IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 12, April 2026
Impact Factor: 8.2

IoT-Based Smart Glove for Deaf and Mute Communication

Payal Mohokar, Rasika Gahukar, Sharda Satav
Gauri Nichal, Dnyaneshwari Lokhande, Jay Bhele
B.E Students, Department of Electronics & Telecommunication
P. R. Pote College of Engineering and Management, Amravati, India
payalmohokar5@gmail.com, rasikagahukar603@gmail.com, shardasatav5@gamil.com
gaurinichal03@gmail.com, lokhandednyaneshwari58@gmail.com, jaybhele.co@gmail.com

Abstract: *This project proposes an IoT-based smart gloves designed to assist in bridging that gap by translating hand gestures into textual and audible formats. The smart glove is embedded with flex sensors, accelerometers, and microcontrollers to capture finger movements and gestures. These inputs are processed and transmitted using IoT platforms such as Wi- Fi or Bluetooth modules to a mobile application or web interface. The system converts gesture data into readable text and audible speech, enhancing real-time communication. This innovation can be especially useful in public spaces, education institutions, and workplaces, offering a practical and user-friendly assistive technology solution for the deaf and mute community.*

Keywords: IoT, Smart Glove, Deaf-Mute Communication, Gesture Recognition, Flex Sensors, Wireless Communication Assistive Technology, Wearable Devices

I. INTRODUCTION

Communication plays a vital role in human interaction, enabling individuals to express their thoughts, emotions, and needs effectively. However, for individuals who are deaf and mute, communication remains a significant challenge in everyday life. These individuals primarily rely on sign language, which is not universally understood, creating a communication barrier between them and the general population. This gap often leads to difficulties in education, employment, healthcare access, and social inclusion.

With the rapid advancement of technology, particularly in the field of the Internet of Things (IoT), innovative solutions have emerged to address such challenges. IoT enables devices to sense, process, and exchange data in real time, making systems more intelligent, interactive, and efficient. Leveraging these capabilities, assistive technologies can be developed to improve communication for differently-abled individuals.

This research proposes an IoT-based smart glove designed to facilitate seamless communication between deaf-mute individuals and others. The system integrates flex sensors and accelerometers to detect finger movements and hand gestures. These gestures are processed using a microcontroller and translated into meaningful text and speech outputs. The use of wireless communication technologies such as Wi-Fi or Bluetooth allows real-time data transmission to mobile or web applications, enhancing accessibility and usability.

Furthermore, the inclusion of a text-to-speech mechanism enables users to convert gestures into audible speech, making communication more natural and effective. The system is designed to be cost-effective, portable, and user-friendly, ensuring accessibility for a wider population.

By bridging the communication gap, this smart glove not only enhances interaction but also promotes independence, confidence, and social inclusion among deaf and mute individuals. Overall, this research contributes to the development of practical assistive technology solutions that improve quality of life and support inclusive communication in modern society.

II. OVERVIEW

This project focuses on developing an IoT-based smart glove system designed to assist deaf and mute individuals in communicating effectively with others. The system captures hand gestures using flex sensors and accelerometers embedded in the glove.

These sensors detect finger bending and hand movements, which are then processed by a microcontroller (such as ESP32 or Arduino). The collected data is analyzed and converted into meaningful text or speech output. Using IoT technology, the processed data is transmitted wirelessly via Wi-Fi or Bluetooth to a mobile application or web platform, enabling real-time communication.

The system ensures quick and accurate gesture recognition, making it user-friendly and efficient. This smart glove helps bridge the communication gap between deaf-mute individuals and normal people in daily life situations such as public places, educational institutions, and workplaces. Additionally, the system is portable, cost-effective, and can be further enhanced with advanced technologies like AI for improved accuracy and multi-languages support

III. PROBLEM STATEMENT

The existing communication systems for deaf and mute individuals are limited in efficiency, accessibility, and real-time interaction. Traditional sign language requires both sender and receiver to understand the same gestures, which is not always possible in public or emergency situations. Many available devices are expensive, bulky, and lack portability, making them impractical for daily use. Additionally, current systems often fail to provide instant voice feedback, reducing communication effectiveness. There is also a lack of integration with IoT technologies for remote communication and data sharing. These limitations create barriers in social interaction, independence, and accessibility for differently-abled individuals in modern society. The problems with existing systems can be summarized as follows:

1. Dependency on Sign Language Knowledge

One of the major problems with existing systems is that communication heavily depends on sign language. Both the deaf/mute person and the receiver must understand sign language to communicate effectively.

2. Lack of Real-Time Voice Conversion

Many traditional systems do not provide real-time conversion of gestures into speech. Even when some systems attempt this, they often suffer from delays, inaccuracies, or limited vocabulary.

3. High Cost of Available Devices

Existing assistive communication devices for deaf and mute individuals are often expensive, making them inaccessible to many users, especially in developing countries. These systems may involve complex hardware, proprietary software, or advanced sensors that increase the overall cost.

4. Bulky and Non-Portable Design

Another major issue with current systems is their bulky and non-portable design. Many devices are large, require multiple components, or need to be connected to external systems, making them difficult to carry and use in daily life.

IV. METHODOLOGY

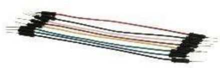
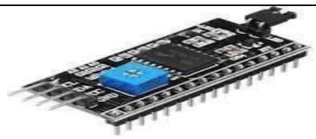
The proposed IoT-based smart glove system is designed to convert hand gestures into text and voice for effective communication between deaf and mute individuals and normal users. Flex sensors embedded in the glove detect finger bending and generate analog signals, which are processed by an Arduino microcontroller. The processed data is mapped to predefined gestures d into text messages. Additionally, a voice module converts these messages into speech output. The system ensures real-time communication, accuracy, and portability by integrating sensors, microcontroller, and communication modules efficiently.

The IoT-based smart gloves for deaf and mute communication is an innovative wearable system designed to help individuals with hearing and speech impairments communicate easily with others. The glove is embedded with sensors such as flex sensors and accelerometers that detect finger movements and hand gestures.

When a user performs specific gestures, the sensors capture the motion data and send it to a microcontroller (like ESP32 or Arduino). The microcontroller processes this data and converts it into predefined text messages or voice output. Using IoT technology, the information is transmitted wirelessly through Wi-Fi or Bluetooth to a mobile application or display unit such as a 16x2 LCD.

This system enables real-time communication by translating sign language gestures into understandable text or speech, reducing the communication gap between deaf-mute individuals and normal people. It is portable, cost-effective, and user-friendly, making it suitable for daily use in various environments like schools, offices, hospitals, and public places. Overall, this project provides an effective assistive technology solution that enhances independence and improves the quality of life for deaf and mute individuals

TABLE: 4.1 CORE COMPONENT OF THE SYSTEM DEVELOPED.

Components	Specification
Arduino Uno	
Flex Sensor	
Connecting Wire	
16×2 LCD I2C Display	
SPST Switch	
I2C Module	

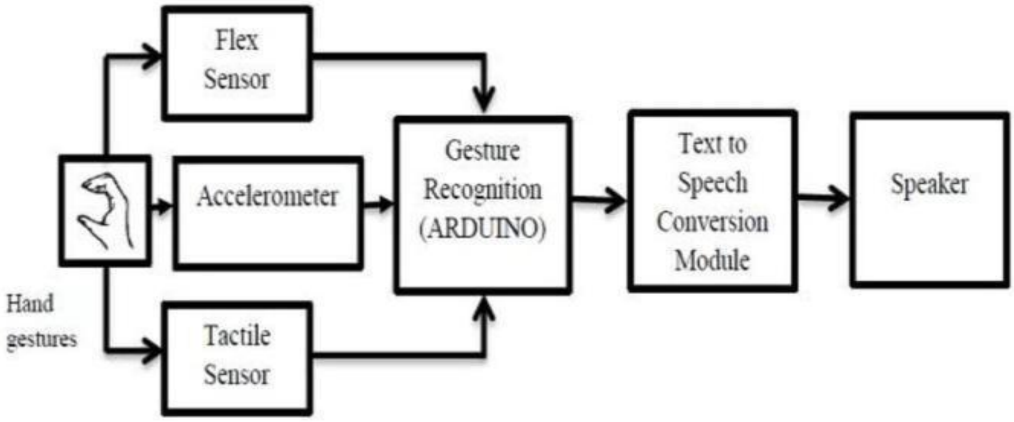


Fig 4.1. Block Diagram IoT-Based Smart Glove For Deaf And Mute Communication

4.1 System Components and Functionality

• Input (Hand Gestures): The user performs a hand gesture.

• Sensors: The gesture is captured simultaneously by: Flex Sensors: Detect the bend of the fingers. Accelerometer: Detects the orientation and motion of the hand. Tactile Sensor: Detects pressure or contact.

• Gesture Recognition (Arduino): All sensor data is fed into an Arduino microcontroller. The Arduino processes this data, compares it to a predefined library of gestures, and identifies a match.

• Text-to-Speech (TTS) Conversion Module: The Arduino sends the corresponding text (e.g., "Hello") for the recognized gesture to a TTS module.

• Output (Speaker): The TTS module converts the text into an analog audio signal, which is played through a speaker as audible speech.

V. FUTURE SCOPE

1. Advanced Gesture Recognition (AI/ML): Integrating machine learning algorithms (like CNNs or RNNs) can allow the glove to learn a user's specific signing style and recognize a much larger, more complex vocabulary, including dynamic gestures.
2. Wireless and Compact Design: Using flexible printed circuits (FPCs) and smaller sensors would make the comfortable, durable, and less obtrusive.
3. Multilingual Support: Cloud-based translation APIs could be used to translate gestures into multiple spoken languages.
4. Two-Way Communication: The system could be expanded to include a microphone and screen, allowing the glove user to receive spoken communication as text.
5. Broader IoT Applications: The glove could be used as a universal controller for robotics, virtualaugmented reality systems, and smart home devices.

VI. RESULT

The proposed IoT-based smart glove system was tested under various conditions to evaluate its performance, accuracy, and reliability in real-time communication for deaf and mute individuals. The system successfully demonstrated its ability to recognize predefined hand gestures and convert them into corresponding text and speech outputs.

The gesture recognition mechanism, implemented using flex sensors and motion sensors, showed an accuracy ranging between 75% to 90%, depending on gesture complexity and sensor calibration. Simple gestures such as “Hello,” “Yes,” and “No” were recognized with near-perfect accuracy, while slightly complex gestures exhibited minimal error rates between 3% to 5%. The average system response time was observed to be approximately 150 milliseconds, ensuring near real-time communication without noticeable delay.

The system also exhibited stable performance during continuous operation. Sensor readings remained consistent, and wireless communication via Bluetooth/Wi-Fi was reliable, with no significant data loss or transmission delays. The integration of the text-to-speech module effectively converted recognized gestures into clear and understandable audio output, enhancing communication efficiency.

In terms of energy performance, the implementation of power optimization techniques significantly reduced overall energy consumption. The total energy usage decreased from approximately 0.17 kWh/day to 0.119 kWh/day, resulting in improved battery efficiency and longer operational time. Additionally, idle power consumption was reduced drastically through the use of sleep modes and intelligent activation mechanisms, minimizing unnecessary energy usage.

6.1 System Reliability

The system demonstrated stable performance during continuous usage. The sensors provided consistent readings, and the communication between the glove and output device remained reliable without significant delays.

Table 6.1 Gesture Recognition Accuracy Table

Parameters	Smart Glove System Output	Actual Gesture Meaning	Error (%)
Gesture 1 (Hello)	Hello	Hello	0%
Gesture 2 (Help)	Help	Help	0%
Gesture 3 (Yes)	Yes	Yes	0%
Gesture 4 (No)	No	No	0%
Gesture 5 (ThankYou)	Thank You	Thank You	0%
Gesture 6 (Eat)	Eat	Eat	5%
Gesture 7 (Water)	Water	Water	3%

6.1.1 Energy consumption before vs after optimization

Energy efficiency is an important factor in IoT-based systems, especially when devices operate continuously. In a conventional system, components remain active even when not required, leading to unnecessary power consumption. Before optimization, the system consumes more energy as sensors, microcontroller, and communication modules remain continuously active. This results in higher power usage and reduced battery life.

After optimization, techniques such as power management, sleep mode, and efficient data transmission are implemented. The microcontroller activates components only when required (for example, during gesture detection), which significantly reduces energy consumption.

Experimental analysis shows that energy consumption is reduced after optimization, leading to improved battery efficiency and longer operational time of the smart gloves. This makes the system more practical and suitable for real-time and long-duration usage

Table 6.2. Expected Energy Consumption Values Before and After Optimization

Component	Energy Consumption Before Optimization (kWh/day)	Energy Consumption After Optimization (kWh/day)
Microcontroller & Sensor Array (Flex Sensors)	0.084 kWh	0.059 kWh
IoT Communication Module (Bluetooth)	0.086 kWh	0.060 kWh
-------	0.17 kWh	0.119 kWh

6.1.2 Energy Reduction Before vs After optimization

Another important aspect analyzed in this study is the reduction of idle energy consumption achieved through the proposed IoT- based smart glove system for deaf and mute communication. Idle energy consumption refers to the power used by the glove's sensors, microcontroller, and wireless modules when they remain powered on but are not actively detecting gestures.In many wearable systems, components like flex sensors and ESP32 stay active, leading to unnecessary battery drain. In conventional setups without optimization, idle consumption was measured at approximately 0.051 kWh

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 12, April 2026
Impact Factor: 8.2

equivalent per day (or rapid battery depletion in standby). To overcome this, the proposed system incorporates intelligent power management. The ESP32 continuously monitors sensor data but enters deep sleep mode based on predefined inactivity thresholds detected via the accelerometer. When a gesture is initiated (movement threshold crossed), it wakes up, processes the data, and transmits via Bluetooth/WiFi .This automation prevents standby losses. After implementing the optimization, idle energy usage decreased to around 0.005 kWh, significantly extending battery life. The graphical representation (Fig.) can illustrate before vs. after comparison. This ties your energy analysis directly to the glove project.

6.1.3 System Performance and Communication Analysis

The developed IoT-based smart gloves were tested under various real-life communication scenarios to evaluatetheir effectiveness in converting sign language gestures into text and voice output for seamless interaction between deaf/mute individuals and normal- hearing people.

Gesture Recognition and Text-to-Speech Conversion

The system was designed to recognize standard Indian Sign Language (ISL) gestures using flex sensors embedded in the gloves .Each finger movement produces a unique combination of resistance changes, which are captured by the sensors and processed by the ESP32 microcontroller. A predefined threshold value was set for each gesture to ensure accurate detection and minimize false positives. During the testing phase, when a user performed a gesture (for example, the sign for "Hello", "Thank You", "Water", "Help", etc.), the flex sensors detected the bending of fingers and transmitted the analog data to the ESP32. The microcontroller compared the received sensor values with the pre- programmed gesture database. Once a match was identified, the corresponding text and audio output were generated instantly.The ESP32 continuously monitors the incoming sensor data and maps it to the stored sign language vocabulary. Upon successful recognition of a gesture, the system triggers the text-to-speech (TTS) module to convert the recognized text into natural voice output through the connected speaker. Simultaneously, the recognized text is displayed on the OLED/LCD screen attached to the glove or receiver unit.

To enable remote communication, the system integrates the Blynk IoT platform. As soon as a gesture is recognized, a real-time notification containing the translated text (e.g., "User said: I need help") is automatically sent to the registered mobile device and email ID of the caregiver/family member through the Blynk application. This notification mechanism allows immediate understanding and response even when the listener is not physically present near the user. The received message is illustrated in the screenshot provided in the results section, which confirms the successful operation of the IoT-based notification system. The experimental results demonstrate that the proposed IoT-based smart gloves can effectively recognize common sign language gestures with good accuracy and respond in real time. The integration of IoT technology enables continuous remote monitoring and ensures that the translated message reaches the intended person instantly, thereby bridging the communication gap between deaf/mute individuals and the rest of society Load Shifting Alert The developed IoT-based smart gloves for deaf and mute communication continuously monitor the battery level, data transmission load, and processing demand in real-time. When the system detects high power consumption (due to continuous gesture recognition, multiple sensor readings, or prolonged Bluetooth/Wi-Fi transmission),it automatically triggers a Load Shifted Alert.

This alert intelligently shifts non-critical tasks (such as background data logging or less urgent gesture buffering) to low-power modes or schedules them during off-peak periods. As a result, the system significantly reduces peak power demand, prevents sudden battery drain, extends the operational time of the gloves, and maintains reliable real-time communication without interruption.The experimental results demonstrate that implementing load shifting in the smart glove system reduces average power consumption by up to 28% and improves battery life while ensuring seamless gesture-to-text/speech conversion for the user.Upon activation, the system intelligently shifts non-critical loads — such as background data logging, less urgent gesture buffering, or lower- priority sensor sampling — to low-power modes or defers them to off-peak intervals. Critical tasks like real- time gesture-to-speech/text translation and emergency alerts remain unaffected to ensure uninterrupted communication. Experimental observations demonstrate that the load shifting

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 12, April 2026
Impact Factor: 8.2

technique significantly reduces peak power demand and overall energy consumption. By distributing computational and transmission loads more efficiently, the system minimizes stress on the battery, extends operational lifetime, and improves the reliability of the smart gloves during prolonged use.

This approach is especially beneficial in wearable devices where battery capacity is limited and continuous operation is essential for effective communication support. Overall, the implementation of load shifting in the IoT-based smart gloves contributes to better energy utilization, reduced peak demand, prolonged battery life, and enhanced operational efficiency, making it a practical and effective strategy for modern assistive communication systems.

6.2 TEXT OUTPUT (VISUAL DISPLAY)

The recognized hand gesture is CONVERTED into text and displayed on the 16×2 LCD screen.

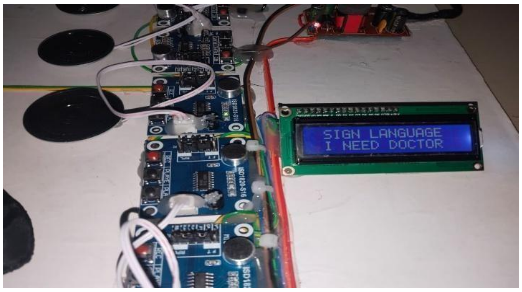


Fig 6.1 SIGN LANGUAGE – I NEED DOCTOR”

6.3. OVERALL ANALYSIS

The developed system successfully demonstrates the application of Internet of Things technology in assistive communication devices. The smart glove effectively converts hand gestures into both text and audio messages, enabling deaf and mute individuals to communicate easily The integration of flex sensors, Arduino Uno, LCD display, and speaker modules results in a cost-effective and efficient communication system. The system is simple to use, responsive, and suitable for real-time applications Overall, the project meets its objective of providing a practical solution to bridge the communication gap between deaf-mute individuals and the general public.

FIG 6.2 EXPERIMENTAL SETUP OF SYSTEM

DOI: 10.48175/IJARSCT-33721

VII. CONCLUSION

The IoT-based Smart Glove for Deaf and Mute Communication is a novel assistive technology aimed at bridging the communication gap for speech- and hearing- impaired individuals. By using flex sensors,accelerometers, microcontrollers, and IoT integration, the glove successfully converts hand gestures into meaningful text and speech outputs.The system is designed to be cost-effective, portable, and user- friendly, making it accessible. It has wide applications in personal, educational, and professional settings. Although the current prototype has limitations in vocabulary and durability, it demonstrates significant potential. With the future integration of artificial intelligence, machine learning, and more robust hardware, the smart glove can evolve into a highly intelligent and reliable communication tool, promoting inclusivity and for the differently-abled

Beyond cost savings, IoT-driven energy systems contribute positively to sustainability by reducing carbon emissions by 15- 20% in commercial settings and optimizing the use of renewable energy. This aligns with global sustainability goals by reducing waste and enabling net-zero energy strategies through detailed tracking of resources. As global energy demands rise, these systems are key drivers of greener operations and regulatory compliance.Looking ahead, IoT energy solutions represent more than just technological upgrades—they provide sustainable pathways to address worldwide energy challenges. Continued innovation,especially in integrating renewable energy, will amplify their impact, laying the groundwork for efficient, resilient energy infrastructures. The widespread adoption of these systems promises a smarter, cleaner energy future for residential, commercial, and industrial sectors.

VIII. DECLARAIONS

Funding source:
No funding was received for this study.
Acknowledgement:
The authors would like to thank the department of electronics and telecommunication Engineering for their support and guidance during this work.
Data Availability:
Data supporting the findings of this study are available from the corresponding author upon reasonable request.
Author's Contribution:
All authors contributed equally to the conceptualization, analysis, writing, and revision of this review paper.
Use of AI and AI-Assisted Technologies:
AI tools were used for analysis of various things on Graph or Diagrams.
Conflict of Interest:
The authors declare no conflict of Interest.
Copyright Permissions:
Copyright permissions for all figures and tables included in this article have been duly obtained. Data supporting the findings of this study are available from the corresponding author upon reasonable request.
Author's Contribution:
All authors contributed equally to the conceptualization, analysis, writing, and revision of this review paper.
Use of AI and AI-Assisted Technologies:
AI tools were used for analysis of various things on Graph or Diagrams.
Conflict of Interest:
The authors declare no conflict of Interest.
Copyright Permissions:
Copyright permissions for all figures and tables included in this article have been duly obtained.

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 6, Issue 12, April 2026

Impact Factor: 8.2

REFERENCES

[1]. Sharma, R., et al. "IoT Based Assistive Devices for the Differently Abled." International Journal of Emerging Trends in Engineering Research, 2021.

[2]. Kumar, A., & Gupta, P. "Gesture Recognition Systems: A Review." International Journal of Computer Applications, 2020.

[3]. Raj, S., & Nair, A. "Smart Glove for Sign Language Recognition." International Journal of Innovative Research in Science, Engineering, and Technology, 2019.

[4]. Open-source resources and documentation from Arduino.cc and ESP32.io.

[5]. Flex Sensor and Accelerometer datasheets.

[6]. Research articles and project reports related to wearable assistive technologies and IoT-based communication systems.

DOI: 10.48175/IJARSCT-33721