AI Powered Sign Language Translation Wearable Glasses

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ABSTRACT

This Communication barriers faced by the speech- and hearing-impaired community can hinder daily interactions and social integration. To address this issue, this project presents a smart, wearable solution titled "AI Powered Sign Language Translation Wearable Glasses", which interprets sign language gestures and converts them into audible speech in real-time. The system is built using an ESP32-CAM module mounted on glasses to capture hand gestures. These gestures are then processed via Wi-Fi enabled ESP32 microcontroller, utilizing Adafruit IO for cloud-based data handling. Upon successful recognition, the gestures are translated into voice output using a DF Mini MP3 Player Module, with audio amplified through a PAM8403 amplifier and played via a speaker. The wearable nature of the device allows users to move freely while maintaining seamless communication. It eliminates the need for text or manual input, making the interface natural and intuitive. The system is also powered by a rechargeable Li-ion battery, making it portable and eco-friendly.

Keyword: - Include ESP32 Microcontroller, ESP32-CAM Module, DF Mini MP3 Player, PAM8403 Audio Amplifier.

1. INTRODUCTION

Communication is the cornerstone of human connection. It enables individuals to share thoughts, express emotions, and interact with the world around them. However, for individuals who are speech- or hearing-impaired, this simple task becomes a daily challenge. These individuals often rely on sign language, a visual language that uses hand gestures, facial expressions, and body movements to convey meaning. While sign language is a powerful mode of communication, its effectiveness is significantly limited by the fact that most people in society do not understand it. This communication gap creates barriers in education, employment, healthcare, and social life for individuals who rely on sign language. To address this issue, it is crucial to develop technology that can serve as a bridge between sign language users and non-signers. The project titled "AI Powered Sign Language Translation Wearable Glasses" aims to provide an innovative and user-friendly solution by translating sign language gestures into audible speech. This is achieved through a wearable smart glasses system equipped with an ESP32-CAM module to capture real-time hand gestures, an ESP32 microcontroller to process the input, and a DF Mini MP3 player module to play the corresponding audio. The system uses Adafruit IO, a cloud-based IoT platform, to facilitate gesture data handling and response communication. This combination of embedded systems, IoT, and audio technology enables real-time, portable, and efficient translation of sign language into speech. The device is powered by a rechargeable battery and mounted on a lightweight glasses frame, making it suitable for continuous use in everyday life. With this project, we aim to empower differently-abled individuals and contribute toward a more inclusive society.

2. OBJECTIVE

This paper is designed with the following key objectives in mind:

- Gesture Recognition: To capture and recognize hand gestures using a vision-based system embedded in wearable glasses.

- Real-Time project is designed with the following key objectives in mind.
- Gesture Recognition: To capture and recognize hand gestures using a vision-based system embedded in wearable glasses.
- Real-Time Processing: To process gesture data immediately using ESP32 and IoT technologies for timely translation.
- Speech Output: To play pre-recorded voice messages corresponding to specific gestures using a DF Mini MP3 Player and speaker setup.
- Portability & Comfort: To design the system in a compact, lightweight, and wearable form that does not interfere with the user's comfort or mobility.
- IoT Integration: To use Adafruit IO for wireless data transmission and monitoring of gesture activity, ensuring smooth cloud-based communication.
- Energy Efficiency: To use low-power components and rechargeable batteries to make the system environmentally friendly and long-lasting.
- Scalability: To create a modular system that can be upgraded in the future with features like dynamic gesture recognition, text display, or multi-language support.
- Processing: To process gesture data immediately using ESP32 and IoT technologies for timely translation.

These objectives collectively aim to enhance the quality of life for sign language users and bring technological empowerment to the differently-abled community.

4. BLOCK DIAGRAM

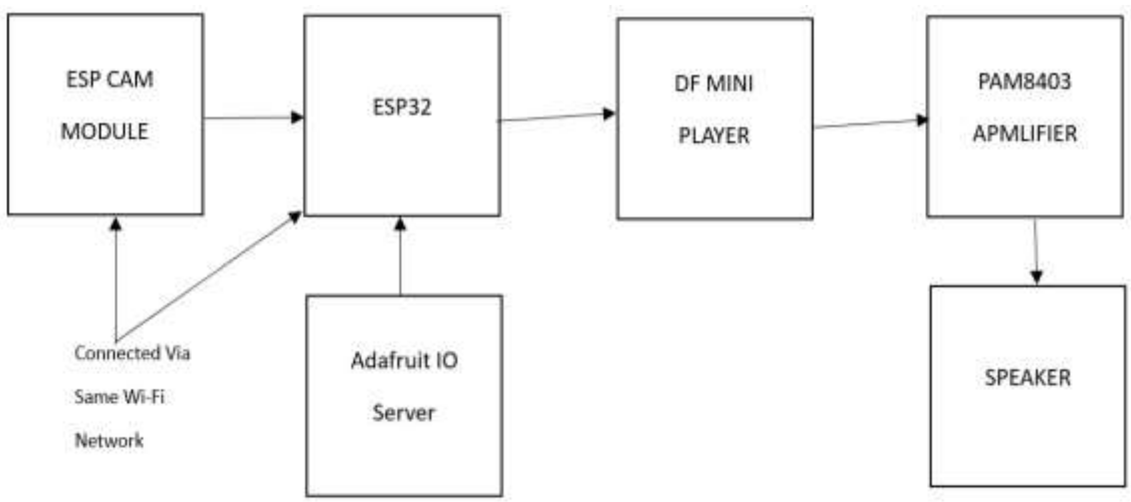


Fig1: Block diagram of project

5. HARDWARE DESIGN AND CONNECTIONS

1. ESP-CAM: Captures real-time images of hand gestures.
2. ESP 32: The core controller responsible for processing gestures and managing audio playback.
3. DF Mini MP3: Plays predefined voice responses from SD card.
4. PAM8403: Amplifies the audio output.
5. Speaker: Outputs speech.
6. TP4056 + Battery: Portable rechargeable power system.

6. WORKING

The system works in a series of steps, from detecting a gesture to providing an audio response.

1. Startup Phase:
   - Both the ESP32 and ESP32-CAM connect to the Wi-Fi network.
   - The system initializes the MP3 module and establishes a connection with Adafruit IO.

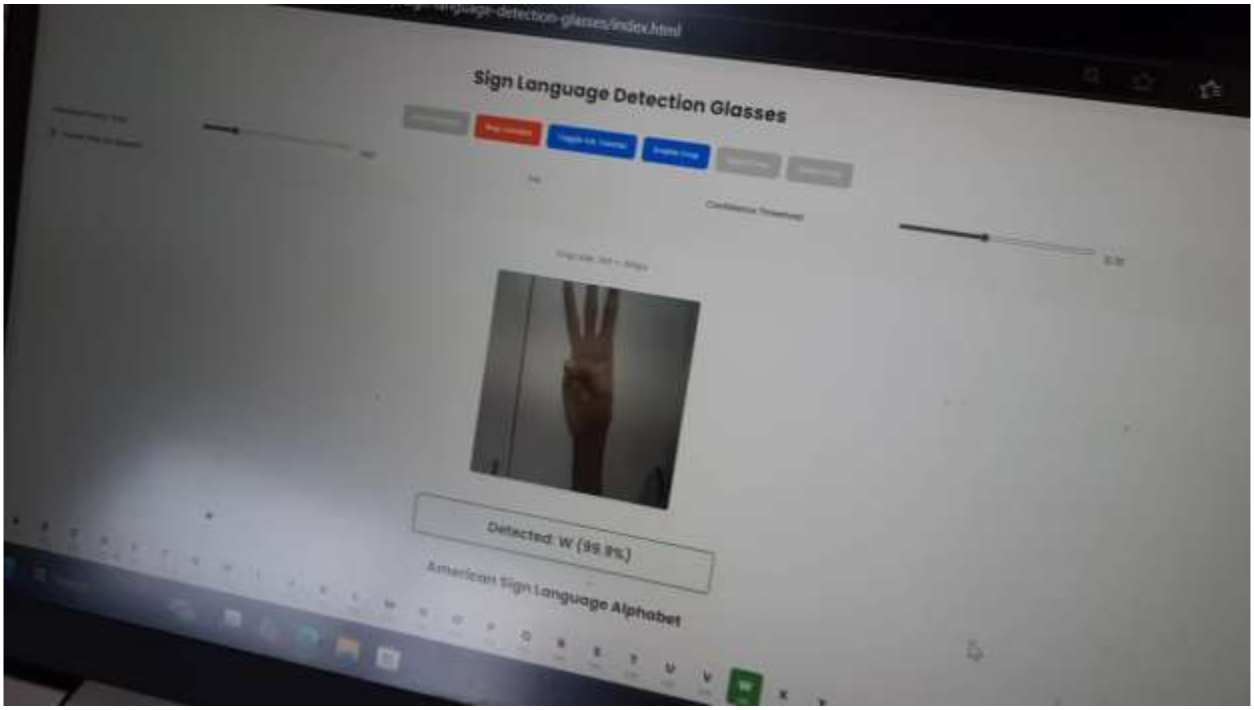
2. Gesture Detection:
   - The ESP32-CAM continuously monitors for hand gestures.
   - When a valid gesture is detected, it captures and processes the image (or sends it to the cloud for processing).
   - A gesture ID (e.g., G1, G2) is generated and sent for further processing. AI Powered Sign language Translator Wearable Glasses

3. Gesture Transmission via IoT:
   - The gesture ID is transmitted using the MQTT protocol to Adafruit IO.
   - The ESP32 subscribes to the feed and waits for updates on the gesture ID.

4. Gesture Reception and Processing:
   - The ESP32 receives the new gesture code and maps it to a corresponding audio file stored in the micro SD card.

5. Audio Response Generation:
   - The ESP32 sends a command to the DF Mini MP3 Player to play the specific audio file.
   - The audio is amplified by the PAM8403 and output through the speaker, providing the user with a translated message.

7. OUTPUT


Sign Language Detection Glasses
Detected: W (99.9%)
American Sign Language Alphabet

8. ADVANTAGES

· Real-time communication between sign language users and non-users.

· Wearable and portable, ensuring ease of use in public spaces.

· Cost-effective using easily available components.

· User-friendly interface – no complex operations required.

· Energy efficient with low power consumption.

· Expandable system with support for more gestures and responses.

· Promotes inclusion for differently-abled individuals in mainstream society.

9. CONCLUSIONS

Our project is a significant step toward bridging the communication gap between speech- or hearing-impaired individuals and the rest of society. Through a combination of ESP32 microcontrollers, ESP32-CAM, IoT (Adafruit IO), and MP3 audio playback, the system successfully converts sign language gestures into audible speech.

The prototype demonstrates high usability, accuracy in gesture recognition, and real-time response, making it a promising assistive technology. The wearable format ensures that users can carry it comfortably in day-to-day life without the need for a bulky setup or third-party assistance.

This solution is cost-effective, compact, user-friendly, and scalable. It promotes inclusive communication and empowers individuals who rely on sign language by giving them a voice in both public and private interactions. The success of this project proves that with the right integration of hardware, IoT, and embedded systems, innovative tools can be created that serve real societal needs.

10. REFERENCES

Below is the list of references and resources that were consulted during the research, design, and development of the project:

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