SIGN RECOGNITION SMART GLOVE FOR DEAF AND MUTE PEOPLE

A PROJECT REPORT

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in partial fulfillment for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

AMRITA SCHOOL OF ENGINEERING, BANGALORE

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January-2024

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BONAFIDE CERTIFICATE

This is to certify that the project report entitled **"SIGN RECOGNITION SMART GLOVE FOR DEAF AND MUTE PEOPLE"** submitted by

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in partial fulfilment of the requirements for the award of the **Degree Bachelor of Technology** in **"ELECTRONICS AND COMMUNICATION ENGINEERING"** is a bonafide record of the work carried out under my guidance and supervision at Amrita School of Engineering, Bangalore.

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EXAMINER 1 EXAMINER 2

ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without mentioning the people whose constant guidance and encouragement made it possible. We take pleasure in presenting before you our project, which is the result of a studied blend of both research and knowledge.

We express our earnest gratitude to our internal guide, Assistant Professor Sarda Sharma, Department of ECE, for her unwavering support, encouragement, and invaluable guidance. Her cooperation and insightful suggestions have been instrumental in shaping the trajectory of our project.

In addition, we extend our gratitude to the entire faculty of the Department of Electronics and Communication Engineering for fostering an environment conducive to learning and research. Their commitment to academic excellence has been a driving force behind our endeavours.

In addition to expressing our gratitude to the faculty and staff, we would also like to acknowledge the visionary leadership of our Mata Amritanandamayi, the Chancellor of our College Amrita School of Engineering. Her unwavering commitment to education and holistic development has been a guiding light for the entire academic community. We are grateful for her vision and leadership, which have significantly contributed to our educational journey.

ABSTRACT

This study focuses on the development of a Sign Recognition Smart Glove tailored to assist individuals who are deaf and mute. The smart glove incorporates advanced sensor technologies and Embedded C algorithms to interpret and translate gestures into text or speech in real-time. The primary objective is to provide a seamless communication bridge between the deaf and mute community and the general populace, thereby fostering inclusivity and accessibility. The research methodology involves the integration of flex sensors, microcontrollers, and Bluetooth modules within the glove to capture and analyze hand movements and gestures. These data are then processed through a microcontroller unit, which recognizes and interprets the gestures accurately.

The Sign Recognition Smart Glove is designed to be user-friendly, lightweight, and non-intrusive, facilitating ease of use for individuals with varying dexterity. Furthermore, the system aims to be adaptable to different regional sign languages, making it inclusive for a global user base. The study also addresses the ethical considerations and user acceptance through field trials and user feedback, ensuring that the smart glove aligns with the cultural and social needs of the target user group. The potential impact of the Sign Recognition Smart Glove extends beyond individual users to educational institutions, public service sectors, and social interactions, fostering greater integration and understanding for the deaf and mute community.

Overall, this research contributes to the advancement of assistive technologies by leveraging modern sensor and machine learning technologies to create a practical and empowering tool for individuals with hearing and speech impairments.

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CHAPTER-1

INTRODUCTION

Developing a Sign Recognition Smart Glove for the Deaf and Mute community represents a significant leap in the realm of assistive technologies. This innovation seeks to address the communication barriers faced by individuals who rely on sign language as their primary mode of communication, aiming to bridge the gap between the deaf and mute community and the general populace. By leveraging cutting-edge sensor technologies and machine learning algorithms, this smart glove endeavours to interpret and translate gestures into comprehensible text or speech in real-time. The implications of this technology are far-reaching, as it not only aims to facilitate seamless communication but also to promote inclusivity and accessibility for individuals with hearing and speech impairments.

The introduction of this research delves into the multifaceted nature of the challenges faced by the deaf and mute community, emphasizing the need for innovative solutions that can enhance their ability to interact with the world around them. Through a comprehensive exploration of the current landscape of assistive technologies, the introduction sets the stage for the emergence of the Sign Recognition Smart Glove as a pioneering advancement in the field. It underscores the transformative potential of this technology, shedding light on its capacity to revolutionize the daily lives of individuals who navigate a world predominantly designed for those with typical hearing and speech capabilities.

Moreover, the introduction delves into the technical underpinnings of the smart glove, elucidating the integration of flex sensors, microcontrollers, and resistors to capture and interpret intricate hand movements and gestures. It underscores the sophisticated Embedded C models employed to recognize and decipher gestures accurately, emphasizing the real-time nature of the translation process. The introduction also highlights the user-centric design principles that underpin the smart glove, emphasizing its user-friendly, lightweight, and non-intrusive nature, ensuring accessibility for individuals with varying dexterity and comfort preferences.

In addition, the introduction delves into the global relevance of the Sign Recognition Smart Glove, addressing its adaptability to different regional sign languages, thereby catering to a diverse user base. It also underscores the ethical considerations and user acceptance aspects, emphasizing the importance of aligning the technology with the cultural and social needs of the target user group. This comprehensive introduction sets the stage for the research's overarching goals, emphasizing its potential impact on individual users, educational institutions, public service sectors, and social interactions, ultimately fostering greater integration and understanding for the deaf and mute community.

In summation, the introduction provides a thorough exploration of the rationale, technical foundations, and societal implications of the Sign Recognition Smart Glove. It serves as a compelling prelude to the research, framing the innovative technology within the broader context of assistive technologies and the pressing need for enhanced inclusivity and accessibility for individuals with hearing and speech impairments.

MOTIVATION

The motivation behind the Sign Recognition Smart Glove Project for Deaf and Dumb People is rooted in the desire to address the unique challenges faced by individuals who are deaf and mute, and their ability to communicate and express themselves. Several key factors drive the motivation for this project:

1. **Communication Accessibility**:

   Deaf and mute individuals often face significant barriers to effective communication with the hearing and speaking world. Traditional methods, such as writing or using basic communication devices, can be slow and cumbersome, making real-time, nuanced conversations difficult. The motivation is to provide a more efficient and accessible means of communication to enhance their daily interactions.

2. **Social Inclusion**:

   The inability to communicate effectively can lead to social isolation. Deaf and mute individuals may feel excluded from conversations, educational opportunities, and social events. The project's motivation is to foster social inclusion, helping them connect with others more easily, engage in conversations, and participate in various social activities.

3. **Inclusivity and Equality**:

   The project is motivated by a commitment to inclusivity and equality. It seeks to level the playing field by providing a communication tool that allows deaf and mute individuals to interact with the world on an equal footing with hearing and speaking individuals. The goal is to ensure that everyone, regardless of their abilities, has the opportunity to participate in society fully.

4. **Independence**:

   By enabling deaf and mute individuals to communicate independently, the project promotes self-reliance. It allows them to make choices, seek help when needed, and express themselves more freely in everyday situations. This motivation aligns with the broader goal of empowering individuals with disabilities to lead fulfilling lives.

5. **Technological Innovation**:

   Technology has the potential to revolutionize the lives of individuals with disabilities. The motivation behind this project is to harness the power of cutting-edge technology to create a wearable device that can make a significant impact on the lives of deaf and mute individuals. It showcases the potential of innovation in addressing pressing societal challenges.

6. **Empowerment**:

   The project's ultimate motivation is to empower deaf and mute individuals by giving them a tool that enables them to express themselves and be understood. This empowerment leads to increased confidence and a higher quality of life.

7. **Global Research**:

   The project has the potential for a broad impact, addressing communication barriers on a global scale. This makes it relevant and beneficial for diverse communities worldwide.

In summary, the motivation for developing a sign recognition smart glove is rooted in the principles of inclusivity, accessibility, and leveraging technology to empower individuals with hearing and speech impairments in their daily lives.

OBJECTIVES

- To develop a wearable sign language translation device.
- To enhance communication accessibility.

SUB-OBJECTIVES

- To create a lightweight and comfortable smart glove with integrated sensors and microcontrollers.
- To implement Embedded C codes for recognizing a wide range of sign language gestures.
- To enable real-time, efficient communication for deaf and mute people.
- To reduce isolation and enhance participation in educational and social activities.
- To promote technological innovation and empowerment.
- To inspire further research and development in assistive technology for individuals with disabilities.

CHAPTER-2

LITERATURE SURVEY

Paper1 Title:

B. G. Lee and S. M. Lee, "Smart Wearable Hand Device for Sign Language Interpretation System With Sensors Fusion," in IEEE Sensors Journal, vol. 18, no. 3, pp. 1224-1232, 1 Feb.1, 2018, doi: 10.1109/JSEN.2017.2779466.

Objectives:

- To detail the design process and the development of the smart wearable hand device, including the integration of sensors, the choice of materials, and the selection of a suitable microcontroller.
- To investigate and discuss the techniques used for sensor fusion, combining data from inertial measurement units (IMUs), flex sensors, pressure sensors, etc., to provide a more accurate representation of sign language gestures.
- To develop and evaluate a robust sign language interpretation algorithm, exploring machine learning or deep learning techniques to accurately recognize and interpret a variety of sign language gestures.
- To describe the user interface design, whether on the wearable device or a companion app and the incorporation of feedback mechanisms, such as haptic feedback, to enhance user experience.
- To Investigate the wireless communication module's role and functionality, detailing how the wearable device transmits data to external devices like computers or smartphones for further processing or display.
- To Discuss the potential impact of the technology on improving accessibility and inclusivity for individuals with hearing impairments, addressing social and communication challenges.

Methodology used:

Requirement Analysis:

- Clearly define the requirements of the smart wearable hand device.
- This involves understanding the involvement of specific needs of users who rely on sign language, considering the variety of gestures cultural aspects, and the real-world environment in which the device will be used.

Sensor Collection and Calibration:

- Implement and evaluate different sensor fusion techniques.
- This includes methods such as Kalman filtering, sensor fusion algorithms, or neural network architectures for combining data from multiple sensors to obtain a more accurate representation of hand movements.

Sign Language Dataset Collection:

- Collect a diverse dataset of sign language gestures, ensuring the representation of different signs, variations, and cultural nuances.
- This dataset will be used for training and evaluating the sign language interpretation algorithm.

Machine Learning Development:

- Develop a machine learning model for sign language interpretation.
- This may involve training the model on the collected dataset to recognize and interpret a wide range of sign language gestures.

User Interface Design and Evaluation:

- Design a user-friendly interface either on a wearable device or a companion app, to visualize interpreted signs.
- Evaluate the usability and effectiveness of the interface through user testing and feedback.

Wireless Communication Module Implementation:

- Integrate a wireless communication module and establish a communication protocol for transmitting data from the wearable device to external devices, such as computers or smartphones.

Haptic Feedback System Implementation:

- Implement a haptic feedback system to provide real-time feedback to users about the accuracy of their signs or to notify them of interpreted signs. Evaluate the effectiveness of the feedback system through user testing

Performance Evaluation and Testing:

- Conduct thorough performance evaluations of the overall system, including accuracy in gesture recognition, response time, and power efficiency.
- Test the system with individuals proficient in sign language to assess its practical utility and user satisfaction.

Comparison with Existing Solutions:

- Compare the developed system with existing technologies or solutions, highlighting its advantages, limitations, and potential improvements.
- Test the system's adaptability to different sign language dialects or regional variations to ensure cultural sensitivity.

The research paper aims to provide a thorough and well-rounded exploration of the development and implementation of the smart wearable hand device for sign language interpretation.

Results:

Structure:

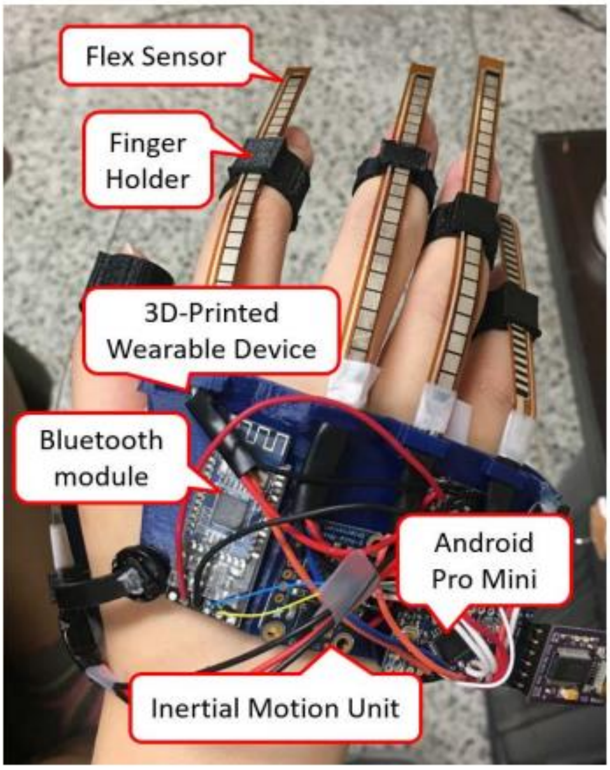
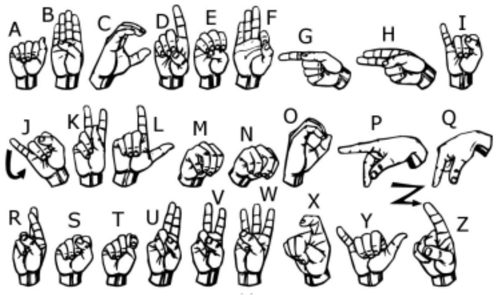


Fig 2.1: 3D-printed wearable device

Fig 2.2: 3D printed finger holder using flexible filament that can accommodate different finger sizes, providing flexibility

Alphabets interpretation:



Sensor Plots:

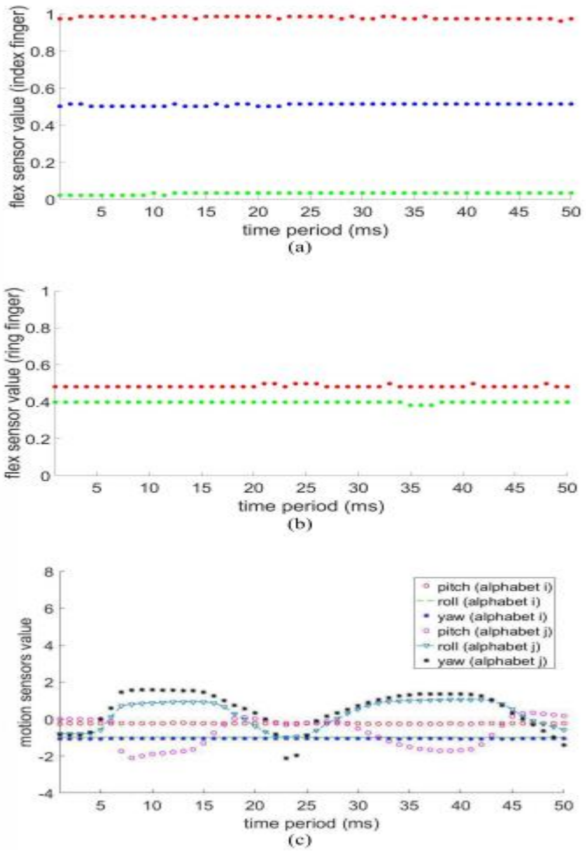


Fig 2.3: The sensor values of (a) index finger for the alphabet 'A' in red, 'B' in green and 'C' in blue, and sensor values of (b) ring finger for the alphabet 'M' in green and 'N' in red. (c) The plotting of hand motion sensor data for the alphabet 'I' and alphabet 'J'.

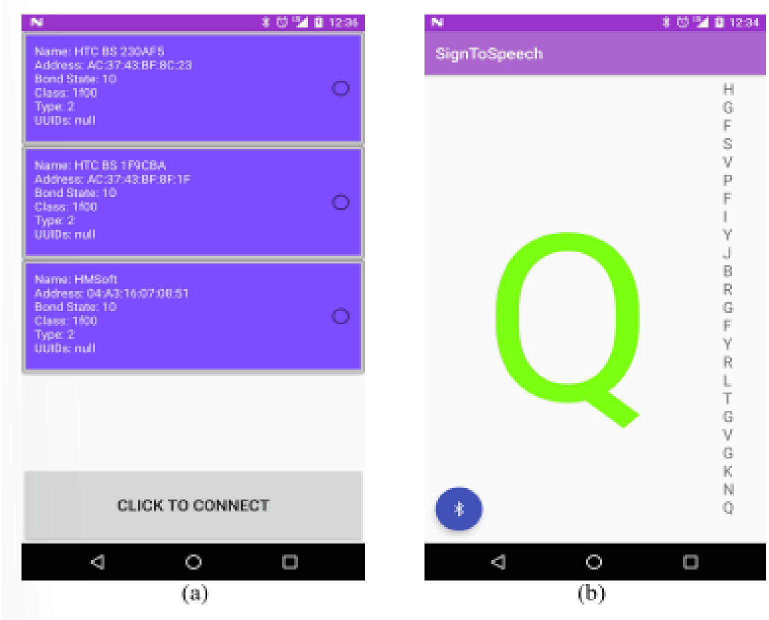


Fig 2.4: Sign interpretation system showing (a) Bluetooth search screen and (b) text received from the proposed wearable device through a Bluetooth connection.

The system incorporates flex sensors, pressure sensors, and an inertial motion sensor to capture hand movements and gestures. The sensor data is processed using a support vector machine (SVM) classifier to recognize the ASL alphabet. The study involved 12 subjects performing sign gestures, and the results showed that the addition of pressure sensors significantly improved the accuracy of sign recognition. The accuracy rate for sign recognition increased dramatically for the alphabet "R," "U," and "V" when pressure sensor data was included. The study also compared the proposed system with previous methods, demonstrating its superior accuracy in sign recognition.

The system achieved a true sign language recognition accuracy rate of 65.7% in the first version, which increased to 98.2% with the addition of pressure sensors. The study also discussed challenges related to differentiating similar signs and the impact of hand size on sensor readings.

The system outperformed existing vision-based methods and demonstrated higher accuracy in sign recognition. The paper also presents the design and implementation of an Android-based mobile application for receiving and displaying the classified sign gestures from the smart wearable device.

Conclusion:

In conclusion, it has highlighted the potential of the proposed smart wearable hand device for sign language interpretation, emphasizing its comfort, flexibility, and portability. Future work on the device will consider the design of a smaller-sized printed circuit board, the inclusion of words and sentences at the sign language level, and instantly audible voice output components.

Hence, the study successfully developed a novel smart wearable hand device for sign language interpretation, demonstrating high accuracy in sign recognition and outperforming existing methods. The proposed system, along with the mobile application, offers a promising solution for facilitating communication for individuals using sign language.

Paper2 Title:

Multipurpose Smart Glove for Deaf and Dumb People

Objectives:

- Develop a Multipurpose Smart Glove for Deaf and Dumb people to bridge the communication gap between them and the normal population.
- Address the challenges faced by the deaf and dumb community due to their disabilities, hindering effective communication with the general population.
- Utilize a transmitter section and a receiver section in the proposed system, incorporating hardware components such as flex sensors, microcontrollers, RF transmitters and receivers, and a voice module.
- Use MPLAB IDE for programming, code upload into the microcontroller, and error correction.
- Recognize hand gestures using flex sensors and produce corresponding voice output.
- Enhance communication between the deaf, dumb, blind, and normal people, and potentially operate home appliances using gestures.
- Provide a comprehensive and effective communication tool for the disabled community, thereby enhancing their integration and interaction with the general population.

Methodology used:

Needs Assessment and Requirements Analysis:

- Conduct a thorough needs assessment to understand the specific communication and daily life challenges faced by deaf and mute individuals.
- Gather input from potential users, caregivers, and relevant stakeholders to identify key requirements for the smart glove.

Literature Review:

- Review existing literature on assistive technologies for individuals with hearing and speech impairments.
- Identify state-of-the-art technologies, methodologies, and challenges related to smart gloves and communication devices.

Conceptualisation and Design:

- Develop a conceptual framework for the smart glove, considering the identified needs and requirements.
- Create detailed design specifications, including the types of sensors, communication modules, and features to be incorporated.

Sensor Integration:

- Select and integrate appropriate sensors (accelerometers, gyroscopes, flex sensors, pressure sensors) onto the glove to capture hand movements and gestures accurately.
- Calibrate and test the sensors to ensure reliable data collection.

Communication Module Integration:

- Integrate wireless communication modules (Bluetooth, Wi-Fi) to establish connectivity with external devices.
- Develop protocols for communication between the smart glove and companion devices.

Speech-to-Text and Text-to-Speech Implementation:

- Implement speech-to-text and text-to-speech technologies to facilitate communication.
- Choose suitable algorithms or APIs for accurate and efficient language processing.

Touch-sensitive Panels Integration:

- Integrate touch-sensitive panels on the glove for additional input capabilities.
- Develop algorithms for touch-based interactions and gestures.

Results:

Fig 2.5: Hardware Implementation of the system

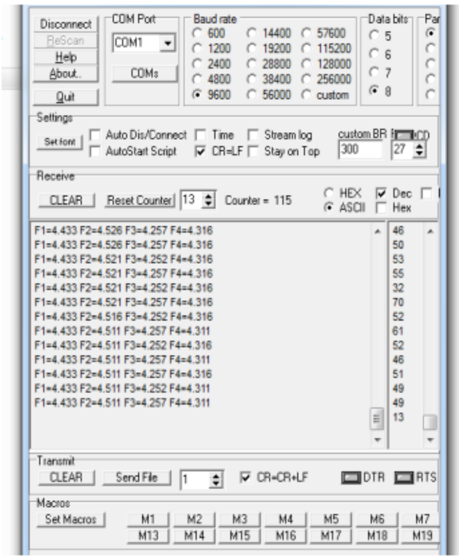


Fig 2.6: Software details

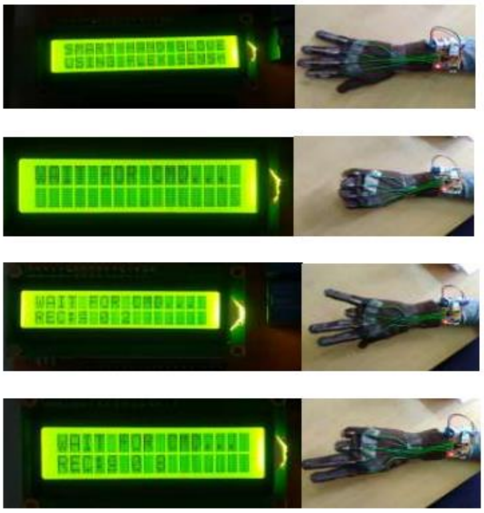


Fig 2.7: Display output

In this proposed system, the user forms a gesture and holds it approximately for 3 seconds to ensure proper recognition. Each gesture comprises of bending of all sensors in certain angles accordingly. Every bend of the finger produces a unique ADC value so that when different hand gestures are made, different ADC values are produced accordingly. Taking such ADC values for 4 different users, a table of average ADC values for each sensor is maintained where F1, F2, and F3, represent the little finger, the ring finger, the middle finger and the index finger respectively. Table 1 shows the gestures and corresponding words voiced out. The hand gestures taken in the prototype can be easily modified using the concept of ADC count according to the user's convenience. At the same time, the voice output can be changed easily by recording to give flexibility in a change of language

according to different regions.

Commands	Voice and Text
Command 1	Light ON
Command 2	Fan ON
Command 3	Bring me a glass of water
Command 4	I am hungry
Command 5	Thank you

Conclusion:

This project is useful for dumb, deaf and blind people to communicate with one another and with normal people. The dumb people use their specific standard sign language which is not easily understandable by any common people and blind people cannot see their gestures. This proposed system converts the sign language is translated into some text from also, to facilitate the deaf and dumb as well. This text is displayed on LCD. To improve and facilitate more gesture recognition, we can accommodate several other gestures as well for better and more efficient communication. It is also useful in operating home appliances by using gestures.

Paper3 Title:

Two-way sign language communication using smart glove

Objectives:

- Design and implement a smart glove system that enables two-way communication in sign language. This involves creating a wearable device for both sending and receiving sign language gestures.
- Enable real-time interpretation of sign language gestures, ensuring minimal latency and a seamless communication experience for users.
- Incorporate wireless communication capabilities to facilitate communication between two smart gloves. This can be achieved using Bluetooth or other wireless technologies to ensure mobility and flexibility in communication scenarios.
- Assess the scalability of the system to accommodate a larger user base and its generalizability across different communication scenarios, including educational, professional, and social contexts.

Methodology:

- The study aims to develop a cost-effective system using smart gloves to enable two-way communication for individuals with disabilities, specifically the deaf and dumb.
- The proposed system utilizes flex sensors on a smart glove to capture hand and finger gestures, which are then converted into text and speech using a microcontroller and a Bluetooth module.
- The system comprises three main modules: sensor module, processing module, and application module, each serving a specific function in capturing, processing, and converting gestures into voice and text.
- The sensor module includes flex sensors on the fingers to capture gestures, while the processing module involves a microcontroller to digitize the signals from the sensors.
- The application module facilitates the conversion of recognized gestures into text and voice, enabling two-way communication.
- The system also incorporates a Bluetooth transceiver for wireless transmission and reception of signals, making it more convenient for disabled individuals to use.
- The study emphasizes the potential impact of the proposed system in facilitating communication for deaf-dumb individuals, enabling them to participate more actively in society, including employment opportunities.
- The document also discusses the potential for home automation using smart gloves, allowing the control of devices such as lights and fans through gesture recognition and voice commands.

Results:

The study successfully designed and implemented a two-way sign language communication system using smart gloves. The system aims to bridge the communication gap between individuals with disabilities, particularly the deaf and dumb, and the general population. By converting sign language into text and speech, the system enables communication between these two communities, eliminating communication barriers. The smart gloves, equipped with flex sensors, allow deaf and dumb individuals to convert their sign language into speech, facilitating interaction with others and enabling them to lead a more normal life. Additionally, the system supports home automation, allowing control of devices such as lights and fans through gesture recognition and voice commands. Despite the progress achieved, the paper acknowledges the need for further improvements for practical implementation and suggests the potential use of nanotechnology to make the device more compact for users in the future.

The system's design incorporates three main modules: the sensor module, the processing module, and the application module. The sensor module includes flex sensors on the fingers to capture gestures, while the processing module involves a microcontroller to digitize the signals from the sensors. The application module facilitates the conversion of recognized gestures into text and voice, enabling two-way communication. The system also incorporates a Bluetooth transceiver for wireless transmission and reception of signals, making it more convenient for disabled individuals to use.

Conclusion:

The conclusion of the paper highlights the successful design and implementation of a two-way sign language communication system using smart gloves. The system aims to bridge the communication gap between individuals with disabilities, particularly the deaf and dumb, and the general population. By converting sign language into text and speech, the system enables communication between these two communities, eliminating communication barriers. The smart gloves, equipped with flex sensors, allow deaf and dumb individuals to convert their sign language into speech, facilitating interaction with others and enabling them to lead a more normal life. Additionally, the system supports home automation, allowing control of devices such as lights and fans through gesture recognition and voice commands. Despite the progress achieved, the paper acknowledges the need for further improvements for practical implementation and suggests the potential use of nanotechnology to make the device more compact for users in the future. The study emphasizes the potential impact of the proposed system in facilitating communication for deaf-dumb individuals, enabling them to participate more actively in society, including employment opportunities.

CHAPTER-3

DESIGN

Developing a Sign Recognition Smart Glove for hearing and speech-impaired individuals involves a systematic approach that encompasses design, data collection, training and testing. Here is the step-by-step methodology for creating such a model:

- Problem Definition: Clearly define the problem the smart glove aims to address, including its primary goals, such as sign language recognition, and any additional features or objectives, like real-time communication output.

- User-Centric Design: Collect user feedback on their needs, preferences, and requirements for the smart glove's design and functionality.

- Glove Design and Sensor Integration: Design a comfortable, lightweight glove to accommodate the necessary sensors and components. Integrate sensors, such as flex sensors into the glove.

- Microcontroller and Circuitry: Select a suitable microcontroller for processing sensor data and controlling the various functions of the glove. Design the circuitry to ensure efficient power management and data flow between components.

- Data Collection and Sensor Calibration: Collect data from the integrated sensors during different sign language gestures to create a dataset. Implement calibration procedures to adjust the sensors for the specific user's hand and movements.

- Data Preprocessing: Filter and preprocess the sensor data to remove noise and ensure data accuracy. Convert analogue data to digital format for further processing.

- Feature Extraction: Extract relevant features from the sensor data to describe the characteristics of sign language gestures. Features may include angles of finger joints, hand orientation, and movement speed.

- Model Training: Train the model on a diverse dataset of sign language gestures. Use labelled data to teach the system how to classify signs accurately. Implement techniques for model validation and optimization.

- Real-time Sign Language Recognition: Implement the trained model into the smart glove's software. Develop algorithms to recognise sign language gestures in real time based on sensor data.

- User Interface and Communication Output: Design a user-friendly interface for the glove, which allows users to choose between visual (e.g., text display) and auditory (e.g., speech output) communication.

- Testing and User Feedback: Conduct extensive testing of the smart glove's functionality and accuracy in recognizing sign language. Involve users in usability testing to gather feedback on their experiences and the glove's performance.

Choice of Material:

In this project, we are concentrating on preparing a glove that interprets gestures into texts and audio on smart phone. For this, we require flex sensors, Arduino NANO, resistors, a capacitor, a Printed Circuit Board, a Bluetooth module and a 9V battery. We are mainly focusing on the degree of bending of flex sensors to get accurate values. A diode, capacitor and battery are connected and act as a power supply to the microcontroller.

Flex Sensors:

Flex sensors are devices that change their resistance in response to bending or flexing. They are commonly used to measure the degree of bending or deformation in a physical structure. In the context of a smart glove for sign language interpretation or similar applications, flex sensors can be utilized to detect the bending or movement of fingers, providing valuable data for interpreting sign language gestures.

- **Mechanism:**

Flex sensors are typically made of a flexible substrate material that changes its resistance when bent. The most common material used is a mixture of carbon particles in a flexible substrate. As the sensor bends, the distance between the carbon particles changes, affecting the electrical resistance of the sensor. When straight, the resistance is higher, and as the sensor bends, the resistance decreases.

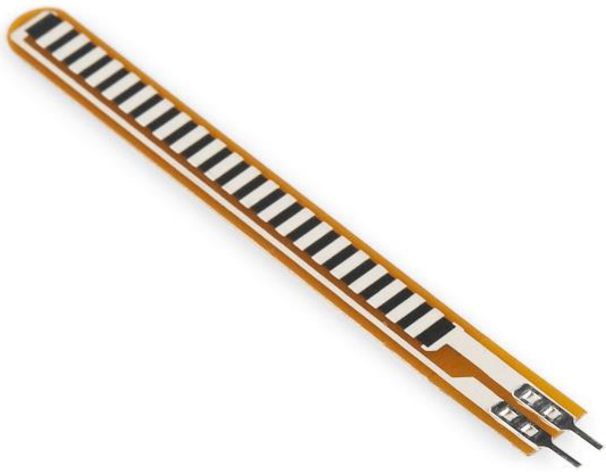


Fig 3.1: Flex sensor

- **Applications in Smart Glove:**

Flex sensors can be strategically placed along the fingers of a smart glove to detect the bending and movement of each finger independently.

The data from flex sensors help in recognizing specific hand gestures and positions associated with sign language, contributing to accurate interpretation algorithms.

- **Integration with other sensors:**

Flex sensors are often combined with IMUs (accelerometers and gyroscopes) for a more comprehensive understanding of hand movements and gestures.

Integrating data from multiple sensors, including flex sensors, allows for more accurate and robust gesture recognition.

- **Challenges:**

  Depending on the material and construction, flex sensors may face wear and tear over time, especially if they are subject to frequent bending.

  Proper calibration is crucial to ensure accurate readings, as the relationship between the degree of bending and resistance might vary between sensors.

- **Advantages:**

  Flex sensors are lightweight and flexible, making them suitable for wearable applications like smart gloves.

  They are relatively cost-effective compared to some other sensors used for similar applications.

Arduino NANO:

The Arduino Nano is a compact and versatile microcontroller board based on the ATmega328P microcontroller.

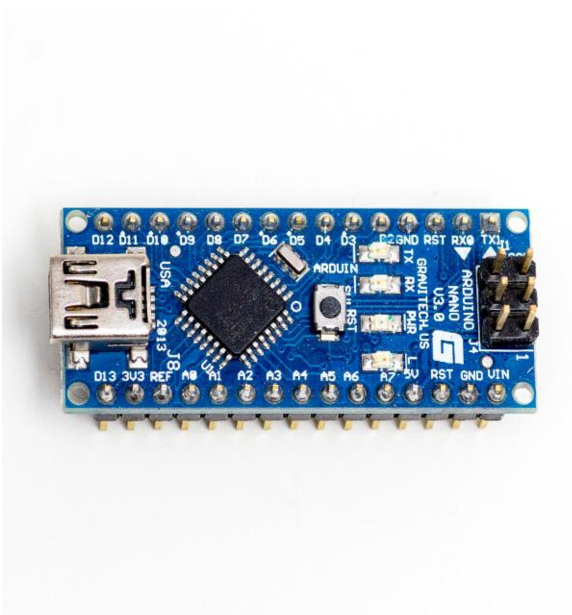


Fig 3.2: Arduino NANO

- **Key features:**
    1. Clock Speed
    2. Flash Memory
    3. SRAM and EEPROM
    4. Size
    5. Programming
    6. Operating Voltage
    7. Voltage
- **Pin Configuration:**
    1. **Digital Pins(D2-D13):** Used for digital input or output operations.
    2. **Analog Pins(A0-A7):** Allow analogue signals to be read.
    3. **Power Pins(5V,3.3V,GND):**Provide power to connected components.
    4. **PWM Pins(D3,D5,D6D9,D10,D11):** Support analog output using pulse-width modulation.
    5. **Serial Communication Pins(RX,TX):**Used for serial communication with other devices.
- **Applications:**
    1. Prototyping: Rapid prototyping of electronic projects.
    2. Embedded Systems: Building embedded systems and gadgets.
    3. Education: Learning and teaching electronics and programming.
- **Variants:**

  There are different versions and clones of the Arduino Nano available in the market, some with enhanced features or different form factors.

The Arduino Nano is a popular choice for projects where space is a critical factor, and its compatibility with the Arduino ecosystem makes it a versatile tool for hobbyists, students, and professionals alike.

Flowchart:

Glove model’s schematic diagram

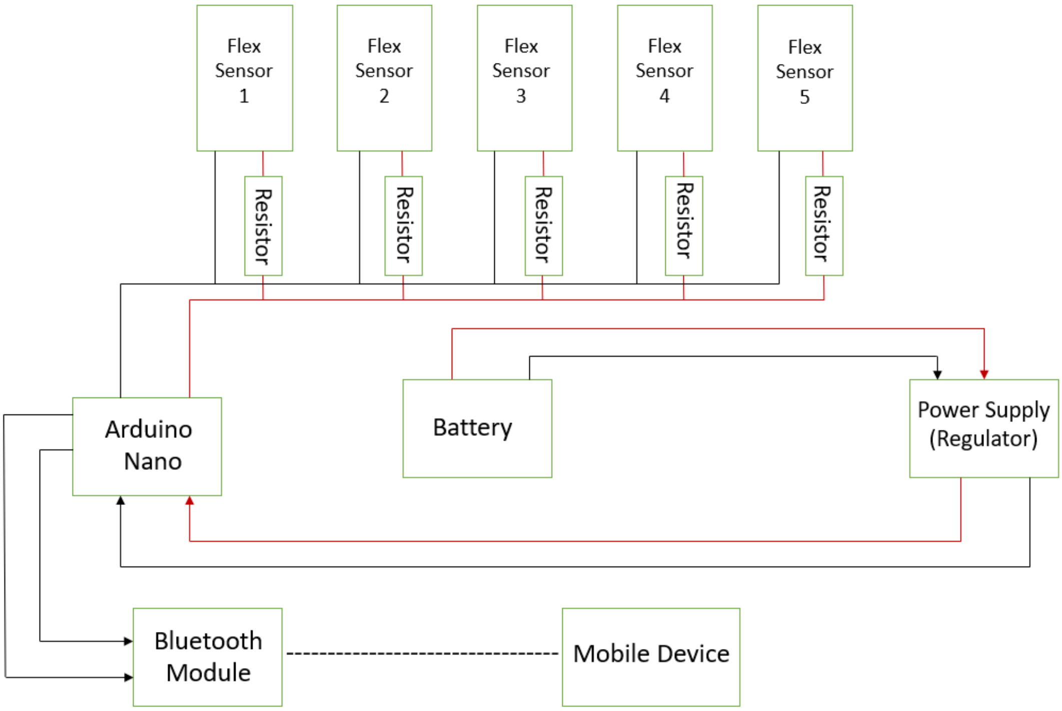


Fig 3.3: Schematic Diagram

Circuit Design:

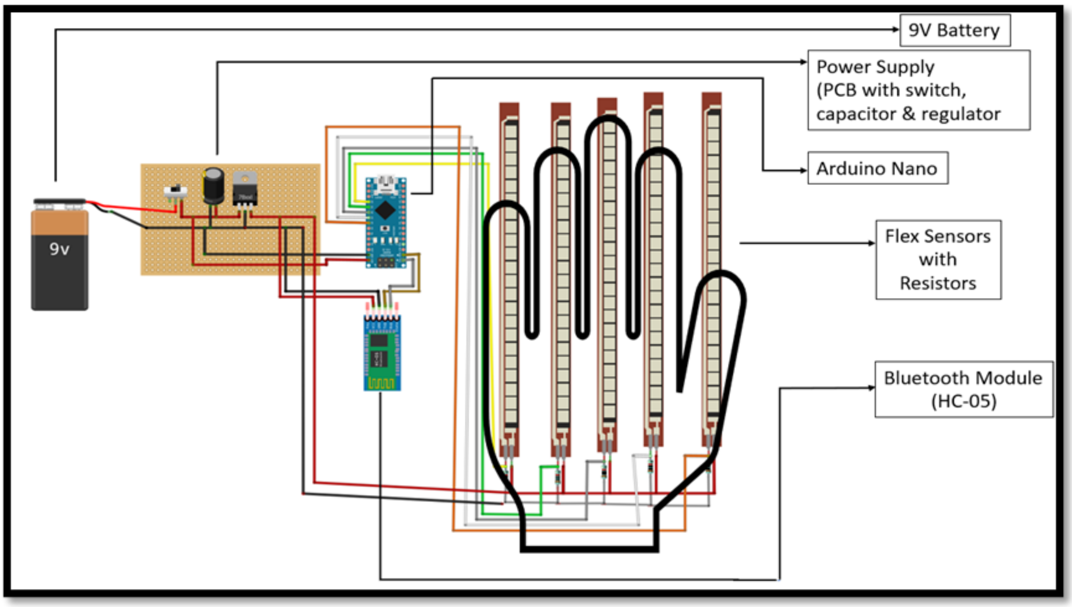


Fig 3.4: Circuit diagram

<u>Components:</u> Two 9V Batteries, Arduino NANO, Bluetooth module, Flex Sensors, Regulator, Resistors.

The circuitry of the smart glove includes 5 flex sensors, One 9V battery, Arduino NANO,

Bluetooth Module, Regulator and Resistors.

- Flex sensors are attached to each finger to detect finger movement and bending.
- Microcontroller collects the data from the flex and motion sensors, preprocesses it, and sends it to software for further analysis.
- Battery provides the necessary power for the smart glove to function.
- The recognized gesture is displayed on the screen or is voiced through the speaker. Bluetooth is used for the communication between the Arduino and the device used.

Mathematical Analysis:

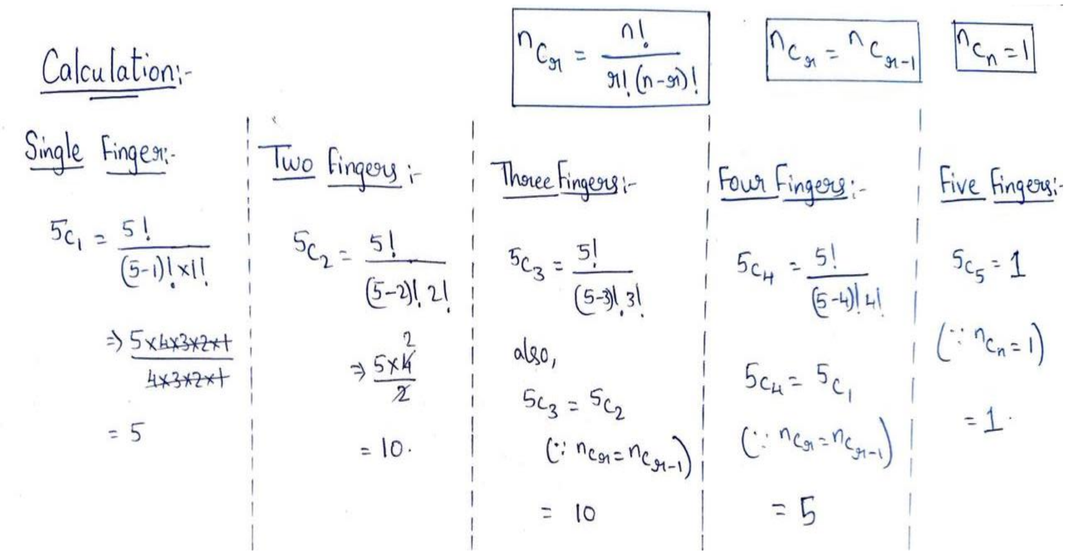


Fig 3.5: Calculation

- Total Combinations = 1 finger + 2 fingers + 3 fingers + 4 fingers + 5 fingers

  = 5 + 10 + 10 + 5 + 1

  = 31 combinations.

Combinations:

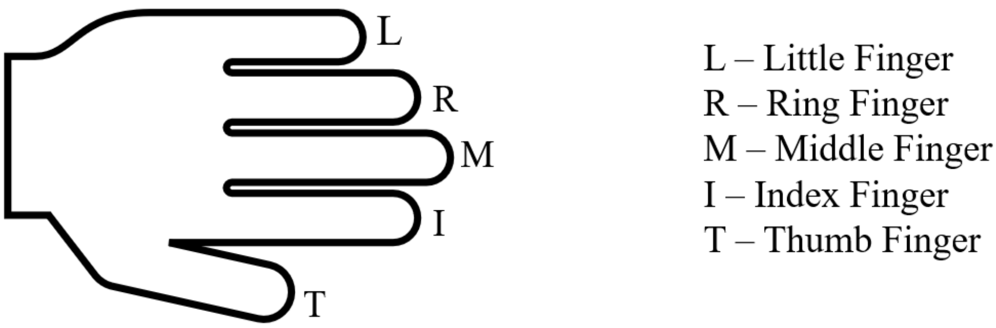


Fig 3.6: Fingers labelling

Combinations:

Single Finger:
- L
- R
- M
- I
- T

Two Fingers:

L:
- L + R
- L + M
- L + I
- L + T

R:
- R + M
- R + I
- R + T

M:
- M + I
- M + T

I:
- I + T

Three Fingers:

L + R:
- L + R + M
- L + R + I
- L + R + T

L + M:
- L + M + I
- L + M + T

L + I:
- L + I + T

R + M:
- R + M + I
- R + M + T

R + I:
- R + I + T

M + I:
- M + I + T

Four Fingers:

L + R + M:
- L + R + M + I
- L + R + M + T

L + R + I:
- L + R + I + T

L + M + I:
- L + M + I + T

R + M + I:
- R + M + I + T

Five Fingers:
- L + R + M + I + T

Fig 3.7: All possible combinations

CHAPTER-4

RESULT

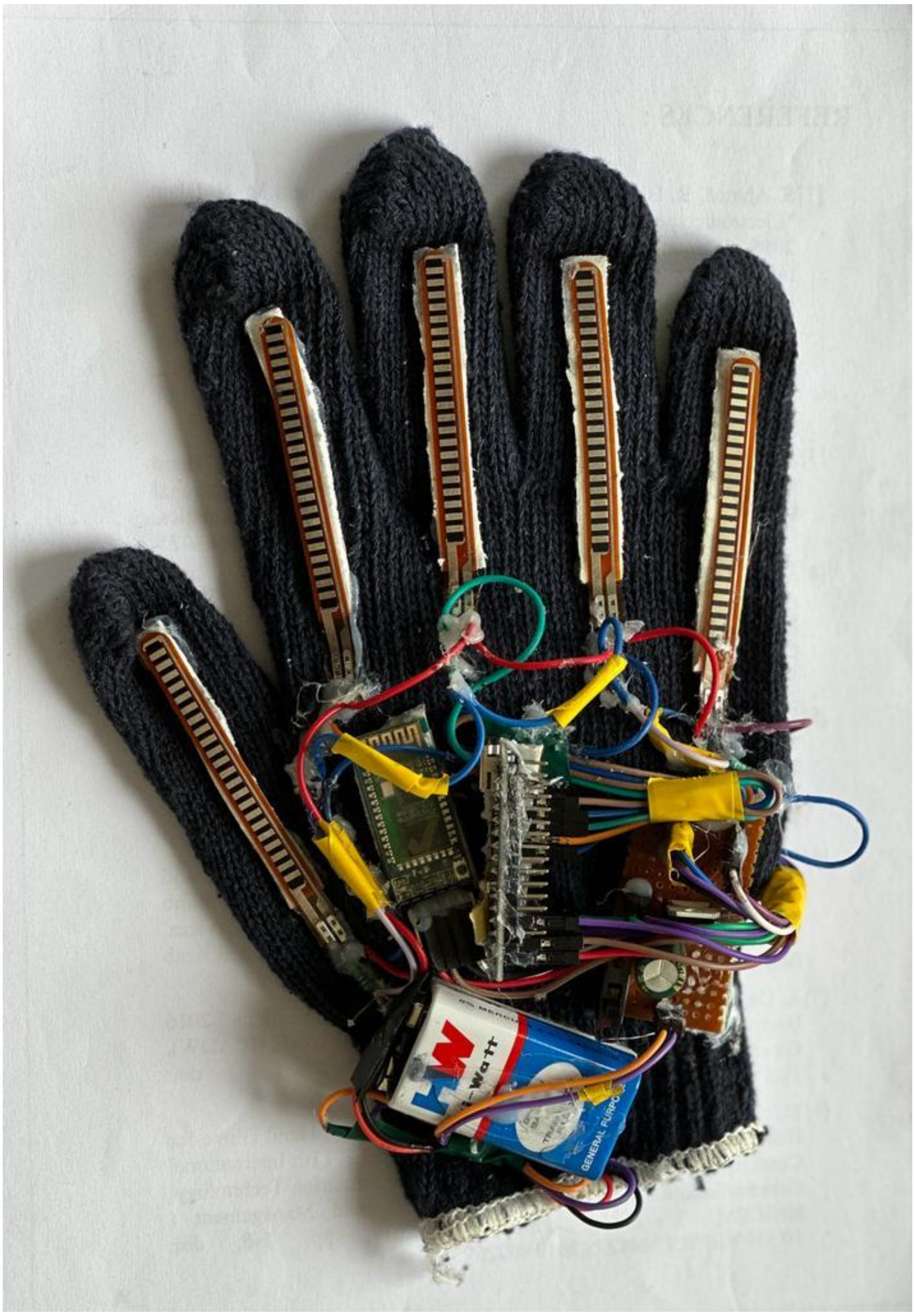
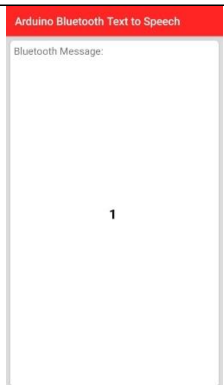
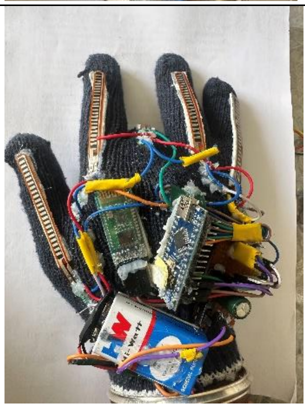
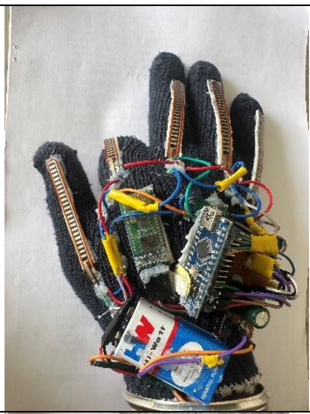
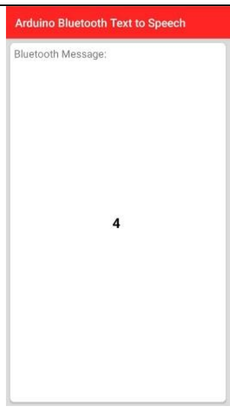
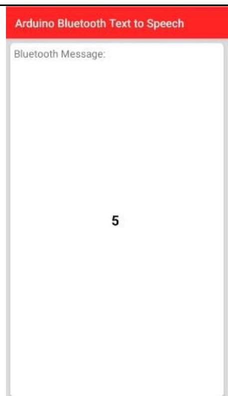
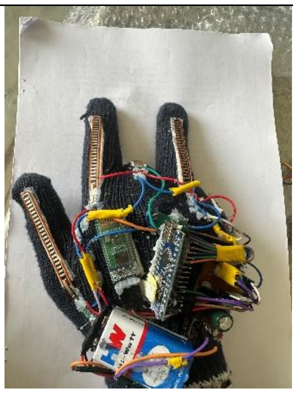
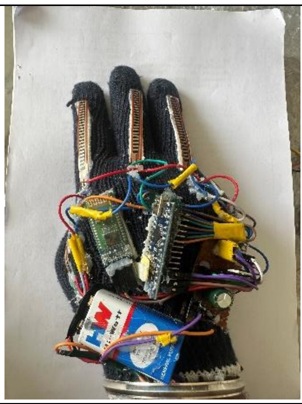
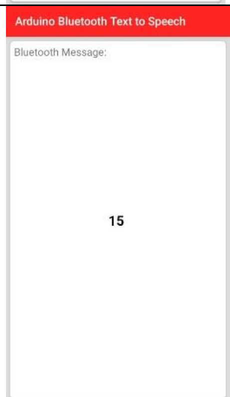


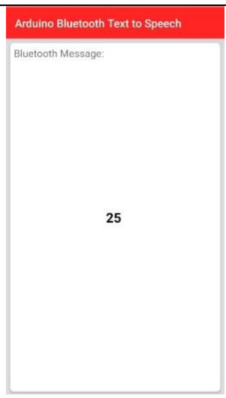
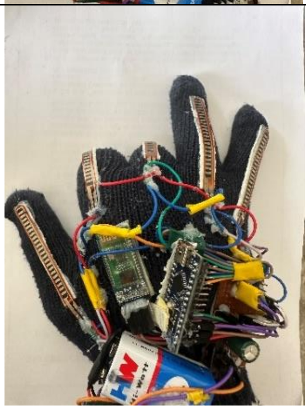
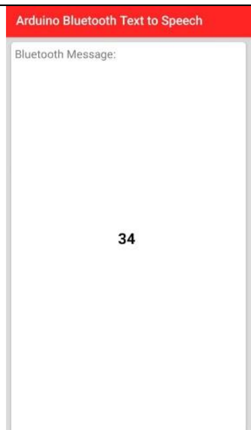
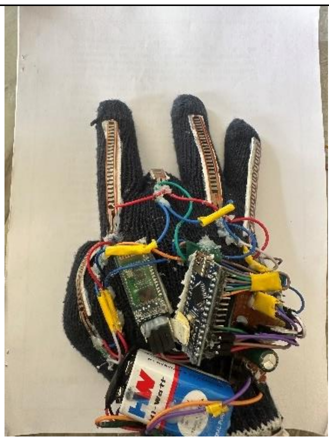
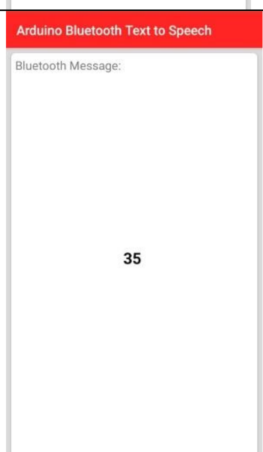
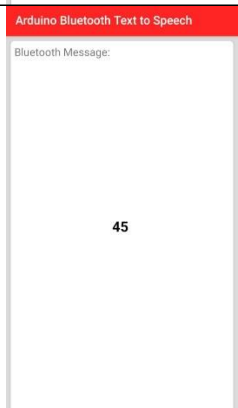
Fig 4.1: Smart glove

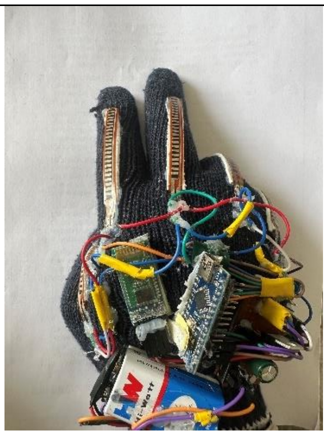
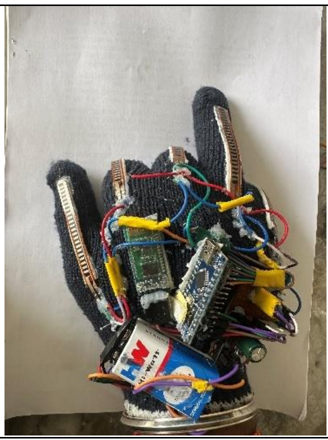
OUTPUT

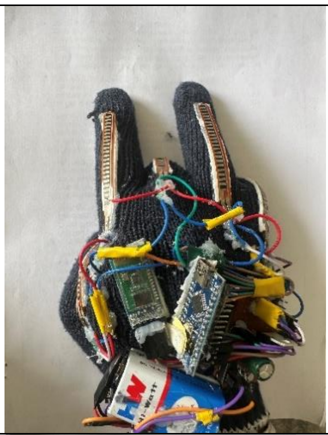
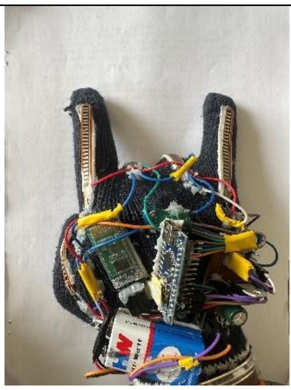
S.No.	Gesture	Fingers Folded	Interpreted Text
1.		L	
2.		R	
3.		M	

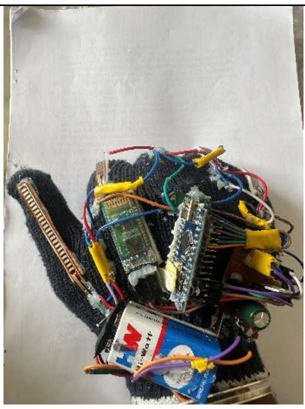
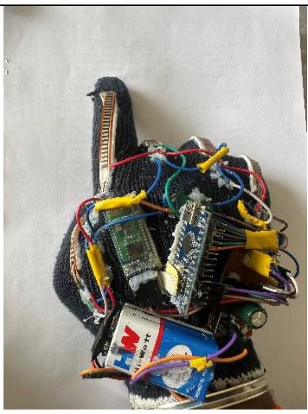
4.		I	 Arduino Bluetooth Text to Speech Bluetooth Message: 4
5.		T	 Arduino Bluetooth Text to Speech Bluetooth Message: 5
6.		L + R	 Arduino Bluetooth Text to Speech Bluetooth Message: 12
7.		L + M	 Arduino Bluetooth Text to Speech Bluetooth Message: 13

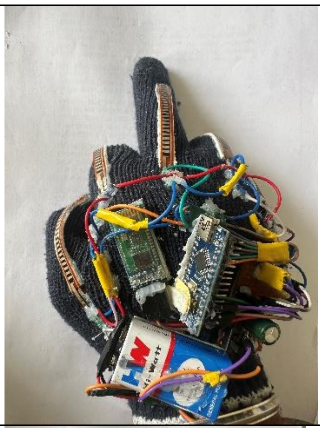
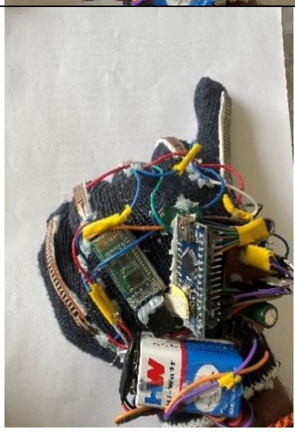
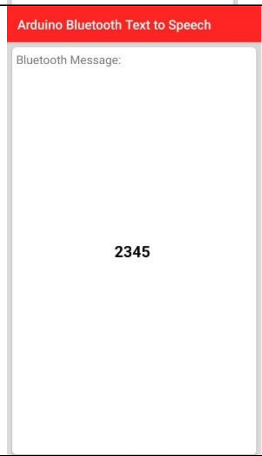
8.		L + I	
9.		L + T	
10.		R + M	
11.		R + I	

12.		R + T	
13.		M + I	
14.		M + T	
15.		I + T	

16.		L + R + M	
17.		L + R + I	
18.		L + R + T	
19.		L + M + I	

20.		L + M + T	
21.		L + I + T	
22.		R + M + I	
23.		R + M + T	

24.		R + I + T	
25.		M + I + T	
26.		L + R + M + I	
27.		L + R + M + T	

28.		L + R + I + T	
29.		L + M + I + T	
30.		R + M + I + T	
31.		L + R + M + I + T	

ANALYSIS

The Sign Recognition Smart Glove project represents a significant advancement in assistive technology, aiming to facilitate communication for individuals with hearing impairments through the interpretation of sign language gestures. The analysis encompasses several critical aspects, providing insights into the project's design, functionality, and user experience.

- The accuracy of the sign language recognition system is commendable, with the smart glove demonstrating a high level of precision in interpreting various sign gestures.
- The reliability of the sensors in capturing diverse gestures showcases the project's thoughtful sensor integration.
- The wireless communication module demonstrates reliable and fast data transfer between the smart glove and external devices, such as computers or smartphones.
- Real-time communication capabilities contribute to the practical usability of the system in dynamic environments.
- The power consumption of the smart glove is within acceptable limits, and the implemented power management features contribute to the efficient use of the device's battery.

CHAPTER-5

APPLICATIONS

- The primary application is to serve as a communication aid for individuals who are both hearing and speech impaired.
- During emergency situations, the smart glove can be used to convey urgent information or requests for assistance
- The glove can help hearing and speech-impaired individuals participate more actively in social and recreational activities, contributing to a more inclusive and diverse society.

FUTURE SCOPE

- During emergencies, the smart glove can be used to convey urgent information or requests for assistance by sending an emergency message to the mobile number.
- Especially in enhancing safety for women during cab rides these gloves could be utilized as a discreet SOS device that shares the real-time location to the emergency mobile number.
- The glove can help visually impaired individuals allowing disabled individuals to communicate their needs and control household appliances and replace the Bluetooth module with a Wi-Fi module to increase the range.
- In defence applications, smart gloves can have various uses, such as enhancing communication in noisy or remote environments through gesture-based signals.

CONCLUSION

In conclusion, the Sign Recognition Smart Glove project represents a significant leap forward in assistive technology, offering a technologically advanced solution to enhance communication for individuals with hearing impairments. The user-centric design, cultural sensitivity, and real-world viability of the smart glove underscore its potential to positively impact the lives of users. The project's commitment to ethical considerations and continuous improvement sets a commendable standard for the development of assistive technologies. As the smart glove concludes its initial phase, there is a clear trajectory for further enhancements, ensuring it remains a pioneering force in fostering inclusivity and accessibility for individuals with hearing challenges.

REFERENCES

[1] B. G. Lee and S. M. Lee, "Smart Wearable Hand Device for Sign Language Interpretation System With Sensors Fusion," in IEEE Sensors Journal, vol. 18, no. 3, pp. 1224-1232, 1 Feb.1, 2018, doi: 10.1109/JSEN.2017.2779466.

[2] Bhalghare, P., Chafle, V., Bhivgade, A., Deokar, V., & Bhele, S. G. (2020). Multipurpose Smart Glove for Deaf and Dumb People. International Research Journal of Engineering and Technology (IRJET), 7(4), 2373. Retrieved from https://www.irjet.net/

[3] Dinesh, P., Kavin, M., Kottai Kumar, N., Mahesh, C., & Sornalatha, M. (2019). Two Way Sign Language Communication Using Smart Glove. South Asian Journal of Engineering and Technology, Vol 8, No 1 (2019): Volume 8, Supplementary Issue 1, Year 2019, 5. Retrieved from https://sajet.in/index.php/journal/article/view/24