Smart Touch-Based Assistive Communication Glove For Speech-Impaired Patients

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Abstract- *This project presents a modified and improved version of a wearable communication glove designed for speech-impaired individuals. An existing gesture-glove concept was analyzed and redesigned to improve reliability, usability, and healthcare applicability. Initially, the system used flex sensors for gesture detection. During testing, the flex sensors produced unstable readings and inconsistent outputs, making the system difficult to use reliably. To solve this issue, the sensing method was redesigned using capacitive touch sensors (TTP223 modules). A thumb-touch interaction method was introduced, allowing the user to easily select communication commands. The modified system uses an Arduino Nano microcontroller, I2C LCD display, DFP layer Mini audio module, speaker, and capacitive touch sensors. When the user touches a sensor, predefined messages are displayed on the LCD and spoken through the speaker. The project focuses on healthcare assistance for speech-impaired individuals by providing a simple, low-cost, reliable, and user-friendly communication system.*

Keywords: Smart Assistive Glove, Touch Sensors, Arduino Nano microcontroller, Disability Support, Smart Healthcare, Accessibility.

I. INTRODUCTION

Communication is a fundamental human need that enables individuals to interact socially, access education, and participate in daily activities. However, people with hearing, speech, and physical disabilities often encounter significant challenges in communication, resulting in social and professional barriers. Recent advances in wearable electronics, embedded systems, Internet of Things (IoT) technologies, and intelligent sensors have led to the development of smart assistive devices that can facilitate communication and improve the quality of life for differently abled individuals. Smart gloves have emerged as one of the most promising assistive technologies due to their ability to recognize hand gestures and convert them into text, speech, or control commands. Recent studies have focused on enhancing communication for disabled individuals through various smart glove architectures. Mukherjee et al. [1] developed a smart glove specifically designed for differently abled persons, while Meena and Angeline [2] introduced a low-cost prosthetic glove called *Signet* for deaf and mute patients. Bentur et al. [3] proposed a multipurpose smart glove using Raspberry Pi Pico to improve accessibility and communication. Similarly, Reddy et al. [4] developed a wireless wearable communication system utilizing Bluetooth technology for physically challenged individuals.

Several researchers have concentrated on improving gesture recognition and wireless communication capabilities. Neerukattu et al. [5] designed a Bluetooth-based smart glove for speech-impaired users, whereas Kale et al. [6] proposed a gesture recognition framework aimed at enhancing accessibility through hand gesture interpretation. Li-Yang et al. [7] developed a wearable smart glove based on flexible printed circuit boards for multi-gesture detection, and Davarzani et al. [8] utilized inductive sensors to improve the accuracy of hand gesture recognition systems. Anitha et al. [9] provided a comprehensive survey of smart glove technologies and their applications for hearing and speech-impaired individuals. The integration of IoT technologies has further expanded the functionality of smart gloves. Khan et al. [10] proposed an IoT-enabled sensor glove capable of supporting both communication and health monitoring for paralyzed patients. Devi et al. [11] developed an IoT-based logical smart glove with voice assistance to support deaf and dumb individuals. Clement et al. [12] introduced a smart aid glove designed for effective communication among disabled users, while Rosli et al. [13] proposed a Braille smart glove to assist visually impaired individuals. Vijay et al. [14] designed an IoT-enabled smart glove using an ESP8266 Wi-Fi-assisted controller and intelligent sensors. Küçükdermenci [15] further extended smart glove applications by integrating sign language interpretation with wireless wheelchair control.

Earlier research laid the foundation for the development of modern smart glove systems. Gurrala et al. [16] developed an IoT-based smart assistance glove for paralyzed individuals. Lalith et al. [17] implemented a LabVIEW-based smart assistive glove for deaf and dumb people. Raen et al. [18] introduced the HandTalk smart glove, which converts gestures into text and speech outputs. Ganguly et al. [19] proposed intelligent gloves specifically designed for deaf and dumb users. Krishna et al. [20] developed an Arduino UNO-based smart hand glove for physically challenged individuals, while Priiyadharshini et al. [21] presented an IoT-based smart glove capable of translating hand gestures into meaningful communication outputs.

Despite significant advancements, challenges such as gesture recognition accuracy, real-time processing, power efficiency, affordability, multilingual support, and user adaptability remain. Therefore, continued research is necessary to develop intelligent, reliable, and cost-effective smart glove systems that can provide seamless communication assistance and improve the independence and quality of life of individuals with disabilities [1]–[21].

Speech-impaired people often struggle to communicate essential needs such as water, food, medicine, or emergency help. Existing gesture-based systems using flex sensors may produce unstable outputs and require complex signal processing. There is a need for a reliable, low-cost, and easy-to-use communication device that can assist speech-impaired individuals in daily life and healthcare environments. The proposed system is a modified and improved version of an existing gesture-glove concept. The original system used flex sensors for gesture detection, but during testing several practical problems were identified such as unstable readings, sensitivity issues, and unreliable gesture recognition.

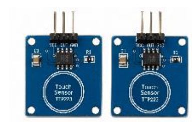
To improve the system, the hardware and software architecture were redesigned. Improvements Implemented Flex sensors were replaced with TTP223 capacitive touch sensors. Thumb-touch interaction method was introduced. Communication messages were redesigned for healthcare assistance. LCD and voice output systems were integrated. Stable touch-based software logic was developed. Long-touch emergency functionality was added. The modified system works as follows: 1. The user touches a sensor using the thumb. 2. Arduino Nano detects the touch input. 3. Corresponding healthcare messages are displayed on the LCD. 4. DFPlayer Mini generates voice output. 5. The speaker communicates the message. This redesigned system provides better reliability, simplicity, and usability for speech-impaired individuals.

II. HARDWARE COMPONENTS

6.1 Arduino Nano

The Arduino Nano serves as the central microcontroller of the proposed smart assistive glove system. It is responsible for receiving signals from the touch sensors, processing user inputs, and controlling the output devices such as the LCD display and DFPlayer Mini module. Due to its compact size, low power consumption, and ease of programming, the Arduino Nano is widely used in embedded and wearable applications. The board is based on the ATmega328P microcontroller, which provides sufficient processing capability for real-time gesture detection and communication tasks.

6.2 TTP223 Touch Sensors

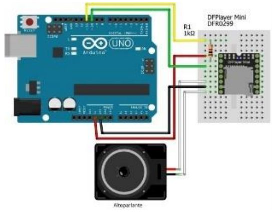


The TTP223 capacitive touch sensors are used to detect finger touch inputs from the user. These sensors operate by sensing changes in capacitance when a finger comes into contact with the touch surface. The detected touch signals are transmitted to the Arduino Nano for processing. The TTP223 sensors offer high sensitivity, low power consumption, reliable touch detection, and simple interfacing, making them suitable for wearable assistive devices. Their ability to accurately detect touch inputs ensures effective communication through the smart glove.

6.3 I^2C LCD Display

A 16×2 I^2C LCD display is incorporated into the system to provide visual communication. The display shows predefined text messages corresponding to the detected touch inputs, enabling users to communicate their needs effectively. The I^2C interface significantly reduces wiring complexity by requiring only two communication lines, namely SDA and SCL. The LCD offers clear message visibility, low pin usage, simple integration, and a user-friendly interface, making it an ideal choice for the proposed assistive communication system.

6.4 DFPlayer Mini



The DFPlayer Mini module is used to generate audio output in the form of pre-recorded voice messages. Upon receiving commands from the Arduino Nano, the module retrieves audio files stored on a Micro SD card and plays the corresponding message through a connected speaker. The DFPlayer Mini supports MP3 playback, provides Micro SD card storage capability, has a compact form factor, and can be easily integrated with microcontroller-based systems. This module enables audible communication for users who may not be able to rely solely on visual displays.

6.5 Speaker

The speaker functions as the audio output device of the system. It receives audio signals from the DFPlayer Mini module and converts them into audible voice messages. The speaker allows nearby individuals to hear the communication generated by the smart glove, thereby improving interaction and accessibility for users with speech impairments. The use of voice output enhances the effectiveness of the communication system in various real-world environments.

6.6 Power Supply

The entire smart assistive glove system is powered using either a USB power source or a battery supply. The power unit provides the necessary electrical energy for the Arduino Nano, touch sensors, LCD display, DFPlayer Mini, and speaker. The option of battery operation improves portability and enables the glove to function as a wearable device suitable for everyday use. A stable and reliable power supply ensures continuous operation and consistent system performance.

III. SOFTWARE REQUIREMENTS

The development of the proposed smart assistive glove system utilizes several software tools and libraries to facilitate programming, hardware interfacing, and system functionality. The Arduino IDE (Integrated Development Environment) serves as the primary platform for writing, compiling, and uploading program code to the Arduino Nano microcontroller. The system is programmed using Embedded C, which provides efficient control over the hardware components and enables real-time processing of touch sensor inputs. To support communication with the LCD display, the LiquidCrystal_I2C Library is employed, allowing messages to be displayed through the I²C interface with minimal wiring and simplified programming. Additionally, the DFRobotDFPlayerMini Library is used to control the DFPlayer Mini audio module, enabling the playback of pre-recorded voice messages corresponding to user commands. Together, these software tools and libraries provide a reliable framework for implementing touch-based gesture recognition, visual message display, and audio communication functionalities within the smart assistive glove system.

IV. WORKING PRINCIPLE

The working principle of the proposed smart assistive glove is based on touch sensing technology. When the user touches a sensor using the thumb, the corresponding touch sensor detects the contact and sends an electrical signal to the Arduino Nano microcontroller. The Arduino Nano receives and processes the touch input to determine which sensor has been activated. Based on the detected sensor, the controller retrieves the predefined message associated with that particular command. The corresponding text message is then displayed on the LCD screen, enabling visual communication. Simultaneously, the Arduino triggers the DFPlayer Mini module to play the related pre-recorded voice message. The audio signal is amplified and delivered through the speaker, allowing the message to be heard by nearby individuals. In addition to simple touch detection, the system supports both short-touch and long-touch operations, enabling multiple commands to be generated from the same sensor and thereby increasing the communication capabilities of the glove. This approach provides an effective, user-friendly, and real-time communication solution for individuals with speech and physical impairments.

V. CIRCUIT DESCRIPTION

The proposed smart assistive glove system consists of touch sensors, an LCD display, and a DFPlayer audio module interfaced with an Arduino microcontroller. Four touch sensors are mounted on the glove to detect user inputs from different fingers. The index finger sensor is connected to digital pin D3 of the Arduino, while the middle, ring, and little finger sensors are connected to digital pins D4, D5, and D6, respectively. These sensors enable the system to identify specific touch inputs and trigger the corresponding communication messages.

For visual communication, an LCD display with I²C interface is used. The Serial Data (SDA) pin of the LCD is connected to the Arduino's A4 pin, and the Serial Clock (SCL) pin is connected to A5. The LCD module receives power through the 5V supply pin and is grounded through the GND pin of the Arduino. This configuration allows the display of predefined messages corresponding to the detected touch inputs.

To provide audio communication, a DFPlayer Mini module is integrated into the system. The TX pin of the DFPlayer is connected to Arduino digital pin D10, while the RX pin is connected to digital pin D11 for serial communication. Similar to the LCD module, the DFPlayer receives power from the Arduino's 5V supply and is connected to the common ground (GND). The DFPlayer stores and plays pre-recorded voice messages corresponding to each sensor input, enabling audible communication for the user. Together, these hardware connections create an effective assistive communication system capable of delivering both visual and voice outputs based on touch sensor activation.

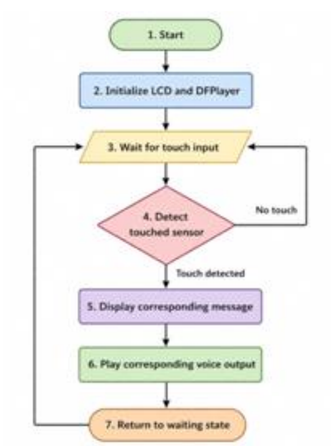


Figure 1 Flow chart of the proposed method

Figure 1 shows the flow chart of the proposed method. The proposed Smart Assistive Glove system operates through a simple and efficient sequence of actions designed to facilitate communication for individuals with disabilities. Initially, the system starts and initializes the connected hardware components, including the LCD display and DFP layer audio module. Once the initialization process is completed, the system enters a monitoring mode where it continuously waits for touch input from the user. Touch sensors embedded in the glove are used to detect finger movements or touch actions. When a touch is detected, the microcontroller identifies the specific sensor that has been activated and retrieves the corresponding predefined message. The selected message is then displayed on the LCD screen, allowing nearby individuals to read the user's intended communication. Simultaneously, the DFP layer module plays a pre-recorded voice message associated with the detected sensor, enabling audible communication. After displaying the message and generating the voice output, the system returns to its waiting state and resumes monitoring for subsequent touch inputs. This continuous cycle ensures real-time communication assistance, providing a reliable, user-friendly, and cost-effective solution for individuals with speech or physical impairments.

The proposed smart assistive glove offers several advantages that make it suitable for communication and assistive healthcare applications. The system is designed as a low-cost solution using readily available electronic components, making it affordable for a wide range of users. Its portable and lightweight design allows users to wear and operate the device comfortably during daily activities. The touch-based sensing mechanism provides reliable gesture detection, ensuring accurate communication. By combining LCD-based text display and audio output, the glove enables both visual and auditory communication, making it effective in different environments. The simple hardware architecture facilitates easy implementation, maintenance, and future modifications. Furthermore, the system can be expanded with additional sensors and communication modules to support more advanced functionalities.

The smart glove has numerous practical applications in the field of assistive technology and healthcare. It can be used as a communication aid for speech-impaired individuals, allowing them to express their needs effectively. In healthcare settings, the glove can assist patients in communicating with caregivers, nurses, and medical staff. It is particularly useful in hospitals, where patients with limited speech or mobility can convey important messages quickly. The system can also support elderly individuals who require assistance in daily activities and can be utilized in rehabilitation centers to help patients recovering from physical disabilities. As a wearable assistive device, it contributes to improving accessibility, independence, and overall quality of life.

Several enhancements can be incorporated into the system in future developments to improve its functionality and performance. Bluetooth and wireless communication technologies can be integrated to enable remote monitoring and communication. A dedicated mobile application can be developed to provide additional user control and customization features. The existing microcontroller can be replaced with an ESP32 module to support Wi-Fi connectivity and advanced processing capabilities. A GSM-based emergency alert system can be added to send notifications to caregivers or family members during emergencies. Artificial intelligence-based voice assistance can further enhance user interaction by providing intelligent responses and voice recognition capabilities. Additionally, the system can be redesigned as a battery-powered wearable device, improving portability, convenience, and usability for everyday applications.

In our work, "Smart Health Monitoring System", there is a complete package of hardware and software .i.e. Different bio-medical sensors like temperature and heartbeat rate sensor are interfaced with Arduino UNO microcontroller and get the reading from sensors. These are sent to server and then mobile app wirelessly.

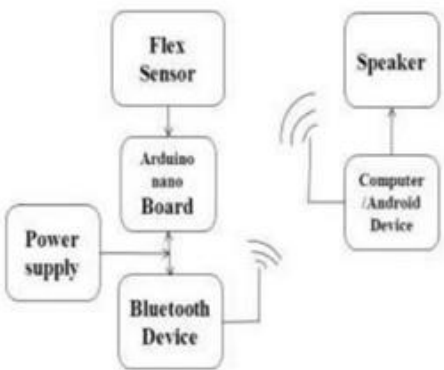


Figure 2 Basic Structure

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