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IoT Based Smart Hand Gesture Glove for Communication

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Abstract: Communication is a basic human need, but people with speech and hearing impairments face many problems in daily life. This paper presents an IoT based Smart Hand Gesture Glove that helps convert hand gestures into text and speech. The system uses finger- mounted sensors, a microcontroller, and wireless communication technologies like Bluetooth and Wi-Fi. The glove captures hand gestures, processes them, and sends meaningful outputs to a mobile or web application in real time. These signals are handled using an Arduino microcontroller and transmitted wirelessly through Bluetooth or Wi-Fi. The recognized gestures are converted into readable text and audible speech instantly. The system is cost- effective, portable, user-friendly, and suitable for use in healthcare, education, and social interaction environments. This solution has significant potential applications in healthcare, education, public interaction, and social inclusion for speech-impaired individuals.

Keywords: IOT, Smart Gloves Gesture Recognition, Arduino uno, IR Sensors, Bluetooth Modules

1. INTRODUCTION:

The growing development of the Internet of Things (IoT) has made it possible for smart devices to communicate with each other easily and automatically. IoT has changed traditional systems by allowing devices to sense, process, and share data through the internet[2]. One of the most important areas where IoT is used as assistive technology. In this, IOT helps in improving usability and freedom for people with disabilities. But providing communication for individuals with speech and hearing impairments is still a major challenge[4]. People with speech impairments mainly use sign language to communicate. But sign language is not understand by everyone, which creates difficulty in daily life, especially in public places, educational institutions, and healthcare environment[1]. To solve this problem, an IoT based Smart Hand Gesture Glove is presented. This glove converts hand gestures into text and speech, making communication easier and more effective with less effort[3]. IoT based assistive technologies help people with physical disabilities in their daily lives. They make

communication easier and give people more freedom to do everyday tasks with less help from others[5,6]. By integrating IoT and wireless communication technologies, the system allows seamless interaction between humans and digital devices, promoting inclusivity and accessibility[6].

2. RELATED WORK
3.

Early gesture based systems mainly used camera based image processing techniques. Although these systems worked well, they were costly and highly affected by lighting conditions.Because of this , researchers started focusing more on sensor based systems.Recent studies use sensor based gloves with flex sensors, accelerometers and IR sensors. These system are lightweight, portable and suitable for real time use. Wearable gloves have become a better option as they are more comfortable and reliable. Sensors

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help in detecting finger movement and hand motion accurately. Many research works also use wireless communication technologies like Bluetooth and Iot platforms to send data in real time. These system allow fast data transfer and easy communication. The presented system builds on earlier research by offering a low-cost, portable, and scalable solution for assistive communication. Some studies have also explored IoT integration, allowing gesture data to be transmitted to cloud platforms for storage and analysis. However, many existing systems are expensive, complex, or lack real-time performance. The proposed system focuses on simplicity, affordability, and real-time communication, making it suitable for practical deployment.

3 TOOLS & TECHNOLOGY

3.1 Hardware Components

- **Arduino Uno :** Arduino Uno is a widely used open-source microcontroller board based on the ATmega328P microcontroller. Arduino is used to interface with various sensors and modules. It Controls data flow between different components and processes the sensor's data in real-time[4].

Fig 1: Arduino

- **IR sensor**: An IR (Infrared) sensor is a gadget that uses infrared light to detect motion, distance, or objects. It functions by emitting infrared light and measuring the amount of reflection**.** In the Smart Hand Gesture Glove, IR sensors are used to detect finger motion and hand gestures without direct physical contact[6].

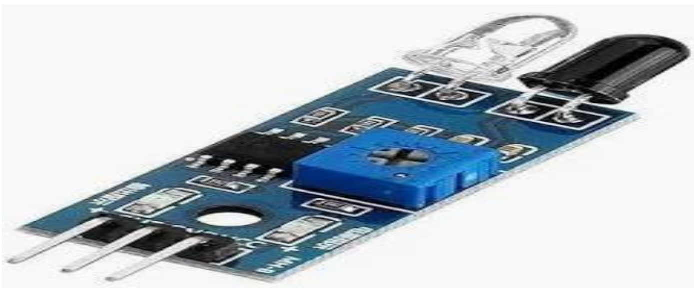

Fig 2:IR Sensor

- **Bluetooth Module:** The Bluetooth Module is used to make the system portable and allow continuous use**.** Its helps to communicate direct and send data to device[8].

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Fig 3: Bluetooth Module

- **Jumper Wire:** Ables to connect devices with each other devices. These are short, electrical wire with connector pins(M to M, F to F,M to F) on each end[3].

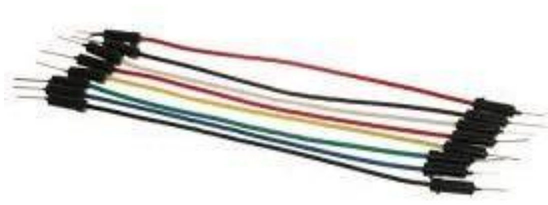

Fig 4: Jumper Wire

3.2 Software Components

- **Arduino IDE:** C/C++ Language, Arduino IDE, and Embedded Programming for Microcontroller Coding. An effective tool for creating, compiling, and uploading programs to microcontrollers like the Arduino UNO, NodeMCU (ESP8266) is the Arduino Integrated Development Environment (IDE). The C and C++ programming languages, which are perfect for developing embedded systems, are supported by its user-friendly interface[5,7].

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Fig 4: Arduino IDE

4. Metholodgy

The methodology of the proposed IoT based Smart Hand Gesture Glove focuses on the systematic design, implementation, and evaluation of a wearable assistive communication system[8]. The overall process is divided into multiple stages, ensuring accurate gesture recognition, efficient data transmission, and real-time output generation. The major steps involved in the methodology are described below[5].

1) The first stage of the methodology involves collecting hand gesture data using sensors mounted on the glove.
2) Sensor calibration is a crucial step in the methodology to ensure accurate gesture recognition. Each sensor is calibrated based on minimum and maximum bending values for different users.
3) Gesture recognition is performed by comparing real-time sensor values with predefined gesture templates stored in the microcontroller. Each gesture is represented as a unique combination of sensor readings corresponding to finger positions.
4) Once a gesture is recognized, the corresponding data is transmitted wirelessly using a Bluetooth (HC-05) or Wi-Fi module. The communication module establishes a secure and stable connection with the receiving device, such as a smartphone or computer.
5) At the receiving end, a mobile or web application decodes the transmitted gesture data. The decoded message is displayed as readable text on the screen. Additionally, text-to- speech technology is used to convert the text into audible speech, enabling verbal communication[9].
6) The system architecture supports future IoT integration by enabling cloud connectivity. Gesture data can be stored on cloud-based IoT platforms for analysis, monitoring, and system improvement. This allows for data-driven enhancements, remote access, and system scalability[4].
7) The final stage of the methodology involves testing and evaluation of the system. Various predefined gestures are tested under different conditions to measure accuracy, response time, and communication reliability[3].

5. Results and Discussion

The proposed IoT based Smart Hand Gesture Glove was designed, implemented, and tested under controlled conditions to evaluate its performance in real-time gesture recognition and communication. Several predefined hand gestures were programmed into the system, each corresponding to a specific message such as greetings, basic needs, or emergency alerts. The system was tested by multiple users to assess accuracy, responsiveness, and usability[10].

1. Gesture Recognition Accuracy

The system demonstrated a high level of accuracy in recognizing predefined gestures. Flex sensor readings varied consistently with finger bending angles, allowing the microcontroller to distinguish between different gestures reliably. Minor variations in finger movement did not significantly affect recognition, indicating good tolerance to natural hand motion[12,13].

2. Response Time and Real-Time Performance

One of the critical performance parameters evaluated was system response time. The delay between gesture execution and output generation was minimal, typically within a fraction of a second. This low latency ensured smooth and real-time communication, which is essential for practical usage[4,7].

3. Wireless Communication Performance

The Bluetooth HC-05 module provided reliable communication between the glove and the mobile device. Data transmission was consistent, and no significant packet loss was observed during testing. The communication range was sufficient for indoor environments such as classrooms, hospitals, and homes. This confirms the suitability of the system for short-range assistive communication applications[4].

4. User Comfort and Wearability

User comfort is a crucial factor for wearable assistive devices. The glove was lightweight and ergonomically designed, allowing users to wear it for extended periods without discomfort. Sensor placement on the fingers did not restrict natural hand movement[6].

5. System Reliability and Limitations

The system performed reliably under normal operating conditions. However, slight variations in sensor readings were observed due to differences in hand size and finger flexibility among users. This limitation can be addressed by incorporating calibration techniques or adaptive threshold in future versions. Additionally, the current system recognizes only predefined static gestures; dynamic gestures can be explored in future work[11,15].

6. Comparison with Existing Systems

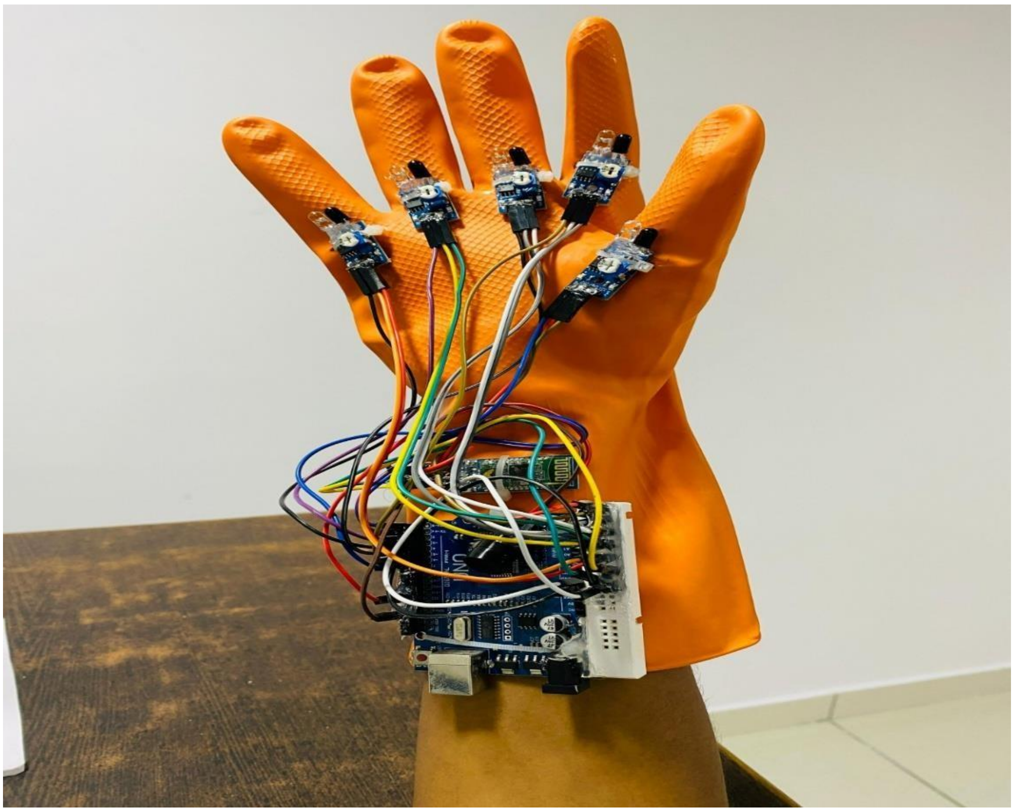
Compared to camera-based gesture recognition systems, the proposed glove-based solution offers better portability, lower computational complexity, and improved privacy. Unlike vision- based systems, it is not affected by lighting conditions or background noise. The system is also more cost-effective, making it accessible for widespread adoption[4].

The experimental results validate the effectiveness of the IoT based Smart Hand Gesture Glove as a practical assistive communication device. The combination of accurate gesture recognition, real-time response, reliable wireless communication, and user-friendly design demonstrates the system's potential for real-world deployment. While there is scope for further enhancement, the current implementation successfully achieves its primary objective of bridging the communication gap for speech-impaired individuals[6].

6. Applications

- Assistive communication for speech and hearing-impaired individuals
- Healthcare environments for patient–doctor communication
- Educational institutions for inclusive learning
- Public interaction and customer service

- Emergency communication systems
- Industrial Safety and Worker Assistance
- Smart Home Control for Disabled Users
- Military and Defence Communication



7. CONCLUSION

The IoT based Smart Hand Gesture Glove proposed in this research effectively addresses the communication challenges faced by speech and hearing-impaired individuals. By integrating wearable sensor technology, microcontroller-based processing, and wireless communication, the system successfully translates hand gestures into meaningful text and speech output in real time. The use of low-cost hardware components such as Arduino Uno, flex sensors, and Bluetooth modules makes the system economically feasible and accessible for widespread adoption.

The experimental results demonstrate that the system is reliable, responsive, and user-friendly. The glove is lightweight and comfortable for continuous use, while the wireless communication ensures seamless interaction with external devices. This solution significantly reduces dependency on interpreters and enhances social inclusion, independence, and confidence

among speech-impaired users. Additionally, the system promotes inclusivity in public spaces, educational institutions, and healthcare environments by enabling effective human–computer and human–human interaction.

8. FUTURE SCOPE

Although the proposed system provides an efficient solution, there is significant scope for future enhancements. Machine learning and artificial intelligence algorithms can be integrated to improve gesture recognition accuracy and

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support dynamic and complex gesture patterns. This would allow the system to recognize a wider range of gestures without relying solely on predefined thresholds[7].

Future versions of the system can incorporate multilingual text-to-speech output to support users from different linguistic backgrounds. Mobile application development with a user- friendly interface can further enhance accessibility and usability. Cloud-based IoT platforms can be integrated to store gesture data, perform analytics, and enable remote monitoring and customization.

Additionally, the system can be extended with haptic feedback to provide confirmation signals to the user, improving interaction reliability. Miniaturization of hardware components and the use of flexible electronics can make the glove more ergonomic and energy-efficient. With these enhancements, the Smart Hand Gesture Glove has the potential to evolve into a comprehensive, intelligent assistive communication device suitable for real-world deployment on a large scale[7,9].

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