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Braille Bridge: An Innovative System to Bridge the Gap Between Blind Person's

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Abstract: *Braille Bridge is an innovative, low-cost assistive device designed to facilitate one-way communication for visually impaired individuals using Braille. The system enables users to input messages through a tactile push-button interface that mimics Braille characters. These inputs are processed by a Raspberry Pi and transmitted wirelessly via Bluetooth to a receiver unit, where solenoid switches generate the corresponding Braille output for the recipient to read through touch. To enhance usability, the device also incorporates an OLED display, LED indicators, and a buzzer for feedback on message status and system operation. Designed to be compact, portable, and affordable, the Braille Bridge prototype demonstrates how embedded technology can provide accessible communication solutions and promote greater independence for the blind community. Future developments may include expanding the system to support two-way interaction, voice integration, and mobile app connectivity.*

Keywords: Braille Communication, Visually impaired, Embedded System

I. INTRODUCTION

Communication is a fundamental human need, yet millions of visually impaired individuals around the world face challenges in expressing themselves and accessing information independently. While technologies like screen readers and Braille books have improved accessibility, there still exists a significant gap in direct, real-time communication for the blind. To address this, our project introduces Braille Bridge—an innovative, user-friendly system designed to facilitate one-way communication using Braille.

The system enables visually impaired users to input messages using a Braille-based push-button interface. These inputs are processed through a Raspberry Pi and transmitted wirelessly via Bluetooth to a receiver unit, which reproduces the message in Braille using solenoid switches. Additionally, the system includes audio and visual cues through a buzzer, LEDs, and OLED display, enhancing user interaction and system feedback.

Designed to be compact, cost-effective, and accessible, the Braille Bridge aims to empower visually impaired individuals to communicate more independently and confidently in various real-world environments such as homes, educational institutions, and public spaces. Its portable design makes it easy to carry and use, while the integration of embedded systems with tactile feedback mechanisms—like solenoid-driven Braille output and push-button Braille input—ensures seamless and intuitive operation. The system also incorporates auditory and visual indicators through buzzers, LEDs, and OLED displays, enhancing usability and reliability. By focusing on affordability and simplicity, the device addresses the technological gap in accessible communication tools. This project is a strong example of inclusive design, demonstrating how assistive technology can break barriers and foster equal opportunities for the visually impaired, ultimately contributing to a more inclusive and connected society.

The most common means of communication preferred by the Deaf-blind person is Braille. Embossed paper is traditionally used for writing Braille characters. Braille was developed by a Frenchman named Louis Braille in 1824, who was also blind. The Braille characters are represented in rectangular block cells with 3x2 array of raised dots which appear like tiny bumps as shown in Fig. 1. The number and arrangement of these dots is used to distinguish one character from another. There are three levels of encoding in English Braille. Grade 1 encoding uses a letter by letter transcription for basic literacy; Grade 2 encoding has added abbreviations and contractions; Grade 3 encoding includes various non-standardized personal stenography.

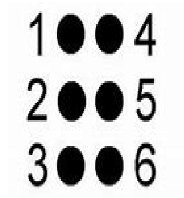

Fig. 1 Braille Cell Format

A typical braille cell includes six raised dots arranged in a 3x2 array format with three rows, each row containing two dots. The braille cell dots are numbered as shown in the figure 1. There are 64 combinations possible using this braille cell, which includes nil raised dots for representing space between words in a sentence. This braille cell format can be used to represent a letter, number, punctuation mark or even a word in some cases[1].

II. LITERATURE REVIEW

Researchers have proposed several models to ease the communication between an abled person and a deaf-blind person. Chen et al. (2024) proposed a refreshable Braille display system aimed at improving digital reading for the blind and visually impaired (BVI). The device addresses issues of high power consumption and low latching force found in traditional Braille displays by using a beam structure that allows Braille dots to latch without continuous energy. Through theoretical analysis and finite element modeling, the actuator's tactile performance was optimized. The system was integrated with the 3D Systems Touch device and the CHAI3D virtual environment, combining haptic and audio feedback to improve recognition accuracy and reading speed. This solution offers a cost-effective and efficient alternative for BVI digital access[2].

Sruthi Ramachandran et al. propose a portable, single-cell refreshable Braille device capable of translating both text and voice inputs into tactile Braille output. The device addresses the need for cost-effective and user-friendly Braille learning tools by simplifying traditional multi-cell Braille systems into a single-cell design, thereby enhancing portability and accessibility for individual users. It also features dual output modes—tactile Braille and voice feedback—enabling blind users to receive both tactile and auditory confirmation of messages[1].

Falgoon Sen Apu et al. proposed a novel, low-cost, and portable Braille translation device that addresses the challenges associated with traditional Braille learning systems, which are often expensive and complex. Their system features a single-cell refreshable Braille display that converts both text and voice inputs into tactile Braille outputs. The device is particularly designed for blind students and can be operated via Bluetooth or USB connection using a smartphone or computer[3].

Ozioko et al. (2020) designed a wearable tactile communication glove using finger Braille to support communication for deafblind individuals. The glove integrates flexible piezoresistive touch sensors and vibrotactile actuators positioned on six fingers to represent Braille dots. Using a Bluetooth-enabled interface, users can send and receive Braille messages through vibrations ranging from 10Hz to 200Hz, which aligns with human tactile perception. In testing with both deafblind and sighted users, the system enabled non-Braille experts to accurately transmit words like “BEST” and “JOURNAL” within 25–55 seconds, achieving up to 75% accuracy. This approach offers an efficient, low-cost assistive communication solution for the deafblind community[4].

III. METHODOLOGY

The proposed system, Braille Bridge, follows a modular and user-centric design methodology to ensure effective communication for visually impaired users. At the transmitter end, a custom Braille keypad consisting of manual push-button switches allows users to input Braille characters. Each button press is captured and processed by a Raspberry Pi, which converts the tactile inputs into corresponding digital characters. The input is simultaneously displayed on an OLED screen, enabling real-time verification and accuracy. The processed data is transmitted wirelessly using a Bluetooth module, which serves as a reliable communication link between the transmitter and receiver units. On the receiver side,

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another Raspberry Pi decodes the incoming Bluetooth data and translates it into control signals that drive solenoid switches or servo motors. These actuators generate tactile Braille patterns that can be sensed through touch, allowing visually impaired users to read messages intuitively. The system also includes LED indicators and a buzzer on both units to provide visual and auditory feedback, aiding users in understanding system states such as input acknowledgment, transmission, and message reception. Furthermore, the device is powered by a stable power source with battery backup, making it portable and suitable for use in various settings such as homes, schools, or public spaces. This integrated approach—combining tactile, auditory, and minimal visual feedback—ensures an inclusive and accessible communication system tailored to the needs of the visually impaired community.

The Braille Bridge system is designed to provide real-time communication for visually impaired individuals using a single-cell Braille output mechanism. Traditional Braille displays use multiple cells (typically 12 to 80) for reading full lines of text. However, in our approach, we simulate the experience of reading multiple Braille cells using just one. Users keep their finger on a single tactile output cell, which dynamically refreshes to display one Braille character at a time. This emulates the natural reading flow by advancing through messages character-by-character, conserving hardware resources while maintaining readability.

A. Braille Input Interface

Visually impaired users input characters through a tactile Braille keypad consisting of six manual switches arranged in a 2×3 format[3]. These switches correspond to the six dots of a Braille cell. When a specific combination of buttons is pressed, it is interpreted as a Braille character. A Raspberry Pi processes this tactile input and converts it into a digital character using predefined Braille encoding logic. The Fig 2 represents the Braille Script.

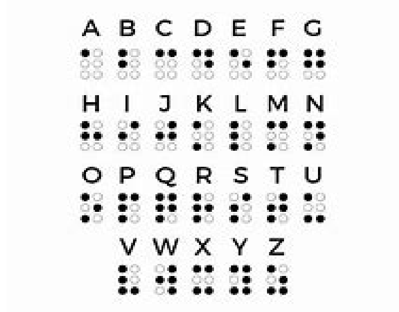

Fig 2. Braille Script

B. Real-Time Feedback Mechanism

Once a character is input, it is simultaneously displayed on a small OLED screen on the transmitter unit. This provides real-time confirmation for sighted users or trainers. Additionally, an LED indicator confirms successful entry, and a buzzer sound is played to alert the user. This multimodal feedback ensures reliable and accessible system interaction.

C. Wireless Data Transmission

The processed character is transmitted from the transmitter to the receiver unit using Bluetooth (HC-05 module), ensuring low-latency and stable wireless communication. A pairing mechanism ensures that data is only transmitted to the correct receiver. If communication fails, retry protocols are initiated to maintain reliability.

D. Data Reception and Processing

On the receiver side, the incoming data is received via another Bluetooth module and passed to a second Raspberry Pi. This Pi decodes the received character and generates control signals to drive the tactile output mechanism.

E. Braille Tactile Output

The output system consists of a single Braille cell constructed using solenoid switches. Based on the received character, corresponding solenoids are activated to form raised Braille dots that the user can read by touch. The cell refreshes character-by-character, simulating the reading motion across a Braille line, while maintaining compact hardware.

F. Audio and Visual Feedback

In addition to tactile output, the receiver unit includes LED indicators and a buzzer. The buzzer signals successful message receipt, while the LEDs provide visual cues about system status for additional accessibility support. This multimodal design enhances usability and reinforces feedback for both blind and sighted users.

G. Power Supply and Portability

The system is powered by a regulated supply with battery backup support, ensuring uninterrupted functionality during power outages. This makes it suitable for use in homes, schools, or during travel, reinforcing its portability and practical deployment.

The Braille Bridge system follows a one-way communication flow designed for visually impaired users. It begins with the user inputting a Braille character using push buttons on the transmitter side, which is processed by a Raspberry Pi and displayed on an OLED screen for confirmation. Audio-visual feedback is provided via LEDs and a buzzer. The encoded character is then transmitted wirelessly via Bluetooth to the receiver unit, where another Raspberry Pi decodes the data and displays it on an OLED screen. LEDs and a buzzer notify the user of a new message, and the final Braille output is produced using solenoid switches or servo motors, allowing the user to read the message through touch. This setup ensures accessible, real-time communication with tactile and multisensory feedback as shown in Fig. 3.

Fig. 3. Block diagram of Braille bridge system

IV. RESULTS AND CONCLUSION

The Braille Bridge prototype was successfully designed, developed, and tested to facilitate real-time communication for visually impaired individuals. The system accurately translated Braille character inputs via a custom keypad into tactile outputs using solenoid switches or servo motors, enabling users to interpret messages through touch. Testing in controlled environments confirmed the system's ability to transmit and receive Braille messages with minimal latency and high reliability via Bluetooth connectivity.

The integration of OLED displays and LEDs provided visual feedback for sighted facilitators, while a buzzer offered auditory cues—such as message confirmation, error alerts, and readiness indicators—enhancing the overall user experience. The device proved to be cost-effective, portable, and user-friendly, requiring minimal training and offering consistent performance.

The modular architecture of the system allows for future enhancements such as voice assistance, smartphone app integration, and internet-based communication. Overall, the Braille Bridge addresses a critical gap in accessible communication technology by empowering visually impaired users with greater independence and social confidence. With further development, it holds strong potential for widespread adoption in homes, educational institutions, and public infrastructure, thereby contributing to digital inclusivity and equality. The below figures (Fig. 4 and Fig. 5) represent the snapshots of the project.

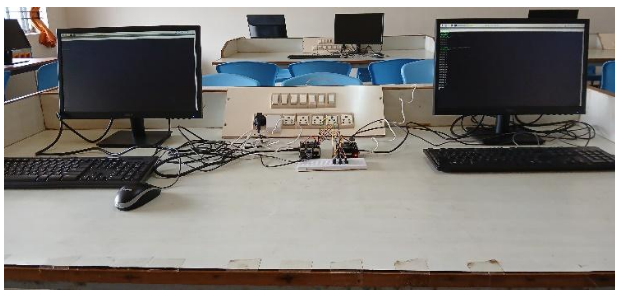

Fig. 4. Snapshot of project

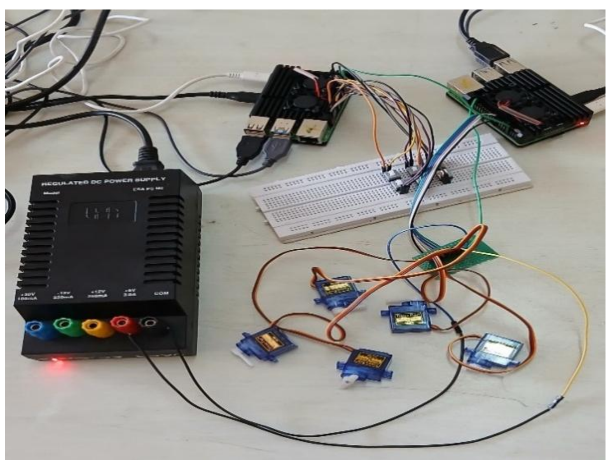

Fig. 5 Snapshot from top view

V. ACKNOWLEDGMENTS

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