

An IoT and AI-Based Text-to-Braille Conversion System

Mrs. R. Yogeshwari

Assistant Professor, Sri Bharathi Engineering College for Women, Pudukkottai, India.
yogasai4@gmail.com

Abstract — This paper presents the design and implementation of an intelligent assistive system for deaf-blind individuals, aimed at improving communication accessibility through the integration of artificial intelligence, embedded systems, and Internet of Things (IoT) technologies. The proposed system utilizes Optical Character Recognition (OCR) based on Tesseract OCR to extract textual information from real-time image inputs. The extracted text is then transmitted to an embedded controller, specifically the Arduino Uno R3, which processes the data and converts it into corresponding Braille patterns using a six-dot Braille cell mechanism. These patterns are displayed through a tactile output interface, enabling users to perceive information through touch. In addition to text-to-Braille conversion, the system incorporates IoT functionality using the NodeMCU ESP8266 module, which facilitates real-time communication with caregivers via the Blynk application. This feature allows the transmission of alert messages and system status updates, enhancing user safety and connectivity. The integration of a buzzer module further provides feedback for system operations. The developed prototype demonstrates a cost-effective and efficient solution for bridging the communication gap faced by deaf-blind individuals. Experimental results indicate that the system is capable of performing real-time text recognition, accurate Braille conversion, and reliable IoT-based notifications. This work highlights the potential of combining AI-driven text recognition with embedded and IoT systems to develop practical assistive technologies. Future enhancements may include the implementation of advanced deep learning models, portable device design, and improved Braille actuation mechanisms for higher precision and usability

Keywords: Braille System, Optical Character Recognition (OCR), Arduino Uno

1. INTRODUCTION

Communication is a significant challenge for deaf-blind individuals, as they are unable to rely on both visual and auditory methods. Braille serves as an effective tactile communication medium; however, accessing digital and printed content in Braille format remains limited due to the high cost and lack of portable assistive devices.

To overcome these challenges, this project proposes an integrated assistive system that converts textual information into Braille output. The system employs Optical Character Recognition (OCR) using Tesseract OCR to extract text from images or documents. The extracted text is then processed by the Arduino Uno R3, which generates corresponding six-dot Braille patterns for tactile representation.

In addition, the system incorporates IoT functionality using the NodeMCU ESP8266 to send real-time alerts and notifications through the Blynk platform. By integrating OCR, embedded processing, and IoT communication, the proposed system provides a cost-effective and efficient solution to enhance accessibility and independence for deaf-blind individuals

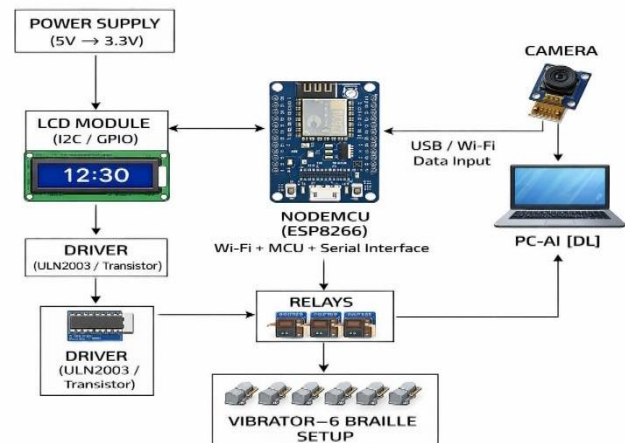


Figure 1: Block Diagram

2. PROPOSED SYSTEM

A. ARDUINO UNO

The Arduino Uno serves as the **central processing unit** of the system. It receives the extracted text data from the PC through serial communication and processes each character based on predefined logic. The controller then converts the text into corresponding **six-dot Braille patterns** and controls the output pins to activate the required Braille dots. It ensures proper synchronization between input, processing, and output

stages.

B. NodeMCU ESP8266

The NodeMCU module is responsible for enabling **IoT-based communication** in the system. It uses built-in Wi-Fi capability to connect to the internet and transmit data to external platforms. In this project, it sends **real-time alerts and notifications** to a mobile device through the **Blynk** application, thereby enhancing user safety and remote monitoring.



Figure 2: NodeMCU ESP8266

C. 16x2 LIQUID CRYSTAL DISPLAY

A liquid crystal display, commonly known as LCD, derives its definition from the unique combination of two states of matter - solid and liquid. The 16x2 LCD display is used to **visually present the extracted and processed text**. It displays each character received from the system, allowing for easy verification during testing and demonstration. This component is especially useful for instructors or developers to confirm the accuracy of the text-to-Braille conversion process.

D. Tesseract OCR

Tesseract OCR is an advanced optical character recognition tool used to extract textual information from images, scanned documents, or printed materials. It analyzes the input image by applying image processing techniques such as noise reduction, edge detection, and character segmentation to accurately identify individual characters. These identified characters are then converted into machine-readable text format using trained recognition models. The generated digital text serves as the primary input for the proposed system, which is further processed by the embedded controller. By enabling the extraction of real-world printed content, Tesseract OCR plays a crucial role in bridging the gap between visual information and tactile communication, allowing the system to convert the extracted text into corresponding Braille patterns for deaf-blind users.



Figure 3: Tesseract OCR Tool

E. Braille Output Module (6-Dot Cell)

The Braille output module is the **core functional unit** of the system. It consists of six output points representing a standard Braille cell. Based on the processed input, specific dots are activated to form the required Braille character. This allows the user to **interpret information through tactile sensing**, making the system suitable for deaf-blind communication.

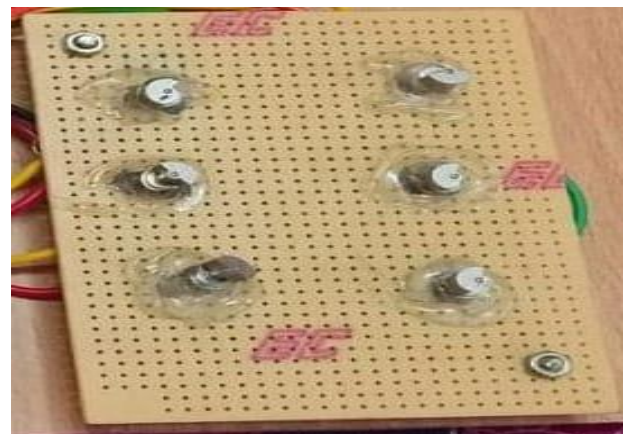


Figure 4: Braille Output Module (6-Dot Cell)

3. WORKING PRINCIPLE

The proposed system operates by converting visual text into tactile Braille output through a sequence of processing stages. Initially, an image containing textual information is captured using a camera or provided as input from a stored image. This image is processed using Optical Character Recognition (OCR) implemented through Tesseract OCR, which extracts the text and converts it into machine-readable format.

The extracted text is then transmitted to the Arduino Uno R3 via serial communication from the PC. The Arduino processes each character and maps it to its corresponding **six-dot Braille pattern** using predefined logic. Based on this mapping, the controller activates specific output pins connected to the Braille module, thereby generating the required tactile representation.

Simultaneously, the processed text is displayed on the 16x2 LCD Display for verification and demonstration purposes. In addition, the system integrates IoT functionality using the

NodeMCU ESP8266, which connects to a wireless network and sends real-time notifications to a mobile device through the Blynk platform.

Thus, the system effectively converts real-world textual information into Braille output while also providing remote alert capabilities, enhancing communication accessibility for deaf-blind individuals.

4. SIMULATION RESULTS

The OCR process implemented using Tesseract OCR effectively extracted textual data from input images with good accuracy under standard conditions. The extracted text was transmitted to the Arduino Uno R3 through serial communication, where it was processed and converted into corresponding six-dot Braille patterns. The output was verified using the 16x2 LCD Display, which displayed the processed text correctly.

Furthermore, the NodeMCU ESP8266 successfully enabled IoT-based communication by sending real-time notifications to a mobile device via the Blynk platform. The system demonstrated stable performance with minimal delay in data processing and communication, confirming its effectiveness as a reliable assistive solution.

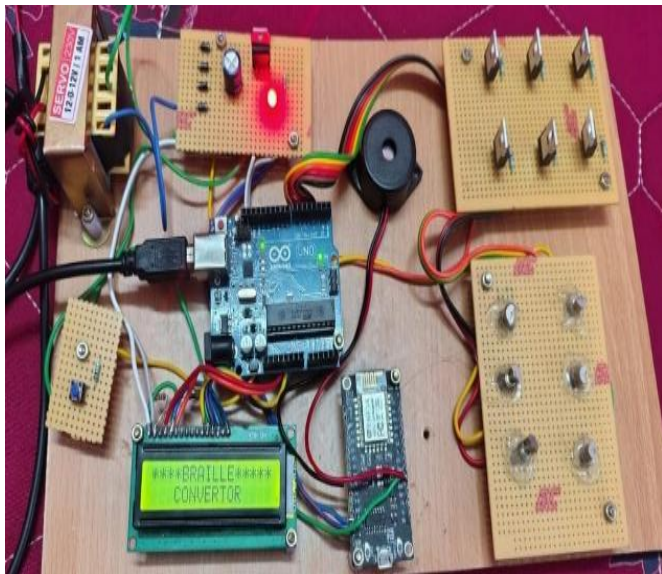


Figure 5: Hardware Module

CONCLUSION

The proposed system provides a cost-effective solution for converting textual information into Braille for deaf-blind individuals. By integrating Tesseract OCR, Arduino Uno R3, and NodeMCU ESP8266, the system enables accurate text extraction, Braille conversion, and IoT-based notifications through Blynk. The results demonstrate reliable performance, making the system a practical assistive tool for improving communication accessibility.

Key Achievements

➤ Implemented accurate **text extraction using Tesseract OCR** and achieved reliable **text-to-Braille conversion using Arduino Uno R3**, ensuring proper mapping

of characters to six-dot Braille patterns.

➤ Integrated **IoT functionality using NodeMCU ESP8266**, enabling real-time communication and mobile notifications through the Blynk platform.

➤ Designed and implemented a **complete working prototype** combining AI-based text recognition, embedded processing, and IoT, demonstrating real-time performance with minimal delay.

Future Enhancements

- Develop a compact and portable version of the system using battery power and miniaturized hardware for real-world usability.
- Enhance text recognition accuracy by integrating advanced AI-based OCR models beyond Tesseract OCR for better performance under different lighting and font conditions.
- Implement voice-to-Braille conversion by adding speech recognition systems, enabling users to receive spoken information in tactile form. Improve the Braille output mechanism by using **advanced actuators or refreshable Braille displays** for faster and more precise tactile feedback.

REFERENCES

1. A. Al-Mansoori et al., "IoT-Powered Braille Access: A Refreshable OCR System for Visually Impaired and Deaf-Blind," *European Journal of Emerging Cloud and Quantum Computing*, 2024.
2. K. K. Reddy et al., "IoT-driven accessibility: A refreshable OCR-Braille solution for visually impaired and deaf-blind users," *Journal of Economy and Technology*, 2024.
3. H. Gautam and P. Gaur, "DRISHYAM: Real-Time Text to Braille Conversion," *IEEE INDICON*, 2020.
4. S. Kumari et al., "Enhanced Braille Display Using OCR and Solenoid," *IEEE INCET*, 2020.
5. K. Hassan et al., "Dual-Purpose Refreshable Braille Display Using OCR," *IEEE SPICSCON*, 2019.
6. G. Holanda et al., "Development of OCR System for Braille Display," *Measurement Journal*, 2018.
7. D. Bhupatkar et al., "Smart OCR for Visually Challenged People," *IJERT*, 2019.
8. A. Sharma et al., "Assistive Reading System Using OCR and TTS," *International Journal of Computer Applications*, 2014.
9. O. Ramos-García et al., "IoT Braille Display for Visually Impaired Students," *MDPI Proceedings*, 2022.
10. A. Llorca et al., "AI-WEAR: Smart Text Reader for Blind Students," *IJARCS*, 2023.
11. S. Smelyakov et al., "Braille Character Recognition Using Neural Networks," *IEEE DSMP*, 2018.
12. S. Tiwari et al., "Sign Language Recognition and Braille Translation," *IEEE SITIS*, 2022.
13. K. Sharavana et al., "Real-Time Text to Braille Converter," 2020.
14. M. Rahimi et al., "Finger-Wearable Electro-Braille System," *arXiv*, 2021.
15. N. Afzal et al., "Neuromorphic BrailleNet for Braille Recognition," *arXiv*, 2026.
16. H. Savindu et al., "BrailleBand: Wearable Braille Communication Device," *arXiv*, 2019.
17. L. Holloway et al., "Refreshable Tactile Displays for Accessibility," *arXiv*, 2024.
18. F. Başçiftçi and A. Eldem, "Interactive Refreshable Braille Device," *Displays Journal*, 2016.
19. P. Gilfeather-Crowley et al., "Wireless Sensor Networks for Visually Impaired," *IEEE SMC*, 2011.
20. V. Manimegala et al., "IoT-Based System for Differently Abled Persons," *IEEE ICACCS*, 2021.
21. D. Russomanno et al., "Refreshable Braille Displays," *IEEE Transactions on Haptics*, 2015.
22. R. de Luna, "Tesseract-Based OCR for Text-to-Braille Conversion," *IJASEIT*, 2020.