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Braille E-Book Reader

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Abstract: *This study aimed to implement a braille display prototype using low-cost materials and components. The Braille impaired individuals for reading 1 System is a widely used method by visually and writing, relying on raised dots arranged in a grid to represent characters. This project aims to develop an E-Book Braille effective communication. The system uses Optical system for more Character Recognition (OCR) technology to convert printed or handwritten text into digital format. The recognized text is then translated into Braille code. An ESP-32 controls a Braille display, which uses solenoids to create a tactile representation of the text dynamically. By integrating OCR technology and tactile feedback, this system offers an innovative approach to improving accessibility and communication for visually impaired individuals.*

Keywords: Text to Braille, Braille Display, OCR

I. INTRODUCTION

The system used by the blind or visually impaired to read is called Braille. Braille was created by Louis Braille and used throughout the blind community. The symbols representing letters, numbers, and short phrases are formed inside Braille cells. Braille cells are made up of six raised dots in three parallel rows; each row has two dots. Each cell used to represent a number, letter, punctuation, or abbreviation. The blind and visually impaired face a gruelling task when learning to read. The equipment available on the market is expensive and not easily accessible for all. Many of these devices are not user-friendly and may not be suitable for people of all age groups, particularly children. As society advances technologically, 10 visually impaired individuals are 3 often left behind as the majority developments and knowledge are designed for those of new with sight. The technology available to assist them is often either incompatible or too expensive for them to access. These individuals rely on Braille for reading and writing.

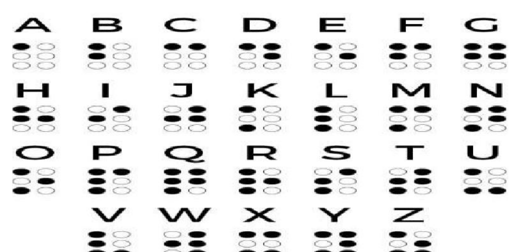

Fig 1. Braille Interpretations

II. DESIGN AND METHODOLOGY

This system consists of an ESP 32-S3 Dev Mod board, Actuators, OCR technology, a USB Cable, a Power Supply, and Jumpers. The Braille E-Book Reader using ESP-32 is a system designed to convert text into Braille Output, making it accessible for visually impaired users. The system is built around the ESP-32-S3 Dev Mod board, which acts as the central processing unit, controlling all the components. It uses Optical Character Recognition (OCR) Technology to scan and process text from documents or images and convert them into a format suitable for Braille output. The processed data is transmitted to actuators, such as tactile pins, which create the Braille character for the user.

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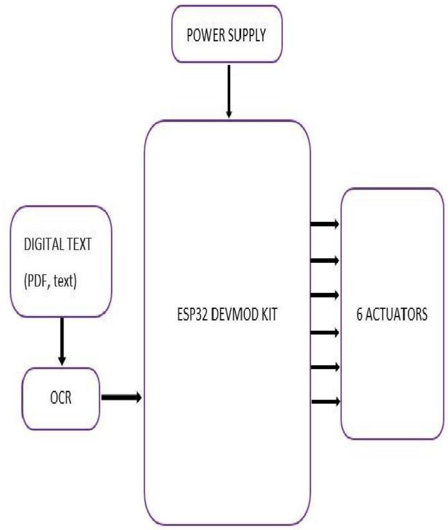

Fig 2. Block diagram of a Braille E-Book Reader using ESP-32

A USB cable is used to connect the device to the system for data input and charging, while a power supply ensures consistent operation. The Braille e-book reader provides numerous benefits, including accessibility, convenience, and customization. Visually impaired users can upload various types of content, including poems, prose, scientific articles, and more, and choose between contracted and uncontracted Braille. However, there are also challenges and limitations associated with Braille e-book readers, such as cost, compatibility, and navigation.

III. FLOW CHART

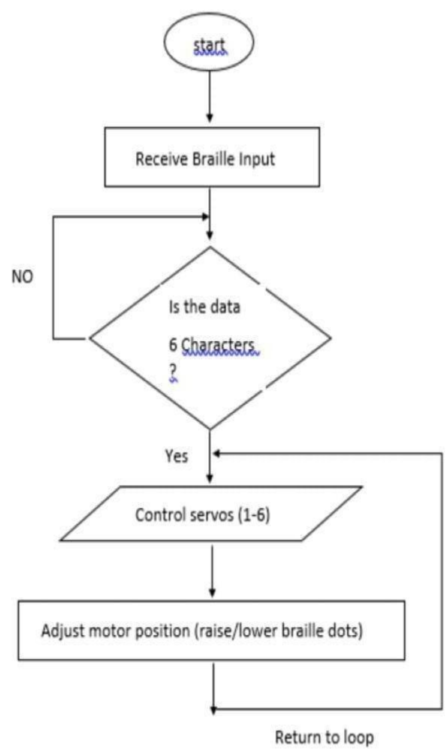

Fig 3. Flow code Diagram

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This flowchart outlines the process of controlling a Braille display device. The process begins by receiving Braille input, which is typically a string of characters. The device then checks if the received input is exactly 6 characters long, as Braille cells typically consist of 6 dots. If the input is not 6 characters long, the device returns to the starting point, waiting for a new input. However, if the input is 6 characters long, the device controls the servos, small motors that raise and lower the Braille dots, to create the desired Braille character. The device adjusts the position of each servo motor to raise or lower the corresponding Braille dot. After adjusting the motor positions, the device returns to the starting point, waiting for the next input. This continuous loop enables the device to receive Braille input, control the servos to create the corresponding Braille characters, and then wait for the next input.

IV. DESCRIPTION

A. ESP32 DevKit

The ESP32 Dev Module is a powerful and versatile development board designed for IoT robotics, and embedded system projects. It integrates the ESP32 microcontroller, which offers robust computing capabilities, wireless communication, and a wide range of interfaces to cater to diverse application needs. ESP32 is based on the dual-core Xtensa LX6 processor. It has a clock speed of up to 240 MHz, providing high-performance processing for complex tasks. It supports Wi-Fi complaints with IEEE 802.11 b/g /n standards. It supports both the 2.4 GHz frequency band and multiple security protocols (e.g., WPA/WPA2). It supports Bluetooth version of 4.2 both classic and BLE (Bluetooth Low Energy). Set of configurable GPIO pins supporting analog input (ADC), digital I/O, and pull-up-down/resistor. Multiple channels are available for ADC.

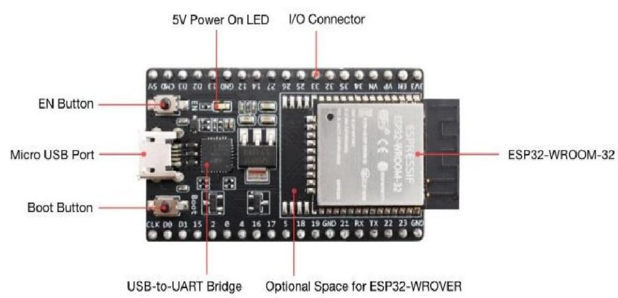

Fig 4. ESP32 DevKit

B. Optical Character Recognition (OCR)

Optical Character Recognition (OCR) is a technology designed to identify and convert printed, handwritten, or typewritten text from images, scanned documents, or other visual formats into machine-encoded text. OCR systems typically use a combination of image pre-processing (e.g., noise reduction, binarization, and skew correction), pattern recognition, and machine learning algorithms to detect characters. Modern OCR systems leverage deep learning techniques to enhance accuracy, even for complex scripts and poorly scanned documents. OCR supports multiple languages and character sets, including Latin, Chinese, Arabic, and more, with some systems enabling customization for specific fonts or symbols.

It is widely used in digitizing books, automating data entry, enabling text-to-speech systems, and powering applications like automated license plate readers and assistive technologies for the visually impaired.

- Functionality: Converts printed, handwritten, or digital images of text into machine–readable text. Recognizes multiple languages and font styles, including structured (tables) and text.
- Image Input: It supports JPEG, PNG, BMP, TIFF and PDF (image-based). Optimal recognition at 200-600 DPI (dots per inch).
- Text Recognition: OCR systems recognize 50+ languages, including complex scripts (e.g., Chinese, Arabic). : High accuracy for clear text, dependent on font, size, and image quality. Supports various fonts, including serif, sans serif, and monospaced styles. Recognizes numbers, special characters, and punctuation.

- Processing Feature: Noise reduction , skew correction, and binarization. Image segmentation to isolate text regions. Post-processing, spellcheck, and contextual correction. Export options to various formats like plain text, PDFs, or Word documents.
- Advanced Capabilities: Handwriting recognition recognizes cursive or block letters, though less accurate than printed text. Extracts tables, forms, and specific fields. Recognizes numbers, special characters, and punctuation.
- Integration and interface: APIs and SDKs offered by platforms like Tesseract, Google Vision, and ABBYY for embedding OCR functionality into applications. It is compatible works with desktop software, mobile apps, and web services.

Fig 5. OCR

C. Optical Character Recognition (OCR)

USB cable is generally used to connect ESP32 development boards to computers or external devices for programming, data transfer, and powering the microcontroller. These cables typically support USB to serial communication and are essential for flashing the firmware onto ESP32 boards or for general communication. The ESP32 board typically operates at **3.3V**, but the cable is designed for **5V** power input from the USB port.

Fig 6. USB Cable

D. Solenoid Actuators

Solenoid actuators 5 are commonly used in Braille displays to convert physical 9 digital signals into movements that represent Braille characters through raised pins. These actuators are essential for tactile feedback, enabling blind or visually impaired users to read text in Braille. Below are the detailed specifications of solenoid actuators typically used in such displays. These solenoid actuators in Braille displays are critical components that enable the tactile feedback system for visually impaired users, ensuring accurate representation of Braille text. They require careful design to balance speed, force, reliability, and power efficiency

- DC Voltage: Typically operates between 3V to 12V DC, depending on the design and power source available. Higher voltages may be used in larger or more powerful actuators.
- Current: Typically ranges between 50mA to 500mA during activation. vary based on the specific solenoid design and number of actuators.
- Power Consumption: Typically ranges between 50mA to 500mA during activation. vary based on the specific solenoid design and number of actuators.

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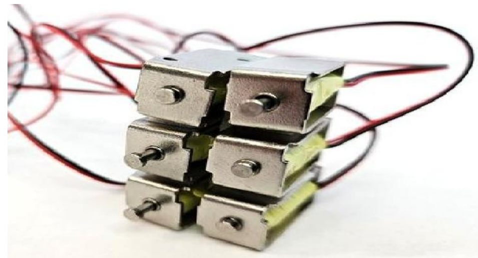

Fig 7. Solenoid Actuators

V. CIRCUIT DESIGN

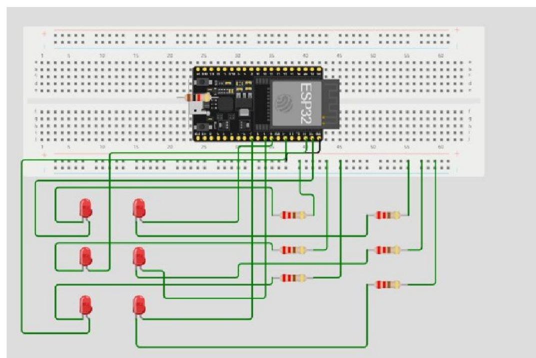

Fig 8. Circuit design Braille E-Book System using ESP-32

VI. RESULTS

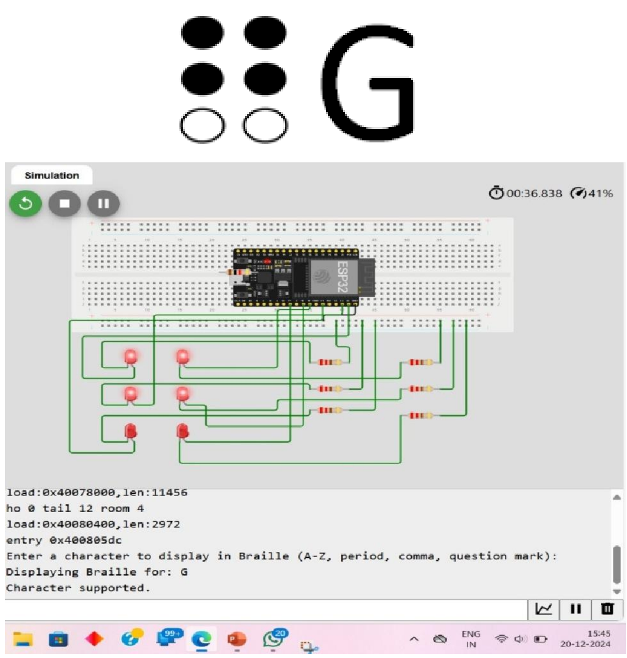

Fig 9. Output

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The above figure displays the braille form of the character ‘G’ which is shown beside the output.

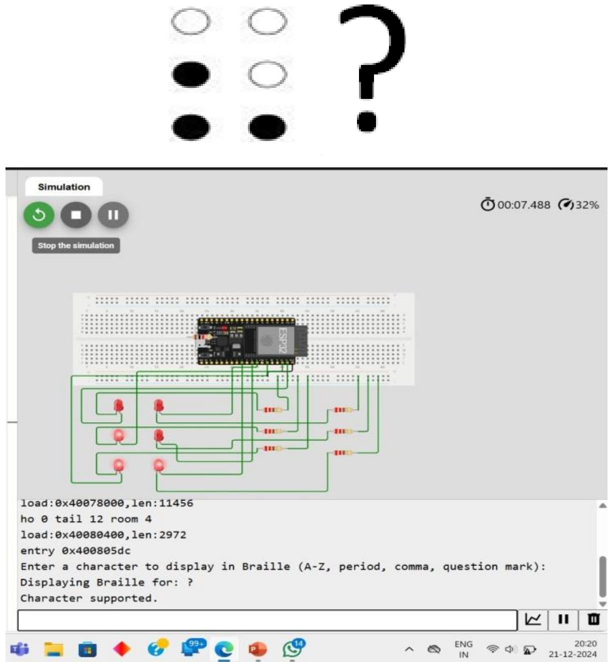

Fig 10. Output

The above figure displays the braille form of the symbol ‘?’ which is shown beside the output

VII. CONCLUSION

In this project, we aimed to develop an accessible and cost-effective Braille display system to support the visually impaired. By exploring various journals on Braille systems and modern Braille display devices, we gained valuable insights into existing solutions and their applications. Using these findings, we designed and implemented a prototype system featuring an ESP microcontroller and six LEDs to represent Braille dots. The Text-to-Braille conversion was successfully coded in C using Arduino IDE the functionality was simulated through WOKWI. The simulation results demonstrate the accurate representations of characters, symbols, and numbers in Braille through LED activation, providing a proof-of-concept for a potential low-cost Braille display device. This project underscores the importance of integrity simple yet effective technology to address accessibility challenges. Our approach offers a foundation for further development and enhancement, paving the way for more advanced and affordable assistive devices for visually impaired individuals.

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