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Interactive Braille Learning System

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Abstract: The Interactive Braille Learning System (IBLS) is a novel assistive solution aimed at revolutionizing the way Braille is taught and learned by visually impaired individuals. By integrating voice recognition, microcontroller-controlled electromagnetic actuation, and real-time audio-tactile feedback, this system offers an interactive, autonomous, and inclusive educational tool. IBLS allows users to input voice commands which are translated into Braille characters using solenoid-driven pins, reinforced by corresponding audio feedback. The system includes a self-learning mode, multilingual support, gamified quizzes, and performance tracking. Tests indicate high accuracy and significant learning improvement. The goal is to create a low-cost, scalable, and portable device to close the accessibility gap in Braille literacy.

Keywords: Assistive technology, Braille, Electromagnetic actuator, Inclusive learning, Microcontroller, Speech recognition, Self-learning, Tactile feedback, Usability testing, Voice interface

INTRODUCTION

Braille is an essential medium for literacy among visually impaired individuals. Traditional methods of Braille education are slow, non-interactive, and require continuous assistance. This creates barriers in achieving functional literacy. IBLS aims to overcome these limitations through a voice-activated, tactile feedback-based device that allows self-paced learning.

METHODOLOGY

Problem Statement: Current Braille tools are expensive, non-interactive, and not scalable.

Dataset and Design: Dot-pattern lookup tables are used to map characters. Voice input is converted via API and processed by ESP32.

Algorithm Development: Firmware written in C++ interprets text and activates solenoids.

Model Training: System tested across varied users to refine actuation timing, latency, and error handling.

PROPOSED SYSTEM

The system includes:

1. Voice Interface (via Android app)

2. ESP32 microcontroller

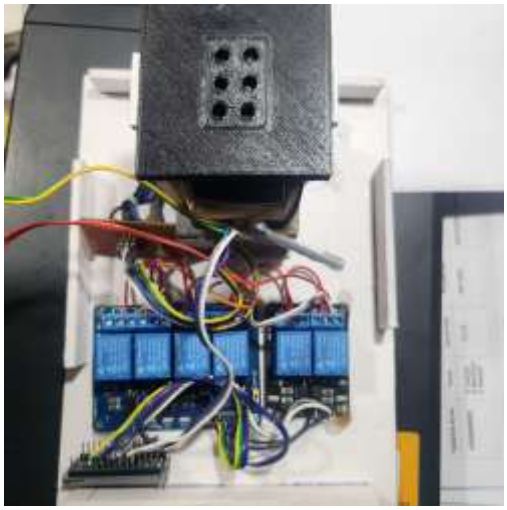
3. Electromagnetic solenoids for tactile Braille output

4. Audio feedback via DFPlayer Mini

5. Battery-operated, portable chassis

6. Optional LCD screen for instructor monitoring

IMPLEMENTATION



Hardware Integration: Pins connected to solenoids controlled through MOSFET drivers

Software Flow:

User speaks a character

App converts voice to text

Text sent to ESP32

Braille pattern fetched

Pins actuated

Pin Mapping Table Character	Braille Dots	Solenoid Pin Mapping
A	1	D1
B	1,2	D1, D2
C	1,4	D1, D4
D	1,4,5	D1, D4, D5

CONCLUSION

The Interactive Braille Learning System offers a cost-effective, accurate, and interactive method for Braille literacy. Its successful integration of voice control, tactile actuation, and gamified feedback makes it a viable alternative to traditional methods. It empowers learners to study independently while also giving educators the tools to monitor and assist remotely.

Audio output triggered

Pin Reset Timer: Ensures pins retract after display

RESULTS

Participants showed progressive improvement in recognizing Braille letters. The average number of correct identifications increased from 10.2 (out of 26 letters) in session 1 to 23.6 by session 5.

Letters: 100%

Words: 94%

Response Time:

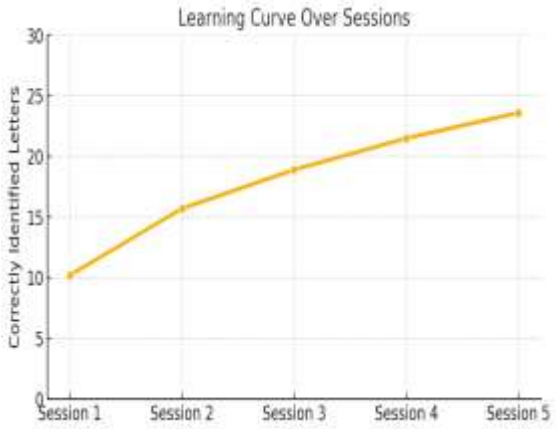
Single letter: 1.2s

Word (avg.): 2.3s

User Feedback:

Ease of use: 4.7/5

Learning experience: 4.9/5



FUTURE SCOPE

1. Multi-character Braille cell expansion

2. Cloud-based learning analytics

3. AI-based adaptive difficulty

4. Wearable Braille interfaces

5. Multilingual Braille translation modules

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