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EMPOWERING SILENT VOICES A NON-VERBAL COMMUNICATION SYSTEM

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Abstract: The "Speaking System for Mute People Using Hand Gestures" is a technology solution aimed at enhancing communication for individuals with speech impairments, specifically those who are mute. The system utilizes computer vision and machine learning techniques to interpret hand gestures in real-time and translates them into spoken language. It includes a gesture recognition module, speech synthesis technology, an intuitive user interface, and allows users to customize and define their own set of gestures. The system also incorporates adaptive learning mechanisms to improve accuracy over time, providing an inclusive and personalized communication experience for individuals with speech impairments.

Keywords: *ESP32, WiFi Multimedia(WMM), Automatic Beacon monitoring (hardware TSF),A 60 MHz crystal oscillator is used for general operation, while a 40 MHz oscillator is specifically required for Wi-Fi and Bluetooth functionality liquid crystal display (LCD),Firefly Optimization (FF), Elliptic Curve Cryptography (ECC), Advanced Encryption Standard (AES).*

I.Introduction

Gesture-to-Speech Assistive System for Speech-Impaired Individuals India, approximately 7.5% of the population is affected by speech impairments. For many of these individuals, Indian Sign Language (ISL) serves as their primary means of communication. However, sign language is often difficult for non-signers to understand and requires significant effort to learn, creating a substantial communication barrier. This lack of accessibility limits the independence and daily functioning of speech-impaired individuals.

Assistive technologies have the potential to address this challenge by enabling more inclusive and effective communication.[2] A well-designed sign language recognition system can bridge the gap between speech-impaired individuals and the wider community, eliminating the need for human interpreters. By converting sign language gestures into speech or text, such systems can empower users to communicate independently and confidently. Despite ongoing research, existing solutions remain limited. Most current systems are capable of recognizing only a small set of signs and are not robust enough for real-world application. This is particularly problematic during emergencies or while traveling, where quick and clear communication is essential. To bridge this gap, we propose the development of a wearable smart speaking system.[1] This advanced technology is designed to facilitate enhanced communication, offering users a more intuitive and efficient way to interact in different environments that translates sign language gestures into audible speech. The system is powered by an ESP32 microcontroller and operates on a battery-powered circuit.[4] It captures and processes variations in hand movements to recognize single-handed gestures representing alphabets. These recognized gestures are then converted into speech and played through an MP3 speaker. This solution aims to enhance the autonomy and communication ability of speech-impaired individuals in everyday life.

II.Review of related works

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The provided literature collectively explores various methods for enabling speech-impaired individuals to communicate using hand gesture recognition systems. These studies focus on both The hardware-based and vision-based approaches are fundamental to the design of the system. The hardware-based approach focuses on incorporating key components such as sensors, microphones, and processors into a wearable device, allowing for real-time speech output and efficient communication. The vision-based approach utilizes cameras and computer vision algorithms to interpret visual cues like gestures, facial expressions, or environmental factors, enabling the system to adjust its responses according to the context. Together, these approaches work synergistically to provide a more intuitive and dynamic user experience, highlighting innovations, technical implementations, and challenges in the field.

G.Aishwarya , V.Snehitha , SK.Abdulayaz , S.Shanulfaiz,"SPEAKING SYSTEM FOR MUTE PEOPLE USING HAND GESTURES",2023 JETIR May 2023, Volume 10, Issue propose a wearable device equipped with flex sensors attached to each finger. The sensors detect hand gestures, and the corresponding values are transmitted via an RF module to a speaker unit. The system identifies predefined gesture patterns and converts them The system converts input into speech using text to speech (TTS) technology, enabling smooth verbal communication. This process transforms written or interpreted data into natural-sounding speech. The device is battery-powered and designed for real-time communication.

Mrs. Prarthana J V, Ms. Kavya S, Mr.Chethan Kumar S N,"Speaking System for Mute People Using Hand Gestures",2022 IJRTI | Volume 7, Issue 7 | ISSN: 2456-3315

also utilize flex sensors, but their model is built around an Arduino UNO microcontroller. The system interprets the resistance changes from gestures and provides a voice output in the user's chosen language. Additionally, it integrates a GSM module to send emergency alerts, enhancing its practical application.

T M Dudhane; T. R. Chenthil; Kanaga Priya P,"Sign Language Recognition System using Convolutional Neural Network",2022 Second International Conference on Advanced Technologies in Intelligent Control, Environment, Computing & Communication Engineering(ICATIECE),DOI: 10.1109/ICATIECE56365.2022.10046883

explore a deep learning-based approach using Convolutional Neural Networks (CNNs) for recognizing sign language through vision. Unlike sensor-based models, this system uses image inputs to interpret gestures, addressing challenges such as skin tone variations with filters. The CNN model includes convolution, pooling, and fully connected layers for accurate recognition.

Noraini Mohamed; Mumtaz Begum Mustafa; Nazean Jomhari,"A Review of the Hand Gesture Recognition System: Current Progress and Future Directions"IEEE 2021 journal

A comprehensive review of vision-based hand gesture recognition research involves summarizing key advancements, methodologies, applications, challenges, and future directions from 2014 to 2020. They analyze studies focused on data acquisition, environmental factors, and gesture representation. Their findings show that while signer-dependent systems achieve high accuracy (average 88.8%), signer-independent models still need improvement, particularly in continuous gesture recognition.

Juginder Pal Singh;Akrati Gupta;Ankita,"Scientific exploration of Hand Guesture Recogonition to text",2020 International Conference on Electronics and Sustainable Communication Systems introduce a gesture-to-text conversion system. The research emphasizes identifying static hand shapes (four fingers and one thumb) and translating them into text using dimensionality reduction techniques. The goal is to build a scalable system with a large vocabulary To bridge the communication gap between speech-impaired and non-signing individuals, an advanced solution like a wearable smart speaking system can be highly effective. This technology would enable speech-impaired individuals to communicate

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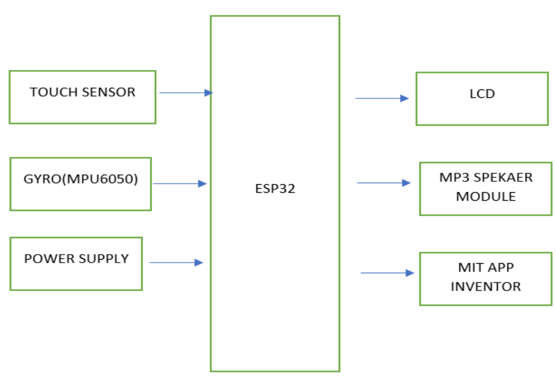
effortlessly with those who do not understand sign language

III. Proposed system to solve the Localization problem

This system utilizes a microcontroller to manage and control all processes involved in gesture recognition. Touch sensors, in combination with accelerometer sensors, are employed to track the movement of both the fingers and the entire palm. An LCD is used to visually display the user's gestures in real time. Additionally, if feasible, a speaker will be integrated to convert the recognized gestures into corresponding audio output. The interpreted message will also be displayed within a dedicated interface on the MIT App Inventor platform, ensuring multi-modal communication support.[3],[5]

BLOCK DIAGARAM



ESP32-Based Gesture Recognition System: Development Overview

1. Requirements Analysis

The project aims to develop a gesture-based communication system for speech-impaired individuals. It will include gesture recognition through touch and accelerometer sensors, with outputs displayed on an LCD, converted to audio via a speaker, and mirrored in a mobile application built using MIT App Inventor. Key system components include: Inputs: Touch and accelerometer sensors. Outputs: LCD screen, speaker, mobile app. Communication: Wi-Fi and/or Bluetooth. Features: Real-time gesture recognition, multi-platform output, emergency messaging (optional).[11][8]

2. System Architecture

A modular, scalable, and maintainable architecture will be designed. The ESP32 microcontroller serves as the central controller, interfacing with sensors, processing data, and handling communication with peripherals and external devices. The architecture will separate functional blocks such as sensing, processing, output, and communication.

3. Peripheral Integration

Sensors (touch and accelerometer) and output devices (LCD, speaker) will be interfaced with the ESP32 using appropriate communication protocols: Touch sensors and accelerometer via GPIO or I2C. LCD display via I2C or SPI. Speaker through DAC or PWM output. Circuit design will ensure reliable signal interfacing and power management for all peripherals[6].

4. Software Design

The system firmware will be developed using either the Arduino IDE or ESP-IDF. The software will follow a modular design, enabling easy maintenance and scalability. Key components include:

Gesture detection and mapping logic. Event-driven or loop-based execution structure. Communication interfaces for display, audio, and app. Error handling, logging, and debugging tools.[8]

5. Networking and Communication

The ESP32’s built-in Wi-Fi and Bluetooth will be utilized for external communication. The system will: Send gesture outputs to a mobile app using HTTP, MQTT, or Bluetooth protocols. Use structured formats like JSON for data exchange. Include encryption and authentication for secure communication.[10][7]

6. Power Management

Power-efficient design will be implemented by: Using low-power modes of ESP32 (light or deep sleep).

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Managing peripheral power consumption. Supporting battery or USB power sources, depending on deployment needs.[12][17]

7. Testing and Validation

A comprehensive testing plan will verify system functionality and performance: Unit testing for software modules. Integration testing across hardware components. Real-world testing in varied environments. Performance metrics will include accuracy, response time, and energy consumption[9].

8. Deployment and Maintenance

Deployment will involve final assembly, installation, and user setup. Long-term reliability will be supported through: OTA (Over-the-Air) firmware updates. Routine diagnostics and fault detection. Maintenance procedures documented for ease of troubleshooting and system longevity[13].

IV.INSTRUCTION AND DATA REGISTER

The HD44780 LCD controller is equipped with two main 8-bit registers: the Instruction Register (IR) and the Data Register (DR). The Instruction Register (IR) holds command instructions that direct the internal functions of the LCD, such as clearing the display, setting entry modes, or controlling the cursor.The Data Register (DR) temporarily stores data that is either written to or read from the LCD. Depending on the command, this data is routed to the Display Data RAM (DDRAM) for screen output or the Character Generator RAM (CGRAM) for defining custom characters.[14][17]

The Data Register is used to send the actual data to be displayed on the screen. When the Enable (E) signal is triggered, the data on the input pins is latched into the Data Register. Depending on the previously set address (via the Instruction Register), this data is then automatically written to either Display Data RAM (DDRAM) for visual output or Character Generator RAM (CGRAM) for custom character creation. In summary, the Instruction Register controls the LCD's behavior and memory addressing, while the Data Register handles the content to be displayed or stored.

The LCD controller allows the microcontroller (MCU) to interact with only two main registers: the Instruction Register (IR) and the Data Register (DR). Before the LCD executes any internal operations, control commands and data are temporarily stored in these registers. This design ensures seamless interfacing with a variety of MCUs and peripheral devices operating at different speeds. The LCD's functionality is controlled through signals from the MCU, which include: RS (Register Select) – selects between instruction and data modes. R/W (Read/Write) – determines the direction of data flow. DB0–DB7 (Data Bus) – carries the actual command or data. These control signals collectively define the instructions used to operate the LCD. Embedded C is an enhanced version of the standard C programming language, tailored specifically for embedded system development. It was introduced by the C Standards Committee to unify and standardize the diverse and often non-compatible extensions used across different embedded platforms. Unlike traditional C, Embedded C includes additional features to efficiently manage hardware-specific requirements such as fixed-point arithmetic, multiple memory spaces, and direct interaction with I/O devices, making it well-suited for low-level programming in resource-constrained environments. Embedded C retains most of the core syntax and semantics of standard C.[15]

In the early days of microprocessor-based systems, programming was done in assembly language, and code was burned directly into EPROMs. Debugging was primitive—engineers relied on hardware components like LEDs and switches to monitor behavior, which was both expensive and unreliable.

Over time, the reliance on processor-specific assembly language diminished, and C became the dominant language for embedded development due to its portability, efficiency, and hardware-level access. Today, C remains the most widely used language for programming embedded processors and microcontrollers.[17]

1.Integrated Development Environment (IDE): Arduino IDE 1.8.5 open-source platform designed for writing, compiling, and uploading code to Arduino boards. It offers an intuitive and easy-to-use interface,

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allowing users to program Arduino microcontrollers with ease. Whether you're a beginner or an experienced developer, the Arduino IDE simplifies the coding process and supports various Arduino boards, providing essential tools and libraries for creating interactive projects.[16]

2.Cross-Platform Compatibility: Arduino IDE 1.8.5 is compatible with major operating systems, including Windows, macOS, and Linux, ensuring it is accessible to a broad user base across different platforms. This cross-platform support makes it easy for users to develop and upload code to Arduino boards, regardless of their operating system preference..

3.Support for Various Arduino Boards: The IDE supports a variety of Arduino boards, including popular ones like Arduino Uno, Nano, Mega, and more. It also supports third-party Arduino-compatible boards.

4.Code Editor: The IDE features a simple yet powerful code editor with syntax highlighting, auto-indentation, and code completion, which helps streamline the coding process and minimizes errors.

5.Library Management: Arduino IDE 1.8.5 includes a library manager that allows users to easily install, update, and manage libraries used in their projects. This simplifies the integration of additional functionality into Arduino projects.

6.Serial Monitor: It comes with a built-in serial monitor tool, which enables users to communicate with their Arduino board and debug their code by sending and receiving data over the serial port.

7.Sketches and Examples: Arduino IDE provides a collection of example sketches and libraries to help users get started with their projects quickly. These examples cover a wide range of functionalities, from basic input/output operations to more advanced sensor interfacing and communication protocols.

8.Community Support: Arduino IDE benefits from a large and active community of users and developers who contribute libraries, tutorials, and troubleshooting advice. This community support enhances the learning experience for beginners and provides valuable resources for advanced users.

Conclusion: This leverages sign language recognition to facilitate effective communication between mute individuals and those who are able to speak. Its core objective is to minimize the communication barrier by translating hand gestures into spoken words. By converting gestures into speech, the system offers a practical solution that not only enhances daily interactions but also helps mute individuals become more confident and socially integrated.

References

[1]. **G.Aishwarya , V.Snehitha , SK.Abdulayaz , S.Shanulfaiz ,S.Surendra Babu, “SPEAKING SYSTEM FOR MUTE PEOPLE USING HAND GESTURES”, 2023 JETIR May 2023, Volume 10, Issue 5**

[2]. **Shanthini E; Akshaya N; Harini Sri S,” Hand Gesture Vocalizer using MobileNetV2 for Deaf Mutes”, 2023 3rd International Conference on Pervasive Computing and Social Networking (ICPCSN)**

[3]. **P.Telluri, S.Manam, S.Somarouth, J. M.Oli and C.Ramesh, “Low cost flex powered gesture detection system and its applications,” Second International Conference on Inventive Research in Computing Applications (ICIRCA), Coimbatore, India, pp. 1128–1131,2020.**

[4]. **Vigneshwaran; M. Shifa Fathima; V. Vijay Sagar; R. Sree Arshika, "Hand Gesture Recognition and Voice Conversion System for Dump People,” IEEE International Conference on Intelligent and Advanced Systems, 2019.**

[5]. **Jinsu Kunjumon; Rajesh Kannan Megalingam, "Hand Gesture Recognition System For Translating Indian Sign Language Into Text And Speech”, IEEE**

International Journal of Engineering Research and Science & Technology
ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

International Conference on Intelligent and Advanced Systems, 2019, pp 597-600.

[6]. M. Taskiran, M. Killioglu and N. Kahraman, "A Real-Time System for Recognition of American Sign Language by using Deep Learning", 2018 41st International Conference on Telecommunications and Signal Processing (TSP), pp. 1-5, 2018.

[7]. G.Lee, Member, IEEE, and S.M.Lee, "Smart wearable hand device for sign language interpretation system with sensor fusion", Apr. 2017.

[8]. Safayet Ahmed; Rafiqul Islam; Md. Saniat Rahman Zishaan; Md.Rabiul Hassan, "Electronics speaking system for speech impaired people", May .2015.

[9]. Sign language recognition and translation: A multidisciplined approach from computer vision to linguistics" by Liang Luo and Jie Yang (2014)

[10]. Ghotkar, Archana S., "Hand Gesture Recognition for Indian Sign Language", International Conference on Computer Communication and Informatics (ICCCI), 2012, pp 1-4.

[11]. S. F. Ahmed, S. Muhammad, B. Ali, S. Saqib, and M. Qureshi, "Electronic Speaking Glove for Speechless Patients A Tongue to," no. November, pp. 56-60, 2010.

[12]. "Hand gesture recognition using depth data" by Cem Keskin, Furkan Kırac, Yunus Emre Kara, and Lale Akarun in 2010.

[13]. "Hand Gesture Recognition: A Survey" by Sushmita Mitra and Tinku Acharya (2007).

[14]. Real-time hand gesture detection and recognition using AdaBoost and Support Vector Machines" by S. Vijayanarasimhan, A. C. Berg, and J. Malik (2004).

[15]. "A Real-Time Hand Gesture Recognition System for American Sign Language" by Thomas Starner, Alex Pentland, and James Weaver (1998).

[16]. Byung-woo min, Ho-sub yoon, Jung soh, Takeshi ohashi and Toshiaki jima," Visual Recognition of Static/Dynamic Gesture: Gesture Driven Editing System", Journal of Visual Languages & Computing Volume 10,Issue 3, June 1999, pp 291-309.

[17]. Chayan Paul, S. Ranjith, R. S. Vijayashanthi, R. Benazir Begam, R. Sabitha. "A multidimensional time series data on wireless network to improve the detection performance of unsupervised learning algorithms", 2022 International Conference on Innovative Computing, Intelligent Communication and Smart Electrical Systems (ICSES), 2022