Smart Glove Sign to Speech Conversion & Home Automation for Mute Community People Using Arduino Mega 2560

Swapna. B [1], A. Sri Chaitanya[2], A. Chinmay Kumar[3], B. Kusuma[4]
[1]*Assistant Professor, Department of Electronics and Communication Engineering, TKR College of Engineering and Technology*
[2,3,4] *UG Scholars, Department of Electronics and communication Engineering, TKR College of Engineering and Technology*

Abstract: **This paper presents the design and development of a smart glove system intended to assist speech-impaired individuals in communicating effectively using hand gestures. The glove integrates flex sensors to detect finger movements, an Arduino Mega 2560 microcontroller for processing, and a Bluetooth module (HC-05) for wireless communication with a mobile device. Predefined hand gestures are translated into corresponding voice messages or used to control home appliances via relay modules. The system also includes a voltage regulator (7805) to ensure stable power supply. This low-cost, portable solution enables real-time gesture recognition and enhances the independence of users by combining communication assistance with basic home automation functionality. The proposed design offers a user-friendly interface, high reliability, and practical utility in real-world applications, particularly for individuals with speech or mobility impairments.**

Keywords: **Arduino Mega 2560, Bluetooth module, Flex Sensor, Smart Glove, Home Automation, Mute Communication, TTS.**

I. INTRODUCTION

Communication is a fundamental human need, and the inability to speak can create significant barriers in daily life, particularly for individuals who are mute or speech-impaired. These individuals often rely on sign language as their primary mode of communication. However, sign language is not universally understood by the general population, which limits effective interaction and can result in social isolation. As a result, there is a growing need for technology that can bridge the communication gap between speech-impaired individuals and society.

In recent years, several assistive technologies have been developed to interpret sign language using various input methods, including image processing, computer vision, and sensor-based systems. Among these, sensor-based solutions have gained attention due to their portability, low power consumption, and ease of use. These systems often involve the use of wearable devices such as smart gloves embedded with flex sensors, microcontrollers, and communication modules. These gloves are capable of translating hand gestures into text or speech, allowing real-time communication without the need for an interpreter.

This project introduces a smart glove system designed using flex sensors, an Arduino Mega 2560 microcontroller, and a Bluetooth module (HC-05). The system captures finger movements through the flex sensors and interprets predefined gestures to either transmit voice messages via a connected mobile device or control electrical appliances using relay modules. A voltage regulator ensures safe and stable power distribution throughout the system. This integration of gesture recognition with wireless communication and home automation makes the device multifunctional and user-friendly.

The primary objective of this work is to create a reliable, cost-effective, and mobile solution to assist mute individuals in communicating efficiently while also providing them with control over their immediate environment.

II. METHODOLOGY

i. EXISTING METHODOLOGY:

In earlier systems, gesture recognition for assisting speech-impaired individuals was predominantly achieved using camera-based techniques. These systems relied on computer vision and image processing algorithms to analyse hand gestures captured by webcams or surveillance cameras. Although capable of accurate gesture detection under ideal conditions, they had several practical limitations. Their performance heavily depended on proper lighting, uncluttered backgrounds, and fixed camera positioning, making them less effective in dynamic or real-life environments. Furthermore, these systems required high processing power and were often stationary, which limited their portability and real-time usability. To address these challenges, more recent methods have shifted towards wearable technology using flex sensors, microcontrollers, and wireless modules. These sensor-based systems offer enhanced mobility, reduced power consumption, and improved usability in everyday scenarios, making them a more practical and user-friendly solution.

ii. PROPOSED METHODLOGY:

The proposed system introduces a smart glove designed to assist speech-impaired individuals in communicating through hand gestures. The glove is embedded with four flex sensors placed on the index, middle, ring, and little fingers. These sensors detect finger bending by producing variable resistance, which is converted into voltage signals and read by the analog pins (A0–A3) of the Arduino Mega 2560 microcontroller. Based on predefined gesture patterns, the Arduino processes the input data and maps it to specific actions.

For communication, the system uses an HC-05 Bluetooth module connected to the Arduino's TX and RX pins. When a recognized gesture is detected, a corresponding text message is transmitted via Bluetooth to a paired smartphone, which then converts the message into speech using a text-to-speech application. Additionally, the glove includes relay modules connected to digital pins (D3 and D4) to control basic home appliances like lights and fans based on specific hand gestures.

A 7805-voltage regulator is used to provide a stable 5V supply to all components from a 12V battery or adapter. This setup ensures safety and consistent performance. The proposed system is designed to be low-cost, portable, and easy to use, offering both communication assistance and environmental control, thereby enhancing the independence and quality of life for users.

III. IMPLEMENTED DESIGN

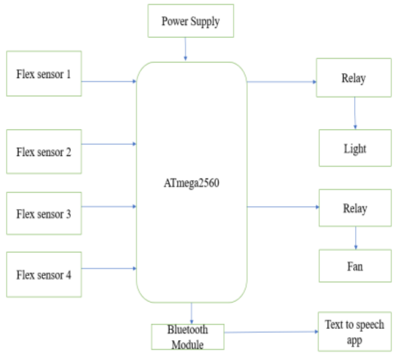

Fig1: Block Diagram

The system includes four flex sensors mounted on a glove (excluding the thumb), an Arduino Mega 2560 for data processing, and an HC-05 Bluetooth module for wireless communication with an Android smartphone.
The block diagram shows the working of a smart glove system that helps in both home automation and speech communication. The main controller used here is the ATmega2560 microcontroller. It receives power from a Power Supply. There are four flex sensors placed on the fingers of the glove. These sensors detect how much the fingers are bent during a gesture. The sensor data is sent to the ATmega2560, which processes the input.

Based on the gesture:
The controller can turn ON or OFF devices like a light or a fan using relays. This allows the user to control appliances with hand gestures. It can also send the gesture data through a Bluetooth module to a mobile phone. On the phone, a text-to-speech app converts the gesture into voice output. This helps mute people communicate by turning gestures into spoken words.
This system makes daily tasks easier and also helps people with speech disabilities to express themselves.
Predefined gestures trigger commands like:

- "I want food": index finger
- "Turn on/off fan": middle finger
- "Turn on/off light": ring finger
- "Emergency": little finger

Each gesture alters the flex sensor resistance, which is read as analog input and converted to digital values for threshold comparison. Corresponding text messages are sent via Bluetooth to an Android app with TTS. Home appliances are controlled via 2-channel relay modules connected to digital I/O pins of the Arduino. Power is stabilized using a 7805-voltage regulator.

Fig2: Flow Chart

The flow chart represents the step-by-step working process of the smart glove system. It starts with powering on the Arduino and initializing all sensors and modules. The system continuously reads the input from the flex sensors attached to the fingers. When a finger is bent, the sensor sends analog data to the Arduino. The Arduino checks if the sensor value crosses a preset threshold. If a valid gesture is detected, it performs a specific action either sending a message via Bluetooth or turning a device ON/OFF using a relay. After the action is completed, a small delay is introduced to avoid repeated triggering, and then the system returns to checking for the next gesture. This loop continues as long as the system is powered on.

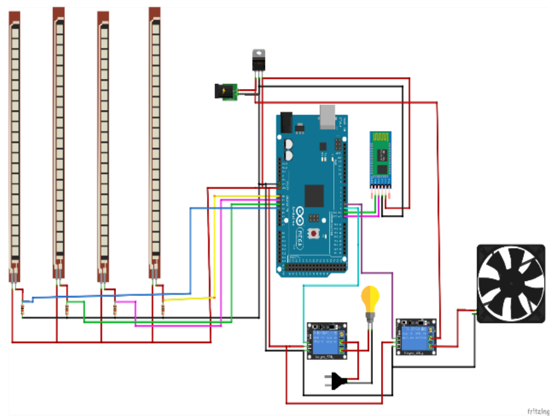

Fig3: Schematic Diagram

The schematic diagram shows how the components of the smart glove are connected and work together. Flex sensors are attached to four fingers (excluding the thumb) and are connected to the analog input pins (A0–A3) of the Arduino Mega 2560. These sensors detect finger bending by changing their resistance, which creates a voltage that the Arduino reads. A Bluetooth module (HC-05) is connected to the Arduino to wirelessly send messages to a mobile phone. The relay modules are connected to digital pins (D3 and D4) to control home appliances like lights and fans. A 7805-voltage regulator is used to provide a steady 5V power supply from a 12V input, ensuring all components get safe and stable power. This setup allows the glove to detect gestures, send messages via Bluetooth, and control devices using relays.

IV. RESULT

The system was successfully implemented and tested. The glove detected finger gestures reliably and converted them into corresponding speech output on the smartphone. Relay-controlled devices (light and fan) responded accurately to gestures. Bluetooth communication was stable, and TTS functionality ensured audible message delivery.

1.When the index finger is bent, the message "I want food" is sent through Bluetooth. This message is shown on the mobile app and also spoken out loud using the Text-to-Speech feature.

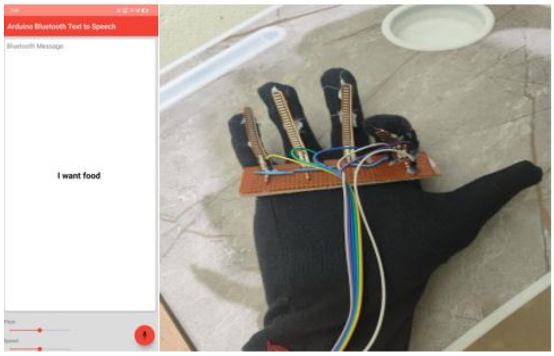

Fig4: The command 'I want food' is triggered when the index finger is bent

2. Similarly, when middle finger the message "Fan turn ON&OFF" is sent through Bluetooth. This message is shown on the mobile app and also spoken out loud using the Text-to-Speech feature.

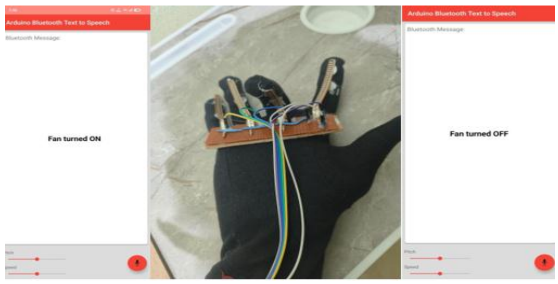

Fig5: The command 'FAN turned ON & OFF' is activated when the middle finger is bent

3. Similarly, when ring finger the message "Light turn ON&OFF" is sent through Bluetooth. This message is shown on the mobile app and also spoken out loud using the Text-to-Speech feature.

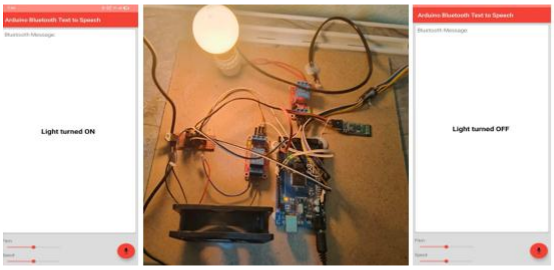

Fig6: The command 'LIGHT turned ON & OFF' is activated when the ring finger is bent

4. Similarly, when little finger the message "I'm in Emergency" is sent through Bluetooth. This message is shown on the mobile app and also spoken out loud using the Text-to-Speech feature.

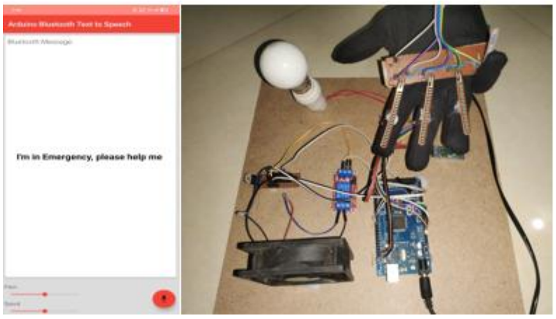

Fig7: The command 'I'm in Emergency' is triggered when the little finger is bent

V. CONCLUSION

This paper presents a smart glove system aimed at enabling speech-impaired individuals to communicate effectively using hand gestures. The design integrates flex sensors, an Arduino Mega 2560, a Bluetooth module, and relay-based automation to convert specific finger movements into voice messages or control signals. The system offers significant advantages over traditional camera-based gesture recognition methods by eliminating dependencies on lighting, background, and fixed setups. Its portability, low cost, and real-time performance make it practical for everyday use. By bridging the communication gap and providing basic home control, the proposed system enhances user independence and quality of life. Future enhancements may involve increasing the gesture vocabulary and implementing advanced learning algorithms for greater adaptability.

FUTURE SCOPE

- Multi-language support for broader applicability.
- Integration with IoT platforms for remote home control.
- GSM module integration for SMS-based emergency alerts.

REFERENCES

[1] K. Pujakumari, A. Ramesh, and M. Venkatesh, "Smart Glove for Speech-Impaired Individuals Using Arduino," IJERT, vol. 9, no. 5, pp. 500–504, 2021.

[2] S. Sharma and P. Singh, "Design and Implementation of Smart Glove for Speech-Impaired Using IoT," IJEAT, vol. 8, no. 6, pp. 112–116, 2019.

[3] M. Delliraj and S. Vijayakumar, "Vision-Based Sign Language Interpretation System," IJAREEIE, vol. 9, no. 4, pp. 1123–1127, 2020.

[4] A. Kadam et al., "Smart Glove: Assistive Device for Speech and Hearing-Impaired People," IJERT, vol. 8, no. 5, pp. 287–291, 2019.

[5] S. Raut and A. Patil, "Hand Gesture Recognition System Using Flex Sensor and Arduino," IRJET, vol. 6, no. 4, pp. 3679–3683, 2019.

[6] R. E. Kahn, "Real-Time Hand Gesture Recognition Using Visual Processing," IEEE Trans. Hum.-Mach. Syst., vol. 48, no. 3, pp. 239–248, 2017.

[7] N. Sharma et al., "Gesture Based Communication System Using Flex Sensor and Bluetooth Module," IJERT, vol. 7, no. 3, pp. 176–179, 2018.

[8] T. T. Nguyen et al., "Smart Glove for Sign Language Recognition Using Machine Learning," Proc. ICTC, pp. 715–720, 2020.

[9] Garg and D. Mehta, "Development of Smart Glove for Sign Language Recognition Using Flex Sensors," IJIRCCE, vol. 5, no. 4, pp. 7890–7896, 2017.

[10] M. A. R. Ahad et al., "Motion Recognition Using Wearable Accelerometer Sensors: A Review," Sensors, vol. 13, no. 9, pp. 12205–12238, 2013.

[11] S. Meena and R. K. Sahu, "Wearable Gloves for Hand Gesture Recognition," IJEAT, vol. 9, no. 2, pp. 146–150, 2019.

[12] S.Wadhwani, R. Singh, and A. Bhattacharya, "Gesture Controlled Home Automation Using Flex Sensor and Arduino," IJIRT, vol. 6, no. 3, pp. 189–193, 2019.
[13] J. Wu, Y. Chen, and M. Lin, "Hand Gesture Recognition Using Sensor Glove," Procedia Engineering, vol. 15, pp. 376–380, 2011.
[14] D. Kumar and R. Rani, "Gesture Controlled Robot Using Arduino and Flex Sensor," IJRASET, vol. 8, no. 4, pp. 45–48, 2020.
[15] P. H. Nguyen et al., "Gesture Recognition Based on Smart Glove and Machine Learning," Sensors, vol. 19, no. 16, p. 3570, 2019.
[16] R. K. Sharma et al., "IoT Based Voice Controlled Automation System for Physically Challenged People," IJESC, vol. 7, no. 6, pp. 10788–10790, 2017.
[17] M. K. Raj and R. Jayasree, "Wireless Glove Based Hand Gesture Recognition System," Proc. IEEE Int. Conf. on Circuit, Power and Computing Tech., pp. 1–5, 2017.
[18] G. Bansal and R. Goyal, "Arduino Based Sign Language Interpreter," IJSRD, vol. 6, no. 3, pp. 812–815, 2018.
[19] S. Mohapatra and T. Mohanty, "Wireless Communication Using Bluetooth in Home Automation," IJARCET, vol. 5, no. 7, pp. 1874–1878, 2016.
[20] R. Thomas and K. Jose, "Low-Cost Smart Glove for Gesture Recognition," IJCA, vol. 164, no. 7, pp. 19–22, 2017.
[21] V. Kumar and S. Roy, "Smart Glove for Virtual Interaction," IJRTE, vol. 8, no. 2, pp. 204–208, 2019.
[22] L. Z. Wang and Y. S. Lin, "Design of a Wearable Glove for Real-Time Gesture Recognition," IEEE Sensors Journal, vol. 15, no. 11, pp. 6391–6397, 2015.
[23] K. Kim and S. Lee, "Wearable Smart Glove for Tactile Sensing," IEEE Transactions on Industrial Electronics, vol. 66, no. 9, pp. 7455–7463, 2019.