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International Journal of Engineering Technology Research & Management
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HAND GESTURE RECOGNITION WITH SPEECH AND TEXT CONVERSION DEVICE

Ketan Jamdar, Prathmesh Jankar, Abhishek Konde
Students, Department of Electronics & Telecommunication Engineering,
Sinhgad Academy of Engineering, Kondhwa - 411048
Prof. Pallavi Shahane
Assistant Professor, Department of Electronics & Telecommunication Engineering
Sinhgad Academy of Engineering, Kondhwa – 411048

ABSTRACT
This paper presents the design and implementation of a Hand Gesture Recognition with Speech and Text Conversion Device, an assistive technology aimed at facilitating communication for individuals with speech and hearing impairments. The system employs an accelerometer for gesture acquisition, and processes these signals to provide dual output in the form of synthesized speech and text on an LCD screen. The device seeks to offer a portable, low-cost solution for real-time communication, thereby enhancing inclusivity and accessibility.

Keywords:
Hand gesture recognition, assistive technology, speech synthesis, text conversion, wearable device.

1. INTRODUCTION

Effective communication is fundamental to human interaction, yet a significant portion of the population faces barriers due to speech and hearing impairments. Traditional methods like sign language, while effective within certain communities, can limit interaction with those unfamiliar with it. This project addresses this challenge by developing a system that translates hand gestures into universally understandable speech and text.

The Hand Gesture Recognition with Speech and Text Conversion Device is motivated by the need for a more inclusive communication tool that can bridge the gap between individuals with speech and hearing impairments and the broader community. The system aims to provide a real-time, portable, and user-friendly solution that empowers users to express themselves effectively in various social and professional settings.

2. LITERATURE REVIEW

Several research efforts have laid the groundwork for this project, exploring various aspects of gesture recognition, speech synthesis, and assistive technologies.

Bouzouane and Mokhtari (2014) provided a review of speech recognition techniques, offering insights into methodologies for converting interpreted gestures into audible speech. Their work highlights the evolution of speech recognition and informs the selection of appropriate synthesis methods for this device. Chandran, Ramakrishnan, and Jayashri (2015) surveyed text-to-speech conversion systems, which are crucial for generating the verbal output of the proposed system. Their review covers different approaches to text-to-speech, evaluating their strengths and weaknesses in the context of assistive devices.

The broader field of sign language and hand gesture recognition has also been explored extensively. Anand, Kumar, and Kumaresan (2016) presented a framework for Indian Sign Language recognition using wavelet transforms, demonstrating effective techniques for gesture analysis. Yadav, Bajpai, and Shrivastava (2018) offered a comprehensive review of sign language recognition systems, discussing various methodologies and their applicability in communication aids. Ravi, Gupta, and Kulkarni contributed a review of computer vision techniques for hand gesture recognition, highlighting the potential of visual approaches. While this project uses an accelerometer rather than computer vision, their survey provides valuable context on the challenges and advancements in the field.

Nagpal, Mitra, and Agrawal (2021) focused on the design and implementation of a communication aid for individuals with hearing impairments. Their work emphasizes the importance of such devices and explores methodologies relevant to this project.

Sun, Zhang, and Guo (2008) examined hand gesture recognition technologies based on vision, providing a

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comparative analysis of different visual recognition methods. Murthy, Ganesan, and Srinivas presented a survey of hand gesture recognition for human-computer interaction, giving a broader overview of the field. Maebatake et al. (2002) detailed sign language recognition based on position and movement using Multi-Stream Hidden Markov Models. Foong, Low, and Wibowo (2008) developed a sign-to-voice system.
These studies collectively illustrate the ongoing research and development in gesture recognition and assistive communication, providing a strong foundation for the design and implementation of the Hand Gesture Recognition with Speech and Text Conversion Device.

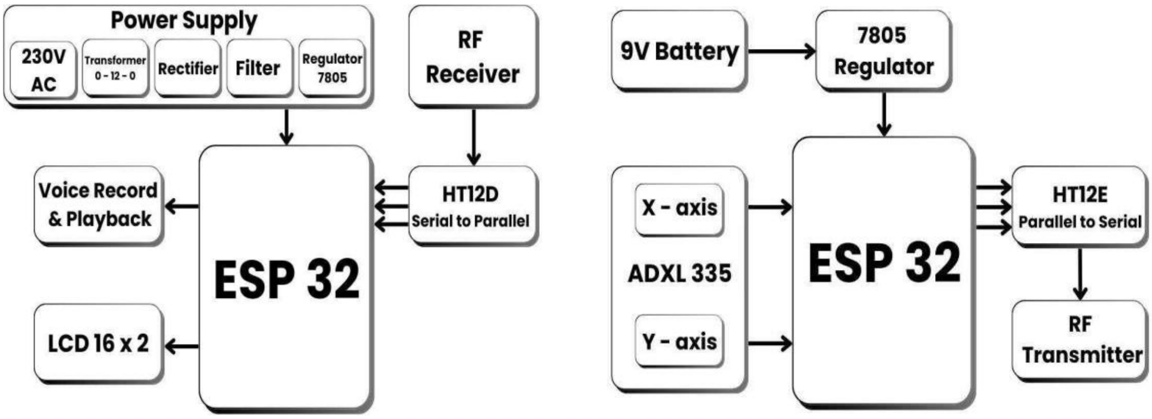
3. SYSTEM DESIGN

The system is designed as a wearable device with two primary units: a transmitter and a receiver. The transmitter captures hand gesture data, and the receiver processes this data to generate speech and text outputs.

3.1 System Architecture

The system architecture is illustrated in the following block diagrams:

Fig: 1.



Transmitter and Receiver

The transmitter unit comprises an accelerometer (ADXL335) to detect hand movements. The accelerometer's output signals are processed by an ESP32 microcontroller, which digitizes the data and transmits it wirelessly using an RF transmitter.
The receiver unit consists of an RF receiver to capture the transmitted data. The received data is then processed by another ESP32 microcontroller, which performs gesture recognition. The recognized gestures are converted into both speech and text. The speech output is generated using a voice playback module, and the text output is displayed on a 16x2 I2C LCD. A 7805 voltage regulator ensures a stable power supply for the system.

3.2 Hardware Design

The hardware design focuses on the selection and integration of components to achieve accurate gesture acquisition and reliable data transmission.

- **Accelerometer (ADXL335):** This sensor measures the acceleration of the hand in three axes, providing the necessary data for gesture recognition.
- **ESP32 Microcontroller:** The ESP32 serves as the central processing unit, handling data acquisition, processing, and transmission/reception. Its features include Wi-Fi and Bluetooth connectivity, though only RF communication is used in this design.
- **RF Transmitter and Receiver:** These modules enable wireless communication between the transmitter and receiver units, providing portability and ease of use.
- **16x2 I2C LCD:** This display shows the text output of the recognized gestures, offering a visual communication channel.

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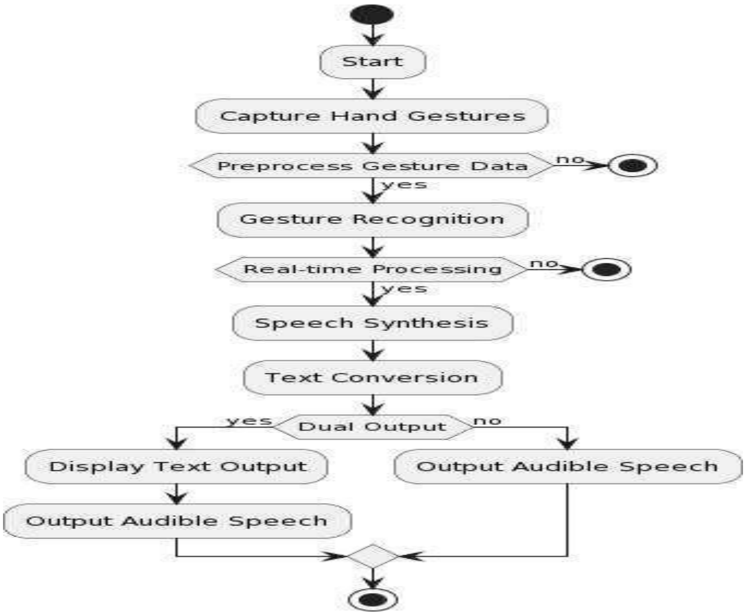
- **Voice Playback Module:** This module generates the synthesized speech output, enabling auditory communication.



- **7805 Voltage Regulator:** This component provides a stable 5V power supply to the system, ensuring reliable operation.

3.3 Software Design
The software design involves programming the ESP32 microcontrollers to:
- Acquire data from the accelerometer.
- Process the accelerometer data to recognize hand gestures.
- Convert recognized gestures into corresponding text and speech.
- Control the RF transmission and reception.
- Display the text on the LCD and generate speech output.

The Arduino IDE was used as the primary software development environment. The program logic is represented by the flowchart.

3.4 Simulation
The system's functionality was initially validated through simulations using Proteus.

(Include Simulation Image from the report)

This simulation allowed for testing and verification of the hardware design and software algorithms before physical implementation.

4. Implementation and Results
The implementation phase involved constructing the physical prototype of the Hand Gesture Recognition with Speech and Text Conversion Device. This included soldering the electronic components, fabricating the printed circuit board (PCB), and integrating the
hardware and software components.

The system was tested to evaluate its performance in recognizing a set of predefined hand gestures and converting them into speech and text. The testing procedure involved:
- Calibrating the accelerometer.
- Defining a set of distinct hand gestures.
- Performing the gestures in front of the transmitter unit.
- Observing the accuracy and latency of the speech and text output at the receiver unit.

The results of the testing, including measurements of voltage and current for different components, are shown in the table.

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Sr. No.	Component Name	Component Testing Parameters (Digital Multimeter and DSO/CRO)
1	Battery	Voltage – 8.67 V Current - 0.058 A
2	ESP32	1. Voltage – 5.01 V 2. Current – ~150mA (During RF Tx - 250mA)
3	Accelerometer (ADXL335)	1. Voltage – 0.220 V Current - 320 µA Left - X constant Y- 2100 Right - X constant Y- 1600 Down - Y constant X - 2100 Up - Y constant X - 1600
4	16x2 LCD Display	1. Voltage – Typ 5V
5	Voice Playback Module	1. Voltage – 2.4 to 5.5 V 2. Current – 20 mA Typ

The system was able to accurately recognize the defined hand gestures and provide corresponding speech and text output. The real-time performance of the device was satisfactory, with minimal delay between gesture execution and output generation.

5. APPLICATIONS

The Hand Gesture Recognition with Speech and Text Conversion Device has several potential applications, including:

- **Assistive Technology for the Hearing Impaired:** Enabling communication with those who do not understand sign language.
- **Smart Home Control:** Integrating with smart home systems to control devices through hand gestures.
- **Healthcare Communication:** Facilitating communication between patients with speech impairments and healthcare professionals.
- **Gaming and Virtual Reality:** Enhancing immersive experiences by allowing users to control actions through hand movements.
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6. ADVANTAGES

The device offers several advantages:

- **Multimodal Communication:** Enhances interaction by integrating gestures with speech and text.
- **Portability:** The wearable design allows users to communicate in various settings.
- **Real-time Conversion:** Provides immediate feedback, enabling natural communication flow.
- **Low-Cost Solution:** Offers an affordable alternative to other communication aids.

7. CONCLUSION

This paper presented the design and implementation of a Hand Gesture Recognition with Speech and Text Conversion Device. The system effectively captures hand gestures using an accelerometer and translates them into both speech and text, offering a valuable tool for individuals with speech and hearing impairments. The device has the potential to significantly improve communication accessibility and promote inclusivity in diverse environments.

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8. FUTURE SCOPE

Further research and development could focus on:

- Expanding the gesture vocabulary and improving recognition accuracy.
- Integrating advanced speech synthesis techniques for more natural-sounding output.
- Developing wireless communication capabilities for increased range and flexibility.
- Exploring integration with mobile devices and other communication platforms.
- Implementing user customization features to adapt the device to individual needs.

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