AI-BASED SIGN LANGUAGE TRANSLATOR FOR DEAF AND MUTE PEOPLE

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ABSTRACT

This paper presents a wearable sign language translation system aimed at improving communication for individuals with hearing and speech impairments. The system employs a glove embedded with flex sensors to capture finger movements and hand gestures. These inputs are processed using a microcontroller and matched with predefined gesture patterns. The interpreted output is displayed as text and converted into speech in real time. The design emphasizes affordability, portability, and ease of implementation. Experimental evaluation confirms that the system performs reliably for basic gesture recognition and provides an effective assistive communication solution.

KEYWORDS: Sign Language, Gesture Recognition, Arduino, Flex Sensors, Assistive Technology, Speech Output, Embedded Systems

I. INTRODUCTION

Communication is fundamental to human interaction, yet it remains a major challenge for individuals who are deaf or mute. These individuals rely on sign language, which is not commonly understood by the general population, creating barriers in daily communication. Technological advancements in embedded systems and artificial intelligence have enabled the development of systems that interpret human gestures. These systems can translate sign language into text or speech, making communication more inclusive.

This work focuses on designing a smart glove system that captures hand gestures and converts them into meaningful outputs. The system is intended to be simple, cost-efficient, and suitable for real-time applications.

The aim of this project is to design a smart glove-based system that detects hand gestures and converts them into understandable outputs. The system is designed to be cost-effective, portable, and suitable for real-time communication. With advancements in embedded systems and artificial intelligence, it is possible to develop systems that translate sign language into text and speech. Such systems can reduce dependency on human interpreters and promote independence.

II. LITRATURESURVEY

Various techniques have been explored for sign language interpretation:

Reference paper [1]: Researchers developed a camera-based recognition system using deep learning. Although accurate, it is affected by environmental conditions such as lighting and background.

Reference paper [2]: A sensor-based glove system was proposed to detect finger movements. This approach provides stable results but supports a limited number of gestures.

Reference paper [3]: Smartphone-based applications were introduced for sign translation. These systems are portable but rely heavily on processing power and camera quality.

Reference paper [4]: Hybrid systems combining sensors and image processing were also studied, offering improved performance but increased complexity.
These studies indicate the need for a system that is accurate, simple, and affordable.

III. EXISTING SYSTEM

Existing sign language recognition systems are mainly categorized into vision-based and sensor-based approaches. Vision-based systems use cameras and image processing algorithms, but they require controlled environments and high computational resources.

Sensor-based systems provide better consistency but often involve complex designs or higher costs. Many current solutions are not suitable for real-time usage or are not easily accessible to common users.

IV. PROPOSED SYSTEM

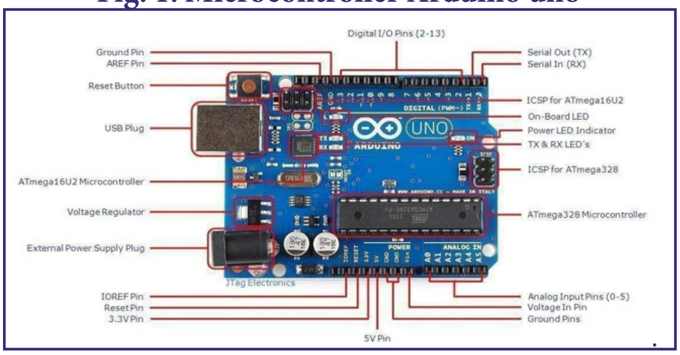
The proposed system is a smart glove that translates hand gestures into text and speech outputs. It consists of the following components:

- Arduino Uno (Microcontroller)
- Flex Sensors
- LCD Display
- Voice Module
- Bluetooth Module
- Power Supply
- Arduino ide

Let us see about the components in brief:

A. MICROCONTROLLER –Arduino uno:

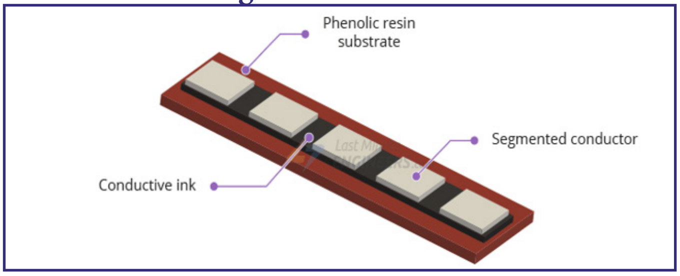
Fig. 1: Microcontroller Arduino uno



The Arduino Uno acts as the central processing unit. It receives sensor inputs and processes them to identify gestures.

B. FLEX SENSORS:

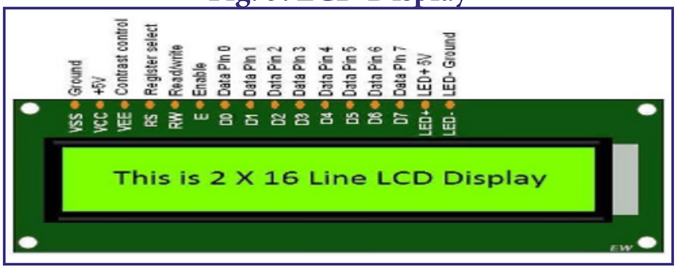
Fig. 2: Flex Sensors



A flex sensor is an electronic component that acts as a variable resistor, whose resistance changes depending on the degree of bending. Because its resistance increases proportionally with the amount of flex, it is often referred to as a flexible potentiometer. These sensors are commonly used in applications that require motion detection, gesture recognition, and angle measurement, such as robotic gloves, wearable devices, and medical instruments.

C. LCD Display.

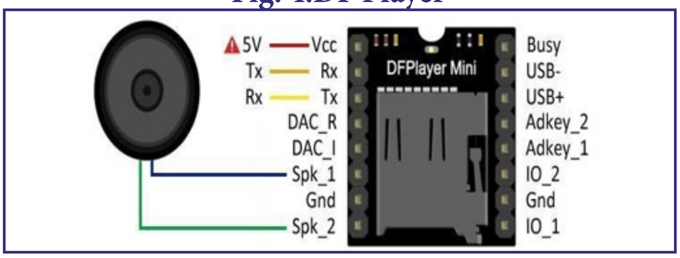
Fig. 3: LCD Display



A Liquid Crystal Display (LCD) is a highly versatile and informative output device, offering far more capability than a single LED. Unlike LEDs, which can only indicate binary states such as ON or OFF, an LCD can display alphanumeric characters, symbols, and messages, making it ideal for projects that require user interaction or real-time status display.

D. VOICE MODULE:

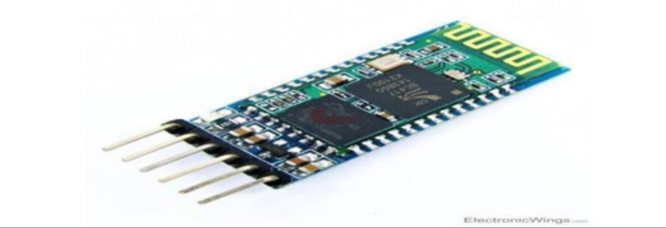
Fig. 4:DF Player



The audio module converts text into speech for verbal communication. The FN-M16P Serial MP3 Module is a highly versatile and efficient audio playback device designed to simplify sound integration into various electronic applications. It is built with a perfectly integrated MP3 and WMV decoder chip, enabling it to decode and play multiple audio formats with ease.

E. BLUETOOTH MODULE:

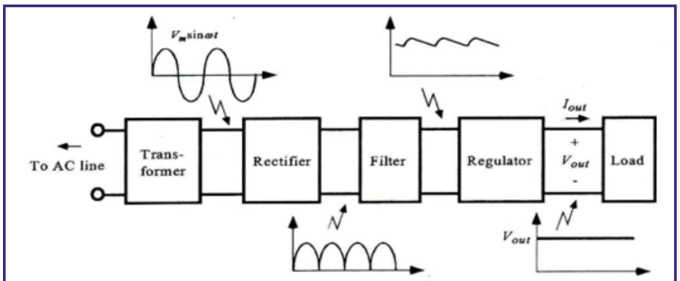
Fig. 5: Bluetooth



This module enables wireless communication with external devices if required. The HC-05 Bluetooth Module is one of the most popular and easy-to-use wireless communication modules designed to establish transparent serial connections between devices. It operates using the Bluetooth SPP (Serial Port Protocol), which allows seamless communication between two devices— such as between a microcontroller (like Arduino) and a smartphone or computer—without the need for complex configuration or wiring.

F. POWER SUPPLY:

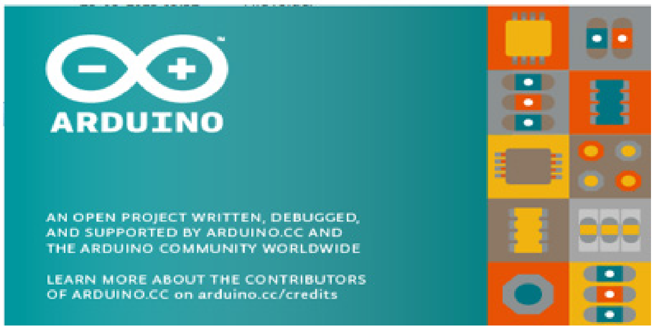
The power supplies are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A RPS (Regulated Power Supply) is the Power Supply with Rectification, Filtering and Regulation being done on the AC mains to get a Regulated power supply for Microcontroller and for the other devices being interfaced to it.



Components of a typical linear power supply

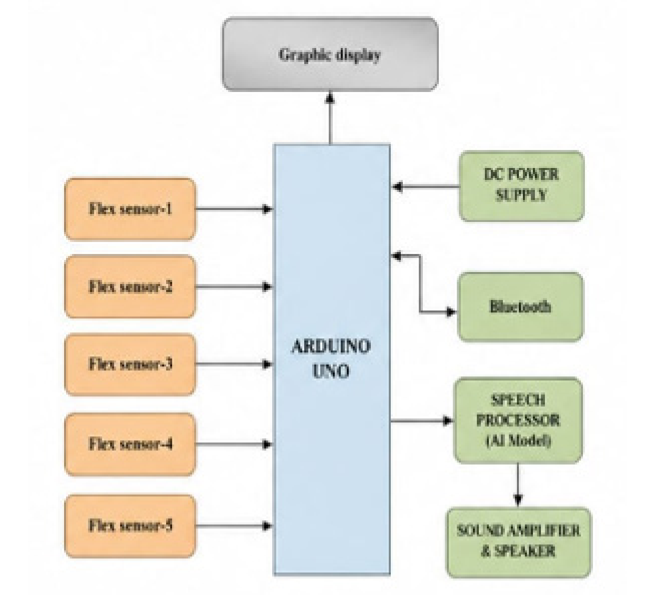
ARDUINO IDE

Fig. 6: Arduino ide



Arduino is an open-source hardware and software platform designed to help users create microcontroller-based projects and interactive electronic systems. It provides a user-friendly environment for building digital devices that can sense and control elements of the physical world. Arduino supports a large user community that contributes to learning, development, and innovation.

V. METHODOLOGY



Arduino is an open-source computer hardware and software company. A microcontroller board contains on-board power supply, USB port to communicate with PC, and an Atmel328 microcontroller chip. A glove is used to fix the flex sensor to detect the sign language input to the microcontroller to process the gesture output as voice as well as displays in LCD [4]. The power supply section is in-built in the Arduino board in different power source input. First one is power adaptor input and second is 6 UNNI USB input and it will act as a serial communication with computer system and program dumping port [5]. A 16x2 LCD display is used to displays the gesture patterns. The displaying message is also announced as a voice using APR33A3 voice board. The voice is pre-recorded in this voice board and playback when the particular gesture is detected corresponding voice is announced in speaker [6].The normal electromagnet speaker is used to detect the voice from the input of the voice board.

The work of this paper start from movement of hand gloves where the flex sensors are attached, and the value of sensor changes when its experiences the bending. The flex sensor is another type of potentiometer are attach to the fingers when we bend the figure the value of the sensor gets changes. The changing value of the sensor is depending upon the resistance and applied angle of the bending when we bend the sensor at some particular angle we can see the value of the resistance is increase and accordingly the output gets reduced [7]. On the other way we can say that it's like an inversely proportional when the resistance of the sensor is increase at that instant the value of output decrease and accordingly we can make paper by getting the advantage of this process.

VI. RESULT

The developed AI-based sign language translator system was successfully designed and tested for basic gesture recognition and communication purposes. The system accurately detected finger movements using flex sensors and processed the input signals through the microcontroller. The recognized gestures were effectively converted into corresponding text displayed on the LCD screen and also generated as audible speech through the voice module. The performance of the system was found to be reliable under normal operating conditions, with consistent output for predefined gestures. The integration of hardware components such as sensors, microcontroller, and output modules ensured smooth and real-time operation. Overall, the system demonstrated its capability to assist deaf and mute individuals by enabling effective communication in a simple, cost-efficient, and user-friendly manner.

VII. CONCLUSION

The implementation of AI-based sign language systems represents a significant advancement in assistive technology for deaf and mute individuals. These systems help bridge the communication gap between the hearing and non-hearing communities, promoting inclusion, independence, and equal opportunity in various sectors such as education, healthcare, employment, and public services.

By translating sign language into text or speech and vice versa, AI tools empower users to interact more confidently and effectively in real-world environments. Although challenges such as accuracy, context understanding, and technical limitations still exist, continuous research and development are steadily improving these technologies. Overall, AI-based sign language solutions are a promising step toward creating a more accessible and inclusive society where everyone, regardless of their ability to hear or speak, can communicate and participate fully.

VIII. FUTURE SCOPE

Although the proposed sign language recognition system effectively converts predefined hand gestures into text and voice output, several enhancements can be implemented to improve its functionality and applicability in real-world scenarios. Future work may focus on expanding the gesture database to support a larger vocabulary, including complete sentences and continuous sign language recognition Advanced machine learning and deep learning algorithms, such as convolutional and recurrent neural networks, can be integrated to improve recognition accuracy and adaptability to different users' hand sizes and gesture styles. Incorporating additional sensors such as accelerometers and gyroscopes can enhance motion detection and enable recognition of dynamic gestures.

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