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Mini Project Report on

"EMG-based Sign Language to Text Converter"

Submitted in partial fulfilment of the requirement for completion of PROJECT WORK 1 [23EC6PWPJ1]

Submitted by:

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Under the guidance of

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Academic Year

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

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<u>CERTIFICATE</u>

This is to certified that the Mini Project entitled **"EMG-based Sign Language to Text Converter"** is a bonafide work carried out by **Rithika P M (1BM22EC198), Aisiri G Aithal (1BM23EC400), Dhananjay L (1BM23EC404), M Adarsha (1BM23EC410),** submitted in partial fulfilment of the requirement for completion of PROJECT WORK 1 [23EC6PWPJ1] of Bachelor of Engineering in Electronics and Communication during the academic year 2024-25. The Project Work 1 report has been approved as it satisfies the academic requirements.

Guide	**Head of Department**
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Associate professor	Professor and Head
Department of ECE	Department of ECE
BMS College of Engineering	BMS College of Engineering

Principal
(Dr. Bheemsha Arya)
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Name of the Examiners — Signature with Date

1.

2.

DECLARATION

We, **Rithika P M (1BM22EC198), Aisiri G Aithal(1BM23EC400), Dhananjay L (1BM23EC404), M Adarsha (1BM23EC410),** hereby declare that the Project work-1 entitled "**EMG-based Sign Language to Text Converter**" is a bonafide work and has been carried out by us under the guidance of Dr. Lalitha S , Associate professor, Department of Electronics and Communication Engineering, BMS College of Engineering, Bengaluru submitted in partial fulfilment of the requirement for completion of PROJECT WORK 1 [23EC6PWPJ1] of Bachelor of Engineering in Electronics and Communication during the academic year 2024-25. The Mini-project report has been approved as it satisfies the academic requirements in Electronics and Communication engineering, Visvesvaraya Technological University, Belgaum, during the academic year 2024-25.

We further declare that, to the best of our knowledge and belief, this Project work-1 has not been submitted either in part or in full to any other university.

Place: Bengaluru
Date:

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ABSTRACT

In India, millions of individuals live with hearing impairments, making everyday communication a significant challenge. With estimates suggesting that over 63 million people are affected, there is a growing need for accessible and effective assistive technology. This project aims to bridge the communication gap by developing a wearable device that can translate sign language into readable text. By combining Electromyography (EMG) sensors, which detect muscle activity, with Inertial Measurement Unit (IMU) sensors, which track hand motion, the system captures complex hand gestures with greater accuracy. The goal is to create a real-time, user-friendly tool that displays translated text on a screen, enabling smoother interaction for people with hearing impairments. This innovation has the potential to make communication more inclusive and empower individuals to connect more easily with the world around them.

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Abbreviations	Full Form
IEEE	Institute of Electrical and Electronics Engineers
IMU	Inertial Measurement Unit
EMG	Electromyography

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Chapter 1:

Introduction

Communication is one of the most fundamental aspects of human life. It allows us to share ideas, express emotions, and build meaningful relationships. But for millions of individuals around the world—particularly those with hearing or speech impairments—communication can be a daily struggle. In India alone, the 2011 Census recorded around 26.8 million people with disabilities, and more recent estimates suggest that over 63 million people live with significant hearing loss. For these individuals, sign language is not just a tool—it's their primary means of communication. However, not everyone understands sign language, and this often creates barriers in education, employment, healthcare, and social interaction. Recognizing this gap, technology offers a promising way forward. Over the past decade, wearable devices and sensors have become smaller, smarter, and more affordable. These advancements make it possible to develop assistive systems that can translate sign language into spoken or written language, helping the hearing and speech impaired communicate more freely with the world around them. This project is built on that vision.

We aim to create a wearable prototype that can interpret hand gestures and convert them into text in real-time. To do this effectively, the system uses two types of sensors: Electromyography (EMG) sensors and Inertial Measurement Units (IMUs). EMG sensors detect muscle activity from the user's forearm or hand, allowing the system to understand subtle movements based on muscle contractions. At the same time, the IMU—specifically an MPU6050 sensor—tracks the motion and orientation of the hand using an accelerometer and gyroscope. Together, these sensors provide a more complete picture of each gesture, making it easier to distinguish between similar signs.

At the heart of the system is an STM32 microcontroller, which collects the sensor data, processes it using predefined algorithms, and identifies the gesture being made. The result is displayed instantly on an LCD screen, making the system easy to use and understand. Whether someone is trying to say "hello," "thank you," or express a more complex idea, the goal is to give them a voice—without needing to rely on someone else to interpret for them.

This project represents more than just a technical achievement. It’s a step toward building a more inclusive society where technology adapts to human needs. By combining hardware and human empathy, we hope to empower those who have been left out of everyday conversations for too long.

Chapter 2:

Literature survey

1. **An EMG Dataset for Arabic Sign Language Alphabet Letters and Numbers** by Al-Quraishi, M.S., et al. [2023] This study introduces an extensive EMG dataset for Arabic Sign Language recognition, covering 28 letters and 10 numerical digits. The dataset provides valuable insights into muscle signal variations while performing different sign gestures. It serves as a foundational dataset for developing EMG-based gesture recognition systems.

2. **Sign Language Recognition Using the Electromyographic Signal: A Systematic Literature Review** by Amina BenHajAmor, et al [2023] This review explores the advancements in EMG-based sign language recognition, highlighting different sensor technologies, machine learning models, and real-world applications. The study discusses the advantages of EMG signals in capturing fine motor movements essential for sign language interpretation.

3. **Design and Development of Hand Movement Detection Device for Sign Language using IMU and sEMG Sensors** by Niti Petranon et al [2023] This paper investigates sensor fusion techniques combining EMG and IMU data for hand gesture recognition. The study emphasizes the role of multimodal signal processing in improving the accuracy and robustness of sign language translation systems. The findings suggest that integrating multiple sensor types enhances the overall performance of assistive communication devices.

Chapter 3:

Problem Analysis & Solution

3.1 Problem Definition:

There is a need for a system that converts muscle and motion-based gestures into text to assist individuals with speech or hearing impairments. Existing solutions using only visual or motion- based recognition methods often lack accuracy in distinguishing similar gestures, making communication less efficient for the hearing-impaired community.

3.2 Proposed Solution:

Develop a wearable system utilizing Electromyography (EMG) sensors and Inertial Measurement Unit (IMU) sensors to capture muscle activity and hand movements. The collected signals will be processed using predefined algorithms to accurately translate gestures into text, which will be displayed on a screen in real-time. This approach enhances gesture recognition accuracy and provides an efficient means of communication for individuals with hearing impairments.

Chapter 4:

Methodology & Implementation

4.1 Structure of the Block Diagram

The block diagram represents a biomedical signal acquisition and processing system that uses EMG and IMU sensors interfaced with an STM32 microcontroller. The processed data is displayed on an OLED screen. The entire system is powered using a battery-based power supply regulated through a buck converter to ensure safe operating voltages

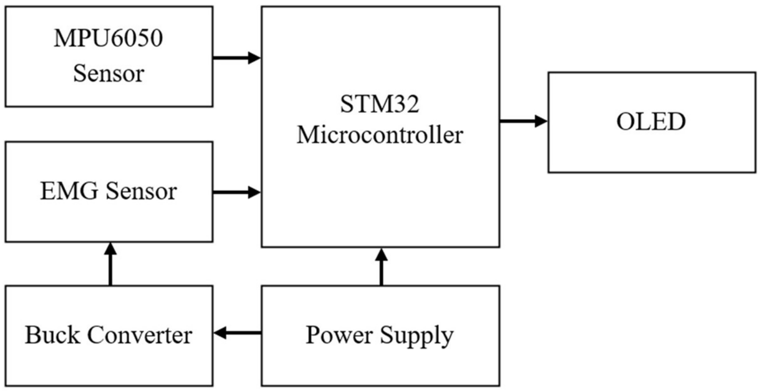

Fig 4.1: Block diagram

1. **Power Supply**

   The power supply block consists of a rechargeable battery or external source that provides the primary input voltage for the system. Since the sensors and microcontroller typically operate at lower voltages (such as 5V or 3.3V), this raw input requires regulation.

2. **Buck Converter**

   The buck converter is a DC-DC step-down converter used to regulate the voltage from the power supply to a suitable level required by the components. It ensures that sensitive components such as the STM32 microcontroller and the sensors are not exposed to overvoltage conditions.

3. EMG Sensor

The EMG (Electromyography) sensor captures electrical signals generated by muscle activity. These signals are typically analog in nature and are used to infer voluntary muscle movement. The sensor outputs are sent to the microcontroller, which processes them for gesture recognition or other control mechanisms.

4. MPU6050 Sensor (IMU)

The MPU6050 is an Inertial Measurement Unit that integrates a 3-axis accelerometer and a 3-axis gyroscope. It provides motion and orientation data by sensing linear acceleration and angular velocity. This sensor communicates with the STM32 microcontroller using the I2C protocol and provides information useful for detecting gestures or movement patterns.

5. STM32 Microcontroller

The STM32 microcontroller serves as the central processing unit of the system. It receives analog signals from the EMG sensor and digital motion data from the MPU6050 sensor. The microcontroller performs analog-to-digital conversion (ADC), filters the input signals, processes the data using embedded algorithms, and controls the output display. The STM32 is selected for its real- time processing capability, low power consumption, and efficient peripheral interfacing.

6. OLED Display

The OLED (Organic Light Emitting Diode) display is used for visual output. It shows either raw sensor readings or processed results such as identified gestures, muscle activity levels, or system status. The display serves as a user interface, enabling real-time monitoring of sensor data and system functionality.

4.1.1 Flow Chart:

This flowchart represents the process flow for a hand gesture recognition system using two EMG sensors, two IMU sensors, and an OLED display. The system recognizes alphabets (A–Z) based on hand closure and directional gestures.

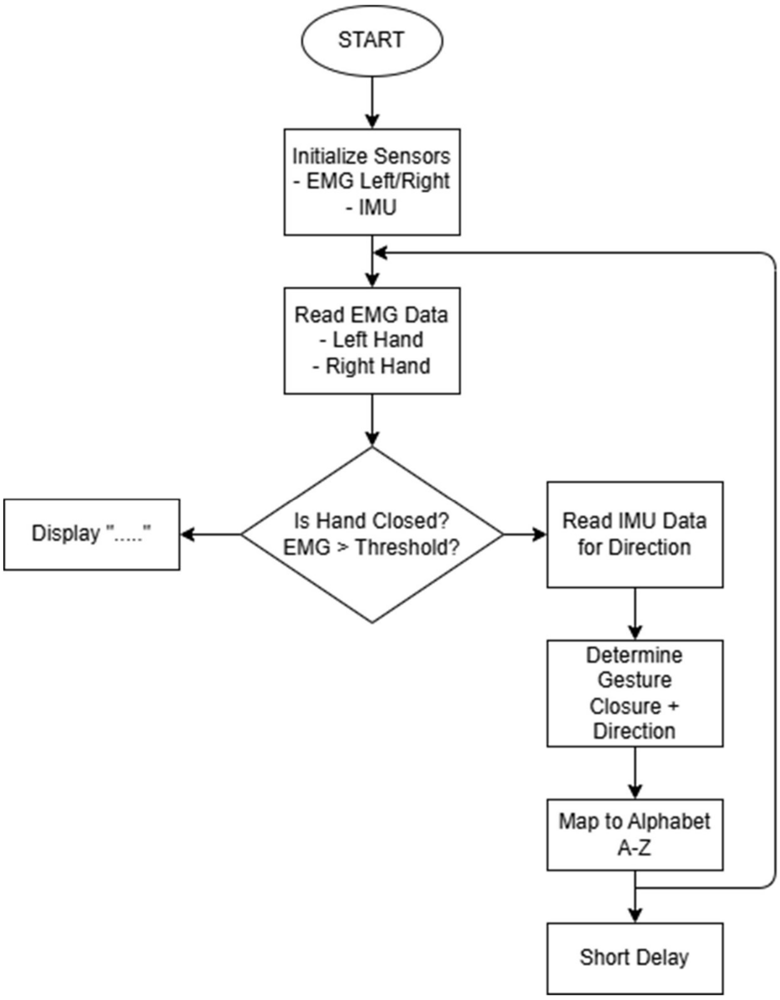

Fig 4.2: Flow of the model

1. **Start**: The system begins operation.
2. **Initialize Sensors**: All required components are initialized, including:
   - EMG sensors for both hands
   - IMU sensors for both hands
   - OLED screen for output

3. **Read EMG Data**: Muscle activity is monitored to detect whether either hand is closed.
4. **Is Hand Closed?**
   - If **No**: The OLED displays "No Input", and the system loops back to read EMG data again.
   - If **Yes**: The system proceeds to read the IMU data.
5. **Read IMU Data**: Hand orientation and motion direction are captured using IMU sensors.
6. **Determine Hand Gesture**: A unique combination of direction and closure is used to identify a specific hand gesture.
7. **Map Gesture to Alphabet**: The detected gesture is mapped to one of the 26 English alphabets (A–Z).
8. **Display on OLED**: The identified letter is shown on the OLED display.
9. **Short Delay**: A brief pause is introduced to avoid multiple detections for the same gesture (debouncing).
10. **Repeat**: The system loops back to continuously monitor for new gestures.

Chapter 5:

Results & Discussion:

The following section presents the observed results, analysis of various test cases, and a summary of key findings from the EMG signal acquisition and processing stages.

Case 1: Right arm muscle movement:

The following table summarizes the test cases based on different right arm movement patterns used during EMG signal acquisition.

Letter	Sensor	Gestures
A	Right MPU6050	Front
B	Right MPU6050	Back
C	Right MPU6050	Right
D	Right MPU6050	Left

Table 5.1: Gesture combination with Right arm

For gesture **A**, where the right arm was moved forward, the EMG signal showed a clear and consistent pattern that matched the expected muscle activity. The signal was stable and easy to distinguish from rest or other movements, which shows that the sensor placement and overall setup worked well for capturing this gesture.

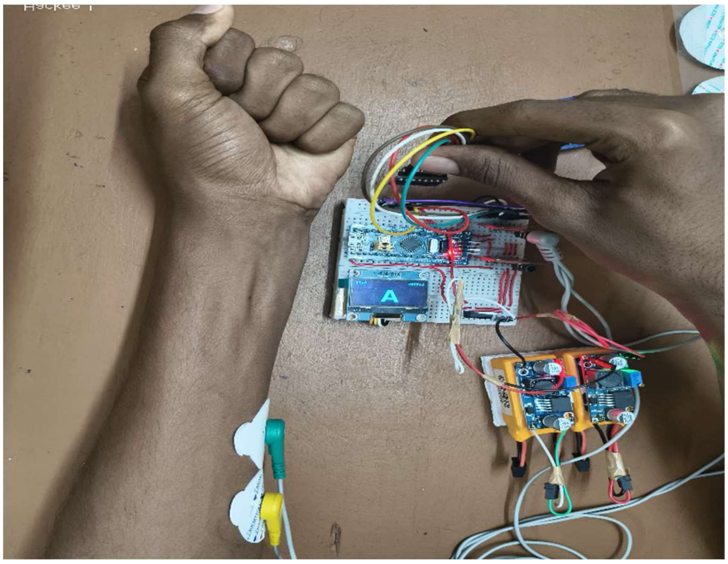

Fig 5.1: Gesture for the letter ‘A'

Even if this movement may have engaged muscles differently than gestures A to D, the sensor was still able to detect the activity with good clarity.

Case 2: Left arm muscle movement:

The following table summarizes the test cases based on different left arm muscle movement patterns used during EMG signal acquisition.

Letter	Sensor	Gestures
E	Left MPU6050	Front
F	Left MPU6050	Back
G	Left MPU6050	Right
H	Left MPU6050	Left

Table 5.2: Gesture combination with Left arm

In this case, gesture **E** involved moving the left arm forward, and the EMG signal captured by the left MPU6050 sensor showed a clear and steady pattern.

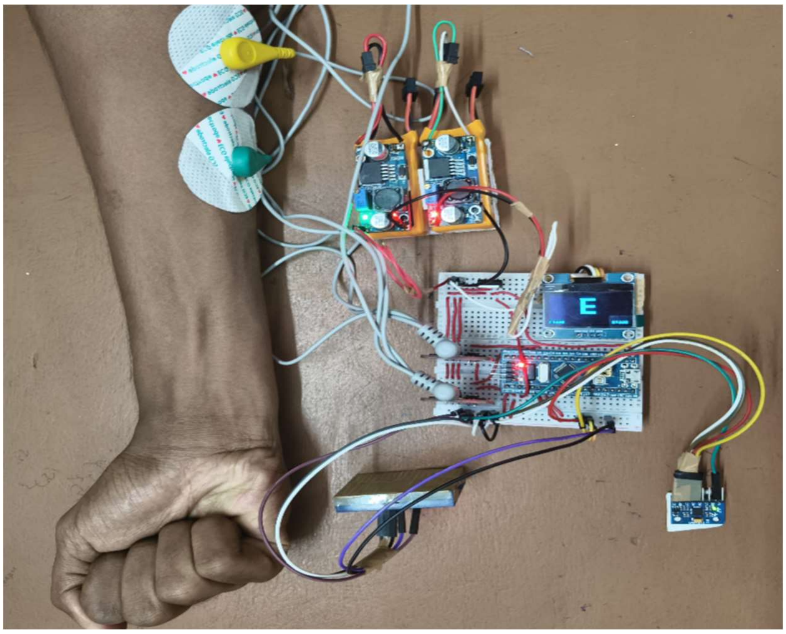

Fig 5.2: Gesture for the letter 'E'

Case 3: Combined muscle movement:

The following table summarizes the test cases based on different hand movement patterns used during EMG signal acquisition.

Letter	Left MPU6050 Direction	Right MPU6050 Direction	Combined Gestures
I	Front	Front	Both Front
J	Back	Back	Both Back
K	Right	Right	Both Right
M	Left	Left	Both Left
N	Front	Back	Left Front, Right Back
O	Back	Front	Left Back, Right Front
P	Left	Right	Left Left, Right Right (Outward)
Q	Right	Left	Left Right, Right Left (Inward)
R	Front	Left	Left Front, Right Left

S	Front	Right	Left Front, Right Right
T	Back	Left	Left Back, Right Left
U	Back	Right	Left Back, Right Right
V	Left	Front	Left Left, Right Front
W	Right	Front	Left Right, Right Front
X	Left	Back	Left Left, Right Back
Y	Right	Back	Left Right, Right Back

Table 5.3: Gesture combination with both arms combined

The results from the combined arm movements demonstrate that the EMG system effectively captures both symmetrical and asymmetrical gestures. Gestures involving both arms moving in the same direction, such as forward or left (I and M), produced consistent and synchronized signals. In contrast, gestures with opposite or cross-directional movements (P and Y) generated distinct and separable patterns for each arm.

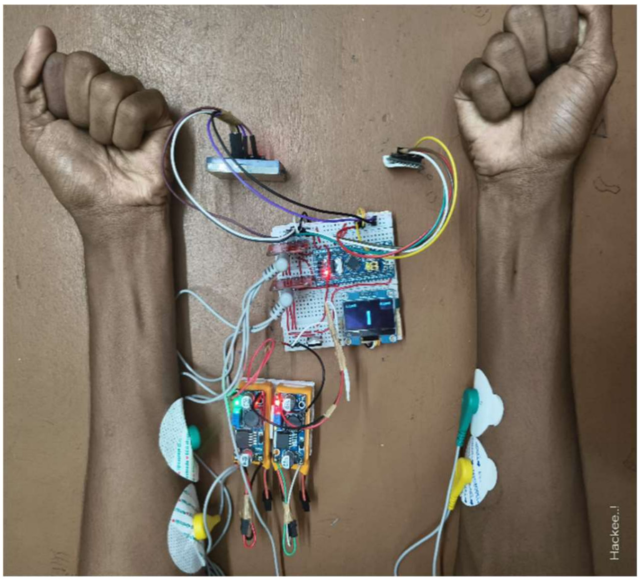

Fig 5.3: Gesture for the letter ‘I'

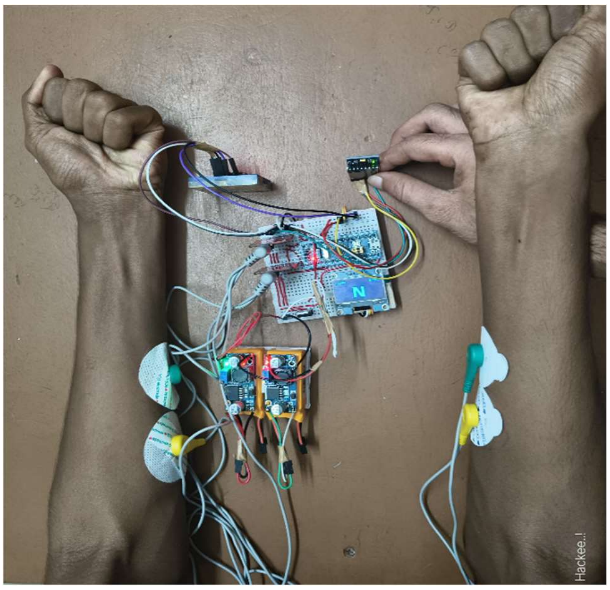

Fig 5.4: Gesture for the letter ‘N'

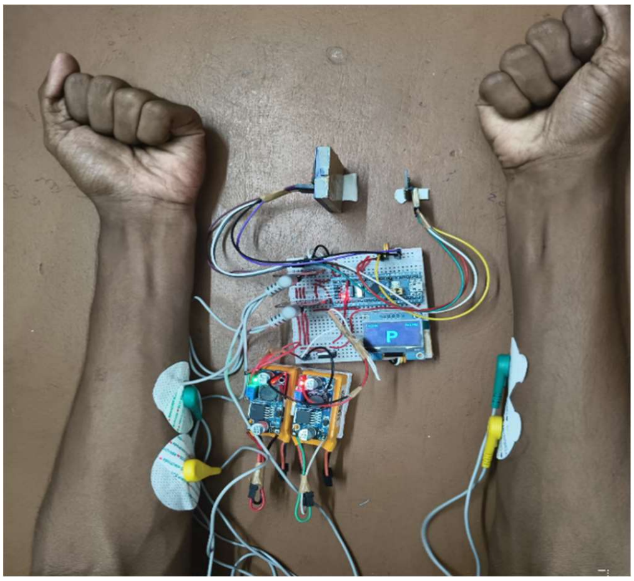

Fig 5.5: Gesture for the letter ‘P'

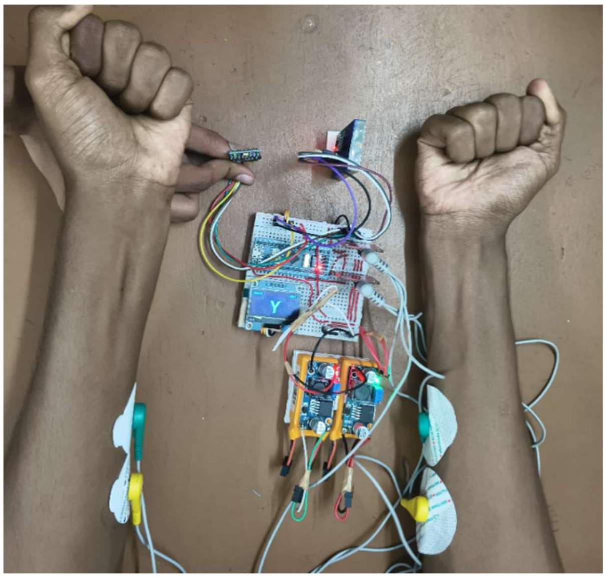

Fig 5.6: Gesture for the letter ‘Y'

The following image shows the EMG signal we recorded, giving a clear view of how the muscle activity looked during the test.

Fig 5.7: Output in serial Plotter showing the EMG muscle movement

Chapter 6:

Future Trends and Conclusion

6.1 Conclusion:

This project presents a practical and meaningful solution for bridging the communication gap faced by individuals with hearing or speech impairments. By combining EMG and IMU sensors, the system accurately captures both muscle activity and hand motion to recognize sign language gestures. The real-time translation of these gestures into text on an LCD display empowers users to communicate more independently and confidently. This prototype not only demonstrates the potential of wearable technology in assistive communication but also emphasizes the importance of inclusive innovation that puts people first.

6.2 Future Trends:

Looking ahead, there are exciting possibilities to further enhance this system:

- **Text-to-Speech Integration**: Adding voice output would allow the translated text to be spoken aloud, making conversations even more fluid.
- **Machine Learning for Personalization**: With AI, the system could learn a user's unique gesture patterns over time, improving recognition accuracy and speed.
- **Mobile App Connectivity**: Pairing the device with a smartphone app could offer features like saving conversations, selecting preferred languages, or sending messages directly.
- **Multilingual Support**: Expanding the system to support sign languages from different regions and languages could make it more globally accessible.
- **Compact Wearable Design**: Future versions could be integrated into smartwatches or armbands for more discreet and comfortable daily use.

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APPENDIX A:

Plagiarism Report

https://searchenginereports.net/plagiarism-checker