIO
20	A11	Analog	Analog input 11 /GPIO
21	A12	Analog	Analog input 12 /GPIO
22	A13	Analog	Analog input 13 /GPIO
23	A14	Analog	Analog input 14 /GPIO
24	A15	Analog	Analog input 15 /GPIO

1.3 Digital Pins

Pin	Function	Type	Description
1	D21/SCL	Digital Input/I2C	Digital input 21/I2C Dataline
2	D20/SDA	Digital Input/I2C	Digital input 20/I2C Dataline
3	AREF	Digital	Analog Reference Voltage
4	GND	Power	Ground
5	D13	Digital/GPIO	Digital input 13/GPIO
6	D12	Digital/GPIO	Digital input 12/GPIO
7	D11	Digital/GPIO	Digital input 11/GPIO
8	D10	Digital/GPIO	Digital input 10/GPIO
9	D9	Digital/GPIO	Digital input 9/GPIO
10	D8	Digital/GPIO	Digital input 8/GPIO
11	D7	Digital/GPIO	Digital input 7/GPIO
12	D6	Digital/GPIO	Digital input 6/GPIO
13	D5	Digital/GPIO	Digital input 5/GPIO
14	D4	Digital/GPIO	Digital input 4/GPIO
15	D3	Digital/GPIO	Digital input 3/GPIO
16	D2	Digital/GPIO	Digital input 2/GPIO
17	D1/TX0	Digital/GPIO	Digital input 1 /GPIO
18	D0/Tx1	Digital/GPIO	Digital input 0 /GPIO
19	D14	Digital/GPIO	Digital input 14 /GPIO
20	D15	Digital/GPIO	Digital input 15 /GPIO
21	D16	Digital/GPIO	Digital input 16 /GPIO
22	D17	Digital/GPIO	Digital input 17 /GPIO
23	D18	Digital/GPIO	Digital input 18 /GPIO
24	D19	Digital/GPIO	Digital input 19 /GPIO
25	D20	Digital/GPIO	Digital input 20 /GPIO
26	D21	Digital/GPIO	Digital input 21 /GPIO

2. TGAM module

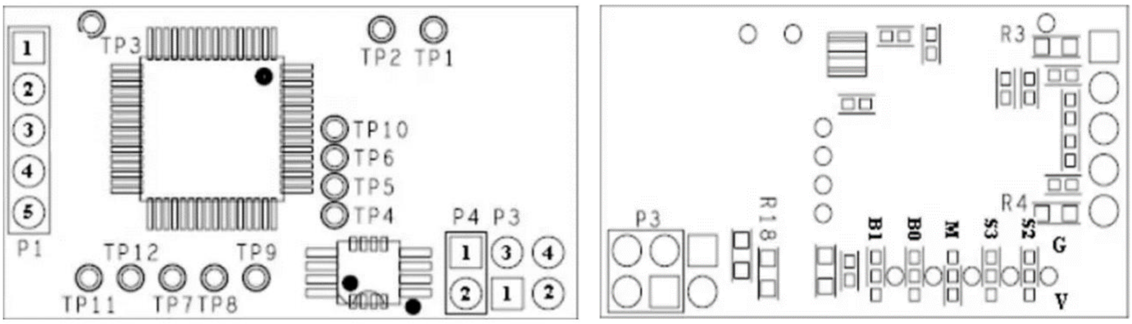


Fig. 33: PCB Layout of TGAM

The TGAM module incorporates configuration pads positioned on its backside, highlighted by the red and blue boxes in the figure. These pads enable the modification of default settings during TGAM chip power-up. The BR0 and BR1 pads are employed for configuring the output baud rate and data content. Conversely, the M pad is utilized to establish the notch filter frequency. The table mentioned earlier outlines the available configuration options and their corresponding settings. For instance, in Figure 3.1, both the BR1 and BR0 pads of the module are connected to the GND pad, resulting in a baud rate of 9600 with Normal Output Mode. While it is possible to configure the baud rate after powering up the module by sending commands through the UART interface, the setting will revert back to the default upon module reset. The M pad allows for the selection of either a 50Hz or 60Hz notch filtering frequency to minimize AC noise. Tying the M pad to the VCC pad selects 60Hz notch filtering, while connecting it to the GND pad selects 50Hz. In contrast to the software configuration available for BR0 and BR1, there is no software configuration option for the M configuration. The figure depicts the typical configuration options for these pads, showcasing a TGAM set for 9600 Baud, normal output, and a 60Hz notch filtering frequency.

BR1	BR0	Function
GND	GND	9600 Baud with Normal* Output Mode
GND	VCC	1200 Baud with Normal* Output Mode
VCC	GND	57.6k Baud with Normal* + Raw Output Mode
VCC	VCC	N/A

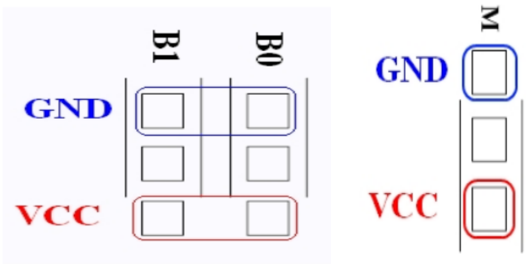


Fig. 34: B0,B1 Configurations

Code:

```
#include <Servo.h>



Servo servo1;
Servo servo2;
Servo servo3;
Servo servo4;
Servo servo5;



int Relay1=22;
int Relay2=24;

int IN1=26;
int IN2=28;



int Buzzer=30;

int a=0;
int b=0;
int c=0;
int d=0;
int e=0;
int f=0;
char ch;
String readvoice;


#define BAUDRATE 57600
#define LED 13
#define ATT_TH 40



byte payloadData[32] = {0};
byte checksum=0,generatedchecksum=0,Poorquality,Attention;
int  Att_Avg=0,Plength,Temp;
int  k=0,j=0;



void setup()
```

```
{
  pinMode(IN1,OUTPUT);
  pinMode(IN2,OUTPUT);

  pinMode(Relay1,OUTPUT);
  pinMode(Relay2,OUTPUT);

  pinMode(Buzzer,OUTPUT);


  digitalWrite(IN1,LOW);
  digitalWrite(IN2,LOW);

  digitalWrite(Relay1,HIGH);
  digitalWrite(Relay2,HIGH);

  Serial.begin(BAUDRATE);
  Serial1.begin(9600);
  Serial.println("Prosthetic Hand");
  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);


//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);
```

```
}

void loop()
{
 Voice_Mode();
 // Flex_Read();

}
void Voice_Mode()
{
  Serial.println("Give voice Command");
  while(1)
  {
    Serial1.begin(9600);
    while(Serial1.available())
    {
      delay(10);
      char c=Serial1.read();
      readvoice += c;

    }
    Serial.println(readvoice);
    delay(1000);
    if(readvoice.length()>0)
    {
      Serial.begin(57600);
      if((readvoice == "thumb")||(readvoice == "1"))
      {
        Serial.println("1st finger close");
        servo1.write(0);
        delay(1000);
      }

       if((readvoice == "fore")||(readvoice == "2")||(readvoice == "Tu"))
      {
        Serial.println("2nd finger close");
        servo2.write(0);
        delay(1000);

      }
      if((readvoice == "middle")||(readvoice == "3"))
      {
        Serial.println("3rd finger close");
        servo3.write(0);
        delay(1000);


      }
       if((readvoice == "ring")||(readvoice == "4"))
```

```
{
 Serial.println("4th finger close");
 servo4.write(180);
 delay(1000);

}
if((readvoice == "little")||(readvoice == "5"))
{
 Serial.println("5th finger close");
servo5.write(0);
 delay(1000);

}
 if(readvoice == "open")
{
 Serial.println("All open");
 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);

}
 if(readvoice == "close")
{
 Serial.println("$Emergency...#");
 digitalWrite(Buzzer,HIGH);
  servo1.write(0);
 delay(1000);
 digitalWrite(Buzzer,LOW);
 servo2.write(0);
 delay(1000);
 servo3.write(0);
 delay(1000);
 servo4.write(180);
 delay(1000);
 //
 servo5.write(0);
 delay(2000);


}
 if(readvoice == "up")
{
```

```
        Serial.println("Hands Up");
        HAND_UP();

      }
       if(readvoice == "down")
      {
        Serial.println("Hands Down");
        HAND_DOWN();

      }
       if(readvoice == "sensor")
      {
        Serial.println("sensor mode");
        Flex_Read();

      }
      if(readvoice == "brainwave")//Brainwave_Signal
      {
        Serial.println("Brainwave mode");
        Brainwave_Signal();

      }


    }
  readvoice="";
  }


}
void HAND_UP()
{
  digitalWrite(IN1,HIGH);
  digitalWrite(IN2,LOW);
  delay(1000);
   digitalWrite(IN1,LOW);
  digitalWrite(IN2,LOW);
  delay(1000);

}
void HAND_DOWN()
{
  digitalWrite(IN1,LOW);
  digitalWrite(IN2,HIGH);
  delay(1000);
   digitalWrite(IN1,LOW);
  digitalWrite(IN2,LOW);
  delay(1000);
```

```
}
void Flex_Read()
{
 while(1)
 {
   int F1_val=analogRead(A0);
   int F2_val=analogRead(A1);
   int F3_val=analogRead(A2);
   int F4_val=analogRead(A3);
   int F5_val=analogRead(A4);


   Serial.print("F1:");
   Serial.println(F1_val);

   Serial.print("F2:");
   Serial.println(F2_val);
//
   Serial.print("F3:");
   Serial.println(F3_val);
//
   Serial.print("F4:");
   Serial.println(F4_val);

   Serial.print("F5:");
   Serial.println(F5_val);
//

   delay(1000);

   if(F1_val<200)
   {
    a=1;
    Serial.println("1st finger close");
    servo1.write(0);
    digitalWrite(Relay1,LOW);
    delay(1000);

   }
    if((F1_val>430)&&(a==1))
   {
    a=0;
    Serial.println("1st finger open");
    servo1.write(150);
    digitalWrite(Relay1,HIGH);
    delay(1000);

   }
    if(F2_val<200)
```

```
 {
  b=1;
  Serial.println("2nd finger close");
  servo2.write(0);
  digitalWrite(Relay2,LOW);
  delay(1000);

 }
 if((F2_val>340)&&(b==1))
 {
  b=0;
  Serial.println("2nd finger open");
  servo2.write(180);
  digitalWrite(Relay2,HIGH);
  delay(1000);

 }
 if(F3_val<200)
 {
  c=1;
  Serial.println("3rd finger close");
  servo3.write(0);
  delay(1000);

 }
 if((F3_val>340)&&(c==1))
 {
  c=0;
  Serial.println("3rd finger open");
  servo3.write(180);
  delay(1000);

 }
 if(F4_val<200)
 {
  d=1;
  Serial.println("4th finger close");
  servo4.write(180);
  delay(1000);

 }
 if((F4_val>340)&&(d==1))
 {
  d=0;
  Serial.println("4th finger open");
  servo4.write(0);
  delay(1000);

 }
```

```
   if(F5_val<200)
  {
   e=1;
   Serial.println("5th finger close");
   servo5.write(0);
   delay(1000);

  }
   if((F5_val>340)&&(e==1))
  {
   e=0;
   Serial.println("5th finger open");
   servo5.write(180);
   delay(1000);

  }
 }
}

byte ReadOneByte()           // One Byte Read Function
{
 int ByteRead;
 while(!Serial.available());
 ByteRead = Serial.read();
 return ByteRead;
}
void Brainwave_Signal()
{

 while (1)
 {
  if(ReadOneByte() == 170)        // AA 1 st Sync data
  {
   if(ReadOneByte() == 170)      // AA 2 st Sync data
   {
    Plength = ReadOneByte();
    if(Plength == 32)   // Big Packet
    {
     generatedchecksum = 0;
     for(int i = 0; i < Plength; i++)
     {
      payloadData[i]     = ReadOneByte();      //Read payload into memory
      generatedchecksum  += payloadData[i] ;
     }
     generatedchecksum = 255 - generatedchecksum;
     checksum  = ReadOneByte();

     if(checksum == generatedchecksum)        // Varify Checksum
     {
```

```
          Poorquality  = payloadData[1];
          Attention    = payloadData[29];
          Serial.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(LED, HIGH);
       Serial.println("ONE...");
       digitalWrite(Relay1,HIGH);
     ONE();
     delay(1000);

     }
     else if (Att_Avg >= 60)
     {
      Serial.println("TWO...");
      digitalWrite(Relay2,LOW);
      TWO();
      delay(1000);
```

```
        }
        else if (Att_Avg >= 50)
        {
         Serial.println("THREE...");
         digitalWrite(Relay1,LOW);
        THREE();
        delay(1000);
        }
         else if (Att_Avg >= 45)
        {
              Serial.println("CLOSE...");
        CLOSE();
        delay(1000);
        }
        else if (Att_Avg >= 40)
        {
            Serial.println("FOUR...");
            digitalWrite(Relay2,HIGH);
        FOUR();
        delay(1000);
        }
       else if (Att_Avg < 40)
        {
          Serial.println("FIVE...");
        FIVE();
        delay(1000);


        }

        j=0;
        Temp=0;

       }
    }
    else
    {
        digitalWrite(Relay1,HIGH);
        digitalWrite(Relay2,HIGH);
        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(0);
    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();

}
```

Paper Presented / Publications related to the Project Work in Conferences & in Journals

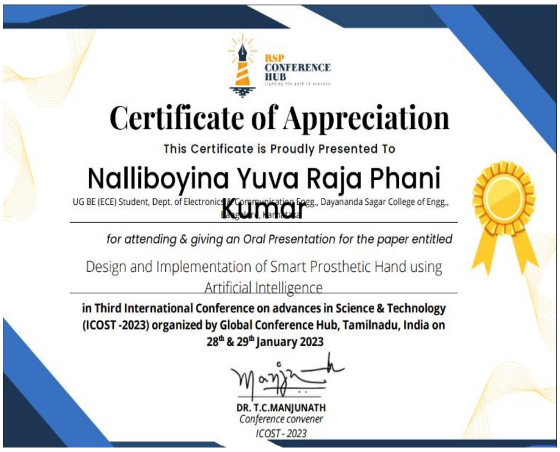
[1] Kavyanjali R, Mo Imran, Nalliboyina Yuva Raja Phani Kumar, Maria Dayana L N, Dr. Pavithra G, Dr. Sindhu Sree M, Dr. T. C. Manjunath, "Design and Implementation of Smart Prosthetic Hand using Artificial Intelligence", *European Chemical Bulletin,* ISSN:2063-5346, Volume-12, Special Issue 4, pp. 13598-13606, May, 2023, doi: 10.48047/ecb/2023.12.si4.1234

[2] Kavyanjali R, Mo Imran, Nalliboyina Yuva Raja Phani Kumar, Maria Dayana L N, Dr. Pavithra G, Dr. Sindhu Sree M, Dr. T. C. Manjunath, "Design and Implementation of Smart Prosthetic Hand using Artificial Intelligence", *International Journal of Engineering Technology and Management Sciences (IJETMS),* ISSN:2581-4621, Volume-7, Issue-1, pp. 237-241, February, 2023, doi : 10.46647/ijetms.2023.v07i01.033

Awards and Recognitions

Published paper in international Journal of Engineering Technology and Management Sciences (IJETMS)

Conference presentation in Third International Conference on advances in Science&Technology (ICOST-2023) organized by Global Conference Hub, Tamilnadu, India on 28th & 29th January 2023



Participated in the State Level Project Exhibition "Protatva-2023" on 27th April 2023 at RV Institute of Technology and Management, Bangalore


ProTatva'23

RV Institute of Technology and Management®

Chaithanya Layout, 8th Phase, JP Nagar, Bengaluru, Karnataka 560076

Recognised by AICTE, New Delhi | Affiliated to VTU, Belagavi

CERTIFICATE

OF PARTICIPATION

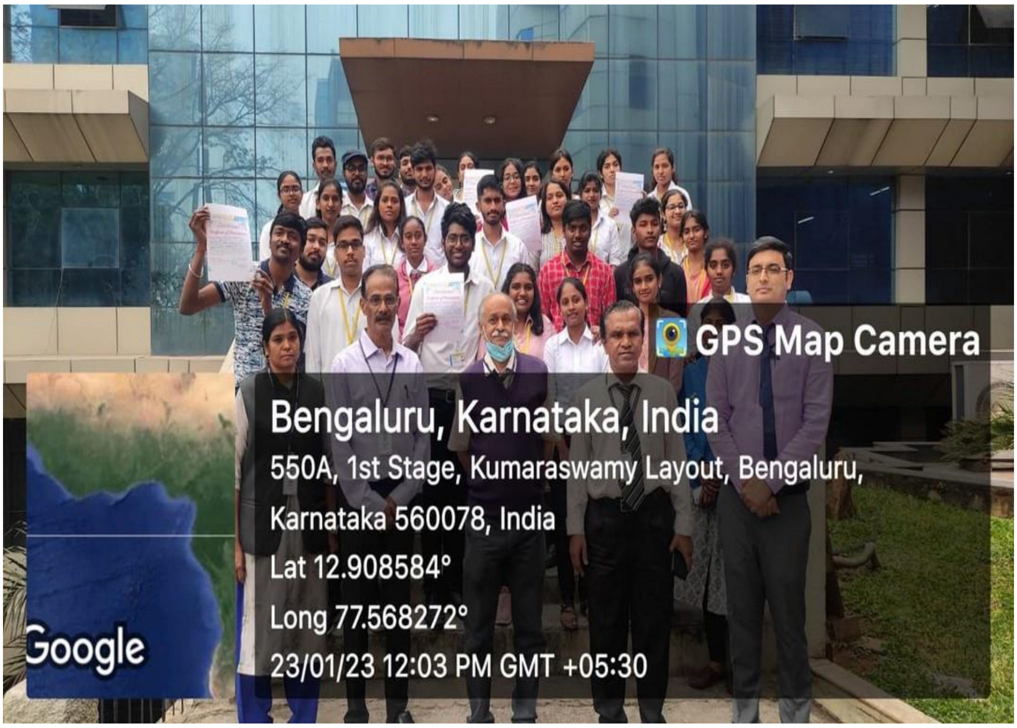
This is to certify that Mr/Miss. NALLIBOYINA YUVA RAJA BHANU KUMAR from ECE - DSBC BENGALURU under the guidance of .... has participated in State Level Project Exhibition "PROTATVA 2023" on 27th April 2023 at RV Institute of Technology and Management, Bengaluru.

Dr.Prashanth Patavardhan
HoD, ECE, Vice Principal
RVITM, Bengaluru

Dr.Latha C A
HoD, ISE
RVITM, Bengaluru

Dr. Jayapal R
Principal
RVITM, Bengaluru

Poster Presentation at College


GPS Map Camera
Bengaluru, Karnataka, India
550A, 1st Stage, Kumaraswamy Layout, Bengaluru, Karnataka 560078, India
Lat 12.908584°
Long 77.568272°
23/01/23 12:03 PM GMT +05:30
Google

Project Open Day at College

Awards

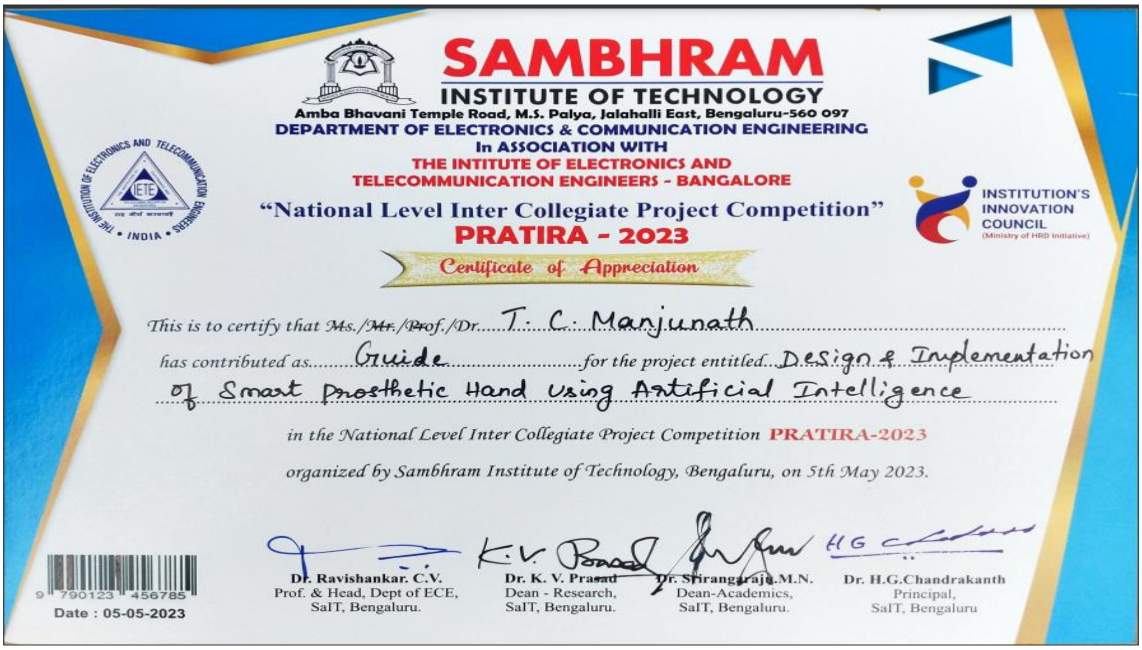
Secured Second Prize in the 16th National Level Inter Collegiate Project Competition PRATIRA-2023 organised by Sambhram Institute of Technology on 5th of May 2023.

SAMBHRAM INSTITUTE OF TECHNOLOGY
Amba Bhavani Temple Road, M.S. Palya, Jalahalli East, Bengaluru-560 097
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
In ASSOCIATION WITH
THE INTITUTE OF ELECTRONICS AND TELECOMMUNICATION ENGINEERS - BANGALORE
"National Level Inter Collegiate Project Competition"
PRATIRA - 2023
Certificate
This is to certify that Ms./Mr. Nalliboyina Yuvaraja Phani kumar
of Dayanand Sagar College of Engineering
has Participated / secured II Prize in the National Level Inter Collegiate Project Competition
PRATIRA-2023 organized by Sambhram Institute of Technology, with the
project titled Design & Implementation of Smart Prosthetic Hand Using Artificial Intelligence
on 5th May 2023.
Dr. Ravishankar. C.V. Prof. & Head, Dept of ECE, SaIT, Bengaluru.
Dr. K. V. Prasad Dean - Research, SaIT, Bengaluru.
Dr. Srirangaraju.M.N. Dean-Academics, SaIT, Bengaluru.
Dr. H.G.Chandrakanth Principal, SaIT, Bengaluru
Date : 05-05-2023

SAMBHRAM INSTITUTE OF TECHNOLOGY
Amba Bhavani Temple Road, M.S. Palya, Jalahalli East, Bengaluru-560 097
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
In ASSOCIATION WITH
THE INTITUTE OF ELECTRONICS AND TELECOMMUNICATION ENGINEERS - BANGALORE
"National Level Inter Collegiate Project Competition"
PRATIRA - 2023
Certificate
This is to certify that Ms./Mr. Maria Dayana L N
of Dayanand Sagar College of Engineering
has ~~Participated~~ / secured II Prize in the National Level Inter Collegiate Project Competition
PRATIRA-2023 organized by Sambhram Institute of Technology, with the
project titled Design & Implementation of Smart Prosthetic Hand Using Artificial Intelligence
on 5th May 2023.
Dr. Ravishankar. C.V. Prof. & Head, Dept of ECE, SaIT, Bengaluru.
Dr. K. V. Prasad Dean - Research, SaIT, Bengaluru.
Dr. Srirangaraju.M.N. Dean-Academics, SaIT, Bengaluru.
Dr. H.G.Chandrakanth Principal, SaIT, Bengaluru
Date : 05-05-2023

SAMBHRAM INSTITUTE OF TECHNOLOGY
Amba Bhavani Temple Road, M.S. Palya, Jalahalli East, Bengaluru-560 097
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
In ASSOCIATION WITH
THE INTITUTE OF ELECTRONICS AND TELECOMMUNICATION ENGINEERS - BANGALORE
"National Level Inter Collegiate Project Competition"
PRATIRA - 2023
Certificate
This is to certify that Ms./Mr. MD Imran
of Dayanand Sagar College of Engineering
has Participated / secured II Prize in the National Level Inter Collegiate Project Competition
PRATIRA-2023 organized by Sambhram Institute of Technology, with the
project titled Design & Implementation of Smart Prosthetic Hand Using Artificial Intelligence
on 5th May 2023.
Dr. Ravishankar. C.V. Prof. & Head, Dept of ECE, SaIT, Bengaluru.
Dr. K. V. Prasad Dean - Research, SaIT, Bengaluru.
Dr. Srirangaraju.M.N. Dean-Academics, SaIT, Bengaluru.
Dr. H.G.Chandrakanth Principal, SaIT, Bengaluru
Date : 05-05-2023

SAMBHRAM INSTITUTE OF TECHNOLOGY
Amba Bhavani Temple Road, M.S. Palya, Jalahalli East, Bengaluru-560 097
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
In ASSOCIATION WITH
THE INTITUTE OF ELECTRONICS AND TELECOMMUNICATION ENGINEERS - BANGALORE
"National Level Inter Collegiate Project Competition"
PRATIRA - 2023
Certificate
This is to certify that Ms./Mr. Kavyanjali R
of Dayanand Sagar College of Engineering
has Participated / secured II Prize in the National Level Inter Collegiate Project Competition
PRATIRA-2023 organized by Sambhram Institute of Technology, with the
project titled Design & Implementation of Smart Prosthetic Hand Using Artificial Intelligence
on 5th May 2023.
Dr. Ravishankar. C.V. Prof. & Head, Dept of ECE, SaIT, Bengaluru.
Dr. K. V. Prasad Dean - Research, SaIT, Bengaluru.
Dr. Srirangaraju.M.N. Dean-Academics, SaIT, Bengaluru.
Dr. H.G.Chandrakanth Principal, SaIT, Bengaluru
Date : 05-05-2023



SAMBHRAM INSTITUTE OF TECHNOLOGY
Amba Bhavani Temple Road, M.S. Palya, Jalahalli East, Bengaluru-560 097
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
In ASSOCIATION WITH
THE INTITUTE OF ELECTRONICS AND TELECOMMUNICATION ENGINEERS - BANGALORE
INSTITUTION'S INNOVATION COUNCIL (Ministry of HRD Initiative)
"National Level Inter Collegiate Project Competition"
PRATIRA - 2023
Certificate of Appreciation
This is to certify that ~~Ms.~~/~~Mr.~~/~~Prof.~~/Dr. T. C. Manjunath
has contributed as Guide for the project entitled Design & Implementation of Smart Prosthetic Hand Using Artificial Intelligence
in the National Level Inter Collegiate Project Competition PRATIRA-2023
organized by Sambhram Institute of Technology, Bengaluru, on 5th May 2023.
Dr. Ravishankar. C.V. Prof. & Head, Dept of ECE, SaIT, Bengaluru.
Dr. K. V. Prasad Dean - Research, SaIT, Bengaluru.
Dr. Srirangaraju.M.N. Dean-Academics, SaIT, Bengaluru.
Dr. H.G.Chandrakanth Principal, SaIT, Bengaluru
Date : 05-05-2023

Our Project was recognized by the Karnataka State Council for Science and Technology and granted Rs.6000

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,
Dayananda Sagar College of Engineering,
Shavige Malleshwara Hills, Kumaraswamy Layout,
Bengaluru – 560 078.

Dear Sir/Madam,

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

Project Proposal Reference No. : **46S_BE_2153**
Ref : Project Proposal entitled **DESIGN AND IMPLEMENTATION OF SMART PROSTHETIC HAND USING ARTIFICIAL INTELLIGENCE**

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)	Ms. KAVYANJALI R	**Department**	ELECTRONICS AND COMMUNICATION ENGINEERING
	Mr. MO IMRAN		
	Mr. NALLIBOYINA YUVA RAJA PHANI KUMAR		
	Ms. MARIA DAYANA L N	**Sanctioned Amount (in Rs.)**	6,000.00
Guide(s)	Dr. T. C. MANJUNATH		
	Dr. PAVITHRA G		

Instructions:

a) The project should be performed based on the objectives of the proposal submitted.
b) Any changes in the project title,objectives or students team is liable for rejection of the project and your institution shall return the sanctioned funds to KSCST.
c) Please quote your project reference number printed above in all your future correspondences.
d) After completing the project, 2 to 3 page write-up (synopsis) needs to be uploaded on to the following Google Forms link https://forms.gle/nWTaJjvrwzp3Wmvt6. The synopsis should include following:
 1) Project Reference Number
 2) Title of the project
 3) Name of the College & Department
 4) Name of the students & Guide(s)
 5) Keywords
 6) Introduction / background (with specific reference to the project, work done earlier, etc) - about 20 lines
 7) Objectives (about 10 lines)

46S_BE_2153

 8) Methodology (about 20 lines on materials, methods, details of work carried out, including drawings, diagrams etc)
 9) Results and Conclusions (about 20 lines with specific reference to work carried out)
 10) Scope for future work (about 20 lines).
e) In case of incompeted projects, the sanctioned amount shall be returned to KSCST.
f) The sanctioned amount will be transferred by NEFT to the bank account provided by the College/Institute.
g) The sponsored projects evaluation will be held in the Nodal Centre/Online Mode and the details of the same will be intimated shortly by email / Website announcement.
h) After completion of the project, soft copy of the project report duly signed by the Principal, the HoD, Guide(s) and studetn(s) shall be uploaded in the following Google Forms Link https://forms.gle/YWz56TrGg7fnSQgc7. The report should be prepared in the format prescribed by the university.

Please visit our website for further announcements / information and for any clarifications please email to spp@kscst.org.in

Thanking you and with best regards,

Yours sincerely,

(U T Vijay)

Copy to:
1) The HoD
 ELECTRONICS AND COMMUNICATION ENGINEERING
 DAYANANDA SAGAR COLLEGE OF ENGINEERING, BENGALURU

2) Dr. T. C. MANJUNATH Dr. PAVITHRA G
 ELECTRONICS AND COMMUNICATION ENGINEERING
 DAYANANDA SAGAR COLLEGE OF ENGINEERING, BENGALURU

3) THE ACCOUNTS OFFICER
 KSCST, BENGALURU


Dr. Pavithra G
Assoc. Prof.
Kavyanjali R.
1DS19EC060
Mo. Imran
1DS19EC080
Nalliboyina Yuva
Raja Phani Kumar
1DS19EC085
Maria Dayana L N.
1DS20EC420
Dr. Manjunath
Prof. & HOD
KSCST Proj. No. 46S_BE_2153
Design and implementation of smart prosthetic hand using artificial intelligence
Dr. T. C. Manjunath, Dr. Pavithra G., Kavyanjali R., Mo Imran Nalliboyina, Yuva Raja Phani Kumar, Maria Dayana L.N.
Rs. 6,000

Hard copy of the presented conference paper / published journal paper

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 1 Volume No.7 January - February – 2023
DOI:10.46647/ijetms.2023.v07i01.033 **ISSN: 2581-4621**

Design and Implementation of a Smart Prosthetic Hand

Kavyanjali R. (1DS19EC060), Mo Imran (1DS19EC080),
Nalliboyina Yuva Raja Phani Kumar (1DS19EC085), Maria Dayana L.N. (1DS20EC420),
[2]Dr. Pavithra G., [3]Dr. Sindhu Shree M., [4]Dr. T.C.Manjunath, [5]Aditya T.G., [6]Sandeep K.V.,
[7]Rajashekar M. Koyyeda, [8]Dr. Suhasini V.K., [9]Dr. Vijayakumar K.N.
[1]Second year BE (ECE) students, Dept. of Electronics & Communication Engg., Dayananda Sagar College of Engineering, Bangalore, Karnataka
[2]Associate Professor, ECE Dept., Dayananda Sagar College of Engineering, Bangalore
[3]Assistant Professor, ECE Dept., Dayananda Sagar College of Engineering, Bangalore
[4]Professor & HOD, ECE Dept., Dayananda Sagar College of Engineering, Bangalore
[5]Second year BE (CSE) Student, PES University, Bangalore
[6]Assistant Professor, Electronics & Telecommunication Engg. Dept., DSCE, Bangalore
[7]Assistant Professor, EEE Dept., Tatyasaheb Kore Inst. of Engg. & Tech., Kolhapur, Maharashtra
[8]Prof. & Head, Mechanical Engg. Dept., DJ Sanghvi College of Engg., Mumbai
[9]Principal & Prof., Dept. of MCA, Bharati Vidyapeeth's Inst. of Mgmt. & Info. Tech., Mumbai

Abstract
An overview of the design and use of a Smart Prosthetic Hand is provided in this study. This study presents an overview of computational methods for brain, gesture, and voice signals to operate a robotic arm. There are several hundred million neurons in the human brain. A prosthetic arm powered by a Brain-Computer Interface (BCI) based on electroencephalograms (EEG) is a non-invasive approach that can be a powerful aid for persons with severe disabilities in their daily lives, particularly to let them use their arm voluntarily. The brain's EEG data is recorded by the Brainsense headset and processed by a microprocessor to move the prosthetic hand via controlling servo motors. Additionally, a glove controller that replicates the gestures is used. The method entails using flex sensors to control the arm's movements. The voice control system was created so that voice commands could be sent through Bluetooth to control prosthetic arms. With the aid of a microcontroller, all actions can be monitored by a user interface. This prosthetic arm can help patients who have amputees below the elbow. This essay's main objective is to enable people with physical disabilities to become less dependent on others for their everyday needs. This model would be very helpful in both the real world, especially for those with disabilities who are unable to use their hands, and in the classroom when employed by college students pursuing robotics as a subject. The work given here is a mini-project that is taken up as a part of the curriculum completed by electronics and communication engineering students in the second year of the electronics & communication engineering department at Dayananda Sagar College of Engineering in Bangalore.
Keywords
Robotic arm, Electroencephalogram, Brain-Computer Interface, Brainsense headset, Bluetooth, Voice control, flex sensors

1. Introduction

The inspiration for this idea came from persons with disabilities, stroke patients who have motor deficits, war veterans who lost their arms, and individuals who are unable to control their hands and arms. According to recent surveys by the World Health Organization (WHO), half of all people worldwide live with some sort of disability, which affects around 15% of the population [1]. There are around 5 million crippled persons in India. In the world, there are approximately 10 million amputees, 30% of whom have lost one arm [2]. The three main causes of limb loss are illnesses, birth abnormalities, and traumatic events. Other common causes are injuries sustained in motor vehicle and cruiser accidents [3]. One of the most coveted robotic and prosthetic accomplishments, as well as one of the most challenging engineering goals ever, is to replicate the human hand [4]. Hand

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 1 Volume No.7 January - February – 2023
DOI:10.46647/ijetms.2023.v07i01.033 ISSN: 2581-4621

gestures are a common form of human contact and are effective in HCI [5]. The prevalence of amputees and patients with limb impairment is rising overall for a variety of political, economic, scientific, and demographic reasons. Although artificial limbs have been around for a while, their use and interaction with the environment are not very natural. They call for invasive surgical intervention [6].

The fundamental objective of such intricate treatments is to redistribute nerves so that amputees may operate their prosthetic devices simply by thinking about what they wish to do [7]. Robots are employed not just in industries but also in everyday life. A robotic arm is a sort of mechanical arm that performs tasks akin to those of a human arm and is typically programmable. To complete jobs, robotic arms are used in a variety of sizes and configurations [8]. This project's main objective is to support physically disabled people in their daily lives. Here, the robot picks up and places any thing to assist the impaired person in becoming independent. For users to benefit in freedom, self-realization, and social inclusion, assistive robot efficiency must therefore be improved at several levels [9]. The invention of electroencephalography (EEG) and Hans Berger's discovery of the electrical activity of the human brain are at the foundation of the history of brain-computer interfaces (BCI) [10]. Berger was the first to use an EEG to capture human brain activity in 1924. Using his or her brain activity, a person can communicate with an automated system like a robot or prosthesis through a BCI, which is a non-muscular communication channel. There are many uses for BCI systems, including controlling a wheelchair prosthesis or a cursor on a screen, as well as multimedia and virtual reality [11].

Acquisition is a representation of one of a BCI system's most crucial elements. The most used acquisition method is EEG, which offers an affordable and transportable acquisition solution [29]. The EEG method relies on scalp electrodes being placed to the subject to record brainwaves. EEG signals have low-level amplitudes of the order of microvolts and oscillate between 1 Hz and 100 Hz in frequency. Specific properties are extracted and linked to various patient brain activity states as well as directives for apps that have been built [12].

Fig.1: Applications of BCI interface prototype that is going to be developed in our project

Fig. 1 gives the prototype of the prosthetic hand that is going to be developed in our project. Although speech recognition algorithms have been developed for a while, they recently gained prominence as a result of significant advancements in voice recognition performance and resilience, which enable cutting-edge machine learning methods [28]. Many elderly assistance robots can be operated with

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 1 Volume No.7 January - February – 2023
DOI:10.46647/ijetms.2023.v07i01.033 ISSN: 2581-4621

joysticks, tablets, PCs, etc. [13], but some people may find it difficult to use them; in this case, a voice-controlled robot can be used to solve the problem. To process the user's voice through distant servers, the majority of modern speech control systems, including those found in smartphones and home automation, need an internet connection. Due to autonomy and safety considerations, it is ideal for an assistive technology to work without an internet connection [14].
This has a significant impact on the use cases that may be developed with voice recognition devices. In this project, we use a robotic arm to carry out the intended action while transmitting voice commands through Bluetooth to a preprogrammed controller [15]. Glove-based techniques that assess hand and arm joint angles and spatial position are among the most widely used methods[16]. The use of this gesture recognition technology has become more widespread in a short period of time. The flex sensors are an effective tool for identifying and detecting human body motions due to their moderately low cost and relatively small size [17]. The primary goal of gesture recognition in this work is to identify a specific hand motion and deliver an appropriate instruction to a robotic system for action execution [18].

2. Objectives & Scopes

The goal of our initiative is to assist people with disabilities in living a normal life and carrying out their everyday tasks more effectively and efficiently without the assistance of others [27]. It mostly aids those who have lost their hands as a result of conflict, those who are paralysed, and those who have lost control of their limbs. Without requiring any brain surgery, BCIs convey the subject's thoughts, which have been converted into control signals by brain electrical activity, for external use [30]. This aids the individual who need support. With the help of this technology, a completely dependent person can become somewhat autonomous, which will benefit both their physical and mental health [26]. The project's specific objective was to make controlling assistive robots more natural and to have them carry out various duties more quickly and efficiently via voice instructions [25]. To accurately duplicate only a few of the motions available with the human hand, it is best to design for a very simple prosthetic hand [24]. Designing a highly complicated prosthesis that could imitate every hand gesture possible would be challenging and unnecessary. However, the prosthesis must be made to allow the hand's selected articulations to appear as natural as feasible [21].
The prosthesis would need to be made with strength, stability of motion, and long-lasting elements, taking into account the necessity for a sturdy design since it may be used in daily life. Aside from needing to be too sophisticated in terms of machine operations, the parts would also need to be designed to allow for simple machining. The major goal is to create a trustworthy, affordable prosthetic arm control circuit. Additionally, it is necessary to create a smart prosthetic arm that can do complicated navigational tasks (select and put objects in a realistic environment) for persons with disabilities. This arm would employ signals from the brain that were recorded and processed [20]. The design of the prosthetic hand mimics the gestures and responds appropriately. voice instructions can be used to control the hand [22]. Additionally, based on the signals analysed, to automate the home and send a warning message to family members in the event of an emergency, as well as the GPS location of the person using the prosthetic hand [23].

3. Conclusions and Next Steps

The work presented in this paper gives a small indepth information about the prosthetic hand which we are going to develop in our project work. Prosthetics is one of the many applications for Human Robot Interaction (HRI). In order to obtain EEG data from the brain utilising the brain's electrodes and take appropriate action, this project develops and implements a comprehensive technique. The speech recognition module will effectively capture the data by responding to vocal commands.

References

[1] Chinbat, "Prosthetic Arm Control by Human Brain," IEEE International Symposium on

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 1 Volume No.7 January - February – 2023
DOI:10.46647/ijetms.2023.v07i01.033 ISSN: 2581-4621

Computer, Consumer and Control (IS3C), 2018.
[2] T. Beyrouthy, "EEG Mind Controlled Smart Prosthetic Arm," A Comprehensive Study Advances in Science, Technology and Engineering Systems, 2017.
[3] Andrews, "Low-Cost Robotic Arm for differently abled using Voice Recognition," Proceedings of the Third IEEE International Conference on Trends in Electronics and Informatics (ICOEI 2019), 2019.
[4] Juan Pablo, "Voice Controlled Prosthetic Hand with Predefined Grasps and Movements," VII Latin American Congress on Biomedical Engineering CLAIB, 2016.
[5] Dr.Sandeep, "Robotic arm control using gesture and voice", IEEE International Journal of Computer, Information Technology & Bioinformatics (IJCITB).
[6] Guoxin, "The Prosthetic Arm: A Dramatic Improvement For The Limb Amputation From The Humerus," IEEE 4th International Conference on advanced Robotics and Mechatronics, 2019.
[7] D. sharma, "Enhanced Framework for Active Prosthetic Arm," IEEE International Conference om Advanced communication and applied informatics., 2022.
A. P. Naik, "Arduino based Voice controlled Robotic Arm," IEEE International Conference on advanced Robotics, 2017.
[8] Shobhan, "Implementation of Pick & Place Robotic Arm for Warehouse Products Management," IEEE International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA), 2021.
[9] Nirsandh G; Preetha S; Sabeer yaccob. "Arthroplasty Advancement: Remodification Design of Total Hip Replacement". International Research Journal on Advanced Science Hub, 2, 6, 2020, 105-108. doi: 10.47392/irjash.2020.45
[10] Muniyandy Elangovan; Mohamed Yousuf; Mohamed Nauman; Mohammed Nayeem. "Design and Development of Delivery Robot for Commercial Purpose". International Research Journal on Advanced Science Hub, 4, 07, 2022, 192-197. doi: 10.47392/irjash.2022.047
[11] Gayathri N Shenoy; Chithu Rajan; Shibi Varghese; Vignesh M.V; ShanmugaPriya M; Priya S; Aparna George. "STERILOID: Room Sanitization Robot". International Research Journal on Advanced Science Hub, 2, 8, 2020, 100-104. doi: 10.47392/irjash.2020.101
[12] R. Devi Priya, R. Sivaraj, Ajith Abraham, T. Pravin, P. Sivasankar and N. Anitha. "Multi-Objective Particle Swarm Optimization Based Preprocessing of Multi-Class Extremely Imbalanced Datasets". International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems Vol. 30, No. 05, pp. 735-755 (2022). Doi: 10.1142/S0218488522500209
[13] Saha, "Progress in brain computer interface, challenges and opportunities," Frontiers in systems Neuro science., 25th Feb. 2021.
[14] J. R. Wolpaw, "Brain–computer interfaces as new brain output pathways," Wadsworth Center, Laboratory of Nervous System Disorders, New York State Department of Health and State University of New York, Albany, Mar 5 2007.
[15] J. kaur, "A review on analysis of EEG signals," IEEE International Conference on Advances in Computer Engineering and Applications (ICACEA), 2015.
[16] Ujwal, "Voice Control Based Prosthetic Human Arm," International Research Journal of Engineering and Technology (IRJET), 07, July 2019..
[17] Z. X. P. Wang, "Design of a voice control 6DoF grasping robotic arm based on ultrasonic sensor, computer vision and Alexa voice assistance," IEEE 10th International Conference on Information Technology in Medicine and Education, 2019.
[18] Poirier, "Voice Control Interface Prototype for Assistive Robots for People Living with Upper Limb Disabilities"," IEEE 16th International Conference on Rehabilitation Robotics (ICORR) Toronto, 2019.
[19] P. Iyer, "Hand Gesture Controlled Robot," IEEE 9th International Conference on Emerging Trends in Engineering and Technology - Signal and Information Processing (ICETET-SIP-19), 2019.
A. B. Bakri, "Wireless Hand Gesture Controlled Robotic Arm Via NRF24L01 Transceiver","

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 1 Volume No.7 January - February – 2023
DOI:10.46647/ijetms.2023.v07i01.033 **ISSN: 2581-4621**

Proceedings of 2016 IEEE Conference on Latest trends in Robotics., 2016.
[20] P. Atre, "Efficient and Feasible Gesture Controlled Robotic Arm," IEEE International Conference on ent Computing and Control Systems (ICICCS), 10 March 2019.
[21] Rajanbabu, "Material Handling Using Pick and Place Robot," IEEE International Conference on Smart Structures and Systems (ICSSS), 2020.
[22] Sonawanc, "Motion Control of Robotic Arm for Micro-Positioning in Industrial Application"," IEEE International Conference on Advances in Communication and Computing Technology (ICACCT), 2018.
[23] M. Fattah, "Gesture controlled prosthetic arm," IEEE 3rd International Conference for Convergence in technology, 2018.
[24] M. k. Doga Akcinar, "Speaker Dependent Voice Controlled Robotic Arm," IEEE International Symposium on Innovations in Intelligent Systems and Applications (INISTA), 2018.
[25] R. Dhotre, "Gesture controlled home automation," International journal of Scientific and Engineering Research, vol. 8, no. 9, 2017.
A. S. Aishwarya Patil, "Haptic Robotic Arm Using Voice & Gesture Recognition," Journal of Advanced Research in Computer and Communication Engineering, vol. 2, no. 3, Mar 2013.
[26] Kanash, "Design and Implementation of Voice Controlled Robotic ARM," IEEE International Conference on Communication & Information Technology (ICICT)., 2021.
[27] Sihombing, "Robotic Arm Controlling Based on Fingers and Hand Gesture", IEEE International Conference on Mechanical, Electronics, Computer, and Industrial Technology (MECnIT), 2020.
[28] Gunapriya, "A review of Arduino based hand gesturec ontrolled robot using IoT," IEEE International Conference on Artificial Intelligence and Smart Systems (ICAIS), 2022.
[29] J. Islam, "ntegration of Home Assistance with a Gesture Controlled Robotic Arm," IEEE Region 10 Symposium (TENSYMP)., 2020.
[30] K. K. Ang, "EEG-based Strategies to Detect Motor Imagery for Control and Rehabilitation,"IEEE proceedinds on Transactions on Neural Systems and Rehabilitation Engineering, 2016.
[31] Ashwal, "" Stress Effect on Attention Level Detection Using Neurosky Mindwave Headset," International Biomedical Instrumentation and Technology Conference (IBITeC), 2021.
[32] Lakshmi Gandan, "EEG Based Brain Controlled Mobile Arm Pick and Place robot," International Journal of Engineering Trends and Technology (IJETT), vol. 45, 8 Mar 2017.
[33] Katona, "Evaluation of the Neuro Sky Mind Flex EEG headset brain waves data," IEEE International Symposium on Applied Machine Intelligence and Informatics (SAMI), 2021.
[34] M. Borghetti, E. Sardini and M. Serpellon, "Evaluation of bend sensors for limb motion monitoring," IEEE International Workshop on Medical Measurement and Applications (MEMEA), 2014.

Design and Implementation of Smart Prosthetic Hand Using Artificial Intelligence

[1] Kavyanjali R, [1] Mo Imran, [1]Nalliboyina Yuva Raja Phani Kumar, [1] Maria Dayana L.N.,
[2] Dr. Pavithra G., [3] Dr. Sindhu Sree M., [4] Dr. T.C.Manjunath* Ph.D. (IIT Bombay)

[1]Eighth Semester BE (ECE) Students, Final Year, Dept. of Electronics & Communication Engg.,
Dayananda Sagar College of Engineering, Bangalore, Karnataka
[2]Associate Prof., Electronics & Communication Engg. Dept.,
Dayananda Sagar College of Engineering, Bangalore, Karnataka
[3]Assistant Prof., Electronics & Communication Engg. Dept.,
Dayananda Sagar College of Engineering, Bangalore, Karnataka
[4] Professor & HOD, Electronics & Communication Engg. Dept.,
Dayananda Sagar College of Engineering, Bangalore, Karnataka

*Corresponding author : tcmanju@iitbombay.org

Abstract
This research paper presents a comprehensive examination of a computational approach for controlling a robotic arm through brain, gesture, and voice signals. The human brain, consisting of numerous neurons, forms the basis for an Electroencephalogram (EEG) based Brain-Computer Interface (BCI) prosthetic arm. This non-invasive technique holds great potential in assisting individuals with severe disabilities in their daily lives, particularly by facilitating voluntary arm movement. The Brainsense headset captures EEG signals from the brain, which are then processed by a microcontroller to control servo motors and manipulate the prosthetic hand accordingly. Additionally, the system incorporates a glove controller that emulates natural gestures, utilizing flex sensors to facilitate precise arm motion control. To further expand the system's capabilities, a voice control system has been developed, enabling individuals to command the prosthetic arm through voice signals transmitted via Bluetooth. A user interface, supported by a microcontroller, facilitates real-time monitoring and oversight of all operations. This innovative prosthetic arm design offers significant benefits to individuals with below-elbow amputations, empowering them to regain independence in their daily lives. The primary objective of this research paper is to enhance the quality of life for physically disabled individuals, enabling them to reduce their reliance on others. This model holds tremendous practical value, particularly for individuals with hand disabilities who are unable to perform manual tasks. Furthermore, it serves as a valuable tool in academic settings, allowing undergraduate students pursuing robotics studies to gain hands-on experience in their curriculum. The work done & presented in this paper is the result of the final year one year project work that has been done by the final year engineering students of the college and as such there is little novelty in it and the references are being taken from various sources from the internet, the paper is being written by the students to test their writing skills in the final stages of their engineering career and also to test the presentation skills during their final year project presentation and the work done & presented in this paper is the report of the undergraduate project work done by the students.

Keywords Robotic arm, Electroencephalogram, Brain-Computer Interface, Brainsense headset, Bluetooth, Voice control, flex sensors

1. Introduction

This project draws inspiration from individuals with motor deficits caused by stroke, soldiers who have lost their arms in war, and those who have limited control over their arms and hands. According to recent studies conducted by the World Health Organization (WHO), approximately 15% of the global population experiences some form of disability, with half lacking access to adequate healthcare [1]. In India alone, there are approximately 5 million people living with disabilities. Worldwide, there are over 10 million amputees, with 30% of them having undergone arm amputations [2]. Causes of limb loss can range from traumatic injuries and birth defects to various diseases, including those acquired during military conflicts or vehicular accidents [3]. Replicating the intricate functionality of the human hand has long been a coveted achievement in the fields of robotics and prosthesis, but it also represents one of the most formidable engineering challenges [4]. Hand gestures are a ubiquitous form of human interaction and can be effectively utilized in human-computer interaction (HCI) [5].

The prevalence of amputees and individuals with limb dysfunction is on the rise due to political, economic, scientific, and demographic factors. Although prosthetic limbs have been available for decades, they often lack natural operation and seamless interaction with the environment. Additionally, their usage typically necessitates invasive surgical procedures [6]. Complex procedures aim to reassign nerves, enabling amputees to control their prosthetic devices through neural signals associated with intended actions [7]. Robots are not limited to industrial applications; they also play a significant role in enhancing human life. Robotic arms, available in various sizes and configurations, are programmable mechanical arms designed to perform a wide range of tasks [8]. The primary objective of this project is to assist individuals with physical challenges in their daily lives, providing them with the ability to independently manipulate and transport objects. To enhance the efficiency of assistive robots, innovative approaches are required to empower users, fostering independence, self-fulfillment, and social inclusion [9].

The history of brain-computer interfaces (BCI) can be traced back to Hans Berger's groundbreaking discovery of the electrical activity of the human brain and the subsequent development of electroencephalography (EEG) in 1924 [10]. A BCI serves as a non-muscular communication channel, enabling individuals to transmit commands and messages to automated systems such as robots or prostheses through their brain activity. BCI systems find applications in various domains, including spellers, wheelchair control, cursor manipulation, multimedia, and virtual reality [11]. Acquisition, a critical aspect of BCI systems, often relies on EEG as a widely adopted, cost-effective, and portable solution. EEG involves the recording of brainwaves through electrodes attached to the subject's scalp. These brainwave signals exhibit low amplitudes in the microvolt range and frequencies ranging from 1 Hz to 100 Hz. Specific features are extracted from the EEG signals, which correspond to different states of the user's brain activity and can be associated with commands for various applications [12] (see Fig. 1 for illustration).

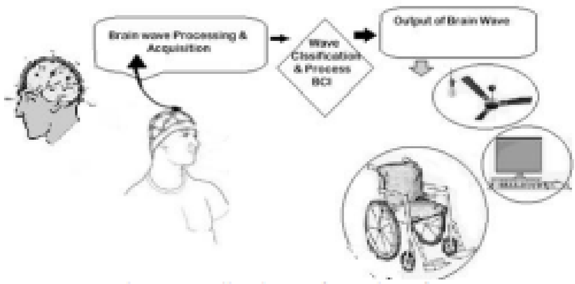


Fig. 1: Applications of BCI interface

Speech recognition algorithms have undergone extensive development over the years and have gained significant popularity due to advancements in voice recognition performance and the robustness of machine learning algorithms. Many elderly assistance robots can be controlled using devices such as joysticks, tablets, or PCs [13]. However, some individuals may encounter difficulties in using these traditional input methods. To address this, voice-controlled robots offer a potential solution. Nonetheless, most current speech control services, including smartphones and home automation systems, rely on internet connectivity to process user voice commands through remote servers. This reliance on internet connection poses limitations for certain use cases, and for assistive technologies, operating without internet connectivity is preferable to ensure autonomy and safety [14]. In this project, we propose using voice instructions as input via Bluetooth to a preprogrammed controller, which in turn generates the desired output using a robotic arm [15]. Among the various techniques available, one popular approach is the glove-based technique, which measures hand and arm joint angles as well as spatial position [16]. Gesture recognition technology has witnessed rapid growth in popularity, primarily due to the relatively low cost and compact size of flex sensors, making them ideal for detecting and recognizing human body motions [17]. The primary objective of gesture recognition in this paper is to detect specific hand gestures and correspondingly send commands to the robotic system for the execution of desired actions [18].

2. Literature Reviews

Numerous studies have explored the development of smart prosthetic arms utilizing various technologies. This section aims to provide an overview of existing technologies and their contributions. In a notable work [1], the authors focused on brain-controlled robots to enhance mobility for individuals with degenerative muscular diseases. Their approach involved a comprehensive methodology for acquiring EEG signals using simple electrodes. Another study [3] addressed a medically-oriented challenge by proposing an intricate mechanical design for the prosthetic arm along with electronic control. The researchers successfully developed a cost-effective yet functional prosthetic arm capable of accepting vocal commands from users. Additionally, a paper [5] delved into the design of a hand gesture recognition module for analyzing and classifying hand gestures in the context of human-computer interaction (HCI), particularly glove-based techniques. This research aimed to establish mappings between angular measurements obtained from a data glove and predefined hand gestures. These examples highlight the diverse range of research endeavors focused on implementing prosthetic hands. Considering these advancements, we have developed a Smart Prosthetic Hand that can be intuitively controlled through voice, gesture, and EEG signals.

3. Scope & Objectives

The scope of our project is to help people with disability to live and lead a normal life and to do their daily activity without any aid of others in an efficient and better way. It mainly helps people who have lost their hands due to war, paralysis and people who have lost the control over their limbs. BCIs used to transmits the subject thoughts, decoded by brain electrical activity into control signal, for external This technology offers a non-invasive solution without the need for brain surgery, providing valuable assistance to individuals in need. By enabling greater independence, it contributes to both physical and mental well-being. The main objective of the project was to enhance the control of assistive robots, making it more intuitive and efficient through voice commands.

The design of the prosthetic hand focused on accurately replicating a limited set of hand motions rather than attempting to mimic the full range of gestures. This approach recognizes the complexity involved in emulating all possible hand movements. However, for the chosen articulations, it was crucial to ensure that the prosthesis appears as natural as possible. Considering the practicality of everyday use, the design prioritized robustness, stability of motion, and durability of parts. Simplicity in machining was also considered, avoiding overly complex manufacturing processes while ensuring functionality.

4. Objectives of the project work

The main objective is to design and develop a reliable low - cost prosthetic arm control circuit. Also, to design a smart prosthetic arm, which uses captured signals from the brain and processes it to control the arm and to accomplish complex navigational tasks (pick and place objects) in realistic environment for people with disability in hand. The prosthetic hand design that mimics the gestures and act accordingly. To control the hand by giving voice commands. Also, to achieve home automation based on the signals processed and to send an alarming message to the family members in case of any emergency situations along with GPS location of the person using the Prosthetic hand.

5. Proposed Methodology

In this section of the paper, the process of approaching the project is explained in brief. As discussed in the previous sections, the project is about building a Smart Prosthetic Hand which can be operated using three methods such as EEG signals, Voice commands and gestures. To realize this project, we bring many contributions. One of our inputs is voice. The user can control the prosthetic arm in the form of human voice commands. The commands given to the Bluetooth module and the Arduino voice control app in the phone acts as an interface. For this, we give our voice commands. The speech recognizer takes input voice commands and converts them to text format and is fed to the Arduino in string format [24]. Here it will parse the string format and check if the given input is present in the built-in library and the pre-coded instructions for example 'open all fingers, 'close' etc,.

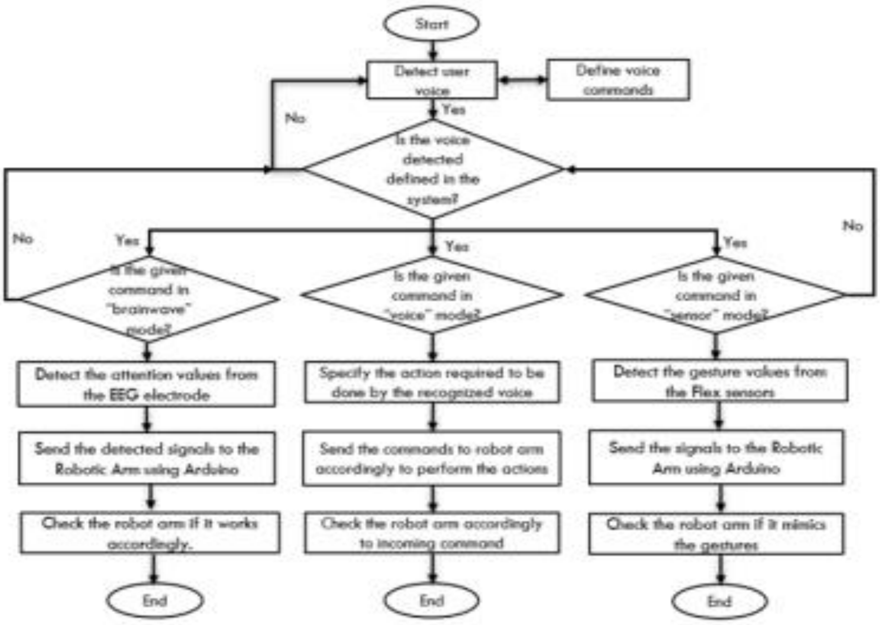


Fig. 2: Flow Chart

Finally, it is inserted into the Prosthetic Hand and it obeys the instructions and in return gives the respective output. As part of the training phase, Hand is trained with user specific voice so that it cannot be misused by any other individual as shown in the Fig. 2 [25]. The robotic hand replicates the gestures performed by the controlling arm, making it a straightforward project that can be recreated by individuals with basic knowledge in electronics and programming [26]. Each finger of the hand is operated by an individual servo motor, receiving signals from an Arduino board that determines their positions [26]. To detect the bending of fingers, flex sensors are utilized as input for the Arduino [25]. These flex sensors are integrated into gloves worn by the user. When the user desires to interact with home appliances, they simply use their hands to control them. When the flex sensors bend and the resistance values change, the Arduino converts the resulting current changes into digital signals, which are then transmitted to a Bluetooth module [27]. The Arduino code uploaded to the board verifies and compares the received data. If the data indicates a value of 1, the bulb is turned on. Conversely, when the received data is 0, the bulb is switched off. This approach allows for the control of various appliances throughout the home. Furthermore, this technology can be applied to perform additional actions such as object manipulation, as depicted in Figure 3 [28].

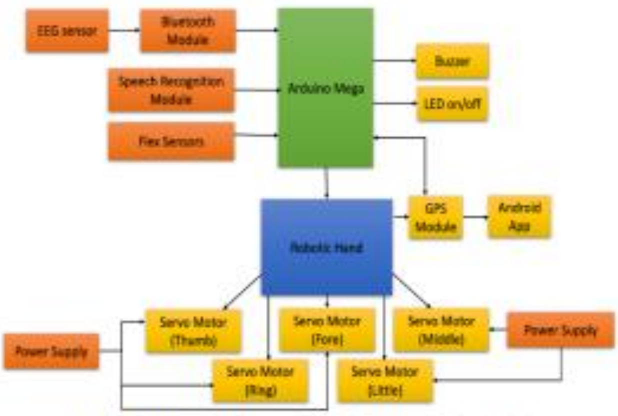


Fig. 3: Block Diagram for the proposed model

The system at hand can be classified as a Brain-Computer Interface (BCI) System [27]. A BCI system allows individuals to communicate with automated systems, such as robotic arms or prosthetic arms, by utilizing their brain activity, rather than muscular control. The fundamental concept behind a BCI is to translate patterns of brain activity produced by the user into corresponding commands [29]. A typical BCI system consists of signal acquisition and signal processing stages, which include pre-processing, feature extraction, and classification. Among the crucial components of a BCI system is the signal acquisition technique. The most commonly used and widely adopted method is electroencephalography (EEG), which offers a cost-effective and portable solution [28]. EEG involves recording brainwaves through electrodes attached to the subject's scalp, capturing signals with low-level amplitudes in the microvolt range and frequencies ranging from 1 Hz to 100 Hz. Specific features are extracted from the EEG signals and associated with different states of brain activity, allowing for the generation of commands for various applications [30]. The EEG headset or brainwave sensor detects the electrical signals from the brain and transmits them to a PC or laptop via Bluetooth in the form of data packets. The received data is then processed using the Arduino Integrated Development Environment (IDE), and the control commands are sent to the robotic arm through serial transmission. Based on the data received by the microcontroller from the PC or laptop, the system performs predefined actions determined by the level of concentration. These actions are outlined in Table 1 [31]..

Commands	Extracted Signal
One	Attention: Above 70
Two	Attention: Above 60
Three	Attention: Above 50
Close	Attention: Above 45
Four	Attention: Above 40
Five	Attention: Below 40

Table 1 : Data received based on concentration

The proposed multimethod controlled system is by default operated via voice commands due to its user-friendly interface and can be changed to any of the remaining modes of operation. In case if there are any emergency situations or if any of the control techniques is not working as desired, buzzer is equipped to send a message describing the issue to the family members of the user. The proposed block diagram is shown below [29].

6. Software & Hardware

The model comprises three modules: a software module, a mechanical module, and an electrical module. This architecture provides a flexible framework that can be customized to suit specific use cases. In a typical BCI system, two fundamental components are involved: signal acquisition and signal processing. Signal acquisition involves capturing brain signals, while signal processing encompasses pre-processing, feature extraction, and classification, as depicted in Figure 4 [30]. The software module plays a pivotal role in implementing signal processing algorithms and facilitating system integration. The mechanical module focuses on the physical design and construction, including components necessary for interaction or manipulation. The electrical module encompasses electronic components and circuitry for signal transmission, amplification, and interfacing with external devices. This modular design can be adjusted as per the requirements of the desired application.

Fig. 4: Brainsense Headset

Signal acquisition - Signal Acquisition is first step in signal processing. Here one is brainwave headset provided by Neurosky, is used to sense the brainwave signal. This EEG signal is passed to the signal pre-processing step [32].

Signal Pre-Processing: In the initial stage, the acquired signals undergo pre-processing to eliminate artifacts such as power line noise, electromyogram (EMG), electrocardiogram (ECG), electrooculogram (EOG), and body movement [31]. Following pre-processing, features are extracted from the signals, which serve as inputs for the classifier. The classifier then translates these extracted features into desired output commands. Filtering techniques, including lowpass, high-pass, band-pass, and notch filtering, are commonly employed to remove artifacts and frequency-specific noise, such as body movement and line noise [32].

Feature Extraction: Feature extraction involves deriving informative and non-redundant values (features) from the measured data to facilitate subsequent learning and generalization steps, leading to improved human interpretations. It is closely related to dimensionality reduction [33]. When input data is large and potentially redundant, feature extraction aims to transform it into a reduced set of features (feature vector) [34]. This process, known as feature selection, aims to retain relevant information for the desired task while reducing data dimensionality [35]. In the context of BCI systems for brain-controlled robots, features can be categorized into time domain features, such as amplitudes of event-evoked potentials, and frequency domain features, such as frequency power spectra of EEG signals [36].

EEG Module: The EEG module consists of a BCI headset responsible for detecting P300 waves and transmitting serial data to the processing unit. Any suitable open-source headset can be utilized, provided it meets latency and accuracy requirements. The construction of an EEG machine involves various raw materials, including flat, resin-coated printed circuit boards and electronic components such as resistors, capacitors, and integrated circuits composed of different metals, plastic, and silicon [37].

Control Module: The control module, implemented in software, serves as the processing unit responsible for translating raw EEG serial data related to specific thoughts into physical actions, such as arm lifting or object gripping. In our implementation, a Long Short-Term Memory Neural Network has been trained using a custom dataset [38].

Bluetooth Module: The Bluetooth technology manages the wireless communication channel, and Bluetooth modules facilitate wireless data transmission and reception between two devices. The Bluetooth module interacts with the host system through the host controller interface (HCI) [39].

Flex Sensors: The flex sensor is a crucial input sensor that plays a major role. It detects bending angles, and as the angle increases, the resistance of the flex sensor also increases. A potential divider circuit is employed to convert the change in resistance to voltage change. Flex sensors are typically attached to gloves using needle and thread. They require a 5-volt input and provide an output voltage ranging from 0 to 5V [41]. The resistance of the flex sensor changes unidirectionally, with a resistance of approximately 10K when unflexed and increasing to 30K-40K when flexed. The voltage divider, formed by the flex sensor and a resistor, divides the input voltage to produce the output voltage based on the ratio determined by the variable (R1) and fixed resistors (R2) [43].

HC-05 Bluetooth Module: The HC-05 module operates in two modes: Data mode, enabling data exchange with other Bluetooth devices, and AT Command mode, allowing changes to the default device settings [44]. The module can be easily paired with microcontrollers using the Serial Port Protocol (SPP). It requires a +5V power supply and connects the module's Rx pin to the microcontroller's Tx pin and vice versa for communication [45].

7. Conclusion & Future Directions

Human-Robot Interaction (HRI) encompasses various domains, and one notable application is in the field of prosthetics. The present project introduces a comprehensive approach to capture EEG signals directly from the brain using specialized electrodes, enabling the execution of corresponding actions based on these signals. By leveraging this methodology, the project aims to enhance the interaction between humans and robotic systems in the context of prosthetics. The speech recognition module will collect the data through vocal command and will perform efficiently. A hand gesture recognition system is built using Flex Sensors. The transmitted data will be mapped onto the arm to perform various actions. The Smart Prosthetic Hand will be integrated with signals from brain, voice commands and hand gestures. Also, a buzzer is included in case of any emergency. Thus, the Smart arm can effectively perform the essential tasks on daily-basis. Future work includes evaluation of the performance of this approach in hand-gesture understanding using both a larger vocabulary and a larger knowledge- base. In this paper, we present a 3-D hand motion tracking and gesture recognition via the wireless data glove using accelerometer. Instead of flex sensors and gloves, an AI algorithm or AI chip with high computational mathematics and programming can be implemented to make the hand respond to the thoughts of the user and head movements.

References

[1] Chinbat, "Prosthetic Arm Control by Human Brain," IEEE International Symposium on Computer, Consumer and Control (IS3C), 2018.
[2] T. Beyrouthy, "EEG Mind Controlled Smart Prosthetic Arm," A Comprehensive Study Advances in Science, Technology and Engineering Systems, 2017.
[3] Andrews, "Low-Cost Robotic Arm for differently abled using Voice Recognition," Proceedings of the Third IEEE International Conference on Trends in Electronics and Informatics (ICOEI 2019), 2019.
[4] [4] Juan Pablo, ""Voice Controlled Prosthetic Hand with Predefined Grasps and Movements," VII Latin American Congress on Biomedical Engineering CLAIB, 2016.
[5] Dr. Sandeep, "Robotic arm control using gesture and voice", IEEE International Journal of Computer, Information Technology & Bioinformatics (IJCITB).
[6] Guoxin, "The Prosthetic Arm: A Dramatic Improvement For The Limb Amputation From The Humerus," IEEE 4th International Conference on advanced Robotics and Mechatronics, 2019.
[7] D. Sharma, "Enhanced Framework for Active Prosthetic Arm," IEEE International Conference om Advanced communication and applied informatics., 2022.
[8] A.P. Naik, "Arduino based Voice controlled Robotic Arm," IEEE International Conference on advanced Robotics, 2017.
[9] Shobhan, "Implementation of Pick & Place Robotic Arm for Warehouse Products Management," IEEE International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA), 2021.
[10] Saha, "Progress in brain computer interface,challenges and opportunities," Frontiers in systems Neuro science., 25th feb 2021..
[11] J. R. Wolpaw, "Brain–computer interfaces as new brain output pathways," Wadsworth Center, Laboratory of Nervous System Disorders, New York State Department of Health and State University of New York, Albany, Mar 5 2007.
[12] J. kaur, "A review on analysis of EEG signals," IEEE International Conference on Advances in Computer Engineering and Applications (ICACEA), 2015.
[13] Ujwal, "Voice Control Based Prosthetic Human Arm," International Research Journal of Engineering and Technology (IRJET), 7, July 2019..
[14] Z.X.P. Wang, "Design of a voice control 6 DoF grasping robotic arm based on ultrasonic sensor, computer vision and Alexa voice assistance," IEEE 10th International Conference on Information Technology in Medicine and Education, 2019.
[15] Poirier, "Voice Control Interface Prototype for Assistive Robots for People Living with Upper Limb Disabilities"," IEEE 16th International Conference on Rehabilitation Robotics (ICORR) Toronto, 2019.
[16] P. Iyer, "Hand Gesture Controlled Robot," IEEE 9th International Conference on Emerging Trends in Engineering and Technology - Signal and Information Processing (ICETET-SIP-19), 2019.
[17] A. B. Bakri, "Wireless Hand Gesture Controlled Robotic Arm Via NRF24L01 Transceiver", Proceedings of 2016 IEEE Conference on Latest trends in Robotics., 2016.
[18] P. Atre, "Efficient and Feasible Gesture Controlled Robotic Arm," IEEE International Conference on ent Computing and Control Systems (ICICCS), 10 March 2019.
[19] Rajanbabu, "Material Handling Using Pick and Place Robot," IEEE International Conference on Smart Structures and Systems (ICSSS), 2020.
[20] Sonawane, "Motion Control of Robotic Arm for Micro-Positioning in Industrial Application", IEEE International Conference on Advances in Communication and Computing Technology (ICACCT), 2018.
[21] M. Fattah, "Gesture controlled prosthetic arm," IEEE 3rd International Conference for Convergence in technology, 2018.
[22] M. k. Doga Akcinar, "Speaker Dependent Voice Controlled Robotic Arm," IEEE International Symposium on Innovations in Intelligent Systems and Applications (INISTA), 2018.
[23] R. Dhotre, "Gesture controlled home automation," International journal of Scientific and Engineering Research, vol. 8, no. 9, 2017.
[24] A.S. Aishwarya Patil, "Haptic Robotic Arm Using Voice & Gesture Recognition,"Journal of Advanced Research in Computer and Communication Engineering, vol. 2, no. 3, Mar 2013.
[25] Kanash, "Design and Implementation of Voice Controlled Robotic ARM," IEEE International Conference on Communication & Information Technology (ICICT), 2021.
[26] Sihombing, "Robotic Arm Controlling Based on Fingers and Hand Gesture", IEEE International Conference onMechanical, Electronics, Computer, and Industrial Technology (MECnIT), 2020.
[27] Gunapriya, "A review of Arduinobased hand gesture controlled robot using IoT," IEEE International Conference onArtificial Intelligence and Smart Systems (ICAIS), 2022.

[28] J. Islam, "ntegration of Home Assistance with a Gesture Controlled Robotic Arm," IEEE Region 10 Symposium (TENSYMP)., 2020.
[29] K.K. Ang, "EEG-based Strategies to Detect Motor Imagery for Control and Rehabilitation,"IEEE proceedinds on Transactions on Neural Systems and Rehabilitation Engineering, 2016.
[30] Ashwal, "" Stress Effect on Attention Level Detection Using Neurosky Mindwave Headset," International Biomedical Instrumentation and Technology Conference (IBITeC), 2021.
[31] Lakshmigandan, "EEG Based Brain Controlled Mobile Arm Pick and Place robot," International Journal of Engineering Trends and Technology (IJETT), vol. 45, 8 Mar 2017.
[32] Katona, "Evaluation of the NeuroSky MindFlex EEG headset brain waves data," IEEE International Symposium on Applied Machine Intelligence and Informatics (SAMI), 2021.
[33] M. Borghetti, E. Sardini and M. Serpellon, "Evaluation of bend sensors for limb motion monitoring," IEEE International Workshop on Medical Measurement and Applications (MEMEA), 2014.
[34] S. Broota, "Building of Inmoov Robotic Arm for Performing Various Operations," International Journal for Research in Applied Science & Engineering Technology (IJRASET), vol. 10, 2018.
[35] Kesar T.N., Pavithra G, Dr. T.C. Manjunath, "Development of Methodology for the Analysis of Kannada Movie/Film Reviews using Machine Learning utilizing the concepts of Natural Language Processing", JASC: Journal of Applied Science and Computations, ISSN NO: 1076-5131, ISO 9001:2008: Certified, JASC Approved By: UGC,NSL, NISCAIR, CSIR, Volume V, Issue XII, Indexed in indianscience.in, DOI:16.10089.JASC.2018.V5I12.453459.1500225, pp. 998-992, IF - 5.8, Paper id 140, An ISO 7021 : 2008 Certified Journal, DOI : 16.10089/JASC, UGC Approved Journal- 41238, Dec. 2018.
[36] Pallavi R. Bhat, Pavithra G, Dr. T.C. Manjunath, "Sentimental analysis, simulation & implementation of regional films using NLPs", JASC: Journal of Applied Science and Computations, ISSN NO: 1076-5131, ISO 9001:2008: Certified, JASC Approved By: UGC,NSL, NISCAIR, CSIR, Volume V, Issue XII, pp. 993-1002, IF - 5.8, Paper id 141, An ISO 7021 : 2008 Certified Journal, DOI : 16.10089/JASC, DOI:16.10089.JASC.2018.V5I12.453459.1500226,
[37] Pallavi R. Bhat, Pavithra G, Dr. T.C. Manjunath, "A review of the annotation based Natural Language Processing System using semi-supervised bootstrapping, ML approaches of Support Vector Machine (SVM) and Random Forest (RF)", JASC: Journal of Applied Science and Computations, ISSN NO: 1076-5131, DOI:16.10089.JASC.2018.V5I12.453459.1500227, ISO 9001:2008: Certified, JASC Approved By: UGC, NSL, NISCAIR, CSIR, Volume V, Issue XII, pp. 1003-1008, IF - 5.8, Paper id 142, An ISO 7021 : 2008 Certified Journal, DOI : 16.10089/JASC, UGC Approved Journal- 41238, Dec. 2018.
[38] Pavithra G., Dr. T.C.Manjunath, "A review on the flash crowd attack & its implications", Int. Journal of Research Engg. & Tech. (IJERT), Journal Paper No. IJERTCONV6IS13013, Impact Factor 7.86 (2018-19), ISSN: 2278-0181, Volume 6, Issue 13, pp. 1-3, Special Issue April 2018.
[39] Pavithra G., Dr. T.C.Manjunath, "A case study of a blue brain working on the neural networking concepts", Int. Journal of Research Engg. & Tech. (IJERT), Journal Paper No. IJERTCONV6IS13003, Impact Factor 7.86 (2018-19), ISSN: 2278-0181, Volume 6, Issue 13, pp. 1-4, Special Issue Apr. 2018.
[40] Pavithra G., Dr. T.C.Manjunath, "Design & development of nanobots for cancer cure applications in bio medical engineering", Int. Journal of Research Engg. & Tech. (IJERT), Journal Paper No. IJERTCONV6IS13024, Impact Factor 7.86 (2018-19), ISSN: 2278-0181, Volume 6, Issue 13, pp. 1-7, Special Issue April 2018.
[41] Dr. T.C. Manjunath, Rajashekher Koyyeda, Pavithra G., "Automatic Steering Mechanism Design Using Brain Networks with Hardware Implementation", IOSR Journal of Engineering (IOSR JEN), Publisher : International organization of Scientific Research (IOSR), UGC Approved Journal, IF-1.645, ISSN (e): 2250-3021, ISSN (p): 2278-8719, pp. 1-4, 2019.
[42] Dr. T.C. Manjunath, Arunkumar K.M., Pavithra G., "Smart Traffic Management System Conceptual View in a Smart City Using Computer Vision Concepts", IOSR Journal of Engineering (IOSR JEN), Publisher : International organization of Scientific Research (IOSR), UGC Approved Journal, ISSN (e): 2250-3021, ISSN (p): 2278-8719, IF-1.645, pp. 5-9, 2019.
[43] Dr. T.C. Manjunath, Satvik M. Kusagur, Pavithra G., "Design of control system for full-fledged automation of a house using CMS & SFD", IOSR Journal of Engineering (IOSR JEN), Publisher : International organization of Scientific Research (IOSR), UGC Approved Journal, Impact Factor-1.645, ISSN (e): 2250-3021, ISSN (p): 2278-8719, pp. 10-16, 2019.
[44] Dr. T.C. Manjunath, Pavithra G., Arunkumar M., "Temperature Scanning Controller Design", Journal of Emerging Technologies and Innovative Research (JETIR), (An International Open Access Journal & UGC and ISSN Approved), JETIRAB06097, Volume 6, Issue 2, UGC Journal No. 63975, ISSN-2349-5162, pp. 549-550, © 2019 JETIR Feb. 2019.
[45] Dr. T.C. Manjunath, M. Kusagur, Pavithra G., "Modelling of discrete events using Verilog language", International Journal of Emerging Technologies and Innovative Research (An International Open Access

Journal & UGC and ISSN Approved), UGC Journal No. 63975, ISSN:2349-5162, Vol. 6, Issue 3, pp. 42-43, Registration ID: 200802, WE Count our Impact Factor based on Google Scholar h-index impact factor of 2018: 5.87, March 2019.

Plagiarism Reports

DrillBit

The Report is Generated by DrillBit Plagiarism Detection Software

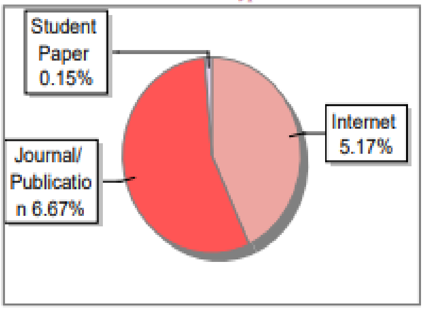
Submission Information

Author Name	maria-1
Title	maria-1
Paper/Submission ID	772937
Submission Date	2023-06-13 16:01:56
Total Pages	37
Document type	Thesis

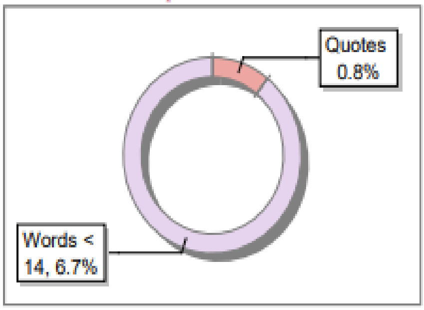
Result Information

Similarity **12 %**

Sources Type



Report Content



Exclude Information

Quotes	Not Excluded
References/Bibliography	Excluded
Sources: Less than 14 Words Similarity	Not Excluded
Excluded Source	**0 %**
Excluded Phrases	Not Excluded

A Unique QR Code use to View/Download/Share Pdf File

DrillBit

DrillBit Similarity Report

12	59	B
SIMILARITY %	MATCHED SOURCES	GRADE

A-Satisfactory (0-10%)
B-Upgrade (11-40%)
C-Poor (41-60%)
D-Unacceptable (61-100%)

LOCATION	MATCHED DOMAIN	%	SOURCE TYPE
1	www.ijert.org	1	Internet Data
2	IEEE 2015 IEEE Global Engineering Education Conference (EDUCON) - Ta	1	Publication
3	IEEE 2015 15th International Conference on Control, Automation and S by	1	Publication
4	arxiv.org	1	Publication
5	iosrjournals.org	<1	Publication
6	epdf.tips	<1	Internet Data
7	Investigating the effectiveness of speech-to-text recognition applications on le by Shadiev-2017	<1	Publication
8	www.ahasurvey.org	<1	Publication
9	www.dx.doi.org	<1	Publication
10	www.freepatentsonline.com	<1	Internet Data
11	IEEE 2017 8th IEEE International Conference on Cognitive Infocommun, by Katona, Jozsef Ujb- 2017	<1	Publication
12	erepository.uonbi.ac.ke	<1	Publication

13	moam.info	<1	Internet Data
14	www.freepatentsonline.com	<1	Internet Data
15	coek.info	<1	Internet Data
16	Digitalized Self-Powered Strain Gauge for Static and Dynamic Measurement by Su-2017	<1	Publication
17	moam.info	<1	Internet Data
18	newmexico.networkofcare.org	<1	Internet Data
19	Thesis Submitted to Shodhganga Repository	<1	Publication
20	Unambiguous position and orientation tracking using a rotating magnet by Schultze-2013	<1	Publication
21	www.longdom.org	<1	Publication
22	directory.eoportal.org	<1	Internet Data
23	dochero.tips	<1	Internet Data
24	mdpi.com	<1	Internet Data
25	africlassical.blogspot.com	<1	Internet Data
26	An analytical model and verification for MEMS Pirani gauges by Santagata-2011	<1	Publication
27	A Decoding Scheme for Incomplete Motor Imagery EEG With Deep Belief Network by Chu-2018	<1	Publication
28	moam.info	<1	Internet Data
29	Simple wavelength monitor for a scanning spectrometer by Rhinewine-1975	<1	Publication

30	Submitted to Visvesvaraya Technological University, Belagavi	<1	Student Paper
31	bmcgastroenterol.biomedcentral.com	<1	Internet Data
32	Division of labor among gay fathers Associations with parent, couple, and child by Tornello-2015	<1	Publication
33	Thesis Submitted to Shodhganga Repository	<1	Publication
34	cpncampus.com	<1	Publication
35	docplayer.net	<1	Internet Data
36	ejournal.undip.ac.id	<1	Publication
37	How Does Social Support Relieve Depression Among Flood Victims The Contribution by Zhen-2018	<1	Publication
38	qdoc.tips	<1	Internet Data
39	Synaptic control of hindlimb motoneurones during three forms of the fictive scra by Robertson-1988	<1	Publication
40	www.ijpsonline.com	<1	Internet Data
41	www.network.bepress.com	<1	Publication
42	IEEE 2017 International Conference on Computer Science and Engineer, by Yildirim, Nilay Va- 2017	<1	Publication
43	arxiv.org	<1	Internet Data
44	avxlive.icu	<1	Internet Data
45	A novel approach for automated detection of focal EEG signals using em by Bhattacharyya-2016	<1	Publication
46	climateimpactnews.com	<1	Internet Data

47	docplayer.net	<1	Internet Data
48	ijarsct.co.in	<1	Publication
49	ijircce.com	<1	Publication
50	ijircce.com	<1	Publication
51	inba.info	<1	Internet Data
52	moam.info	<1	Internet Data
53	moam.info	<1	Internet Data
54	phpmyadmin.sss-solutions.org	<1	Internet Data
55	Recent Trends in Deep Learning Based Open-Domain Textual Question Answering Syst by Huang-2020	<1	Publication
56	riverside.networkofcare.org	<1	Internet Data
57	vdocuments.mx	<1	Internet Data
58	www.ajol.info	<1	Publication
59	www.researchgate.net	<1	Internet Data

CO PO Mapping Justification

Course Outcomes:

COs	PROJECT WORK
CO1	Demonstrate proficient knowledge on the concepts involved.
CO2	Identify the problem and propose the possible solution through literature survey.
CO3	Design and develop engineering solutions to complex problems through systematic approach.
CO4	Build prototype/simulation for the proposed solution and articulate the work
CO5	Provide sustainable solutions considering societal needs by exhibiting individual and cooperative learning.
CO6	Complete the proclaimed work within stipulated time span with financial constraints.

Units	Delivery Method	Assessmen tMethod	CO Attainment	Evaluation Mode
Selection Phase	PPT / Synopsis	Q&A – Oral-Evaluation by Domain experts	C01 – CO6	Internal Exam
Project Phase-1	PPT / Report	Q&A – Oral-Evaluation by Domain experts	C01 – CO6	Internal Exam
Project Phase-2	PPT/ Report	Q&A – Oral-Evaluation by Domain experts	C01 – CO6	Internal Exam
Project Phase-3	PPT/ Report	Q&A – Oral-Evaluation by Domain experts	C01 – CO6	Internal Exam

Mapping of Course Outcomes to Program Outcomes and Program Specific Outcomes:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	3	1	1	2	2	2	1	1	2	2
CO2	2	2	2	2	2	1	2	2	3	3	2	1	3	3
CO3	2	1	2	2	3	2	1	2	2	1	2	2	2	2
CO4	2	2	2	1	2	2	1	1	3	3	1	2	2	1
CO5	1	2	2	3	2	1	1	1	2	2	2	1	2	1
CO6	3	3	2	3	3	1	2	2	3	3	2	1	3	2
CO AVG	2	2	2	2.1	2.5	1.3	1.3	1.6	2.5	2.3	1.6	1.3	2.3	1.8

***High=3, Medium=2, Low=1**

Justification

CO1	We thoroughly understand the concepts related to our project like designing the hand, voice recognition, gesture recognition, AI etc.,
CO2	We actually have to learn and work on sensitive hardware tools like Brainsense headset.
CO3	The project we carry out, would actually tackles the complex problems of like arm amputees.
CO4	Since we are working on a prosthetic hand, the prototype for us would be the simulation in which the functionality is understood
CO5	Since many people are in need of modern prosthesis, we would design an intellectual and user-friendly prosthetic hand.
CO6	We make sure that, we would achieve the objectives in the stipulated time and thus achieve the best results in a cost-effective way.

Project Title		Design and Implementation of Smart Prosthetic Hand using Artificial Intelligence
PO	**Levels 3/2/1**	**Justification**
PO1	2	We shall apply various concepts in the field of AI and Robotics to arrive at a design of Smart Prosthetic Arm.
PO2	2	Identifying the various issues that need to be tackled during project implementation withthe help of relevant literature survey.
PO3	2	Carrying out a thorough literature survey to arrive at a suitable solution for the problemfaced by amputees in hand and people who lost their hands in war.
PO4	2	Using research-based knowledge several approaches will be analyzed to simulate and rectifythe problem.
PO5	3	This project will make use of simulation tool like Arduino IDE to exhibit the proposeddesign.
PO6	1	We are applying engineering practices to design Smart Prosthetic Arm for the handamputees to become independent.
PO7	2	Study of various Brain signals called Electroencephalography to adapt non-invasivemethods.
PO8	2	We are committed to the professional ethics and responsibilities during project work.
PO9	3	Functioned effectively as a team by dividing the work among the team members andimplemented some modification due to team work.
PO10	3	Our communication skills are improved by presenting the project and preparing report.
PO11	2	We are learning about the various stages involved in project management to meet thenecessary requirements
PO12	1	By laying the foundation to learn more concepts involving the design using latest AIRobotics techniques.
PSO1	2	This project proposes a design of Smart Prosthetic Arm for the Hand amputees to becomeindependent.
PSO2	2	We shall design a Smart Prosthetic Hand, verify the design by various EEG signals capturedfrom brain.

Budget Estimation Details

Batch Number: R-02

USN	Name
1DS19EC060	Kavyanjali R
1DS19EC080	Mo Imran
1DS19EC085	Nalliboyina Yuva Raja Phani Kumar
1DS20EC420	Maria Dayana L N

Guide Name: Dr. T. C. Manjunath

Sl. No.	Particulars	Estimated Cost in Rs.
1	Robotic Hand	3,500
2	Brainsense Headset	12,000
3	Arduino Mega	3,000
4	HC-05 Bluetooth Module	500
5	Servo Motors	3,000
6	Jumper Wires	200
7	Flex Sensors	2,000
8	Node MCU	300
9	Relay	350
10	Power Supply Module	600
11	DC Motor, Buzzer & LED	250
	Total	25,700