1. Title of the invention:

SignSpeak: Real-Time Gesture Recognition Glove for Sign-to-Speech Translation

2. Field /Area of invention:

- Embedded Systems and Assistive Technology
- Wearable Electronics for Human-Computer Interaction
- Real-Time Gesture Recognition and Translation
- IoT-Based Communication Systems

3. Prior Patents and Publications from literature (provide a table summarizing the prior art)

Patent / Research Title	DOI	Key Features
[1] The Intelligent System of Digital Glove for Producing Words and Sounds	WO2017208147A1	A digital glove system that translates sign language into spoken words using sensors and software. Available at: https://patents.google.com/patent/WO2017208147A1/en
[2] Context Responsive Communication Device and Translator	US20190311651A1	A glove-based device that detects sign language gestures and converts them into audible words, with capabilities for context-aware translation. Available at: https://patents.google.com/patent/US20190311651A1/en
[3] Wearable Sign Language Translation Device Based on Natural Spelling	CN111462594A	A wearable glove with sensors that detects sign language and translates it into speech in real-time, focusing on natural spelling methods. Available at: https://patents.google.com/patent/CN111462594A/en
[4] Smart Sign Language Glove	KR20160035517A	A smart glove that interfaces with smartphones to translate sign language into text and speech, including foreign language translation capabilities. Available at:: https://patents.google.com/patent/KR20160035517A/en
[5] Intelligent Translation Gloves for Sign Language	CN201356078Y	Gloves equipped with sensors and processors to detect sign language gestures and translate them into audible speech. Available at: https://patents.google.com/patent/CN201356078Y/en
[6] Real-Time American Sign Language Recognition Using Flex Sensors	10.1109/ACCESS.2020.2985644	Uses flex sensors for gesture detection; focuses on alphabet recognition. Does not support sentence formation or TTS.

[7] Smart Glove for Sign Language Translation Using Arduino and Flex Sensors	IJERTV9IS070369	Arduino-based glove outputs characters; lacks Bluetooth and speech output. Good baseline for hardware.
[8] Sign Language to Speech Converter Using Arduino and Bluetooth	10.1109/ICSSIT51439.2021.9540495	Uses Arduino with HC-05 for Bluetooth speech translation; no mobile app or sentence structure.
[9] Hand Gesture Recognition System Using Flex Sensors	10.1109/ICCCI.2019.8821999	Flex sensor-based gesture detection system; no mobile or speech support. Useful for gesture detection logic.
[10] Glove-Based Sign Language Translator with Speech Output	IJRASETV8IS040255	Translates individual letters to speech using Arduino; lacks full-sentence logic or multilingual support.

References

1. WO Patent WO2017208147A1, "The Intelligent System of Digital Glove for Producing Words and Sounds," issued Dec. 7, 2017.
2. US Patent US20190311651A1, "Context Responsive Communication Device and Translator," issued Oct. 10, 2019.
3. CN Patent CN111462594A, "Wearable Sign Language Translation Device Based on Natural Spelling," issued Jul. 24, 2020.
4. KR Patent KR20160035517A, "Smart Sign Language Glove," issued Mar. 31, 2016.
5. CN Patent CN201356078Y, "Intelligent Translation Gloves for Sign Language," issued Jan. 9, 2009.
6. S. U. Rehman, M. Rizwan, H. Jamil and M. A. Javed, "Real-Time American Sign Language Recognition Using Flex Sensors," *IEEE Access*, vol. 8, pp. 61761–61769, 2020. doi: 10.1109/ACCESS.2020.2985644
7. K. Yadav and S. Kumar, "A Smart Glove for Sign Language Translation Using Arduino and Flex Sensors," *International Journal of Engineering Research & Technology (IJERT)*, vol. 9, no. 7, pp. 650–653, July 2020. [Online]. Available: https://www.ijert.org/a-smart-glove-for-sign-language-translation-using-arduino-and-flex-sensors
8. R. R. Ramesh and S. A. L. Banu, "Sign Language to Speech Converter Using Arduino and Bluetooth," in *Proc. Int. Conf. Smart Systems and Inventive Technology (ICSSIT)*, 2021, pp. 370–374. doi: 10.1109/ICSSIT51439.2021.9540495
9. R. S. Kumar and P. M. Durai, "Hand Gesture Recognition System Using Flex Sensors," in *Proc. Int. Conf. Comput. Commun. Informatics (ICCCI)*, 2019, pp. 1–4. doi: 10.1109/ICCCI.2019.8821999
10. A. M. Shaikh and M. A. Patil, "Glove-Based Sign Language Translator with Speech Output," *International Journal for Research in Applied Science and Engineering Technology (IJRASET)*, vol. 8, no. 4, pp. 1451–1455, Apr. 2020. [Online]. Available: https://www.ijraset.com/fileserve.php?FID=29967

How Our Project will Overcomes Existing Patents

Patent Title	Limitation(s)	Our Project's Novelty / Improvement
WO2017208147A1 (Digital glove producing words and sounds)	• Outputs predefined words • No sentence formation • No mobile app or user customization	Forms dynamic sentences from gestures App integration for customization Multilingual speech output using TTS
US20190311651A1 (Context-responsive translator)	• Context-aware but limited to specific gestures • No real-time feedback on app • Lacks language switching	Supports real-time translation and display on mobile app User-selectable languages for speech output
CN111462594A (Natural spelling glove)	• Focused only on spelling, not full sentences • No app or audio feedback • Not designed for real-world conversation	Generates full, meaningful sentences Speech output in real-time Optimized for daily communication
KR20160035517A (Smart glove with smartphone)	• Translates basic signs • Limited vocabulary • No flexibility for user-defined signs or speech	Allows user-defined gestures Vocabulary can expand dynamically Multilingual speech + customization via app
CN201356078Y (Intelligent translation gloves)	• Simple gesture-to-speech • Hardware-only solution (no app) • No multilingual or sentence-building	Combines hardware + mobile app Builds coherent sentences from multiple gestures Multilingual output via TTS

4. Summary and background of the invention (Address the gap / Novelty)

Existing gesture-to-text and sign language converter systems are primarily limited to recognizing individual alphabets using flex sensors and displaying them either on an LCD screen or serial monitor. While they showcase basic communication, they suffer from serious limitations such as lack of sentence formation, no speech output, limited portability, and no multilingual translation capabilities. Furthermore, many systems rely on camera-based gesture recognition, which significantly increases hardware cost, size, and power requirements, making them less practical for real-time personal use.

The limitations of the existing sign language translator systems compared to the proposed glove include:

- No Sentence Formation – Most existing systems translate only one gesture at a time into a single character, without intelligently constructing meaningful sentences.
- No Multilingual Speech Output – Very few systems offer text-to-speech functionality, and even fewer provide multilingual support for speech conversion.
- Bulky or Non-Wearable Designs – Vision-based systems using cameras are not wearable and lack flexibility for mobile users.
- Lack of Wireless Integration – Several designs rely on wired output or serial display, without Bluetooth-based mobile app support.
- Limited Real-Time Application – Systems often process gestures offline or in delayed formats, restricting real-time usability.

Proposed Solution:

The Real-Time Sign Language to Speech Converter Glove addresses these challenges by integrating multiple innovations into a single, wearable solution:

- Bluetooth-Based Gesture Transmission:
  Using an HC-05 Bluetooth module, the glove transmits recognized characters wirelessly to a smartphone, enabling user-friendly and mobile communication.
- Sequential Sentence Builder:
  Instead of outputting isolated characters, the system intelligently appends recognized gestures to build complete sentences in real-time.
- Text-to-Speech with Multilingual Support (Future enhancement):
  The mobile application processes the constructed sentence and converts it into speech, with the potential to support multiple languages using translation APIs.
- Future-Ready Gesture Expansion:
  The glove's modular design supports future integration of additional sensors (e.g., accelerometers) to accommodate dynamic gestures for American Sign Language and beyond.

Key Advantages Over Existing Solutions:

a. Real-Time Sentence Formation – Enables meaningful communication beyond individual characters.
b. Wearable and Wireless – Glove-based design with Bluetooth communication ensures user mobility.
c. Speech Output Integration – Supports voice feedback for hearing users, enabling better interaction in mixed audiences.
d. Multilingual Support (Future enhancement)– Expands accessibility by allowing output in various languages.
e. Low-Cost, Scalable System – Utilizes Arduino Nano, flex sensors, and open-source platforms, making it ideal for wide adoption.

5. Objective(s) of Invention

A. **Real-Time Gesture Recognition:**
Enable continuous detection of finger movements using flex sensors to interpret hand gestures representing letters of the alphabet.

B. **Wireless Communication and Portability:**
Facilitate wireless data transmission of recognized gestures using the HC-05 Bluetooth module, eliminating the need for physical connections and ensuring ease of use.

C. **Sentence-Level Text Output:**
Design a system that not only detects individual characters but intelligently combines them to form complete sentences, enabling coherent communication.

D. **Speech Conversion with Multilingual Support:**
Integrate a mobile application that converts the constructed text into speech, with planned support for multiple languages to improve accessibility and inclusivity.

E. **Expandability with Sensor Fusion:**
Ensure future extensibility by allowing integration of additional sensors like accelerometers to support dynamic gestures (e.g., for American Sign Language) and enhance system accuracy.

6.Working principle of the invent (in brief)

The AI-Based Smart Glove is a wearable assistive technology designed to recognize sign language gestures and convert them into real-time speech and text. It combines sensor input, microcontroller processing, wireless communication, and multilingual voice output. The system operates as follows:

1. **Gesture Detection using Flex Sensors:**
The glove integrates multiple flex sensors along the fingers, each detecting the degree of finger bending. These analog values are read by an onboard microcontroller (Arduino Nano) and interpreted as specific alphabet gestures based on threshold values.

2. **Microcontroller-Based Gesture Mapping:**
The Arduino microcontroller processes the sensor data in real time, maps the readings to corresponding letters or commands, and gradually builds a sentence from continuous gesture inputs. This data is structured and prepared for output transmission.

3. **Wireless Communication via Bluetooth:**
Recognized gesture data is transmitted using the HC-05 Bluetooth module to an Android smartphone. The communication is real-time and wireless, improving user mobility and accessibility.

4. **Mobile App-Based Display and Text-to-Speech:**
The custom mobile application receives the gesture data, displays it as text on the screen, and converts the sentence into speech using an embedded Text-to-Speech (TTS) engine. This enables clear voice-based communication with non-signers.

5. **Real-Time Sentence Construction:**
Unlike existing systems that interpret one character at a time, this glove system accumulates recognized letters to form complete words and sentences before triggering speech output, making communication natural and continuous.

6. **Language Translation Using AI/ML (Planned):**
The mobile application will integrate an AI/ML-based language translation engine to convert the constructed sentence into multiple target languages before initiating speech output.
   - The system will use pre-trained NLP models or cloud-based translation APIs (e.g., Google Translate API or on-device models trained with TensorFlow Lite).
   - This allows users to speak in different languages by simply using their native sign gestures, expanding the glove's impact across diverse linguistic audiences.
   - Over time, AI models can be trained on custom gesture datasets to support dialects, regional signs, and even user-specific shortcuts.

7. **Expandability and Sensor Fusion (Future Scope):**
To support dynamic gestures and more complex signs, an MPU6050 accelerometer-gyroscope sensor can be integrated to detect hand motion and orientation, enabling compatibility with American Sign Language (ASL) and other gesture languages.

7.Description of the invention in detail (Include drawing and or photograph as needed):

The system consists of the following major hardware components, each performing a crucial role in converting sign language gestures into text and speech output:

(a) Flex Sensor Array (5-Sensor Gesture Input System)

Function:
Detects finger bending patterns to interpret sign language gestures.

Working Mechanism:

The glove is embedded with five flex sensors, one for each finger As the user bends or straightens their fingers, each flex sensor changes its resistance. These changes are captured as analog values and read by the Arduino Nano's analog input pins.
Since each sensor can detect two basic states (bent or straight), the system can recognize:
2^5=32 unique binary combinations

- The first 26 combinations are mapped to letters A–Z.
- The remaining 6 are mapped to numbers 0–5.

COMBINATION	VALUE
00000	" "
00001	B
00010	C
00011	D
00100	E
00101	F
00110	G
00111	H
01000	I
01001	J
01010	K
01011	L
01100	M
01101	N
01110	O
01111	P
10000	Q
10001	R
10010	S
10011	T
10100	U
10101	V
10110	W
10111	X
11000	Y
11001	Z
11010	-
11011	-
11100	-
11101	-
11110	-
11111	A

This encoding allows for the formation of complete sentences as the user performs one gesture after another. These gestures are recognized in real-time and translated into a growing sentence string within the microcontroller.

(b) Microcontroller (Arduino Nano)

Function:
Processes input from the flex sensors and transmits recognized gestures.

Working Mechanism:
The Arduino Nano is programmed with threshold logic to interpret analog values from each flex sensor. It converts these values into a corresponding binary pattern, looks up the matching letter or number, and sends the resulting character via serial communication to the Bluetooth module.

It also accumulates each character into a full sentence in memory, clearing the sentence once a termination gesture or signal is detected.

(c) Bluetooth Module (HC-05)

Function:
Transmits processed data wirelessly to a smartphone application.

Working Mechanism:
The HC-05 module is connected to the Arduino Nano's serial communication pins (TX/RX). It transmits the recognized sentence fragments or completed sentence to a smartphone over Bluetooth. This enables a cable-free, mobile, and user-friendly interface.

(d) Android Mobile Application (App Interface)

Function:
Receives data via Bluetooth, displays text output, and converts it to speech.

Working Mechanism:
A custom app developed using Kodular receives the transmitted sentence from the glove. The app displays the sentence on-screen for visual confirmation. Simultaneously, it invokes the Text-to-Speech (TTS) engine built into Android to vocalize the sentence. The app also provides a "clear" or "reset" function for sentence termination and new input.

(e) AIML-Based Multilingual Translation Module (Planned)

Function:
Translate constructed sentences into multiple languages and output corresponding speech.

Working Mechanism:
The app is planned to integrate with AI/ML-based translation models or APIs (e.g., Google Translate API, TensorFlow Lite NLP models) to:

- Convert English text into the desired target language
- Use localized text-to-speech voice engines for spoken output
- Allow the user to choose from a list of supported languages (e.g., Tamil, Hindi, Telugu, etc.)

In the future, this AIML integration will enable hearing- and speech-impaired users to communicate in multiple languages using only their native sign gestures — greatly enhancing inclusivity.

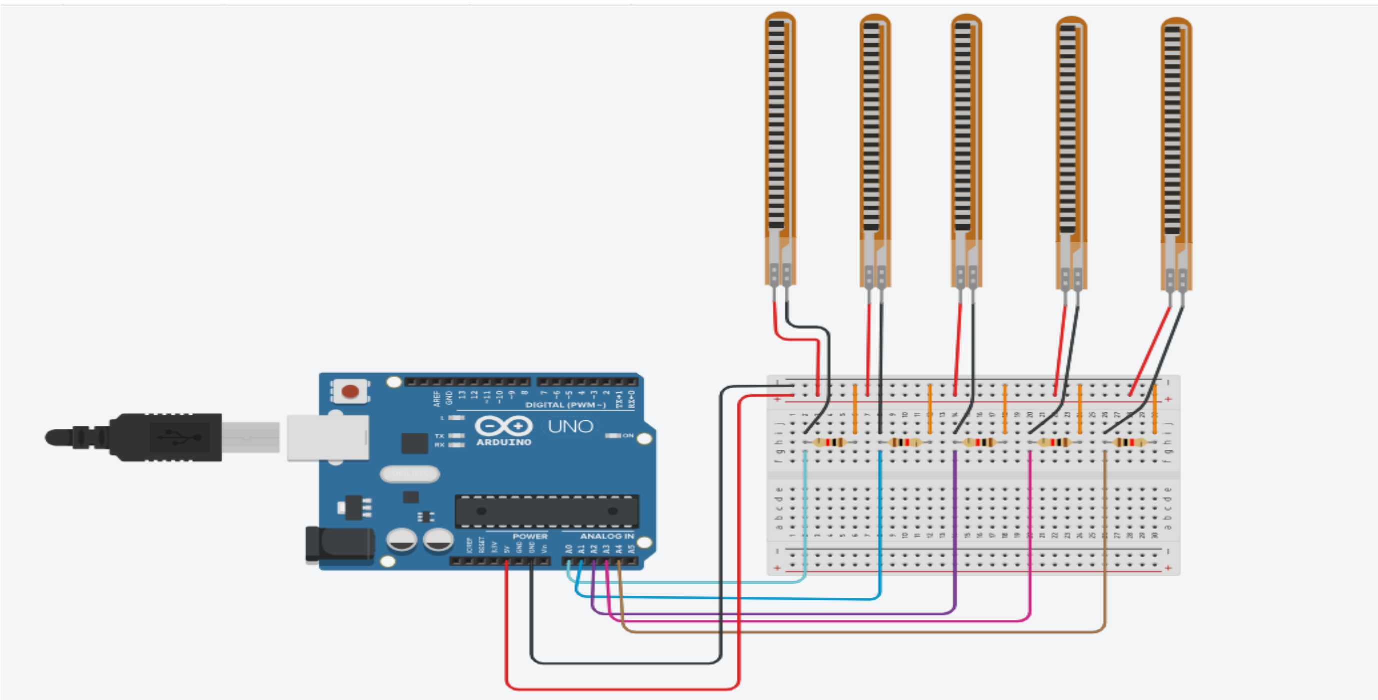

Figure 1 : Circuit diagram of Flex Sensors Connection

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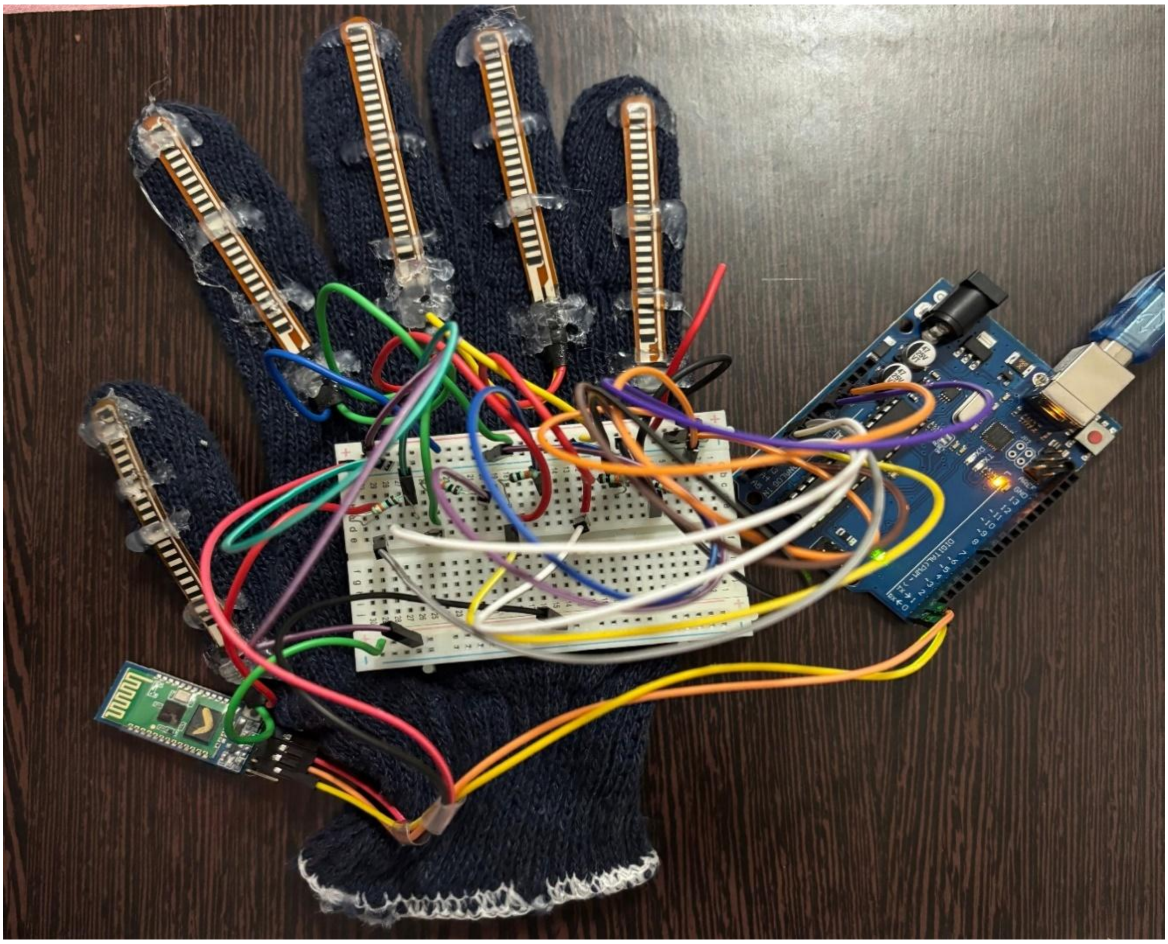
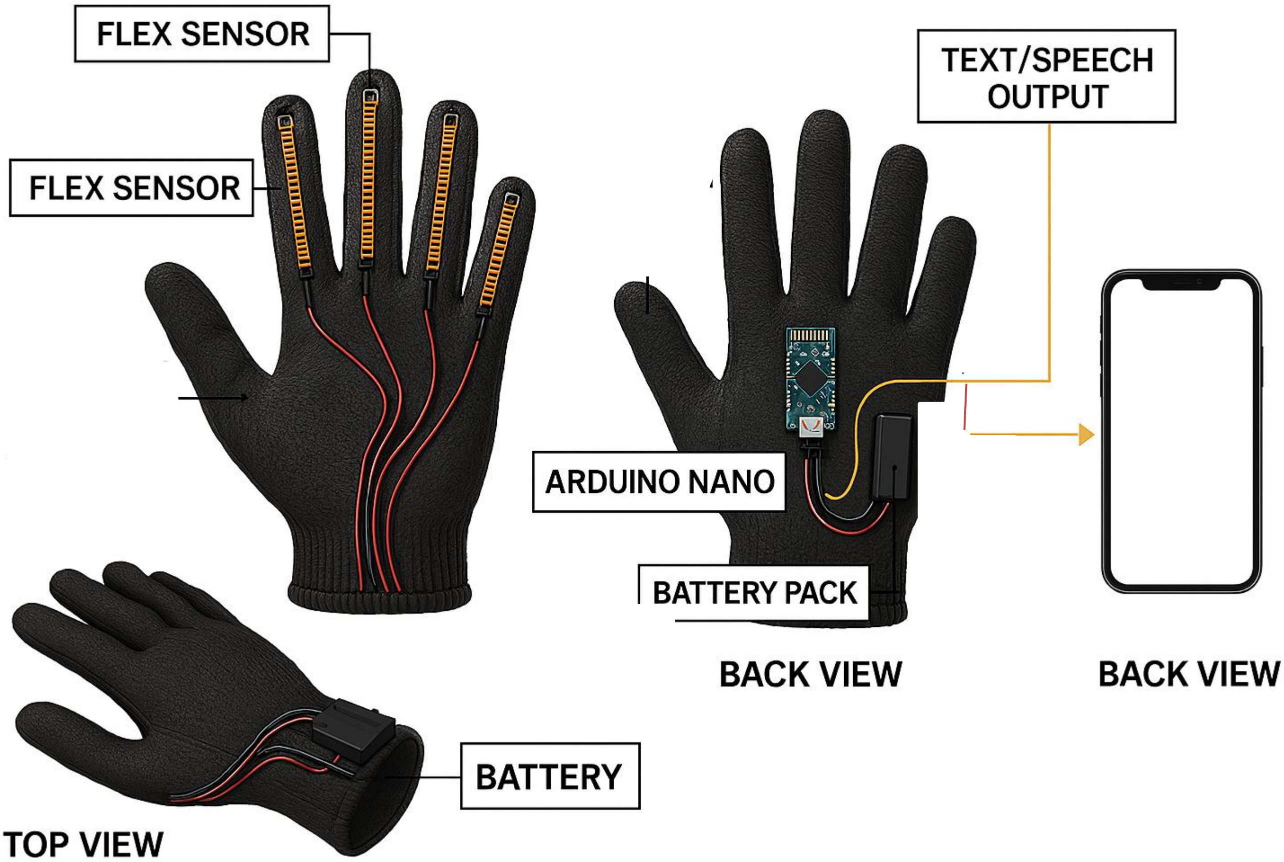


Figure 2 : Prototype



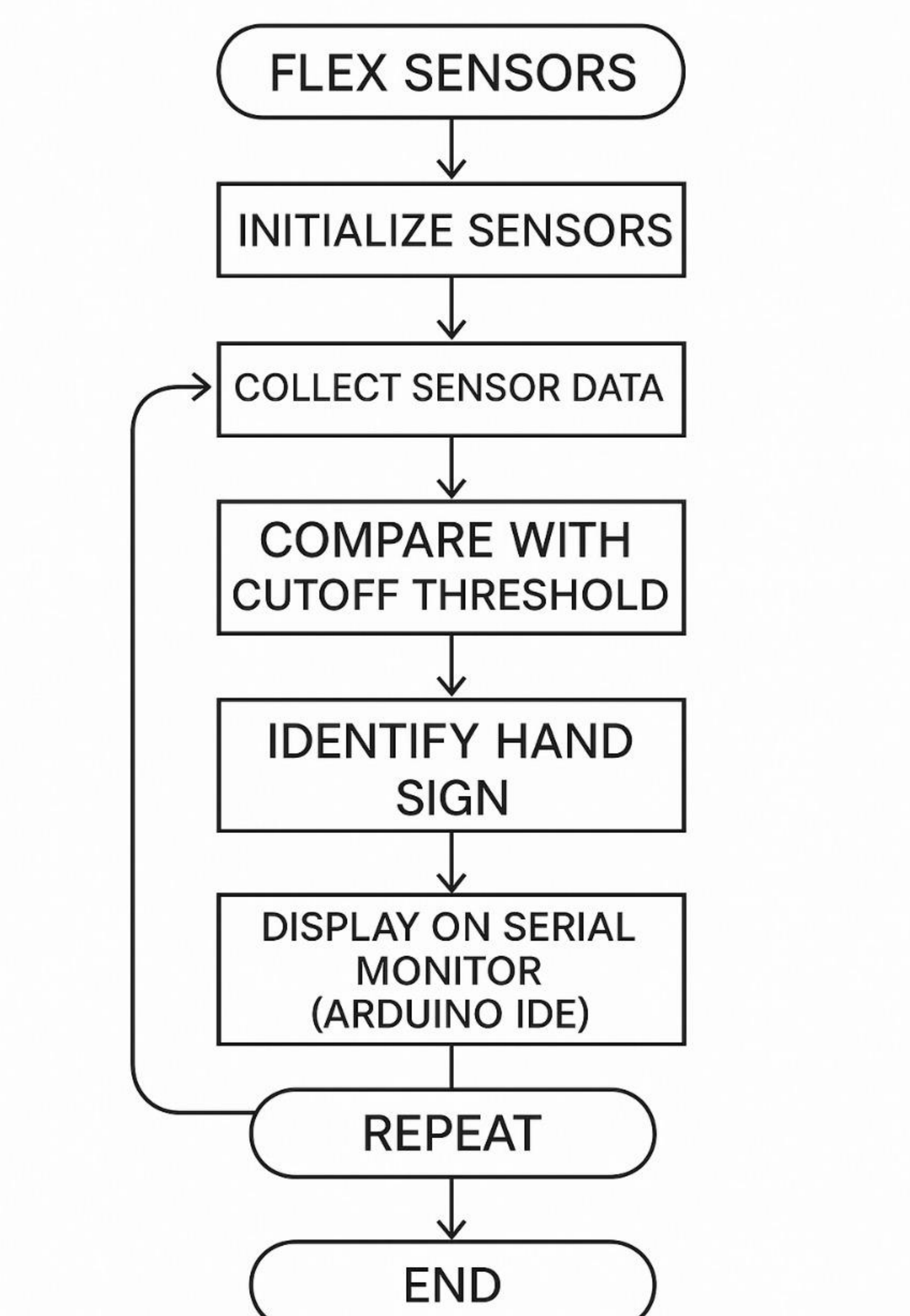
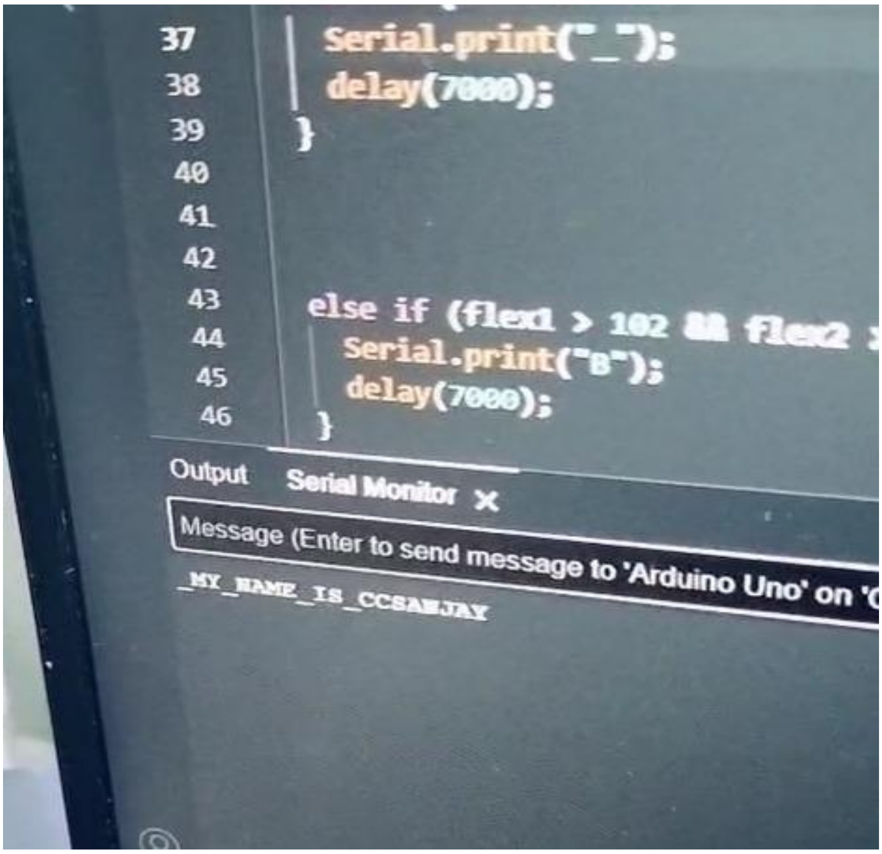
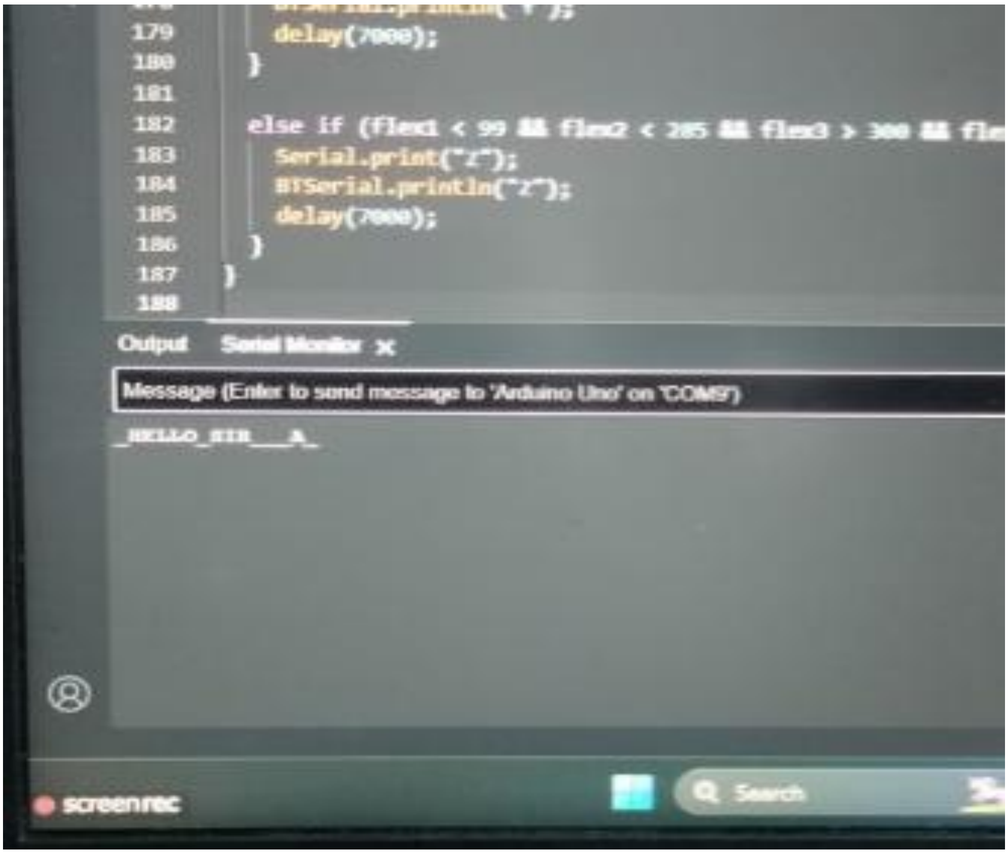


FIGURE 3 : FLOW CHART

8.Experimental validation results:





Model Working video:
https://drive.google.com/file/d/1XI2NKlmikSzVkBMguM419DEreKOTybcL/view?usp=drive_link

9.What aspect(s) of the invention need(s) protection?

1. **Flex Sensor-Based Gesture Encoding and Sentence Formation Logic**

   Unlike basic gesture recognition systems that convert signs into isolated letters, this invention introduces a structured mapping approach using five flex sensors to generate 32 unique binary combinations (2^5). These combinations are assigned to letters A–Z and digits 0–5, enabling real-time construction of meaningful sentences through sequential gestures.

   Key Novelty:
   - A structured gesture-to-character binary mapping algorithm
   - Real-time logic for accumulating individual gestures into complete sentences
   - An intuitive method for "gesture-based typing" without external keyboards or touch interfaces

   Protection Scope:
   - The binary encoding scheme using 5-sensor flex-based input
   - The sentence-building algorithm from real-time gesture streams

2. **Wireless Gesture Transmission via Bluetooth to Mobile App**

   The invention replaces conventional wired or screen-based outputs by integrating the HC-05 Bluetooth module to wirelessly transmit interpreted gestures to a custom Android application. This enhances mobility, accessibility, and real-time usage.

   Key Novelty:
   - Real-time, low-latency wireless communication using low-cost modules
   - Seamless pairing with smartphones to receive and process sign data

   Protection Scope:
   - The data transmission framework from Arduino to mobile over Bluetooth
   - The software protocol used to handle sentence input and trigger app functions

3. **Text-to-Speech (TTS) Output with Multilingual Support via AI/ML**

   This invention doesn't stop at text — it vocalizes the constructed sentence and is designed for future integration with language translation models (AIML/NLP) to speak the output in multiple languages, making the system more inclusive and culturally adaptive.

   Key Novelty:
   - Integration of AI-powered translation (e.g., Google Translate API or TensorFlow models)
   - Real-time switching between language outputs using the same set of gestures
   - Enhanced communication for users interacting with speakers of different languages

   Protection Scope:
   - The full pipeline from gesture → sentence → multilingual voice output
   - AI/ML translation model integration logic and multilingual TTS architecture

4. **Modular and Scalable Wearable Design**

   The glove is designed to be lightweight, scalable, and built with cost-effective components like Arduino Nano, allowing it to be mass-produced or upgraded with components like MPU6050 sensors for dynamic gesture detection (e.g., for American Sign Language).

   Key Novelty:
   - Compact, glove-based design using basic components
   - Expandability to include accelerometer/gyroscope input for motion-based gestures

   Protection Scope:
   - The glove hardware layout and modular sensor integration
   - Compatibility with future gesture sets (ASL, BSL, etc.) through added sensors

6. What is Technology readiness level of your invention? (Tick the appropriate TRL)

Research			Development			Deployment		
TRL 1	**TRL 2**	**TRL 3**	**TRL 4**	**TRL 5**	**TRL 6**	**TRL 7**	**TRL 8**	**TRL 9**
Basic Principles observed	Technology concept formulated	Experimental proof of concept	Technology validated in a lab	Technology validated in a relevant environment (industrially relevant in case of key enabling technologies)	Technology demonstrated in a relevant environment (industrially relevant in case of key enabling technologies)	System prototype demonstration in an operational environment	System complete and qualified	Actual system proven in an operational environment (competitive manufacturing in case of key enabling technologies, or in space)
✓	✓	✓	✓					

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