AFFORDABLE SPEECH-TO-BRAILLE COMMUNICATOR DEVICE FOR DEAFBLIND EMPOWERMENT

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Keywords:

Deafblind individuals, refreshable Braille display, speech conversion, tactile output.

Introduction:

Deaf blindness is a sensory impairment involving varying degrees of both hearing and vision loss. An estimated 15 million people worldwide experience deafblindness, yet only about 5–10% have access to adequate support services. This dual impairment significantly limits communication, independence, and access to information. As a result, deafblind individuals often rely on specialized assistance methods such as tactile communication, which increases dependence on caregivers in daily activities.

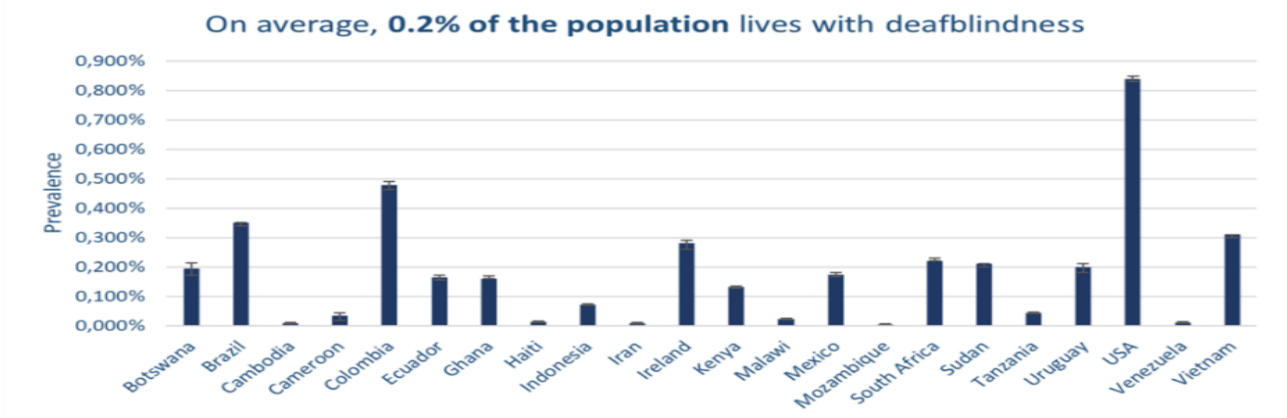


Figure 1: Statistics of deafblind population worldwide [1]

The attached bar chart illustrates the distribution of deafblind populations across different countries and indicates an average global prevalence of approximately 0.2% [1]. Significant variation can be observed between nations, highlighting regional disparities. Existing refreshable Braille devices that convert speech to Braille are expensive and energy intensive. This project aims to develop a low-cost, simplified speech-to-Braille device using 3D-printed Braille cells mounted on an evaluation board to display converted speech input.

Objectives:

1. To design an affordable speech to braille conversion device.
2. To help deafblind people stay connected by understanding conversations in real time by making the device refreshable.

Methodology:

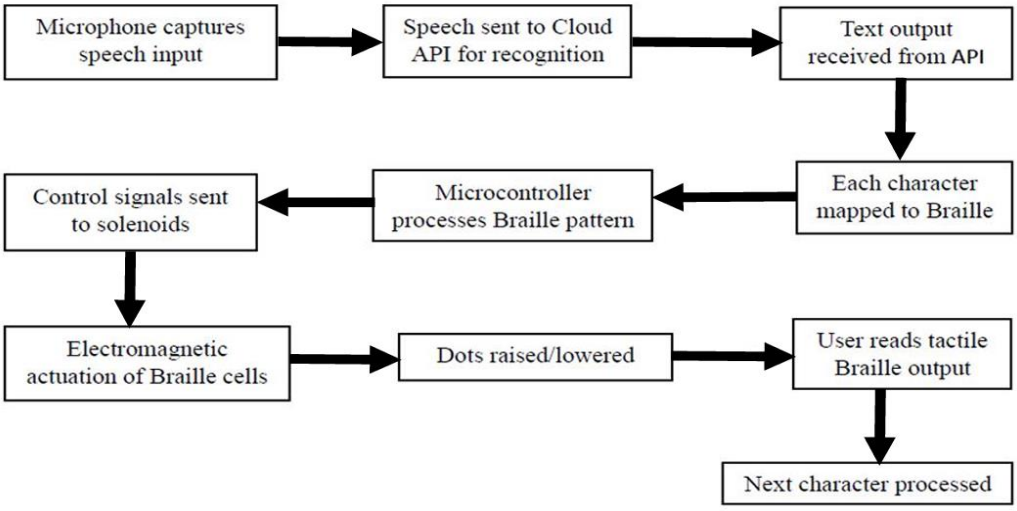


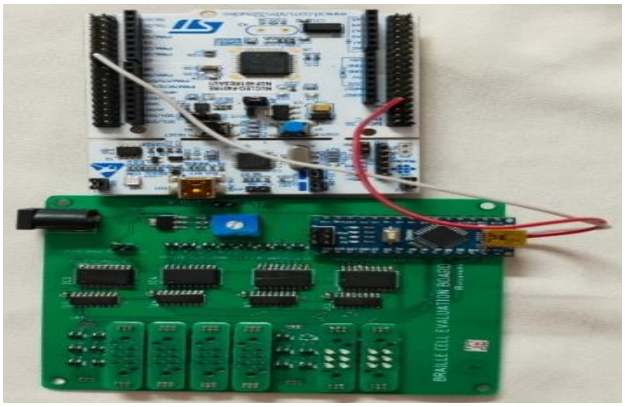
Figure 2: Block diagram for proposed module

This work presents a low-cost, speech-controlled refreshable Braille display developed through an integrated hardware–software approach. During the initial phase, LEDs mounted on a breadboard were used to represent Braille characters for validating the speech-to-Braille software conversion. This preliminary setup enabled accurate testing before integrating the electromechanical Braille cells.

On the software side, speech input is captured through a microphone connected to a computer or Raspberry Pi and processed using a Python script with Google's Speech Recognition API. The converted text transmitted to the STM32F401RE microcontroller. The firmware contains a lookup table that maps each character to its corresponding 3×2 Braille dot pattern, allowing four Braille cells to display four characters simultaneously.

On the hardware side, each Braille cell consists of six solenoids mounted on a PCB, each actuating a single Braille dot, resulting in 24 dots across four cells. The solenoids are driven based on character input, raising or lowering dots through magnetic actuation, with a configurable refresh interval of two seconds. The system is modular and scalable, enabling easy expansion by adding additional Braille cells and updating firmware logic, making it suitable for accessibility research and practical deployment.

Figure 3: Braille Cell Evaluation Board



Result and Conclusion:

The current step of the Speech-to-Braille Conversion System bridges the gap between tactile output and audio input using embedded hardware and software. There has been successfully development of a speech-to-text conversion system using Python. This real-time text is transmitted over STMNucleo microcontroller, which translates each character into its corresponding Braille representation using a predetermined mapping. This setup is effective in reliably converting speech to Braille with low latency, and using voice input reduces the requirement for traditional typing devices.

In conclusion, this project addresses the lack of effective communication devices for deafblind individuals by enabling real-time understanding of spoken conversations. Its simple operation makes it suitable for users without a technical background. The hardware design focuses on accurate Braille representation while keeping costs low to ensure wider accessibility. Overall, the project promotes independence and inclusion and aligns with SDGs 4, 9, and 10 by supporting inclusive education, reduced inequalities, and affordable assistive technologies.

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Future Scope:

The future scope of this project includes:

1. The system can be enhanced by introducing adjustable refresh speeds to accommodate different user reading preferences and improve usability.
2. Adding Braille-to-speech functionality would enable two-way communication, allowing users not only to receive but also respond to spoken content.
3. Future development should focus on improved PCB design, system miniaturization, and battery integration so the device can operate as a fully standalone, independent unit.