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Talking Gloves with Home Automation

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Abstract

Communication barriers faced by deaf and mute individuals often stem from the general public's lack of familiarity with sign language. The Talking Glove project aims to bridge this gap by developing a wearable device that translates hand gestures into spoken words. The glove is embedded with flex sensors, an accelerometer, and a microcontroller (e.g., Arduino) to detect and interpret finger and hand movements. These gestures are mapped to predefined sign language patterns, which are then converted into audio output using a speech synthesizer module. The system enhances accessibility, promotes inclusivity, and offers a portable, cost-effective solution for real-time gesture- to speech translation.

Keywords: Talking Glove; ESP32; Gesture Recognition; Assistive Technology; Home Automation; IoT; Flex Sensor; Speech Impairment.

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Introduction

Communication is a fundamental human need, yet millions of individuals who are deaf or mute face persistent challenges due to the limited familiarity with sign language among the general population, creating barriers in education, employment, and social interaction. The Talking Glove project presents an innovative wearable assistive system designed to bridge this communication gap by translating hand gestures into audible speech in real time. The system integrates flex sensors mounted on the fingers and an accelerometer to accurately capture hand movements and finger bending corresponding to sign language gestures. These sensor inputs are processed by a microcontroller, where predefined gesture patterns are recognized and mapped to meaningful textual outputs. The interpreted text is then converted into speech using a speech synthesis module, enabling seamless interaction between sign language users and non-signers. The proposed solution emphasizes portability, cost-effectiveness, and ease of use, making it suitable for everyday communication. Furthermore, the system can be extended with features such as wireless connectivity, display modules, and machine learning-based gesture recognition to enhance accuracy and scalability, thereby contributing to the development of inclusive and accessible assistive technologies.

Literature Review

A. S. Mane, S. Patil, and S. S. Patil proposed a multi-purpose smart glove that translates hand gestures into text and speech. The system uses sensors to detect finger movements and a processing unit to convert them into meaningful outputs. Additionally, the glove integrates features such as home automation and health monitoring, making it a versatile assistive device.

Sujaya et al. proposed a sign-to-speech conversion system integrated with home automation using smart gloves. The system captures hand gestures using sensors and converts them into speech output while also enabling control of home appliances. This dual functionality enhances usability for speech-impaired individuals but may face limitations in accuracy and scalability.

Taiwo et al. developed an intelligent smart home control and security system based on deep learning models. The system improves automation and security by recognizing patterns and making decisions in real-time. Although not specifically glove-based, this work highlights the importance of AI in enhancing automation systems.

Das and A. Ghosh presented an AI-driven smart glove for real-time gesture recognition and automation. The system utilizes machine learning algorithms to improve gesture detection accuracy and response time. It also supports automation features, making it more efficient and intelligent compared to traditional sensor-based systems.

Proposed methodology

The proposed model is designed with the help of accelerometer, pulse sensor, vibrator sensor, GPS Module, GSM Module, WIFI Module, buzzer and the instructions are fed into the Arduino Uno board. The hand gesture is captured by the accelerometer sensor and a corresponding output is displayed in the form of a sentence Information are displayed in LCD Display and SMS is sent to Admin via GSM Module. The overall process is carried out by Arduino Uno and GSM module. Fig . 2. Is the overall setup of Implementation of IoT Based Smart Assistance Gloves for Disabled Person Using IoT. an accelerator looks like a simple circuit for some larger electronic device. Despite its humble appearance, the accelerometer consists of many different parts and works in many ways, two of which are the piezoelectric effect and the capacitance sensor. The piezoelectric effect is the most common form of accelerometer and uses microscopic crystal structures that become stressed due to accelerative forces. These crystals create a voltage from the stress, and the accelerometer interprets the voltage to determine velocity and orientation. The capacitance accelerometer senses changes in capacitance between microstructures located next to the device.

Block diagram:

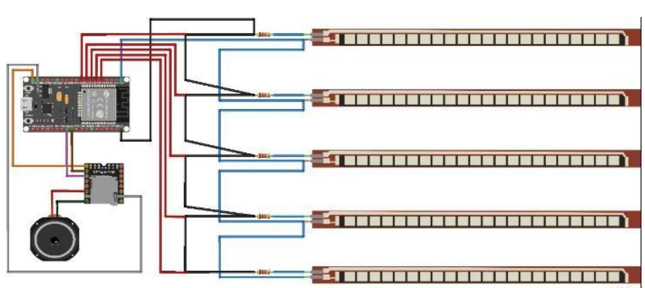

Fig.1. *Block Diagram*

An ESP32-based Talking Glove with Home Automation system is a wearable assistive technology designed to bridge communication gaps while enabling smart environment control. The system integrates flex sensors mounted on the fingers and an accelerometer to capture hand gestures and movements, which are processed by the ESP32 microcontroller to recognize predefined sign language patterns. Once a gesture is identified, it is converted into text and further into audible speech using a speech synthesis module and speaker, facilitating real-time communication for deaf and mute individuals. In addition to communication, the system maps specific gestures to control home appliances such as lights and fans through relay modules, enabling hands-free home automation. The ESP32's built-in Wi-Fi capability allows data transmission to IoT platforms like Blynk or Thing Speak for remote monitoring and control via mobile or web applications. This system enhances accessibility, eliminates dependency on manual interaction, and promotes independent living by combining assistive communication with intelligent home automation, with potential extensions including machine learning-based gesture recognition and multi-language support.

ESP 32 Module:

The ESP32 is a low-cost, low-power microcontroller developed by Espressif Systems, widely used in embedded and IoT applications. It features a dual-core processor, built-in Wi-Fi and Bluetooth connectivity, multiple GPIO pins, and support for analog and digital interfacing, making it suitable for real-time data processing and wireless communication. Due to its high performance, energy efficiency, and versatility, the ESP32 is commonly used in smart systems such as home automation, wearable devices, and sensor-based applications.

Fig.2 *Esp 32 Module*

MP3 Module:

The DFPlayer Mini is a compact and low-cost MP3 module commonly used in embedded systems for audio playback applications. It supports direct playback of MP3 and WAV audio files from a microSD card and can be easily interfaced with microcontrollers such as ESP32 using serial communication. The module includes a built-in audio amplifier, allowing it to drive a speaker directly without the need for external amplification. Due to its simplicity, low power consumption, and ease of integration, the DFPlayer Mini is widely used in voice alert systems, talking devices, and assistive technologies.

Fig.3 *MP3 Module*

NodeMCU ESP8266

It features built-in USB-to-serial support (often CP2102 or CH340), 17 GPIO pins, and operates at 3.3V, making it ideal for Wi-Fi projects, IoT automation, and smart homesystems programmed via Arduino IDE, MicroPython, or Lua.17 pins (with 11 usable) supporting PWM, I2C, SPI, and UART.ADC One 10-bit analog-to-digital converter. 3.3V operating voltage, typically powered via Micro USB (5V).

Fig.4 *NodeMCU ESP8266*

Speaker:

A speaker is an electroacoustic transducer that converts electrical audio signals into audible sound waves. It operates on the principle of electromagnetic induction, where an electric current flows through a voice coil placed in a magnetic field, causing a diaphragm (cone) to vibrate and produce sound. These vibrations create pressure waves in the air that our ears interpret as sound. The main parts of a speaker include the magnet, voice coil, cone (diaphragm), and suspension system.

Fig.5 *Speaker*

Flux Sensor:

A flux sensor is a device used to measure the magnetic flux or magnetic field strength in a given area. It works on the principle of electromagnetic induction, where a change in magnetic flux through a coil or sensing element induces a voltage proportional to the magnetic field. Flux sensors are often made using materials like Hall effect sensors, fluxgate sensors, or magneto-resistive elements. requires external heat sinks for high current operation. L298 is widely used in robotics, automated vehicles, and motor control projects.

Fig.5 *Flux Sensor*

Hand Gloves:

Gloves are wearable coverings designed to protect and cover the hands and fingers. They are made from different materials such as cotton, rubber, leather, latex, or electronic fabric, depending on their application. In electronic and biomedical projects, sensor-based smart gloves are used to detect hand movements, gestures, or physiological parameters. These gloves often include components such as flex sensors, accelerometers, or pressure sensors, which convert finger bending or motion into electrical signals.

***Fig.6**. Hand Gloves*

Final Hardware

It replaces traditional manual interaction methods and reduces communication barriers for deaf and mute individuals by enabling gesture-based speech output and appliance control. The system uses an ESP32 microcontroller with built-in Wi-Fi for real-time processing and wireless communication. Flex sensors are mounted on the glove fingers to detect bending, while an accelerometer captures hand motion and orientation. These sensors provide input signals to the ESP32, which processes and maps them to predefined gestures. A DF Player Mini MP3 module with a speaker is used to generate voice output corresponding to the recognized gestures. For home automation, relay modules are integrated to control electrical appliances such as lights, fans, and motors. The system can also connect to IoT platforms for remote monitoring and control via mobile or web applications. It enables users to control home devices effortlessly through hand gestures, provides real-time voice feedback, enhances independence for specially-abled individuals, and supports smart living with improved accessibility and convenience.

***Fig.7**.Project Model*

Results and discussions

The proposed Talking Glove with Home Automation system was successfully designed and implemented, demonstrating reliable gesture recognition and real-time system response. The flex sensors accurately detected finger bending, and the ESP32 efficiently processed these inputs to identify predefined gestures with minimal delay. The system effectively converted gestures into audible speech using the DFPlayer Mini module, enabling clear communication for deaf and mute users. Additionally, gesture-based commands were successfully mapped to control home appliances such as lights and motors through relay modules, as observed during testing where specific hand movements triggered consistent ON/OFF operations. The integration of Wi-Fi enabled smooth communication with IoT platforms for remote monitoring and control. While the system performed well under controlled conditions, minor variations in sensor readings due to hand positioning and calibration affected accuracy in some cases. Overall, the system demonstrated good responsiveness, low latency, and practical usability, highlighting its potential as an assistive technology combined with smart home automation, with scope for further improvement using machine learning for enhanced gesture recognition accuracy.

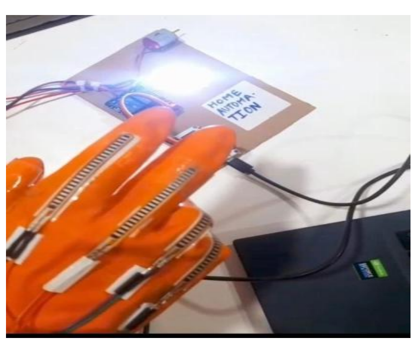

***Fig.8**.Result*

Conclusions

The Talking Glove with Home Automation system presents an effective and innovative solution for bridging communication gaps while enabling smart control of household appliances. By integrating flex sensors, an accelerometer, and the ESP32 microcontroller, the system successfully recognizes hand gestures and converts them into both speech output and automation commands in real time. The implementation demonstrates improved accessibility and independence for deaf and mute individuals, allowing them to communicate and interact with their environment more efficiently. The system is cost-effective, portable, and easy to use, making it suitable for practical applications. Although minor limitations in gesture accuracy exist due to sensor variations, the overall performance validates the feasibility of combining assistive communication with IoT-based home automation, with future scope for enhancements using advanced algorithms and expanded gesture sets.

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We express our sincere gratitude to all the experts and mentors who provided valuable guidance and suggestions to improve this work. The development of the Talking Glove with Home Automation system involves the integration of wearable sensor technology, embedded systems, and IoT-based communication, which required continuous support and encouragement. We are thankful to our project guide and faculty members for their technical insights and constructive feedback throughout the development process. We also acknowledge our institution for providing the necessary resources and facilities to carry out this project successfully. Finally, we extend our appreciation to all those who directly or indirectly contributed to the completion of this work.

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