MULTIFUNCTIONAL SIGN HAND GLOVES FOR WOMEN'S SAFETY

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Introduction:

In the contemporary world, safety and communication are still essential components of interpersonal relationships and individual welfare. For people with disabilities, these elements pose particular difficulties, particularly for women who are deaf and dumb. Although sign language offers the hearing and speech challenged a structured form of communication, most people in the general public do not comprehend it. Dependency on translators or written aids, diminished independence, and social isolation are the results of this gap.

At the same time, women's personal safety is a significant concern. Numerous studies and reports highlight how women are particularly at risk in emergency circumstances, particularly if they have physical or language impairments. Existing safety solutions, such as smartphone apps or SOS buttons, sometimes require physical unlocks, screen taps, or verbal orders, which may not be feasible in an emergency or under duress.

Previous studies have demonstrated potential in the areas of gesture recognition, IoT wearables, and emergency communication systems separately. Glove-based gesture recognition systems have enabled the translation of sign language using flex sensors and microcontrollers. Similar features include GPS tracking, Buzzer alerts, and camera-based evidence collection in wearable safety devices.

But the majority of these ideas only deal with one of the two issues-safety or communication-rather than both on one platform. A wearable solution that is small, easy to use, and has two functions is required because of this technical gap. A smart IoT-enabled glove that combines emergency alerting with gesture-to-speech communication is proposed in this research. The glove uses a combination of flex sensors, MPU6050 motion sensing, Arduino Nano, and Raspberry Pi to translate hand movements into visual and verbal output. In an emergency, a 5-second palm closure sets off an alarm that sends notifications to trusted contacts, activates a buzzer, takes a live picture, and retrieves GPS data.

Building on previous studies, this innovation goes one step further by providing a wearable, comprehensive solution that gives differently abled women more personal safety in real-time settings and communicative independence.

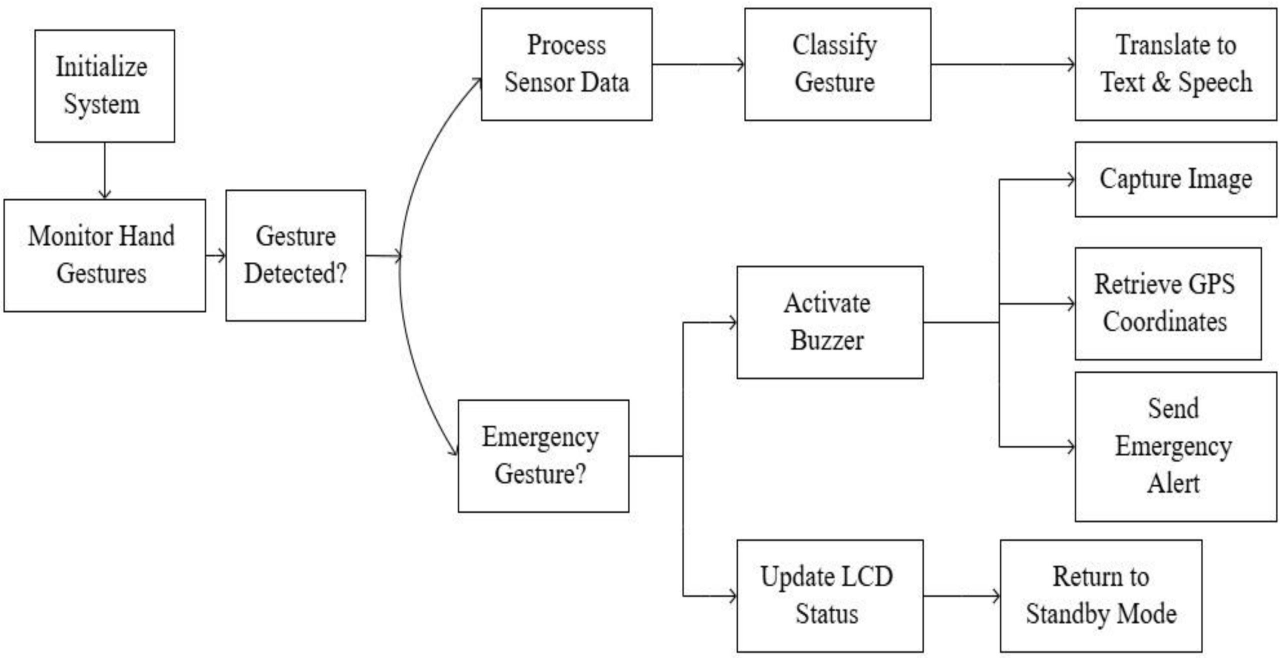

Figure 1: The functional architecture of the IoT- Enabled Glove for Women's safety and Sign Language Translation

Objectives:

- To develop a wearable glove that translates sign language gestures into readable text and voice.
- To design an emergency alerting system activated by gestures, but not voice or touch screen.
- To combine hardware elements (flex sensor, GPS, buzzer, camera) into a neat, user-friendly package.
- To offer prompt responsiveness and dependability for safety and communication features.
- To introduce an open-source, low-cost, and scalable solution available for field deployment and future study.

Methodology:

The approach is interdisciplinary, and it leverages expertise from disciplines such as: Electronics, Embedded Systems, IoT, Communication Technology, and Wearable Design

1. Research and Requirements Analysis:
   Studies are carried out on deaf/mute communication matters and women's safety.

2. Components Selection:
   Choose low-power and small modules carefully.

3. Circuit Design:
   Design the hardware in modular configuration with layered cabling.

4. Prototyping:
   Place all the equipment on the glove and ensure that the glove is comfortable and can be flexed.

5. Programming:
   Develop Arduino and Raspberry Pi firmware to interpret deconstructed gestures and

trigger appropriate action in due course. Program structure should be carefully thought out; not least prior programming anticipating step number 2 (or indeed step number two with the associated modules, wiring schematics, etc.) risks causing hardware and workload issues.

6. Testing:
   In the lab and in real life, test to determine if the gestures can be correctly interpreted as well as observe that the system operates in an emergency response situation.

7. Evaluation:
   Review data gathered through testing and how every individual responded from the story, feedback, and system.8. Documentation and Deployment: Final report preparation and awareness generation for future purposes.

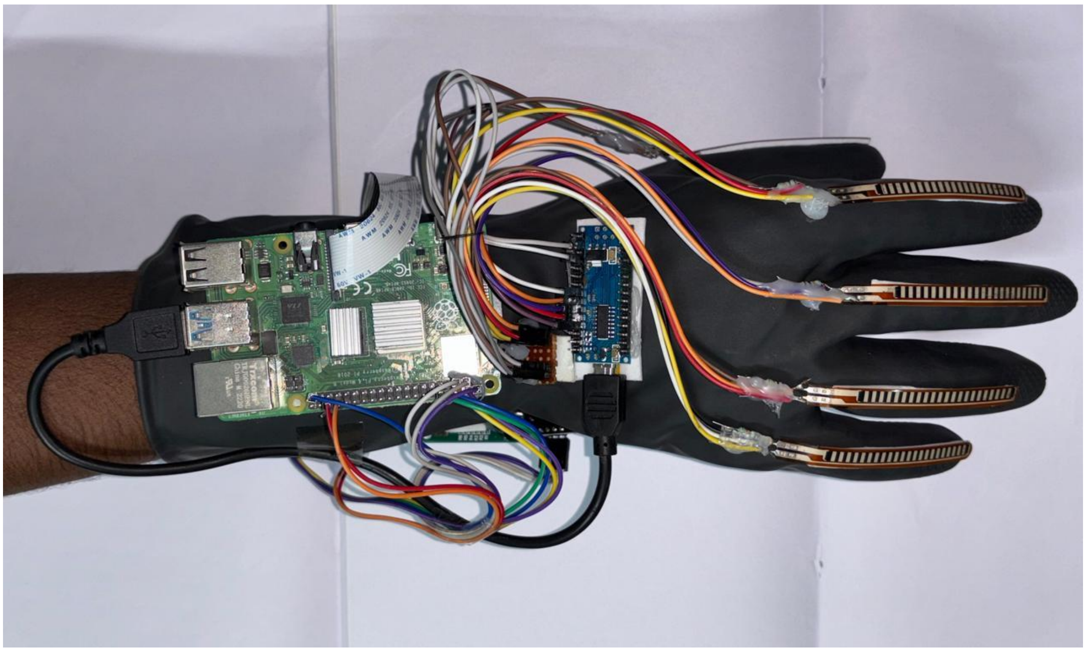

Figure 2: Front side Final Outlook of the IoT- Enabled Glove for Women’s safety and Sign Language Translation

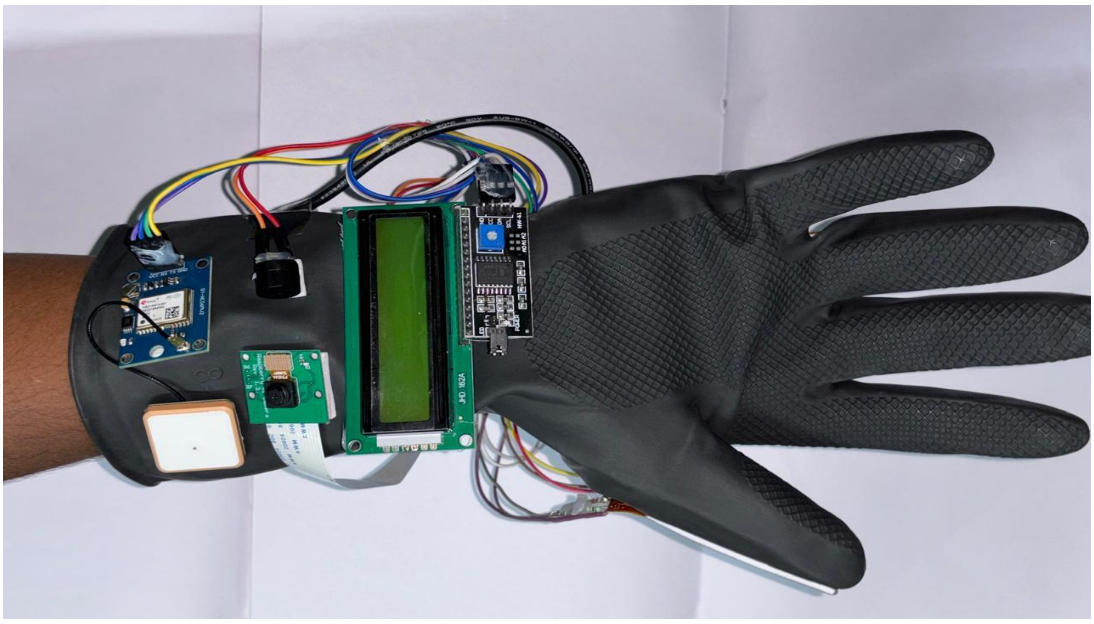

Figure 3: Back side Final Outlook of the IoT- Enabled Glove for Women's safety and Sign Language Translation

Result and Conclusion:

- Dual Purpose Device:
  - ✓ Designed to address communication and safety issues for differently-abled women.

- Gesture Recognition:
  - ✓ Translates sign language signs into readable and audible form.
  - ✓ Driven by Arduino Nano to process sensor information.

- IoT-Based Safety Features:
  - ✓ Enables alarm mode with a simple palming motion.
  - ✓ Triggers an onboard buzzer for audio notification.
  - ✓ Raspberry Pi camera takes live photographs in cases of emergency.
  - ✓ GPS module provides accurate location data for response and tracking.

- Dependable Performance:
  - ✓ Testing of all features under real conditions.
  - ✓ Experienced high user satisfaction and consistent performance.

- Enabling Users:
  - ✓ Makes the wearer more independent and self-assured.
  - ✓ Enhances their ability to interact with society and stay secure during crises.

- Technological Integration:
  - ✓ Combines embedded systems, wearables, human-centered design, and IoT.
  - ✓ Illustrates how interdisciplinary.
  - ✓ Innovation is capable of creating socially relevant solutions.

Project Outcome & Industry Relevance:

Project Outcome:

The final deliverable of this project is a completed, functioning IoT-capable, wearable glove for a double objective:

- Gesture-to-Text and Speech Communication – For the deaf and mute, the glove enables real-time communication through recognition of hand gestures which are then displayed as text on a screen and vocalized through a speaker.
- Emergency Response System – For women's safety, the glove includes an emergency mode activated through a natural gesture (closed palm for 5 seconds), which triggers a buzzer, camera capture, GPS tracking, and alert transmission via Bluetooth or cloud services.
- The glove is compact, lightweight, low-cost, and easy to use. It runs offline (no internet dependency for communication), supports modular hardware expansion, and demonstrates high accuracy and responsiveness in real-time scenarios. It has been tested successfully under both controlled lab conditions and real-world simulations

Industry Relevance:

- Assistive Technology Industry: The glove is aimed at solving key accessibility issues for people with speech and hearing disabilities, which directly benefits inclusive communication solutions.

- Personal Safety & Security Industry: Wearable's panic alert function is well-positioned to address consumer demand for covert, real-time safety wearables—particularly women, children, and the aged.
- IoT and Embedded Systems: The project illustrates the possibility of how microcontrollers, sensors, and IoT modules can be miniaturized in a smart, mobile form, presenting a reference design for future industrial use in healthcare, smart wearables, and human-computer interaction.
- Healthcare & Rehabilitation: The glove has potential applications in therapy and rehabilitation, especially for patients recovering motor function or those needing support for expressive communication.
- Education & Research: This open-source, scalable platform can serve as a base for academic projects or R&D in the fields of AI-based gesture recognition, wearable electronics, and embedded systems.
- In essence, this glove bridges a significant gap in the current technology landscape by providing a unified solution that combines usability, safety, and communication—making it highly relevant for both consumer-focused industries and social impact initiatives.

Working Model vs. Simulation/Study:

Working Model:

- ✓ Created a working smart glove that can instantly translate text and audio from sign language.
- ✓ Installed a system for emergency alerts that uses a distress gesture to activate and uses Telegram to transmit SOS messages, GPS location, and photos.
- ✓ Using flex sensors, an MPU6050 connected with an Arduino Nano, and a k-NN algorithm, real-time gesture recognition was accomplished.
- ✓ Enabled smooth Bluetooth and Wi-Fi-based IoT communication for cloud and smartphone connectivity.
- ✓ Designed to accommodate several languages, allowing the system to grow with additional languages and gestures in the future.

- ✓ For mobility and prolonged use, a small rechargeable battery was used to create a wearable variant that uses less power.

Study:

- ✓ Real-time sensor interface, Raspberry Pi, and Arduino Nano experience in embedded systems
- ✓ For effective system operation and user engagement, hardware and software must be synchronized.
- ✓ Using a k-NN algorithm for gesture categorization requires a basic understanding of machine learning.
- ✓ Enhanced project management and teamwork via task allocation and synchronization.
- ✓ Hands-on IoT integration, such as wireless alert transmission and the Telegram Bot API.
- ✓ Signal processing and sensor calibration methods to improve the precision of gesture recognition.
- ✓ Improved ability to solve problems by resolving technological problems such as data latency and sensor noise.
- ✓ Increased awareness of societal impact, comprehension of how technology may empower those with disabilities, and improved safety for women.

Project Outcomes and Learnings:

Project Outcomes:

- ✓ For multifunctionality, modular design integrates software and physical components.
- ✓ Using the k-NN algorithm, the Arduino Nano Microcontroller processes flex sensor data and recognizes gestures.
- ✓ The Raspberry Pi microprocessor controls IoT-based alert communication, GPS, and cameras.
- ✓ Flex sensors recognize sign language motions by detecting finger bending.
- ✓ MPU6050 Gyroscope & Accelerometer tracks hand motion and direction.

- ✓ 85 dB emergency alarm is triggered by the buzzer module.
- ✓ When the ESP32-CAM is in emergency mode, it takes live pictures.
- ✓ The precise location data in real time is provided by the NEO-6M GPS Module.
- ✓ Speech is produced from identified motions by the DF Player Mini Voice Module.
- ✓ The Bluetooth/Wi-Fi module makes sure that cell phones and the cloud may communicate wirelessly.
- ✓ An efficient rechargeable battery pack powers the complete glove system.

Learnings:

1. Communication using Gesture Recognition:
   Flex sensors send analog data to the Arduino Nano when they detect finger bends.
   Arduino uses the supervised k-NN algorithm to map input to predetermined gestures.
   The translated output was seen on the screen and played using DF Player Mini as Voice output.
2. Emergency Safety System:
   A clenched fist held for more than five seconds initiates the emergency procedure.
   Image capture, GPS coordinate retrieval, and buzzer activation are all done by the Raspberry Pi.
   provides Telegram with a real-time alert (with a picture, GPS link, and SOS message).

3. Integrating IoT:
   Wi-Fi or Bluetooth wireless connectivity for syncing smartphones and the cloud.
   records emergency data and gestures to the cloud for tracking.
   allows for remote assistance and real-time user tracking.

4. Flowchart of Real-Time Operations:
   Start → Initialization of the System → Sensor Monitoring
   Detected Gesture? → Yes: Use k-NN to classify gestures.
   LCD display plus voice output
   Found an Emergency Gesture? (Fist clenched for 5 seconds)
   Yes, you can set off an alarm, take a picture, and send a GPS alert.
   Update Status → Standby/Reset → Finish

5. Display of Prototypes:

   Communication: Accurately converted standard sign signals into text or speech.

   Safety: Alerts are received accurately and emergency mode is started in 34 seconds.

   Comfort: Long-lasting performance, wearable, and lightweight.

Future Scope:

The future scope of this project includes:

The existing system is complete, but there are a number of directions to further increase its capabilities:

1. Machine Learning Integration:

   Use computer vision or dynamic time warping-based gesture learning models for real-time adaptive recognition.

   Integrate a camera-based AI model to recognize complex gestures without the use of flex sensors.

2. Mobile App Synchronization:

   Create an Android/iOS application for receiving emergency messages, location tracking, and gesture logs storage.

   Implement user customization of emergency messages and contact books.

3. Cloud & IoT Expansion:

   Integrate with cloud storage platforms such as Firebase or AWS for storing alerts, images taken, and usage statistics.

   Enable remote monitoring of glove activity by authorized users (parents, guardians).

4. Miniaturization and Aesthetics:

   Develop a compact, flexible PCB design and apply stretchable electronics.

   Research textile integration towards complete glove-fabric embedding.

5. Multilingual Voice Output:

   Provide local and global language support with dynamic TTS libraries.

6. Health Monitoring Extension:

   Include heartbeat, temperature, or fall detection sensors to increase its applicability for the elderly or differently abled health care.