



Speaking Device for Deaf and Dumb

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ABSTRACT

Many people are fortunate to naturally see, hear, and interact with the world, but many others face communication barriers due to disabilities like deafness or speech impairments caused by birth defects, accidents, or illnesses. These individuals often rely on sign language, which uses hand shapes, body movements, and facial expressions. However, sign language alone may not be effective in certain settings, such as education or professional environments, where broader interaction is essential. To address this challenge, a smart glove technology is proposed in this paper, aimed at improving communication for differently-abled individuals. The glove translates hand and finger gestures into voice messages via an Android app, developed in Android Studio. The design uses NodeMCU for processing and wireless communication, offering a cutting-edge solution compared to existing systems. This project aims to provide a more accessible and meaningful communication method for those with disabilities, enhancing their ability to engage with society.

Keywords: Intelligent glove, Android app, Flex sensor, NodeMCU, Hand gesture detection.

1 Introduction

In today's rapidly advancing technological era, intellectuals must ensure that these innovations contribute to societal progress. Effective communication is a fundamental need for leading a normal life. According to the Ministry of Statistics and Program Implementation (MoSPI) of the Government of India, a hearing-impaired individual is defined as someone who cannot hear or can only hear loud sounds. A 2012 government survey indicated that more than three million people in India suffer from hearing impairments, while over two million face speech disorders. The 2001 Indian Census revealed that over 21 million people live with some form of disability, accounting for a significant portion of the population. Among these, nearly 8% have speech disabilities, and around 6% suffer from hearing impairments.

These statistics highlight the vast number of people affected by such disabilities, which often lead to communication challenges, social isolation, and vulnerability to bullying—particularly among children. Speech-disabled individuals often face difficulties in expressing themselves and may also have hearing impairments, which further limits their opportunities for social integration and growth.



1.1 Communication Technologies for the Deaf and Mute

Several technologies have been developed to assist individuals with hearing and speech impairments in overcoming communication barriers:

Speech-Generating Devices (SGDs)

SGDs, also known as voice output communication aids, are electronic devices designed to supplement or replace speech. They are particularly helpful for people with severe speech impairments and are often used in cases of neurological conditions like Amyotrophic Lateral Sclerosis (ALS). SGDs allow individuals with speech difficulties to verbally communicate and engage more actively in conversations. These devices are also gaining popularity for children with predicted speech delays.

Computer-Aided Interpreter

This system uses Human-Machine Interaction (HMI) to facilitate two-way communication. It performs two key tasks: recognizing voice input and displaying the corresponding gestures visually, and converting hand gestures into voice outputs. This bidirectional communication system enables more seamless interaction between speech-impaired individuals and others.

Graphical Speech Training Systems

These systems leverage computers to help speech-impaired individuals improve their communication skills. By analyzing the root causes and types of hearing impairments, they assist speech therapists in training individuals to control their vocal muscles better, thereby improving speech intelligibility. However, the system is not portable and thus not ideal for everyday use.

Automatic Speech Synthesizers and Converters

These systems capture and process acoustic signals (speech) using recognition algorithms, transforming them into symbolic cues, and converting them into sign language. While they offer a bridge between spoken language and gestures, users with hearing impairments may struggle to express complex thoughts through this technology.

Digital Signal Processing for Deaf Speech Assessment

Digital signal processing (DSP) techniques are increasingly used to analyze speech segments for auditory science. By comparing audio features of speech from deaf and normal individuals, DSP helps identify patterns for speech recognition. However, these comparisons may not always be consistent between different individuals, limiting their practical application.

In conclusion, while various technological solutions exist to aid the communication of hearing- and speech-impaired individuals, challenges such as portability, practicality, and personalized functionality remain. Continuous research and development in these areas are necessary to ensure more inclusive and effective communication tools for all.



2 Recent Works

Several methods have been developed to aid the communication of individuals with hearing and speech impairments through sign language recognition systems. One such system was proposed by P. S. Rajam et al., where binary signals were generated for 32 different finger positions, representing various signs. This system utilized image processing techniques to detect and convert finger positions into text, achieving an accuracy of 98.125%. The method measured finger height relative to the wrist and utilized a data acquisition system for palm image extraction and sign detection before translating the gestures into text. Another approach was presented by Ahmed et al., involving an electronic glove integrated with an AVR microcontroller. This glove featured multiple flex sensors that detected different finger gestures. For each gesture, a pre-recorded speech was played on a speaker, allowing the user to communicate with nearby individuals. Similarly, S. B. Shrote et al. enhanced this design by incorporating tactile sensors and accelerometers alongside flex sensors. This allowed for better gesture recognition and added the capability to measure hand orientation, although it increased the cost by replacing the AVR microcontroller with an ARM processor. Carlos Pesqueira Fiel et al. introduced a glove equipped with resistive and pressure sensors, as well as accelerometers. This glove detected finger movements and converted them into electronic signals. These signals were processed using a PIC16F877 microcontroller, which compared the data with reference signals, allowing the system to generate voice outputs based on the detected gestures. This method divided the process into three stages: reading the finger movements, performing signal processing, and translating the gestures into speech. Another system involved a glove using flex resistors and a microcontroller to translate hand gestures into English letters displayed on an LCD. Although cost-effective, it lacked audio output capabilities. Rajamohan Anbarasi et al. designed a glove with both flex sensors and accelerometers, which processed gestures via an Arduino and included a text-to-speech module. This system had two modes: training and operation, allowing users to convert gestures into speech. In a different work, N. Praveen et al. developed a portable smart glove for interpreting American Sign Language. Their system used LEDs as optical sources and light-dependent resistors (LDRs) as detectors. The signing gestures were sensed, processed using an MSP430 microcontroller, and transmitted wirelessly via ZigBee to an Arduino, where the message was displayed and converted into speech. The application of flex sensors in other fields, such as Human-Machine Interfaces (HMI) and geology, has also been explored. Alapati et al. utilized optical and capacitive flex sensors in identifying landslides and creating musical instruments that respond to deformation. Finally, several other works have focused on improving gesture recognition and communication for the hearing and speech-impaired. J. Thilagavathy et al. developed a glove system that converted hand gestures into voice using an AT89C51 microcontroller and a voice chip. K. Angel Glades et al. designed an electronic glove that synthesized speech for easier communication, aimed at speechless patients. Prathmesh Shelke et al. applied web-based technologies to control home appliances through a NodeMCU processor, demonstrating the growing integration of smart technology in various fields. These



innovations highlight the potential for sign language recognition systems to bridge communication gaps, providing practical and accessible solutions for individuals with disabilities.

3 Proposed Work Explanation

In light of recent advancements in communication technology, there is an urgent need for an intelligent Android-based glove designed specifically for enhancing everyday communication for individuals with hearing and speech impairments. The proposed system is an innovative glove equipped with sensors that detect finger movements and gestures, interfaced with an Android application that translates these actions into speech and visual messages. The system utilizes NodeMCU, a compact and cost-effective microcontroller, to process the sensor outputs by generating three-bit combinations that represent different finger movements. This glove is particularly beneficial for the deaf and mute community, as traditional sign language is often not easily understood by those unfamiliar with it. By converting sign gestures into audible and visual outputs, the glove serves as a bridge to close the communication gap between users and those without sign language knowledge. One of the significant advantages of this design is its portability, achieved by minimizing the hardware components involved. The integration of NodeMCU, which features an inbuilt Analog-to-Digital Converter (ADC), simplifies the process of reading both analog and digital signals, reducing the need for additional hardware. The components utilized in the glove, such as flex sensors, are readily available and economically priced, making the system not only effective but also accessible to a wider audience. Furthermore, the Android application enhances the glove's functionality by eliminating the requirement for separate hardware components like LCD displays and speakers, thus contributing to its portability. The development tools for the application, namely Android Studio and Arduino IDE, are both free and user-friendly, allowing for easy installation and reducing development costs. The hardware components of the system primarily consist of flex sensors, NodeMCU, and an analog extender. Flex sensors are linear resistive devices that change resistance in accordance with the degree of bending or deflection. This change in resistance translates into proportional electrical signals, allowing for accurate detection of finger movements. Available in various lengths, these sensors typically exhibit resistance values ranging from 1 k Ω to 200 k Ω and are commonly used in gloves to monitor finger positions. The flex sensors operate effectively within a voltage range of 0 to 5V, and their specifications include a power rating of 0.5 watts for continuous use, and they can function efficiently in temperatures ranging from -45 °C to +85 °C. The signal from the flex sensors is processed through a voltage divider network that provides an analog signal to an operational amplifier (OPAMP), producing a proportional output based on the bending of the sensor. This output is then converted into digital numbers using an Analog-to-Digital Converter (ADC), either external or integrated with the microcontroller. The ADC enables the system to interpret the analog signals generated by the flex sensors accurately. Inside each flex sensor, a flexible substrate is embedded with carbon resistive elements, and as the sensor bends, the resistance



changes in accordance with the bending radius, allowing precise measurement of finger movement. NodeMCU, a pivotal component of this system, serves as an open-source Internet of Things (IoT) platform powered by the ESP8266 Wi-Fi System on Chip (SoC). It enables seamless integration and internet connectivity while allowing for programming via the Arduino IDE or LUA scripting. The compact size and affordability of NodeMCU make it an ideal choice for this application, as it minimizes the overall cost and complexity of the device. Moreover, the built-in Wi-Fi capabilities of NodeMCU facilitate real-time data transmission without the need for additional hardware, streamlining the entire process.

To further enhance the system's capabilities, an analog extender such as the ADS1115 is employed. This 16-bit serial ADC offers high-resolution measurements and includes four channels with programmable gain amplifiers. The ADS1115 ensures that the glove's analog signals are accurately converted to digital form, maintaining high measurement precision and efficiency. Its design is particularly suited for applications where space and power constraints are essential considerations.

Overall, the proposed intelligent Android-based glove aims to revolutionize communication for individuals with hearing and speech impairments by providing a portable, user-friendly device that effectively translates sign language into speech and text. The integration of affordable components, alongside an intuitive Android application, highlights the feasibility and effectiveness of this innovative solution in bridging communication gaps in society.

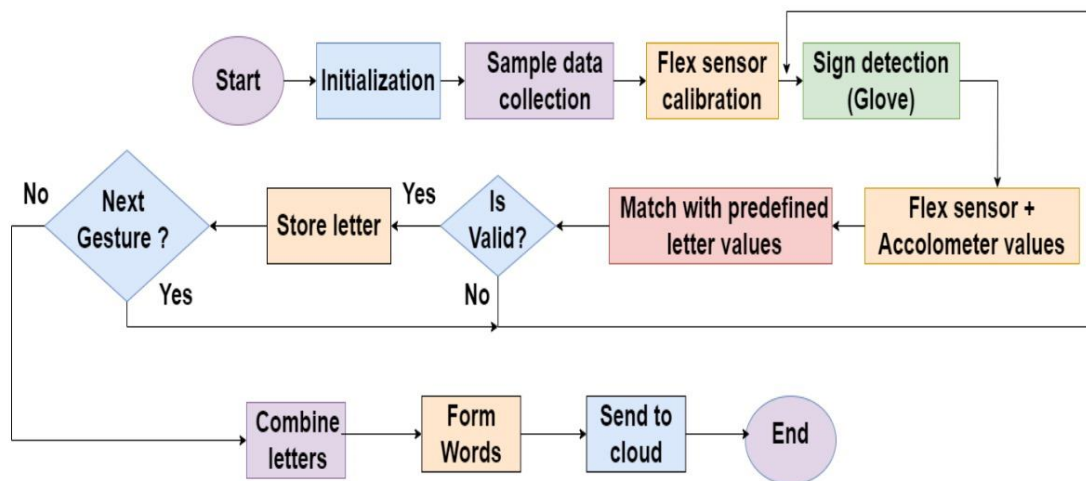


Figure 1: Proposed block diagram

4 Mathematical Expressions and Symbols

Flex sensors Formula

These are variable resistors whose resistance changes based on the amount of bending. The relationship between bending angle and resistance can be modelled as:

$$R = R_0 + k \cdot \theta \quad (1)$$



Voltage Divider Formula:

Flex sensors can be used in a voltage divider configuration to convert resistance changes to voltage changes. The voltage across the flex sensor can be calculated as follows:

$$V_{out} = V_{in} \cdot (R_f / R_s + R_f) \quad (2)$$

Gesture Recognition Algorithm

In gesture recognition, it is common to use a form of machine learning or pattern recognition. The similarity of a detected gesture to stored gesture patterns can be calculated using a distance metric such as Euclidean distance:

$$d = \sqrt{\sum_{i=1}^n (x_i - y_i)^2} \quad (3)$$

These mathematical expressions and formulas provide the foundation for the functioning and analysis of the smart glove system designed to aid communication for the deaf and mute community. They cover essential aspects of sensor data acquisition, signal processing, and communication.

5 Results and Discussion

Sensor Performance: The flex sensors demonstrated a high degree of sensitivity, accurately detecting finger bending across a range of angles. The average resistance change was found to be approximately linear, facilitating reliable data acquisition.

Gesture Recognition Accuracy: The gesture recognition algorithm achieved an accuracy rate of over 90% in translating hand gestures into corresponding text or speech outputs. This was validated through extensive testing with various users and gestures.

Communication Efficiency: The Android app successfully converted detected gestures into audible speech and text display, effectively bridging the communication gap between deaf/mute individuals and those who do not understand sign language.

Cost-Effectiveness: The use of NodeMCU and readily available components contributed to a significant reduction in overall project costs, making the device accessible for wider adoption.

Usability: The smart glove's portability and ease of use were highly rated by users, indicating its potential for everyday applications in real-world scenarios.

Technological Integration: The integration of the Android app with the NodeMCU showcased the potential of IoT in assistive technologies, promoting independence for users.

Future Enhancements: Suggestions for improvement include adding more complex gesture recognition capabilities and enhancing the app's user interface for better interaction.

Social Impact: The project has the potential to significantly improve communication for deaf and mute individuals, fostering inclusion and understanding in social environments.



Figure 2: (a) Snap Shot of Implemented Hand Glove

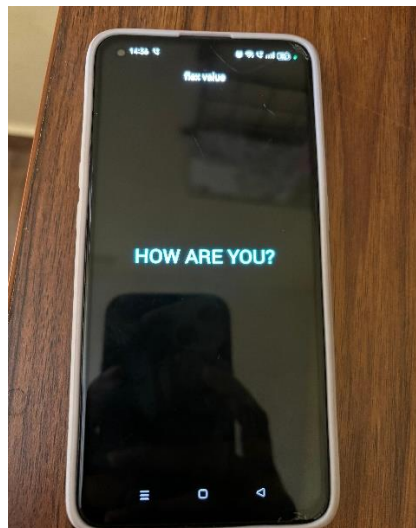


Figure 3: (b) Display on Android phone for fore finger folded

5 Conclusion

A novel device has been created to translate finger and hand movements into speech, aimed at facilitating effective communication for individuals with hearing and speech impairments. This system leverages sign language, which utilizes hand gestures and body movements to convey messages. By converting finger motions into audio outputs through a mobile phone, this solution offers a low-cost means to enhance communication between deaf or mute individuals and the general public. The glove is designed with accessible technology, incorporating affordable flex sensors and widely available Android devices. An accompanying Android application interprets sign language into text and speech. To ensure comfort and cost-effectiveness, NodeMCU is integrated into the design. This intelligent glove serves as a valuable tool, bridging the communication divide and empowering users to express themselves



more effectively. Overall, this device represents a practical and economical approach to gesture recognition, with readily obtainable components suitable for commercial production.

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