TWO WAY COMMUNICATOR BETWEEN BLIND-DEAF-DUMB PERSON AND NORMAL PEOPLE

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Introduction:

Among the most difficult disabilities a person may experience are blindness, deafness, and speech impairments. Between 25 and 30 million people worldwide suffer from these combined conditions, which make it very difficult for them to communicate on a daily basis. Connecting with others becomes extremely difficult if you are unable to see, hear, or speak The Braille system has long been essential in bridging this communication gap. Braille is a lifeline, not just a tool Imagine not being able to see, hear, or speak every simple conversation becomes a silent struggle for people who are blind, deaf, or mute, communication can feel like being trapped in an invisible box. Those around them often want to help but don't know how. It's not a lack of empathy. It's a lack of understanding This project aims to bridge that gap Not just by translating words, but by creating real, two- way communication Through smart sensors and intelligent interpretation, this tool becomes a voice for those without one and ears for those who cannot hear.

Today, Braille is used throughout the world and is taught to children from an early age. Physically challenged human beings, like visually impaired or deaf-blind human beings, are going through plenty of issues while speaking or interacting with different human beings. To bring a helping hand closer to the visually impaired, the most recent technological boom has resulted in the development of unique professional techniques to beautify their conversation procedures. Illiteracy among this organization could be very high; lots of that's attributed to the dearth of analyzing fabric in handwritten format.

Visually impaired people typically use Braille. Communication is essential for daily life, yet people who are blind, deaf, and mute often face severe limitations in expressing themselves and understanding others. Traditional methods like sign language or Braille alone may not be sufficient for smooth interaction, especially when communicating with people unfamiliar with these systems.

Objectives:

1. To design a system that allows effective two-way communication between a person who is blind, deaf, and mute and a person with normal sensory abilities.
2. To ensure the system supports near real-time communication to make interactions practical and seamless in daily life.
3. To build a compact, lightweight, and easy-to-use device or application that can be operated by both types of users with minimal training.

Methodology:

Phase 1: Voice-to-Braille Communication Flow
Step 1: Speech Capture and Processing
Normal user speaks into a microphone, the audio is processed by a Python script, and then sent to a speech-to-text API.

- Python script continuously listens for voice input using a speech recognition library
- Audio is captured at a 16 kHz sample rate with noise filtering
- Google Speech Recognition API converts speech into text
- The text is mapped to a predefined command dictionary

Step 2: Firebase Data Upload
A text message is processed through Firebase Authentication, stored in a real-time database, and organized into a JSON structure.

- Authenticated connection is established with Firebase
- Message is stored with timestamp, sender ID, and message type
- Data structure: {message: "hello", timestamp: 1234567890, type: "voice"}

Step 3: ESP32 Data Reception
The ESP32 (Braille controller) listens to Firebase, parses the incoming message, and converts it into Braille using a mapping system.

- Two ESP32 boards (ESP1 and ESP2) continuously monitor the Firebase path
- On data change, a callback function is triggered
- Message text is converted into a Braille binary pattern using a lookup table
- Each character is represented as a 6-bit binary code (standard Braille format)

Step 4: Stepper Motor Actuation
The Braille pattern is sent to the ULN2003 driver, which controls the stepper motor to set the physical pin positions.

- Each ESP32 controls 3 stepper motors (total 6 motors = 1 Braille character)
- ULN2003 driver receives step signals from ESP32 GPIO pins
- Stepper motors rotate to raise or lower corresponding Braille dots
- Position is maintained using motor holding torque
- Sequential actuation: 200ms per dot, total display time ≈ 1.2 seconds

Phase 2: Braille-to-Voice Communication Flow

Step 1: Braille Input Detection

When the user presses a button combination, the ESP32 (input controller) reads it and decodes it into Braille.

- Third ESP32 (ESP3) monitors 6 push buttons using GPIO interrupts
- Buttons represent the 6 dots of a standard Braille cell
- Simultaneous button press is captured as a 6-bit binary pattern
- Debouncing is implemented (50ms delay) to avoid false triggering
- Pattern is decoded into ASCII characters using a reverse lookup table

Step 2: Data Routing Decision

The button combination is used to determine the mode, whether Bluetooth, Firebase, or both.

- Buttons 1–3: Emergency mode → data sent via HC-05 Bluetooth AND Firebase
- Buttons 4–6: Normal mode → data sent only to Firebase
- HC-05 configured in master mode and paired with mobile application
- Firebase JSON format: {message: "help", source: "braille", mode: "emergency"}

Step 3: Mobile App Notification (Emergency Mode)

The HC-05 transmits data to an Android app, which uses an SMS API to send messages to registered contacts.

- Android app receives Bluetooth serial data
- Message is parsed and SMS manager is triggered
- Sends emergency SMS with GPS location to registered contacts
- Format: "EMERGENCY: [Message] from [User Name]. Location: [GPS coordinates]"

Step 4: Audio Response Generation

Firebase data is processed by a Python script, which selects an MP3 file and sends it via a Bluetooth MP3 module to a speaker.

- Python script monitors Firebase for new Braille messages
- Message triggers selection of a corresponding MP3 file
- Audio files are pre-recorded in multiple languages
- Bluetooth MP3 module (DFPlayer Mini) receives serial commands
- Audio is played through a Bluetooth speaker with adjustable volume

Emergency System Operation:

Emergency SMS Protocol & Tactile Confirmation Mechanism:

1. User presses emergency combination (Buttons 1 + 2 + 3 simultaneously)
2. Stepper motors vibrate in pattern: short–long–short (tactile alert)
3. User confirms by pressing center button within 5 seconds
4. After confirmation:

- Firebase updated with emergency flag
- HC-05 transmits emergency signal to mobile app

- App sends SMS to all registered contacts
- Braille display shows confirmation pattern

Emergency Call Protocol:

1. User presses predefined emergency shortcut
2. System identifies emergency type:
   Button 1 → Police
   Button 2 → Ambulance
   Button 3 → Fire Protection
   Button 4 → Family
3. Firebase triggers corresponding emergency handler
4. Python script initiates automated call using Twilio API (or similar)
5. Pre-recorded message is played:
   "This is an emergency call from [User Name] at [Location]. [Emergency Type] assistance needed."
6. Tactile feedback confirms call initiation.

System Initialization and Calibration:

Power-On Sequence:

1. All ESP32 boards boot and connect to Wi-Fi
2. Firebase authentication is established
3. Stepper motors perform homing (all dots lowered)
4. HC-05 enters discoverable mode for pairing
5. Python scripts start and establish Bluetooth communication
6. System indicates readiness through tactile feedback ("Ready" pattern)

Calibration Procedure:

1. Stepper motors calibrated for precise dot height (1.5 mm raised, 0 mm lowered)
2. Button sensitivity adjusted using software thresholds
3. Speech recognition optionally trained with user voice samples
4. Emergency contacts configured via mobile application

Result and Conclusion:

The proposed IoT-based Two-Way Communicator effectively bridges the communication gap between blind-deaf-dumb individuals and normal users through the integration of advanced technologies such as ESP32 microcontrollers, Firebase real-time database, speech processing, and Braille tactile systems. By enabling both voice-to-Braille and Braille-to-voice communication, the system provides an innovative solution for real-time, two-way interaction. The implementation of stepper motor-driven Braille displays, Python-based speech recognition, and Bluetooth-enabled mobile interfaces ensures smooth, accurate, and efficient message transfer. The inclusion of emergency alert functionalities and tactile feedback patterns further enhances the system's practicality, reliability, and safety in real-world use.

In essence, this project demonstrates the potential of IoT in assistive technology by combining cloud computing, embedded systems, and haptic communication into a single inclusive platform. It not only promotes accessibility and independence for specially-abled individuals but also highlights how engineering innovation can serve a humanitarian purpose. The developed system represents a significant step toward inclusive communication design, paving the way for future enhancements such as AI-based emotion detection, gesture interpretation, and multilingual support ensuring that technology truly connects everyone, regardless of physical limitations.

References:

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Future Scope:

The future scope of this project includes:

1. **Expanded Braille Display:**
   Upgrade the system to support a 20–40-character refreshable Braille display with automatic scrolling for complete sentence representation.
2. **Advanced Actuators:**
   Replace conventional stepper motors with faster and quieter actuators such as piezoelectric or shape memory alloy (SMA) actuators for improved performance.
3. **Battery Optimization:**
   Integrate Li-Po batteries with solar charging support and implement power-saving techniques to extend device operation time beyond 12 hours.
4. **Miniaturization:**
   Develop a compact system using custom PCB design, surface-mount components, and a wearable enclosure (e.g., wristband format) to enhance portability.
5. **AI and Software Enhancements:**
   Incorporate natural language processing, offline speech recognition, and machine learning for smarter communication, predictive responses, and reduced internet dependency.