IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⩾ Peer-reviewed & Refereed journal ⩾ Vol. 14, Issue 12, December 2025

DOI: 10.17148/IJARCCE.2025.1412127

Haptic Based Feedback Sensor

S Manya[1], Dr. R Kanagavalli[2], Sonika B M[3], Prithviraj[4], Nisarga A R[5]

Department of Information Science and Engineering, The Oxford College of Engineering,

Affiliated to Visvesvaraya Technological University, Belagavi, Karnataka, India[1-5]

Abstract: Communicating effectively becomes extremely difficult for individuals with speech and hearing impairments, especially as the majority of people are not familiar with sign language. Existing assistive solutions often fall short as they are costly, influenced by environmental conditions, or lack real- time confirmation for the user. To overcome these limitations, the proposed IoT-based Smart Support Glove translates hand gestures into readable text and audible speech instantly. The glove integrates flex sensors and an MPU6050 module to accurately capture finger movements and hand orientation. An Arduino Nano processes these signals and identifies the performed gesture, which is then transmitted to a server through an ESP8266 Wi-Fi module. The server-side algorithm converts the encoded gesture data into text or speech within a mobile application. Additionally, a vibration motor provides haptic feedback, assuring the user whether their purpose has been delivered. Designed to be lightweight, affordable, and scalable, this wearable system offers a practical assistive tool that enhances communication, accessibility, and social inclusion.

Keywords: IoT (Internet of Things), Assistive Technology, Gesture Recognition ,Smart Glove / Wearable Device ,Flex Sensor ,MPU6050 (Accelerometer/Gyroscope) ,Arduino Nano , ESP8266 Wi-Fi Module ,Text-to-Speech (TTS) ,Haptic Feedback/ Vibration Motor / Buzzer ,Wireless Communication ,Speech and Hearing Impairment ,Embedded System.

I. INTRODUCTION

Human connection is built entirely on the ability to communicate. It is how we share our thoughts, ask for help, and find our place in the world. Even with all the technology we have today, people who are speech or hearing impaired still face massive hurdles every day. The biggest problem isn't the disability itself, but the fact that most people simply don't understand sign language. This gap often leads to social isolation and makes it much harder for these individuals to get an education or find a job.

Our project, the "IoT-based Smart Support Glove," was designed specifically to tear down this wall. We wanted to create a wearable tool that turns simple hand movements into digital messages anyone can read or hear. By combining hidden sensors and a small microcontroller with IoT connectivity, the glove tracks gestures and instantly translates them through a mobile app. The goal is to make conversation feel natural and immediate, rather than a struggle for both parties. This section covers the "why" behind our project, the specific problems we set out to solve, and the goals we hope to achieve. While tools like hearing aids and braille displays have changed lives, they don't always help with two-way conversation. Many older gesture-recognition systems rely on cameras, but those are prone to failure if the lighting is bad or the background is too busy. They also raise uncomfortable privacy issues. We found that wearable sensors—specifically flex sensors and gyroscopes—are much more reliable. They track the exact curve of a finger or the tilt of a wrist regardless of the environment. By linking these sensors with modern wireless tech, we've built a communication tool that is actually practical for daily life.

II. PROBLEM STATEMENT AND OBJECTIVE

- Sign Language Barrier: The biggest obstacle isn't the inability to speak, but the fact that the world around these individuals doesn't "speak" their language. Since very few people outside the deaf community know sign language, even a simple task—like ordering a coffee or asking for directions—becomes a stressful ordeal. This disconnect turns a vibrant form of communication into a wall, leaving users with hearing or speech limitations feeling like outsiders in their own neighbourhoods. Our goal is to turn those complex hand signals into a language that everyone can understand instantly.
- Limitations of Current Devices: Many existing tools require typing or manual input, which is slow and im- practical in real-time communication.
- Camera-Based Drawbacks: Vision-based systems depend heavily on lighting, background clarity, and computational power, and they raise privacy concerns.
- High Cost: Advanced gesture-recognition gadgets are frequently too costly for widespread use.
- Lack of Feedback: Many existing solutions do not notify users when a message has been successfully transmitted.

DOI: 10.17148/IJARCCE.2025.1412127

- Building a sensor-integrated glove using flex sensors and an MPU6050 module to detect finger and hand movements.
- Developing an Arduino-based processing unit to interpret gesture patterns.
- Establishing real-time wireless data transmission using the ESP8266 Wi-Fi module.
- Creating a server-side application to convert gesture codes into meaningful text or speech.
- Implementing a mobile application for user-friendly message display and voice output.
- Adding a haptic feedback mechanism to reassure users that their gestures have been recognized and transmitted.

Therefore, the core problem addressed by this project is:
"How can we develop an affordable, portable, and dependable gesture-to-speech system that enables real-time communication without requiring users to rely on external devices or complex interpretations?"

III. SCOPE

The developed system focuses on the following areas:

A. Hardware Integration
- Flex sensors for finger bending detection
- MPU6050 for motion and orientation recognition
- Arduino Nano as the microcontroller
- ESP8266 for wireless connectivity
- Vibration motor for user feedback

B. Software Development
- Firmware for sensor processing
- Server-side API for gesture interpretation
- Mobile app for text and speech output

C. Gesture Compatibility
- Supports basic predefined gestures
- Can be expanded to accommodate more gestures in future versions

D. Communication Model
- Real-time data flow from glove to server finally to mobile app
- Acknowledgment sent back to glove to confirm successful transmission

IV. LITERATURE REVIEW

Gesture recognition and assistive communication technologies have been extensively researched throughout across different re- search domains. Over the years, multiple approaches—ranging from camera-based systems to advanced sensor-driven wearables—have been developed to support individuals with speech and hearing impairments. This chapter reviews these existing solutions, highlights their limitations, compares representative studies, and identifies the research gap that motivates the proposed Smart Support Glove.

A. Existing Gesture Recognition and Assistive Communication Systems
- Vision-Based Gesture Recognition Systems: Camera- based Recognising gestures has always been some of the earliest and most common research approaches. Traditional systems rely on image processing methods such as contour detection, color segmentation, and edge tracking to interpret hand shapes and movements. [1] With the advancement Convolutional neural networks (also known as CNNs) and other deep learning approaches have significantly improved the accuracy of recognizing static and dynamic gestures in sign languages such as ASL (American Sign Language) and ISL (Indian Sign Language). [2], [10]
- Sensor-Based Wearable Gesture Recognition Systems Using sensors in wearable devices at least provides environmental independence. Real-time systems using accelerometers and gyroscopes to determine hand position and movement in addition to flex sensors, which detect finger bending by measuring resistance changes provide reliable systems. [3] Smart gloves have been created as prototypes to capture gestures and map and display them as text on integrated screens and mobile applications.
- Hybrid Approaches Hybrid systems take advantage of both vision-based systems and sensor-based systems (for example, integrating camera recognition with glove sensors or EMG sensors and flex sensors) to increase precision for complicated gestures. These systems, unfortunately, become complex and costly, which tends to halt their use on a larger scale.
- Communication Systems with IoT Integration New studies are centered on solutions with IoT capabilities, where a wearable and an embedded device transmits data to a console or mobile app, which interprets the data using

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 12, December 2025
DOI: 10.17148/IJARCCE.2025.1412127

Wi-Fi, Bluetooth, or Zigbee. The data exchange is facilitated using Firebase or MQTT brokers. [7] In addition to translating text, these systems utilize TTS (Text-to- Speech) technology to produce an instant voice output, demonstrating whether these systems are flexible, interconnected, and designed with the end-user in mind.

B. Limitations of Current Approaches

Drawbacks include:

- Models frequently face difficulty when surrounding conditions change or when the background is shattered, which reduces recognition perfection.
- Systems of Deep Learning require very strong processors or GPUs, making them unuseful for low-cost and portable devices.
- Gloves that are wearable and portable require regular resetting of data .
- Systems depend mostly on stable connectivity.
- Some prototypes are inappropriate for regular use since being bulky, wired, and uncomfortable making.

C. Identified Research Gap

The critical review reveals a clear gap in existing literature and devices, justifying the proposed work:

- Affordability and Accessibility: Many current high- performance solutions are priced far beyond what most users can afford.
- Many previously proposed gloves focus on accuracy and comfort, leading to designs that are difficult to wear for long.
- The absence of instant feedback reduces the user confidence and interrupts smooth communication. Therefore there is a need for a wireless, lightweight glove which provides feedback and usability.

V. SYSTEM ARCHITECTURE

The Smart Support Glove is created to convert hand gestures into meaningful and understandable communication. The system has a clear processing pipeline that starts with reading hand movements, then goes with data analysis, and ends with wireless transmission of the recognized gesture.

Once a gesture processed, the output is given in both text and audio formats. A closed-loop mechanism is used in our project so that the user receives instant and fast confirmation whenever a gesture is successfully recognized.

Gesture Recognition Module (Flex Sensors,MPU6050)

This module acts as the sensing layer of the framework and is in charge of collecting all motion-related information from the user's hand. It focuses on detecting finger movements in addition to wrist orientation.

- Each finger is equipped with a flex sensor that detects bending by varying its electrical resistance. The values obtained from these sensors shows the degree of finger bending and are used to identify gestures.
- To capture wrist motion and dynamic gestures, the MPU6050 sensor is used. We used accelerometer and a gyroscope, which measures linear and rotational movements respectively. By combining data from the flex sensors and the MPU6050 that we have used , the system is able to distinguish gestures based on both finger position and hand orientation according to our views.[4], [5]
- Output is a unified gesture profile that combines finger bend data and wrist data..

A. Data Processing Module (Arduino Nano Preprocessing)

We selected the Arduino Nano as the main processing unit of the glove (wearable). Its main function is to process the raw signals received from the flex sensors into a meaningful representation. Flex sensors rarely provide a signal that is free of imperfections, and our software pipeline refines the flex sensor data prior to outputting it from the glove.

Preprocessing Steps:

- **Initial Calibration:** Because each individual hand size and grip can be different, the first step in preprocessing is to provide the user with a baseline for the glove. This baseline is necessary for the system to understand what the range of movement is between fully opened and fully closed.
- **Noise Filtering:** Noise near the sensors from electronic devices can cause fluctuations. We utilized moving average filtering to eliminate these fluctuations from the signal before producing text output.
- **Standardization of Raw Voltage Readings (Normalizing):** We will normalize the raw voltage readings into a

similar range in order for our system can effortlessly compare gestures regardless of battery levels.

- **Gesture Definition** (Creating Signatures For Each Gesture): Each gesture is defined using the specific ratio between the bends in the fingers and the tilts of the hands, generating a specific mathematical signature for the gesture;
- **Mapping the Gesture:** The mathematical signature of the gesture will be compared to our stored templates to retrieve a matching gesture. We will compare the identified gesture signature to retrieve a stored gesture template to find a matching gesture to be recognized.
- **Efficiency and Transmission Efficiency of Data through Wi-Fi and Output:** The largest benefits of performing local processing is that saves on bandwidth usage. We no longer need to send a constant stream of numbers over Wi-Fi to process gestures. Instead of sending a large number of raw numbers generated by sensors, the Arduino board identifies the gesture and sends a compact gesture ID (i.e. G1 for "hello" or G2 for "help"). Therefore, the transmission time from the Arduino board to the Communication Module is instantaneous.

B. Wireless Communication Module (ESP8266 to Server/Cloud)

When the gesture is found, the Arduino may convey a message to the server or cloud.ESP8266 Wi-Fi module comes in to fill the space glove and the electronic world. Takes in the already processed gesture packets of the Arduino and creates a Wi-Fi using an inbuilt TCP/IP stack connection.

- **The Connection**: The module uses its built-in TCP/IP stack to hook into a local Wi-Fi network.
- **The Handshake**: It packages the gesture ID and sends it to the Internet of Things server via common protocols .
- **The Goal**: Our main focus here was minimizing latency; we wanted to ensure that as soon as a user finishes a movement, the message is already hitting the server

C. Turning Codes into Conversation Module

Use Turning the system into a Conversation On the server-side (with a Flask-based system), this system behaves like a digital dictionary.

- Input It The simple, lightweight code (such as G1) transmitted by the glove gets to input It.
- The Search It carries out a quick mapping procedure, and the ID is searched against a database of held words and phrases.
- The Consequence When ID 123 is received The server immediately recognizes it as I need help and forces that full text to the mobile app E.

D. Mobile Application Module

This is the interface of the end user of the system and it makes sure that the translated messages are available. accessible to the listener.

- Text Display :The translated message is received by the server and shown in text.
- Voice Output: Integrates with a Text-to-Speech (TTS) engine to read the messages aloud for listeners.
- User Features: Provides a simple UI for readability and potentially allows storage of conversation history.

E. Feedback Module

This module closes the communication loop, providing essential user confidence.

- Trigger: The server sends an acknowledgment signal back through the ESP8266 once the message is successfully processed and sent to the mobile app.
- Action: The Arduino triggers the mini vibration motor (or buzzer).
- Confirmation: A short vibration confirms delivery, while a long vibration could signal an error.

F. Algorithms

The system’s logic relies on specific algorithms implemented across the Arduino and Server:

- **K-nearest neighbours (KNN) algorithm** : is a kind of supervised ML algorithm which can be applied to both classification as well as issues with regression prediction. But it's mostly utilized for classification predictive issues in industry. The following two properties of Algorithm for lazy learning and Non-parametric learning algorithm makes it best suitable.
- **Random Forest Algorithm** :Random One kind of controlled machine learning method called "forest" is based on sustainable education. In order to create a more potent prediction model, ensemble learning combines many algorithms or the same algorithm several times. The algorithm known as random forest creates a forest of trees—thus the name "Random Forest"—by combining several algorithms of the same kind, such as multiple decision trees. Regression as well as classification tasks can both benefit from the application of the random forest technique. [6]

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 14, Issue 12, December 2025

DOI: 10.17148/IJARCCE.2025.1412127

- **A controlled machine learning approach called a Support Vector Machine, or SVM, can be used for regression as well as classification.** SVMs frequently utilized in classification problems and as such, this is what we will focus on in .

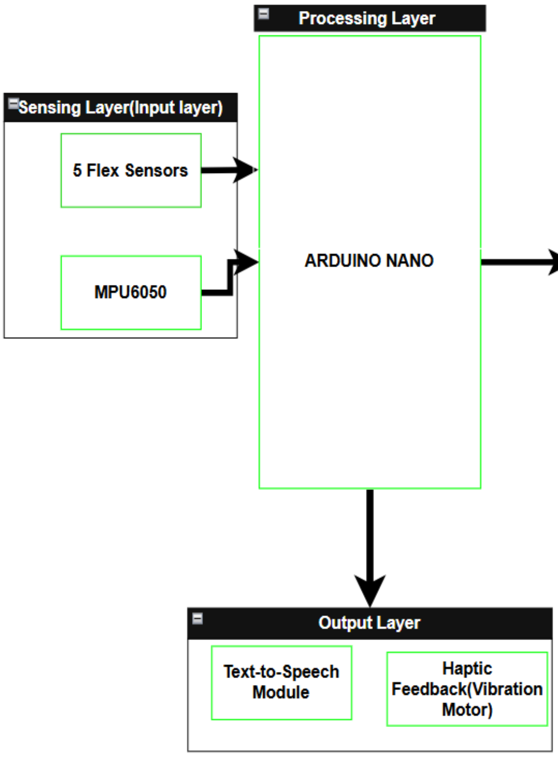

Figure 1: 4 Layer System Architecture

VI. METHODOLOGY

A. System Design Overview

We organized the system into four distinct layers that work in harmony to turn a physical movement into a digital voice.

- **The Sensing Foundation (Acquisition Layer):** Everything starts at the hand. We embedded five flex sensors and an MPU6050 motion sensor directly into the glove's fabric. While the flex sensors track how much each finger is curving, the MPU6050 monitors the tilt and orientation of the wrist.
- **The Intelligence Layer (Processing & Control):** It is here that the Arduino Nano comes in. It is not merely relaying data, it first grooms it. We coded it to do calibration and noise reduction such that small shakes will not cause the text to be garbled. After the movement has been cleansed, the Arduino compares the pattern to our library and downsizes it to a small one. digital code of quicker passage.
- **The Bridge (Communication Layer):** To create the glove part of the IoT ecosystem, we employed ESP8266 Wi-Fi. module. This is employed to act as the wireless connection between the hardware on the hand and our backend server. This is achieved by not sending the sensor streams but only the compact gesture codes so that we guarantee that we have lag-free communication. free.
- **The User Interface & Confirmation (Application & Feedback):** The last point is the mobile app. The server decodes the received code into a complete sentence and the app then presents it takes the shape of a text and reads the text aloud. using Text-to-Speech (TTS). In order to complete the loop, we have incorporated a haptic feedback step when the message is received.
- **Vibration motor** : when the glove buzzes, the user is alerted without the need to look into the display that they were called.

B. Hardware Components

The core components are integrated into a wearable glove platform:

- **Flex Sensors:** Five flex sensors, one on each finger, measure the degree of bending.

DOI: 10.17148/IJARCCE.2025.1412127

- **MPU6050 (Motion Tracking):** is sensor is essential in the use of tracking the movement of the hand in space. Whereas the accelerator detects linear motion (linear motion), the gyro monitor detects the rotation of the. wrist. This will enable the system to distinguish between a pose that is not dynamic such as holding a sign and a dynamic gesture that. involves a specific motion.
- **Arduino Nano (The Controller):** We used the Nano as the central processing unit due to its small size. It collects all the coming analog and digital information, executes our proprietary noise filters and normalization mathematical operations, and then compares those values to our templates of gestures.
- **ESP8266 Wi-Fi Module (IoT Connectivity):** When it gets a match it codifies the result in to a small ID and drives it into the Wi-Fi module. And ESP8266 Wi-Fi Module (IoT Connectivity) This small part provides the glove with its wiring potential. It also deals with the internet connectivity and forwards the gesture IDs to the server in real-time. The reason why we chose this particular module is that the power consumption of this module is very low, which is required in a battery operated module. wearable.
- **Vibration Motor & Buzzer (User Feedback):** To improve the system to be more user-friendly we added a haptic feedback. mechanism.
- **Wearable Glove Platform** :The glove houses all sensors and components in a compact, comfortable design. Ensures mobility and ease of use for long-duration wear.

C. Software Components

The system utilizes multiple software environments:

- Arduino IDE and Embedded C: Handles interaction with flex sensors and the MPU6050.

Performs data calibration, noise reduction, thresholding, and gesture identification.
Sends gesture codes to the ESP8266 through serial com- munication..

- Flask/IoT Server: Acts as the central processing unit to convert gesture codes into meaningful text.

Provides a RESTful API to interact with themobile application.
Stores gesture-to-text mappings and may integrate ma- chine learning models in future versions.

- WEB(Android Studio/Java): Displays the translated ges- ture in clear, readable text.

Uses TTS to convert the message into audible speech. Allows users to review communication history and inter- act with the glove in real time.

- Communication Protocols: HTTP or MQTT depending on the server setup.

Ensures fast and lightweight data transfer between the glove, server, and mobile application.

D. Data Flow and Communication Model

The system employs a multi-stage data flow pipeline for real-time communication:

- **Gesture Acquisition**: The user performs a hand gesture. Flex sensors measure the bending of fingers, and MPU6050 measures movement and orientation of the hands.
- **Data Preprocessing:** Data is read by Arduino and subjected to noise filter and calibration. Process values are contrasted with templates of gestures. When a match has been found, a compact gesture ID is created.
- **Gesture Recognition:** In case a match is found, the Arduino will assign a unique gesture ID (eg, Gesture 1 =human Arduino To a match, the Arduino will give out a unique gesture ID (eg, Gesture 1 =human Gesture Recognition To a match, the Arduino will output a different gesture ID (eg, Gesture 1 =human)Gesture Recognition To a match, the Arduino will set out a unique gesture ID (eg, Gesture 1 "Hello").
- **Wireless Data Transmission:** Once the Arduino Nano detects the gesture, it forwards the small gesture. ID to the ESP8266 module.
- **Backend Intelligence (Flask Server):** When the Flask server gets the incoming ID, then it will behave as a digital. translator. It searches its database with the particular ID and retrieves the word or entire sentence that is associated with it. This is then immediately sent to the mobile application as a translated piece of writing.
- **User Output:** The message is sent to the mobile interface and clearly presented on the screen to the listener. read.
- Meanwhile, there is a Text-to-Speech (TTS) engine that reads the message out loud to enable a more natural one. conversational experience.
- **The Haptic Confirmation Loop:** Nowadays, one of the most significant elements of our working process is the acknowledgment (ACK). signal. After the server has been able to accept the message reached the app, it replies to the glove. This activates the vibration motor which provides the user with a physical.

We believe this closed-loop approach makes the system far more practical for real-world use than standard one-way devices. It ensures the system remains scalable and affordable while maintaining a high level of user confidence. [4]

- In our opinion, this closed-loop model makes the system much more realistic in real-world application than the standard one-... way devices. It achieves this by making the system scalable and affordable and at the same time, high user confidence.

DOI: 10.17148/IJARCCE.2025.1412127

VII. FUTURE SCOPE

A. Developing with Machine Learning

At this point, the glove uses a specific number of fixed pre- programmed gestures. To push it a notch higher we will incorporate advanced machine learning models right into the system. It could also learn to adapt to the user using neural networks or sequence-based algorithms so that the glove would really learn. their distinctive movement language and the enlargement of the vocabulary to complex, fluid expressions of the sign language. This would bring the device out of a dormant tool to one that develops and matures with the individual who wears it.

B. Breaking Language Barriers

he other significant objective will be to introduce multilingual support. Using the real-time translation engines, a gesture could be translated to more than one by connecting our backend to them. immediately in different languages. This would turn the tide in such locations as international hospitals or government service centers where there has to be clarity. communicating is usually on a hurry basis.

C. Enhanced Wearability And Connectivity

The current design still uses external wiring and visible boards. In future iterations, we want to miniaturize the hardware using flexible circuits or even conductive fabric sensors to make the glove feel like a natural part of the user's clothing. Additionally, the glove's functionality could be expanded to act as a remote control for smart homes—allowing users to turn on lights or call for help with a simple hand flick.

D. Moving Beyond Speech: Smart Home Integration

The potential for this glove goes far beyond just translating speech. We imagine one that is a universal remote control of the environment of the user.

This would create a new range of autonomy to the user, and bring them into full smart home and industrial control systems.

E. Faster Responses with Edge Computing

The data processing is heavy and one of our key objectives is to have it moved. out of the cloud and upon the glove itself. We can eliminate the overdependence on a by, with the help of microcontrollers that can be powerful enough to support on- device AI. stable internet connection. This kind of edge computing approach would result in the glove being highly responsive and more importantly reliable in. rural or areas that have poor Wi-Fi signal.

F. Use in Healthcare and Rehabilitation

The glove also has potential in medical applications. The simple hand moves can be used to express by patients who are recovering after a stroke or have mobility limitations. needs. The device might also assist therapists to check the recovery progress through capturing data on the hand motion with time.

G. Better Use Of Power

There is a possibility of using rechargeable batteries to improve power efficiency in the future. consumption, or searching of energy- harvesting solutions [1], [2]. This would ensure that the glove is more sustainable, charge less, and enhance reliability in general in the day-to-day. use.

H. Millennium Cloud-Based Analytics and Personalization

With cloud storage, the system will have the capability to keep gesture logs and user. behavior data. This information used over time to customize the gesture interpretation of every user and also improve the system. accuracy. User activity could also be monitored by the caregivers remotely.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 12, December 2025
DOI: 10.17148/IJARCCE.2025.1412127

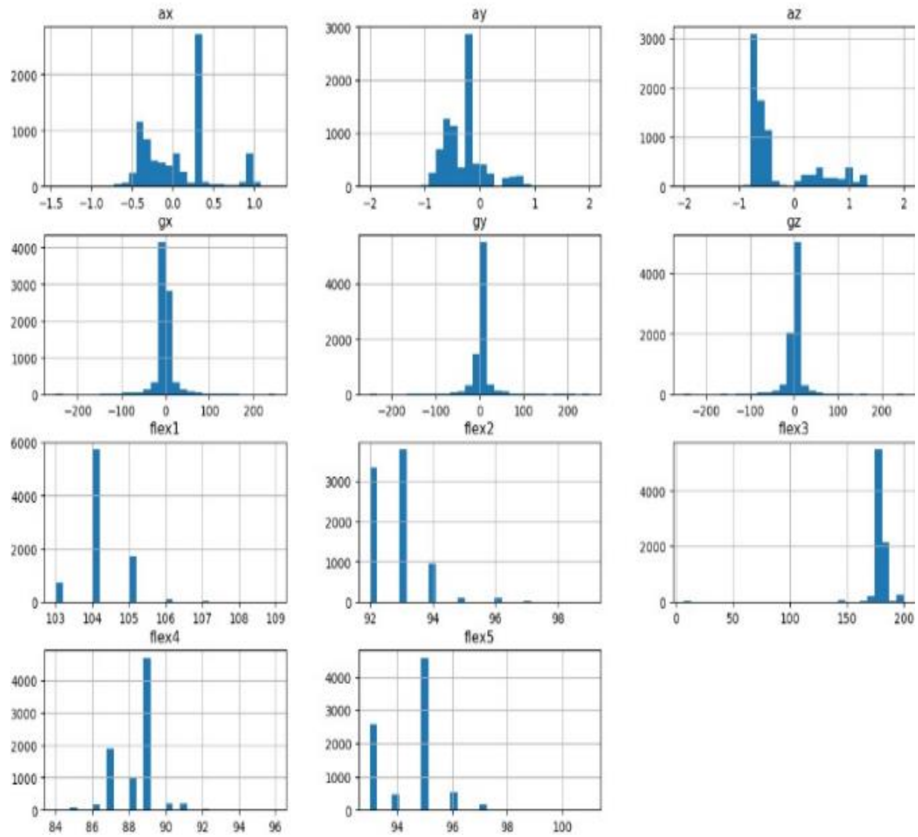

Figure 2: Distribution of sensor features showing the distinct, repeatable clusters we observed for each gesture during testing

Accelerometer Performance: Tracking Posture

The data from the accelerometer wasn't just a random mess of numbers; instead, we saw very distinct clusters for the ax, ay, and az axes. This tells us that the users were able to perform gestures in a controlled, repeatable way.

- For instance, the ax axis showed a few specific peaks, which means the hand was usually in one of a few predictable left-to-right tilt positions.
- The ay axis stayed mostly centered, proving that there wasn't much unnecessary sideways shaking during gestures.
- Most interestingly, the az axis hovered near 1g, which is exactly what you'd expect from gravity when a hand is held upright.

Ultimately, this confirms that the accelerometer is great at capturing the actual posture of the hand rather than just picking up background noise.

Gyroscope Trends: Stability and Focus

Our gyroscope data showed very narrow, tall peaks right at the zero mark. This is a good sign—it means that while users were making signs, they held their hands steady without rotating their wrists. Because these readings remained so stationary, it allows our model to focus entirely on finger positions rather than getting distracted by wrist movement. This basically confirms that our dataset is built on solid, static gestures.

Flex Sensors: The "Finger Signature"

The flex sensors (flex1 through flex5) are the most crucial component of the system because they do the heavy lifting for classification.

- We observed multiple concentrated peaks for each sensor, which shows that users were remarkably reliable in their bending angles.
- Because the "gaps" or spacing between these peaks are so clear, the system can easily tell one gesture from another.
- Some fingers stayed in similar spots for multiple signs, while others moved across a wider range depending on how complex the gesture was.

Overall, these sensors successfully captured a unique and consistent "finger signature" for every word in our library.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 14, Issue 12, December 2025
DOI: 10.17148/IJARCCE.2025.1412127

A correlation heatmap was used to illustrate the interaction of our various sensor features with each other. In this map, strong positive links are emphasized using warmer tones, and weak or negative are emphasized using cooler colors. relationships. Of course, the diagonal line on the map indicates an absolute correlation of 10 because all individual features are a. perfect match for itself.

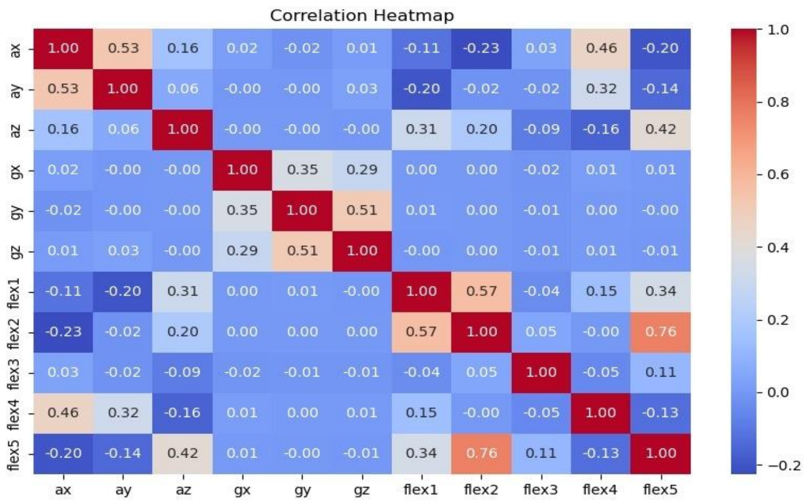

Figure 3: Feature correlation map highlighting the independent behaviour of wrist motion compared to specific finger bends.

Accelerometer and Gyroscope

The accelerator and gyroscope data suggest the following: and ay axes have a moderate positive correlation. This can be understood since at times when a user is tilting vertically with his hand, they usually result in a slight lateral tilt that occurs at. the same time. The az axis is however to a large extent independent as it is largely a response to the gravitational pull which is not. change much based on tilt. These specific differences are in fact a good attribute; since they enable our model to determine the exact orientation of the wrist and not get mixed up. The gyroscope data indicated that there were minor correlations between the axes of the gyroscope such as gz and gy, indicating that users experienced. some extremely minimal rotation of the head in their gestures.

More to the point, the accelerator values were hardly connected with the readings of the gyroscope. This proves that rotation and linear tilt are distinct two forms of motion and it proves that the gestures were. rotated in a constant manner with minimal rotational noise".

Finger Movement and Cross-Sensor Insights

The **flex sensors** (flex1 through flex5) revealed some interesting patterns. We have seen better correlations between **flex1 and flex2**, and the **flex2 and flex5**. This actually tells that few fingers bend together while performing sign language shapes. Other fingers showed low correlation, which is best for us because it means those fingers.

VIII. RESULT AND ANALYSIS

Looking at the system, the most essential finding was that the motion sensors showed zero correlation with the flex sensors. This distinction of information is the secret to the system's reliability. By getting posture-based information from the wrist with finger-based data from the glove, we have given our model two completely independent ways to confirm a gesture.

Healthcare and Recovery: There is a great opportunity to utilise this technology in hospitals and rehabilitation centers. For patients recovering from stroke or those living with paralysis, simple gestures could provide easy communication to caregivers for their most vital needs.

Centrally the Glove is about more than circuits and sensors; it is a tool for **human openness**. We should empower individuals with confidence, laying the foundation for a world where technology makes communication effortless for everyone.

DOI: 10.17148/IJARCCE.2025.1412127

Figure 4: Final Prototype Output

The final prototype of the IoT-based Smart Gesture Glove demonstrates a fully integrated wearable system capable of capturing and transmitting gesture data in real time. The glove includes flex sensors mounted along each finger, firmly secured to the surface so that every bend and movement can be reliably detected. These sensors are connected through lightweight jumper wires that run along the glove and converge at the central processing module. In the middle of the assembly, an Arduino microcontroller acts as the core unit, collecting input from all sensors and managing data communication. Additional modules—such as the MPU6050 for motion tracking and a wireless communication unit—are neatly arranged beside it, forming a compact electronics cluster. The wiring harness is organized using tape and insulation to keep the connections stable while still allowing the user to comfortably move their hand.

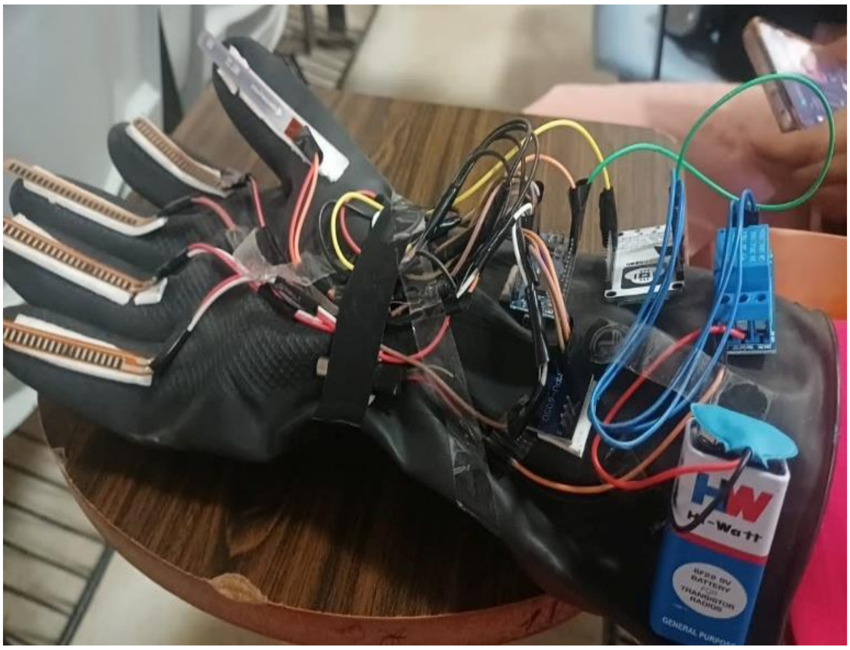

Figure 5: The Model Of The Sensor

In order to make sure the glove is completely portable and doesn't require a wall outlet, we purposefully used a standard 9V battery to power the entire system

IX. CONCLUSION

Our Glove is developed with the goal of solving real world communication problems and not only demonstrating a technical concept. Our actual idea was to design a system that is simple to use comfortably in daily life.
During testing, we had observed that the glove could correctly recognize hand gestures and convert them into both text and voice output.. The system considers the overall hand movement, which helped improve the recognition accuracy. The use of flex sensors and the MPU6050 made it possible to catch both finger bending and wrist motion conveniently. The Processor Arduino Nano handles the sensor data efficiently, the ESP8266 module helped wireless communication

DOI: 10.17148/IJARCCE.2025.1412127

with the application. This reduced delay and made the system response almost immediate.

However, the smart support glove performs efficiently and meets the objectives of the project. It offers a practical and low-cost solution that can help bridge gaps between differently abled individuals and others in daily situations.

ACKNOWLEDGMENT

The authors thank the faculty and staff of the Department of Information Science and Engineering at The Oxford College of Engineering for their advice and assistance. We are grateful to the open-source communities that support Web3, IPFS, and Ganache as well as to **Dr. R Kanagavalli**, for her technical advice and mentoring.

REFERENCES

[1]. A. Kumar and S. Gupta, "Deep learning based real-time identification of hand gestures utilizing wearable sensors," *IEEE Sensors Journal*, vol. 21, no. 4, pp. 5006–5014, 2021.

[2]. M. Alhussein and G. Muhammad, "A Sign Language Glove using Flex Sensors as well as machine learning for Real-Time Gesture Recognition," The IEEE *Access*, vol. 8, pages. 21980–21990, 2020.

[3]. R. K. Das, P. K. Mohapatra, and S. Lenka, "IoT-based assistive wearable technology for speech and hearing impaired persons," *IEEE Internet of Things Journal*, vol. 7, no. 5, pp. 4103–4111, 2020.

[4]. S. M. S. Nugraha et al., "Smart glove for gesture-based communication using flex sensors and MPU6050," in *Proc. IEEE Int. Conf. on Electronics*, 2021, pp. 125–130.

[5]. L. Yang, F. Chen and J. Cao., "A low-power multi-sensor wearable system for gesture recognition," *IEEE Exchanges on Industrial In- formatics*, volume 16, issue 5,pages. 3305–3313, 2020.

[6]. H. Wang and Z. Yu, "BLE-enabled wearable sign language translation device with mobile app integration," *IEEE Communications Magazine*, vol. 58, no. 6, pp. 45–51, 2020.

[7]. P. Tripathi and R. Mallik, "Cloud-connected IoT glove for remote gesture monitoring and analytics," in *2022 IEEE International Conference on IoT and Applications*, pp. 90–95.

[8]. J. Kim et al., "Haptic feedback techniques for wearable assistive systems," *IEEE Exchanges on Haptics*, volume 13, issue 2, pages. 351–360, 2020.

[9]. S. Dey and T. Mitra, "A multilingual speech synthesis system for assis- tive communication devices," *IEEE Access*, vol. 9, pp. 135122–135134, 2021.

[10]. Y. Zhang and X. Li, "Gesture recognition for AR/VR interaction using wearable sensor fusion," *IEEE Transactions on Human-Machine Systems*, vol. 51, no. 3, pp. 200–210, 2021.

