1.1 INTRODUCTION

This device can be used to turn your hand gestures into text. People in more than 300 countries make use of sign languages, speaking for about 70 million men and women. Sign languages are just one way that all of these people communicate. Even though no official statistics exist on the number of people who depend mainly on sign language, the users of British Sign Language could help us estimate the figure. There could be a lack of skill in a local language, problems with speech, some autistic individuals use sign languages and in stressful circumstances, it can be hard to connect with those who have hearing. Many services and products have been launched to help sign language users get through their daily routines more easily. Unlike modern translators, the solutions I mentioned do not directly translate signs to speech. Unlike other translations that depend on words spoken or written, sign language translation requires moving hands, expressive hands and entire body actions ever present and directly synchronized. Keeping ergonomics at the top of the list is important during device design for sign language translation, as it would not make sense to give a too heavy device to users struggling with everyday tasks.

1.2 PROBLEM STATEMENT

Difficulties in self-expression may lead the differentially abled to sometimes feel misunderstood or frustrated. It can be difficult for them to make use of the right letters or sentences to make their speech easy to understand. Reading another person's body language, face or tone is not always easy for some people. As a result, it can result in people misunderstanding you which makes it harder to connect with them.

1.3 AIMS AND OBJECTIVE

The main purpose of the sensor glove in this project is to build a wearable tool that can convert the actions of the hands used for sign language into text or speech. The main objective of this project is to reduce the communication barrier between a common person and a deaf or a dumb person. The key objective of this project is to develop equipment that can identify the gestures, movements and hand and finger positions in sign language. Once connected to sensors in the glove, it reads the hand movements and turns them into text or spoken speech in real-time. Real time translation makes it possible for nonsigners to understand what the signers say, helping inclusivity in many social, educational and work situations. The creators made sure the glove is easy to use and comfortable, still letting it fit a variety of hands and still making sure it can detect many different sign language gestures accurately.

1.4 SCOPE

The limits of this project involve building, designing and employing (sensor-embedded) gloves that can change sign language into the spoken or written form as it is used.

The project scope includes:

Development of Smart Gloves:

- Including sensors including flex sensors and inertial measurement units to detect how the sensors moves and what gestures are made.

Real-Time Gesture Recognition:

- Use of algorithms or machine learning models to correctly recognize and categorize signs made by a person's hands.

Language Translation Module:

- Transforming spotted signs into speech or text that makes sense, through the help of an extra device such as a smartphone or PC.

Wireless Communication:

- They use Bluetooth or Wi-Fi technology to carry signals from the gloves directly to the device for processing or viewing.

CHAPTER 2
LITERATURE SURVEY

LITERATURE SURVEY

A Sensory Glove with a Limited Number of Sensors for Recognition of the Finger Alphabet of Sign Language by JAKUB PISKOZUB AND PAWEL STRUMILLO, (Senior Member, IEEE)

This paper discusses the obstructors faced by the differently abled and prescribes a way to maintain unimpeded communication with others in society. We created a model for a new data glove with the smallest number of sensors and relied on machine learning during experiments to reach the highest accuracy in gesture recognition. We worked with 15 participants who acted out gestures from the Polish Sign Language alphabet both at rest and on the move in our tests. The earlier analysis using a decision tree showed that the hierarchy of individual piezoelectric sensors has 94% accuracy when only three sensors are considered at each level. Recognition of dynamic gestures achieved 99% accuracy using a neural network with convolutional layers and GRU units, along with data from all available sensors. As a result, researchers settled on using three piezoelectric sensors with six axes on the inertial sensors which improved the letter classification accuracy to more than 98%. It appears that having fewer than five sensors in sensory gloves results in better ergonomics, dependability and usefulness for most users.

Sign Language Recognition based on Data Glove with Bending Sensor by Yunhao Zhang and Lei Jing University of Aizu, Graduate School of Computer Science and Engineering Fukushima 965-0006, Japan (IEEE 2024)

A data glove was designed for this paper ("Sign Language Recognition based on Data Glove with Bending Sensor") to recognize the 26 letters of ASL with the help of flex sensor and inertial measurement unit (IMU). Movements of the finger and hand bend are logged by the glove and a specially designed LSTM model analyses the data for classifying time-series. This system performs at 98.63% recognition which is higher than that of conventional systems SVM or Random Forest.

Sign Language Interpreter System: An alternative system for machine learning by Salma A. Essam El-Din and Mohamed A. Abd El-Ghany. (IEEE 2025)

The paper "Sign Language Interpreter System: "An Alternative System for Machine Learning" experiences a cost-effective and customized method for changing American Sign Language (ASL), Arabic Sign Language (ArSL) to text and speech with your own glove and hands instead of using standard machine learning sets. The system includes five flex sensors and a MPU6050 sensor, both placed in a glove that can interface with the Arduino Mega microcontroller. The glove data is delivered directly to a GUI in python, letting the end user see the results in real-time translation. At first, the system takes notes on the gestures each user makes, downloading it in individual user files to help it recognize gestures with high accuracy. Using costs and ease-of-use as principles, the design helps ease communication between hearing-impaired people and the general public by changing the signs into audible and readable language.

Development of an OTDR-Based Hand Glove Optical Sensor for Sign Language Prediction by Deep Pal and Amitesh Kumar, Vikas Kumar, Sakshi Basangar, and Pradeep Tomar, Senior member IEEE.

A new system is described in the paper with the title "Development of an OTDR-Based Hand Glove Optical Sensor for Sign Language Prediction", using optical fibre sensors inside a glove to detect ASL gestures. The glove is produced using SMF material along with microbands on every finger, so measurable optical losses are recorded when the fingers are bent. A real-time check of the losses is performed using an Optical Time Domain Reflectometer (OTDR). After processing the macro bending loss data, special properties are analyzed and arranged using an optimum ensemble learning process. The glove can recognize gestures made by the hand and it is right 93.57% of the time. It is precise, delivers few false alarms, can be repeated many times with no differences and is better than standard electronic sensors or cameras.

Smart Gloves for Hand Gesture Recognition in Kannada by Pooja B S, Sara Mohan George, Neha Tarannum N Department of Electronics and Communication Engineering Ramaiah Institute of Technology Karnataka, India. (IEEE 2022)

According to the papers "Smart gloves for hand gesture recognition in Kannada," a system was designed which is very easy to use, costs less than a dollar and supports Kannada, a language spoken widely in India by people with speech impairments. The system includes gloves with flex sensors and an accelerometer and its parts are linked to an Arduino Nano microcontroller. The glove catches movements of the hand and bending of the fingers in order to recognize the hand gestures in Kannada Sign Language. The information gathered by the sensors is processed and delivered wirelessly via Bluetooth to an Android app that both displays text translations and gives a speech output in Kannada by using text-to-speech software. The choice of Kannada as the language responds better to regional needs than the majority of the systems that are in English.

Hand sign language translation using flex sensors and gyro sensors by Nanticha Supmool,Pawarit Kositanon,Supakorn Chaichalotornkul,Udomporn Manupibul, Biomedical Engineering International Conference (BMEiCON). (IEEE 2024).

The research introduces a glove that allows made hand signs to be translated into speech using sensory technology. Nanticha Supmool and her team created the system which records finger motions and hand position and uses recognition to interpret the gestures accurately. It achieves accuracies from 93.3% to 100% which lets the glove convert words said aloud into text that appears on a screen. The goal of this innovation is to offer deaf and hard-of-hearing people easy and quick communication using advanced technology.

Smart Gloves Technology for Sign language translation: Enhancing Communication Accessibility by Yasheseve Bhat;Ashok; Sandeep,2024 International Conference on Cybernation and Computation (CYBERCOM).

In their paper "Smart Gloves Technology for Sign Language Translation: Enhancing Communication Accessibility," published at CYBERCOM 2024, Yasheseve Bhat, Ashok Panchapakesan and Sandeep Prabhu introduce a system of gloves that supports communication for people with hearing or speech disabilities by helping them sign. Using sensors, the glove detects your sign language gestures and translates them to either speech or text immediately. Using machine learning, the system correctly reads sign language gestures to help those who use sign language communicate smoothly with those who do not. The authors underline how the glove might help more people join in and communicate, making it simpler for the deaf and hard-of-hearing to take part in conversations.

American sign language translation via smart wearable glove technology by Shaheer Bin Rizwan, Muhammad Saad Zahid Khan, Muhammad Imran.2019 International Symposium on Recent Advances in Electrical Engineering (RAEE).

This paper investigates how to use a wearable glove filled with sensors to interpret ASL gestures in real time. Flex sensors, IMUs and microcontrollers integrated in the glove allow it to follow the movements of hand and fingers when signing in ASL. After that, machine learning algorithms convert the signals into text or speech that can be transmitted wirelessly to other devices. With the help of this technology, deaf and hard-of-hearing people can better communicate with others and use it in schools, hospitals and with computers. Another important focus of the paper is on new and improved ways to recognize gestures; sensors people can wear and concerns about power efficiency.

Modelling of sign language smart gloves, based on bit equivalent implementation using flex sensors by Nitin Thoppey Muralidharan, Rohidh M. R., Senthil Nathan M., Harikumar M.E. 2022 International Conference on Wireless Communications Signal Processing and Networking (WiSPNET).

In this research, a cost-effective and efficient glove that can interpret sign language gestures is introduced. The sensors added to the fingers of the glove detect the angles the fingers make and turn those readings into digital values. Every set of hand positions represents a sign language sign, so they can be used to provide near-instant text-based translation of gestures. Using an Arduino, the system takes the sensor readings and shows the text version on the LCD monitor. Its goal is to bring convenience and affordability by connecting people with hearing or speech challenges to sign language interpreters.

CHAPTER 3
METHODOLOGY

3.1 METHODOLOGY

The tools and technology that will be used include Atmega328p microprocessor, Bluetooth (Bluetooth module) Flex sensors, accelerometer, power module, resistors, text-to speech software (Bluetooth terminal app). The flex sensor uses the gesture of bending fingers in order to determine the bending and outputs changes in resistances in terms of the bending degree. The Accelerometer sensor detects the linear movement of the hand in the X, Y and Z axis and gives out different values of X, Y and Z depending on the movement on the X, Y and Z axis. All the data from the sensors is then worked out by the Arduino Nano with IF/ELSE, AND and OR logical configurations of all the output from each sensor in order to ensure that the actual output matches with the pre-saved values carrying different sign of alphabets. There is also a HC-05 Bluetooth module connected to Arduino NANO. The data are then passed to the Bluetooth module (transmitter) in form of a string. Android mobile also has an inbuilt Bluetooth ability. The Android application acquires data in bytes format from Bluetooth then converts them to string. Lastly, the string is converted into a voice through the text-to speech application of the Android mobile phones. This entire system is fitted over a regular glove for convenience in handling and quite accurately identifies hand gestures.

3.2 REQUIREMENTS

- Arduino Nano
- Analog Accelerometer: ADXL335
- Jumper wires
- HC-05 Bluetooth Module
- Flex Sensors
- Arduino IDE
- Python
- JAVA script

3.3 Hardware requirements:

- **Arduino Nano**
  The Audino Nano is a tiny, compact and powerful microcontroller board that is based on ATmega328 processor meant for use in embedded applications and projects where space is an issue. Working at 5V, it has 14 digital input/output (6 PWM outputs) and 8 analog input pins, to connect a wide variety of sensors and actuators. With 32 KB flash memory, 2 KB SRAM, and 1 KB EEPROM, the Nano can be used to perform moderately computational and storage-based tasks. It is programmed using the Arduino IDE, using a Mini-B USB cable and it supports serial communication via USB or ICSP

➢ Analog Accelerometer: ADXL335

The ADXL335 is a small and thin device, which is low in power consumption; it is a 3-axis analog accelerometer, which provides a measure for the acceleration in the X, Y and Z-axis. It works on a range of voltages from 1.8V to 3.6V and produces analog voltage signals which reflect the acceleration it measures. The ADXL335 has a measuring range of ±3g and can be used to detect tilt, motion and vibration in small and portable applications. Due to its analog outputs that can be conveniently decoded by microcontrollers that have built-in ADC (analog- to-digital converter), it has been in great demand for use in embedded systems, mobile device, and in wearable electronics tracker of motion.

➢ HC-05 Bluetooth Module

The HC-05 Bluetooth module is a popular and an affordable device that is used in order to enable wireless serial communication between microcontrollers and the Bluetooth-enabled devices like smart phones or computers. It works at the 2.4 GHz ISM band and has support for the Bluetooth SPP (Serial Port Protocol), which makes it very suitable for wireless transmission of data in the embedded systems. The module can be set to be either master or slave hence be able to initiate or receive connections. It communicates with microcontrollers through UART (TX/RX), using a standard 3.3V or 5V supply, and it is widely used in projects that are utilizing wireless control, data logging, or real-time communication (e.g., remote controlled robots, wireless sensors, and smart gloves)

- **Flex Sensors**

  Flex sensors are resistive sensors whose resistance varies by the degree that they bend and flex. At a straight position of the sensor, we have a baseline resistance while as it bends the resistance increases in direct proportion to the degree of bend. Generally created out of thin, flexible materials, flex sensors are excellent for motions and finger position screening and gesture trends in clothing such as smart gloves. Integration of these sensors with microcontrollers through voltage divider circuits is easy, and their wide application is in projects such as robotic control, gaming, rehabilitation devices as well as sign language recognition systems owing to their simplicity, low power consumption, and effectiveness in capturing dynamic movements of fingers.

3.4 Software Requirements:

- **Arduino IDE**

The Arduino IDE (Integrated Development Environment) is a software tool that helps creating, compiling, and uploading your code to the Arduino-compatible boards. It has a simple, user-friendly interface where both novices and the experienced developers can develop programs (called sketches) based on a simpler variant of C/C++.IDE has a code editor with such functions as syntax highlighting and error checking; it has a message area, text console, and toolbar with the most common buttons, for example verify, upload, and save. It also comes with built-in serial monitor for live communication with attached arduino boards. Moreover, the Arduino IDE is available on Windows, macOS, Linux and it can work with a variety of Arduino boards and third-party microcontrollers, making it a key element of the embedded systems and DIY electronics.

➢ Python

Python is a high-level interpreted language that has its readability, low-level facilities, and high-level capabilities in a clean syntax. Developed by Guido van Rossum and first published in 1991, Python focuses on simplicity of the code and offers support for several programming paradigms, including procedural, object-oriented, and functional programming. It has proven to be popular in so many areas including web development, data science, artificial intelligence, automation, software development.

➢ JAVA script

JavaScript is a high-level interpreted programming language, which is majorly used to write dynamic and interactive scripts on websites. First created by Netscape in the middle of the 90s, JavaScript is one of the core technologies of the World Wide Web together with HTML and CSS. It lets developers perform such features as form validation, animations, interactive maps, and real-time content updates without having to reload a page.

3.5 BLOCK DIAGRAM

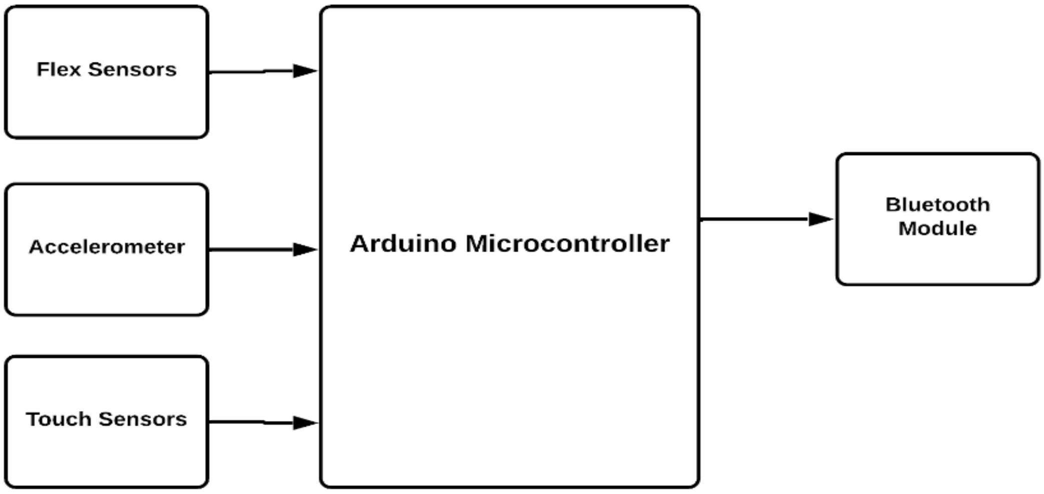


Fig 3.1 Hardware part

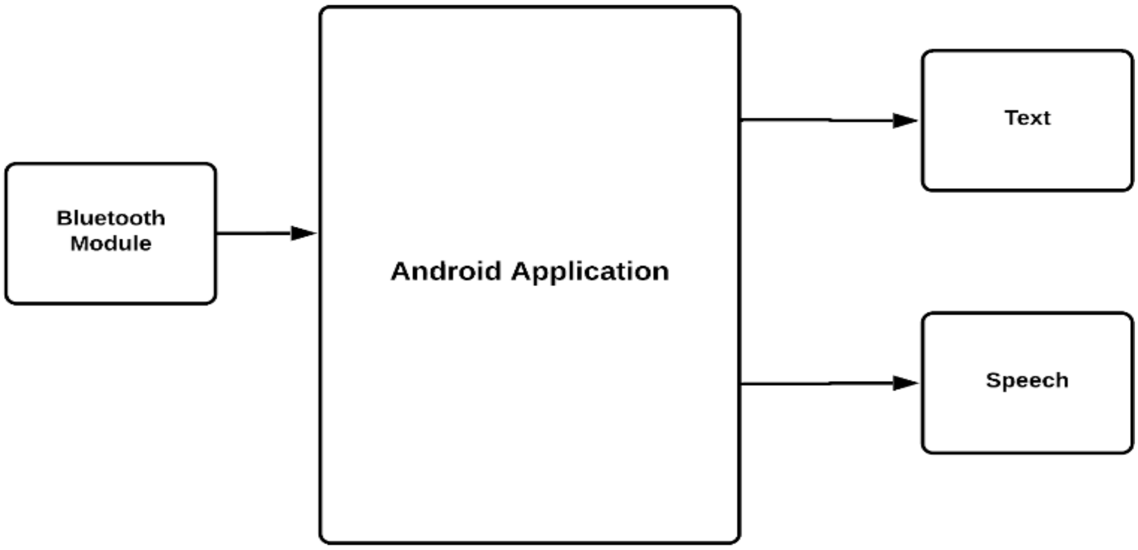


Fig 3.2 Software part

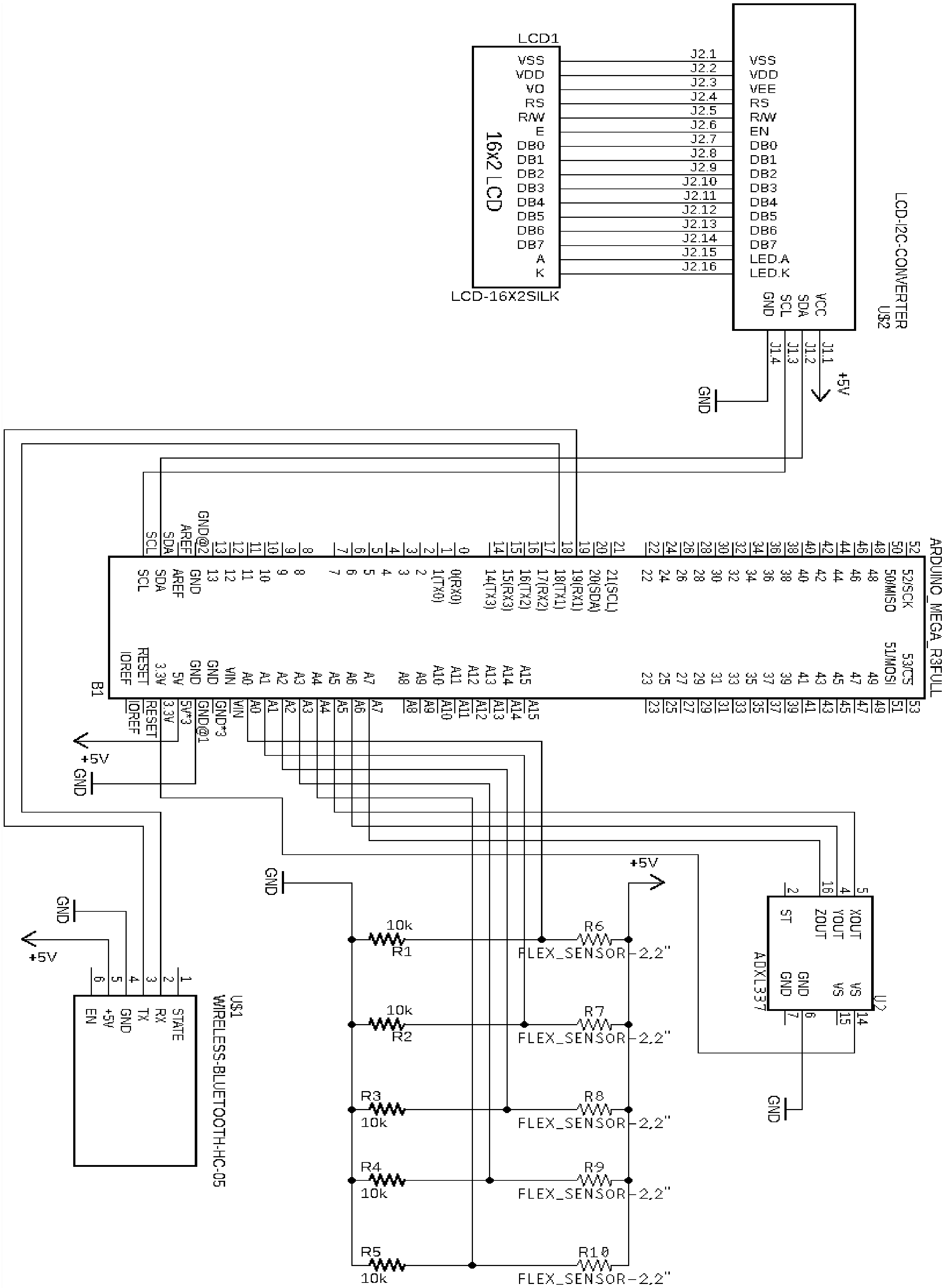
3.6 IMPLEMENTATION

The tools and technology that will be applied in the scope of this project include: Atmega328p microprocessor, Bluetooth (Bluetooth Module), Flex Sensors, Accelerometer, Power Module, Resistors, And Text – To – Speech software (Bluetooth terminal app). The flex sensor determines the bending of fingers from gesture and provides outputs of changes in resistances in the form of how much the fingers bend. The Accelerometer sensor detects the linear motions of the hand along the X, Y and Z axes and gives out different X, Y and Z values, on account of the motion on these axes.

All the received information from the sensors is then processed by the Arduino Nano for which logical IF/ELSE, AND, OR operations of all the sensor outputs are made with a view to comparing the resulting output with the values previously stored of opposite signs relative to the alphabets. For this, proper ranges are assigned for each alphabet and the words that can be identified using a single hand; using the measured data attained from multiple measurements. Arduino Nano is connected with HC-05 Bluetooth module. The processed data are then sent to the Bluetooth module (transmitter) in terms of string format. The Android mobile equally has an inbuilt Bluetooth functionality. These two Bluetooth devices are therefore paired and the string is sent to the Android-application.

The Web application gets data in bytes format through a Bluetooth and then converts this into a string. Finally, the string is transformed into voice with the help of text-to-speech application of the Android mobile. This whole system gets mounted on a normal glove so that it is easy to handle and has a high rate of accuracy in detecting hand gestures.

3.7 CIRCUIT DIAGRAM



3.8 WORKING (WIRELESS COMMUNICATION)

This system is meant to transform hand gestures detected by a sensor glove (connected to an Arduino Nano) into spoken words using the help of a Bluetooth module (HC-05), Python WebSocket server and a web application that allows using a TTS to generate voice.

In this sign language translation system, WebSocket server acts as the crucial communication link between Arduino-based glove and the speech system embedded in the browser. Because web browsers do not have direct access to the hardware-level serial (or Bluetooth classic, such as HC-05 module), local Python-based WebSocket server is utilized for the purposes of mediating the interaction. This server keeps on reading gesture-translated text data from HC-05 Bluetooth module (which becomes a serial COM port on the computer after pairing). At the same time, it operates a lightweight WebSocket server with the WebSocket's library written in the Python's language, which accepts any connections from clients on the localhost – particularly so from the web browser. Once web application is loaded in browser, it connects to this WebSocket server and waits for messages. When the Python server gets a message from the Arduino (e.g. a recognised word such as “Hello”), it immediately sends it to the browser over the open WebSocket connection. The browser, on receiving the text, shows it in a user interface and right away stages it through the browser's inbuilt Text-to-Speech (TTS) engine to speak it out. This real time, -event driven communication, which is facilitated, by WebSocket's guarantees that every gesture identified by the glove is instantly and fluently transformed into spoken words, thereby, making the system timely and very effective for use in interpreting sign language.

The first step in the process is the reading of inputs from such sensors as flex sensors or IMUs connected to a wearable glove by the Arduino Nano. These sensors recognize particular finger bends or gestures that Arduino reads as a special character or a word. When a gesture is detected, it is sent as corresponding text through the serial port of the Arduino to the HC-05 Bluetooth module. The HC-05 is used as a serial bridge via the Bluetooth and wirelessly sends over this data to a computer near that is paired to the module. When the HC-05 is plugged into the computer, it can be seen as a COM (e.g. COM7) port. This is basically a tiny Python program on the PC which is a WebSocket server and a serial listener. This script connects to the COM port, gets incoming data on HC-05, and concurrently gets it through the WebSocket running on localhost (e.g., ws://localhost:8765). WebSocket's afford a real-time full-duplex communications pipe from the Python back end to a web browser.

On the browser side, a simple HTML and JavaScript web application connects to this WebSocket server. As soon as the user opens the web page, JavaScript establishes a WebSocket connection to the Python server. When a gesture-based word is sent from the glove, it is relayed via the HC-05 to the Python script, and immediately pushed to the web app via WebSocket. Once the browser receives the text, it displays it in a text box and instantly invokes the browser's built-in Text-to-Speech (TTS) engine using the API. This converts the text into audible speech, essentially allowing the glove to "speak" the translated sign language gesture out loud.

As soon as the user opens the web page JavaScript opens connection to the Python server using WebSocket. Once a gesture-based word is sent from the glove, it is sent to HC-05 which in turn sends it to the Python script where it is instantly sent to web app through WebSocket. Once text is received by the browser, it will provide it on text box and immediately invoke the browser's inbuilt Text-to-Speech (TTS) engine of the browser through the API. This turns the text into audible speech which in effect means that the glove is able to "speak" the translated sign language gesture in speech. Optionally, the web app also suggests having a button opening a new tab in Google Translate with the obtained text for real-time translation to other languages. This gives more accessibility options and multilingual communication options. This architecture effectively connects hardware (Arduino + HC-05) middleware (Python WebSocket) and user interface (web app with TTS) with each other creating a fully-featured sign language to speech instrument where kinks have been removed while using no proprietary apps and cloud services.

CHAPTER 4
OBSERVATION AND RESULTS

4.1 OBSERVATION AND RESULTS

When there are any hand movements the flex sensors detect all the movements and sends it to the software interface. The software interface which is created using python language receives the text through Bluetooth and finally converts into voice, so that a common person can understand by listening to it.

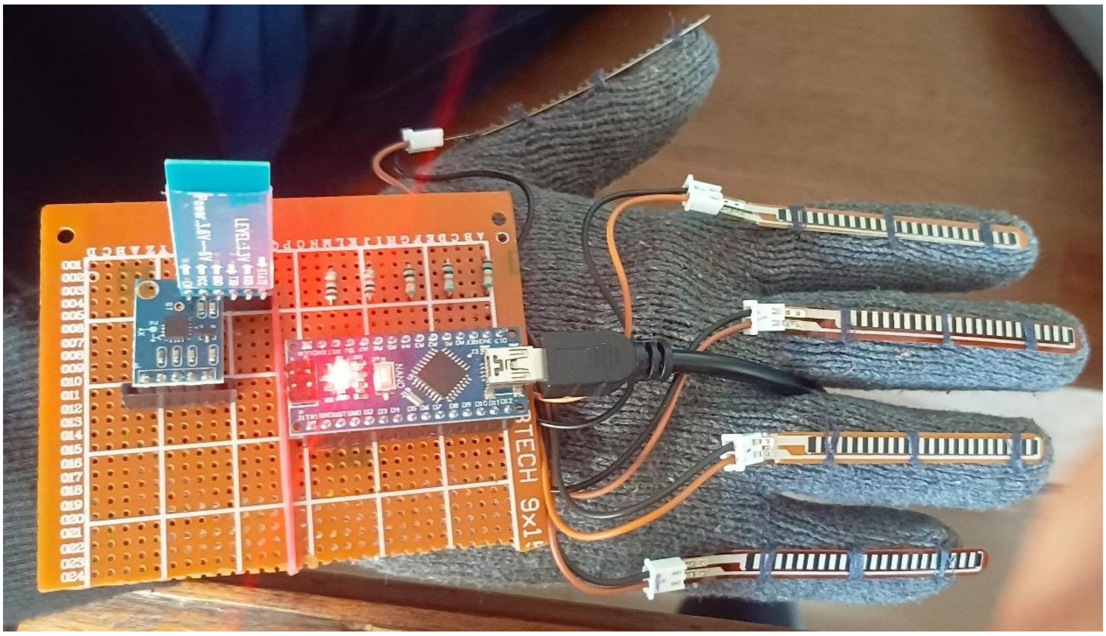


Fig 4.1 Top view of the sensor gloves

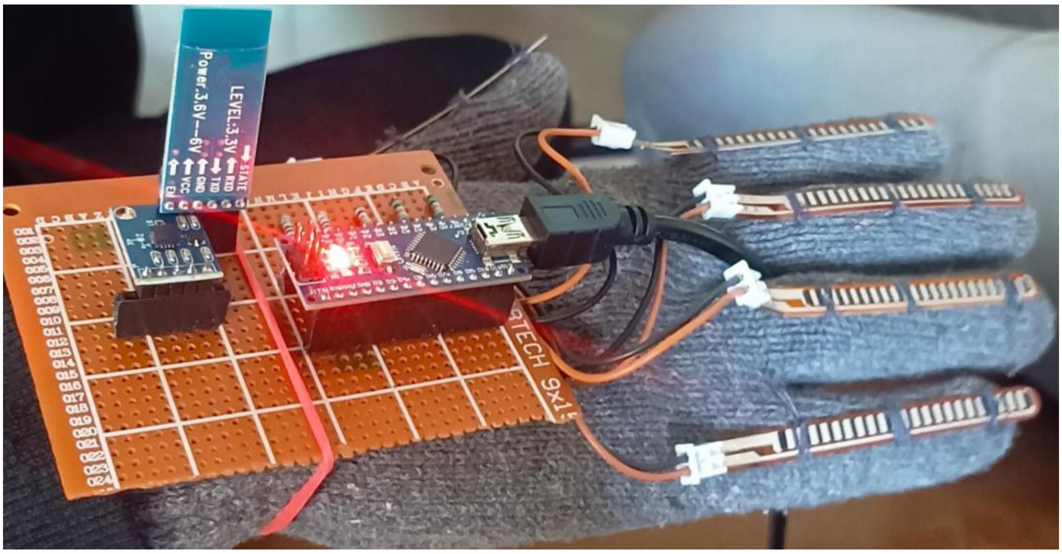


Fig 4.2 Side view of the sensor gloves

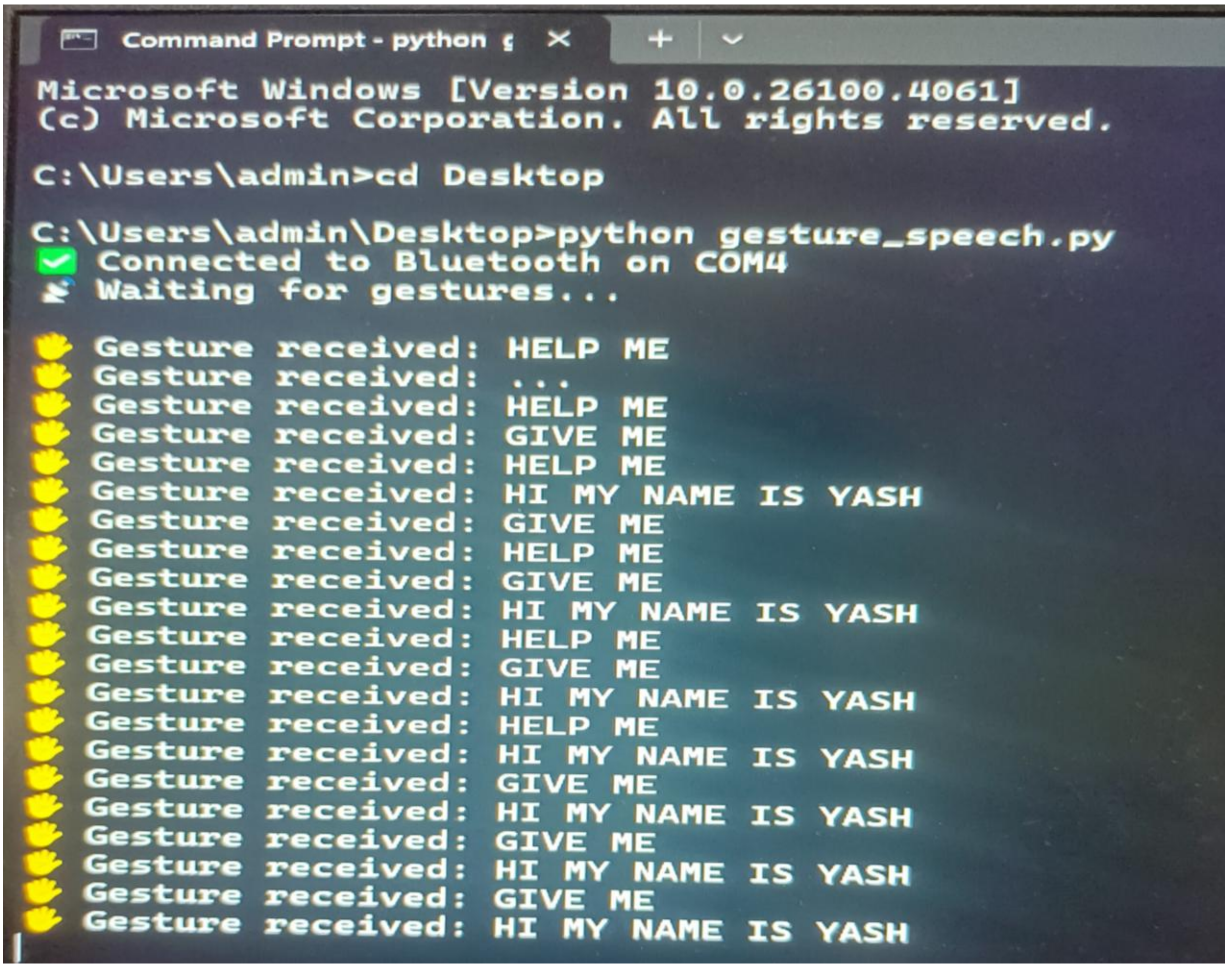


Fig 4.3 Output of the Python code

Fig 4.4 represents the website that converts normal human voice to text along with emoji. This website is created so that people who are disabled (Deaf/Dumb) can understand what a normal person is trying to communicate, by reading the text or seeing the emojis.

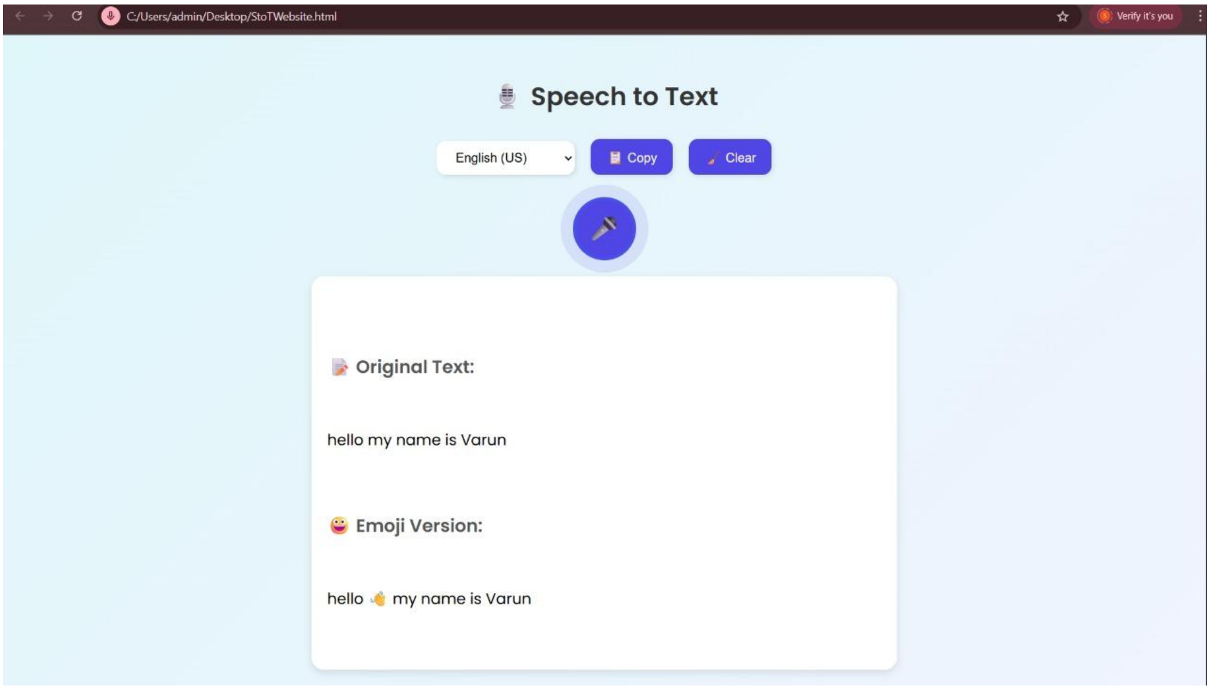


Fig 4.4 Speech to text website

CHAPTER 5
CONCLUSION

5.1 CONCLUSION

This is a good example of an innovative way of solving the communication gaps among people with speech or hearing impairments. This wearable module utilizes flex sensors and an accelerometer to recognize hand gestures, which are converted to text and speech by the aid of an Android app that is Bluetooth supported. The design is simplified with an effortlessly compact and efficient microcontroller that is the Arduino Nano. The HC-05 Bluetooth is the module allowing for smooth wireless communication.

Using the Python and JAVA scripts for the development of the Web application, the project attains a user-friendly interface that shows the interpreted gestures with auditory responses. The design of the project is focused on affordability, portability, and ease of replication, and hence, is affordable for mass implementation. Its modular architecture can support future improvements such as the expansion to the vocabulary of gestures, the introduction of machine learning algorithms for the dynamic recognition of gestures, and adding new sensors for higher precision.

5.2 FUTURE WORK

Researchers will work on growing its functionality and optimizing its performance in the future. To accomplish a surpassing goal, machine learning algorithms like neural networks should be integrated into the glove, enabling it to detect many things with high precision and respond-well to multiple users. Different ways to enhance the controls is to equip the gloves with other different sensors such as gyroscopes or pressure detection sensors, to identify more perfect hand gestures. Adding the ability to use the app in different languages would open the system to users from non-English speaking countries. Additional improvements in the UI could allow users to review their last five gestures, change how signs are assigned and change the tone of their speaking voices. To finish, working on smaller hardware that is more flexible and wirelessly powered would improve the glove's comfort and usefulness in regular wear.

On top of the improvements stated earlier, some upcoming changes can strongly impact how the project is used and functions.

1. **Cloud Integration and Data Storage:** Users who connect the system to a cloud service can store gesture data for use in extended monitoring, study or making unique models. You wouldn't have to go near the glove or update the app yourself if remote updates were in place.

2. **Personalized Learning Mode:** It is possible to add a personalized training mode that allows the glove to adjust to a user's personal touching style, improving accuracy and making the technology more inclusive for people with motor problems.

3. **Two-Way Communication Support:** The system can be improved to allow two-way exchange by turning what hearing people say or write into text or gestures that appear in haptic or visual form for deaf users.

4. **Battery Optimization and Energy Harvesting:** In the future, versions might use battery-extending functions or combine energy-generating films or small solar cells to make the glove friendlier to the environment.

5. **Integration with Wearable Ecosystems:** Connected to a smartwatch, AR glasses or a hearing aid, the glove makes communicating smoother. If a message is detected by the glove, the smartwatch may vibrate or flash to let you know.

6. **Robust Gesture Dataset Creation:** It would benefit the model even more if we collected gestures that cover multiple age groups, a variety of hand sizes and all the signing speeds commonly seen.

7. **Real-Time Translation for Full Sentences:** If the glove uses NLP, people could interact with a computer using complete sentences and better understand each other instantly.

8. **Use in Educational and Therapeutic Settings:** Kids in school can use this glove to help with hand dexterity and hand mobility, while injured adults can use it in physical therapy to track their exercises and be provided instant feedback.

The resulting improvements would allow the glove to do much more, upgrading it from a simple translator to a system that supports communication and other needs.

5.3 REFERENCE

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3. **Sign Language Interpreter System: An alternative system for machine learning** by Salma A. Essam El-Din and Mohamed A. Abd El-Ghany. (IEEE 2025).

4. **Development of an OTDR-Based Hand Glove Optical Sensor for Sign Language Prediction** by Deep Pal and Amitesh Kumar, Vikas Kumar, Sakshi Basangar, and Pradeep Tomar, Senior member IEEE.

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