Smart Book Reader for Visual Impairment Person Using IoT Device and Deep Learning

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Abstract - People with normal vision can easily see the world around them and can read and write without difficulty. For those who are visually impaired, the Braille script enables them to read and write just like sighted individuals. According to WHO data from 2023, about 15 million people worldwide have significant vision loss. The Braille system uses cells with six raised dots, each dot numbered from one to six, arranged in two columns. This system is crucial for visually impaired individuals to keep up with the world around them. Providing Braille-assisted technology and incorporating it into daily life is essential to make life more comfortable and efficient for visually impaired people, enabling better communication with others.

Key Words: Braille script, OBR.

1.INTRODUCTION

Vision is a profound sense, but not everyone enjoys its full benefits. Visually impaired individuals, whether blind or with limited sight, face unique challenges in accessing written information. Braille, a tactile system of raised dots representing letters and numbers, has been revolutionary in enabling blind individuals to read and write independently by feeling these dots with their fingertips. However, mastering Braille can be daunting due to its complexity and the time required for proficiency.

To overcome these challenges, modern technology has greatly enhanced accessibility and educational opportunities for the visually impaired. The integration of IoT devices and deep learning algorithms has led to significant advancements in assistive technologies. For instance, the Smart Book Reader utilizes IoT sensors and deep learning to convert Braille text into spoken language in real-time, facilitating easier comprehension and promoting greater independence in learning.

Deep learning, inspired by neural networks, has revolutionized Braille recognition by automating the interpretation of tactile patterns, thereby improving the accuracy and speed of converting Braille into audible content. This technological convergence holds promise in enhancing the lives of visually impaired individuals by breaking down barriers to information access and fostering greater participation in society.

2. RELATED WORK:

In this section, various authors have presented various IoT and Deep Learning techniques.

This section discusses various IoT and Deep Learning techniques used by different authors. One innovative method converts Braille images to English text using a convolutional neural network (CNN) model. Optical Braille recognition (OBR) systems have been developed to translate Braille images into text, addressing the unique characteristics of Braille symbols compared to standard characters. The process begins with image binarization, converting a color image into a binary format by calculating the brightness from the RGB values of each pixel [1].

A K-means clustering algorithm is then applied to the extracted features. This involves assigning features to the nearest cluster center and updating the centers based on these assignments until they stabilize. Each pixel is classified into a cluster, segmenting the image into distinct regions [3].

The workflow includes Braille image acquisition and pre-processing, where original Braille images are collected (OrgImgs) and processed into preprocessed and segmented images (PreImgs, SegImgs). Braille cells are then cropped using the Character Positioning Cropping Algorithm (CPCA) to isolate individual Braille symbols. These symbols are recognized by a Deep Convolutional Neural Network (DCNN) model trained with a specific dataset (Trainset) and labels (Train Labels). The recognized symbols (TstLabel) are mapped to corresponding characters and symbols of the selected language using a lookup table, forming sentences in text or voice format [7].

The paper emphasizes moving beyond sight-centric views of reading, highlighting the need to consider the diverse contextual factors affecting Braille users. It stresses the importance of intentional participant recruitment, considering the sparse and distributed population of Braille users. Researchers are encouraged to account for the heterogeneity of Braille users and advocate for responsible, informed research that recognizes the diversity of reading and writing experiences, avoiding print-centric biases [10].

In the image processing module, text extraction is achieved using optical character recognition (OCR) to convert text in color images into editable text. The process includes image capture via webcam, pre-processing to convert images to grayscale and binary formats, character extraction and resizing, template matching for recognition, background removal, and edge detection, with results written to a text file. The voice processing module converts extracted text to speech

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using a text-to-speech synthesizer (TTS) on a Raspberry Pi, amplified and played through a speaker. The system is built around a Raspberry Pi B+ processor board, which controls the entire setup [11].

3. METHODOLOGY:

A. Design:

Rapid Application Development model is applied to develop the system as shown in Fig. 1. The development process goes through the requirements planning phase, user design phase, construction phase and cutover phase.

- Requirements Planning Phase: In this phase, we analyze problems that occurs among blind people when reading a book, and then determine adequate solutions that might solve the problems. We also identified hardware and software required for the development.

- User Design Phase: In this phase, the problems that occur among visual impairment person is analyzed to determine adequate solution/modules that might help them and their family in having a low cost, portable and easy to use product. The hardware and software required for the development are also identified in this phase.

- Development Phase: In this phase, the system based on design in the user design phase is developed. Early tests to ensure functionality of the system have been done.

- Cutover Phase: In this phase, the functionality of the system is improved based on testing in the previous stage. The overall tests for the developed system are then finalized.

The physical design of the prototype is shown in Fig. 2. The Raspberry Pi is integrated with Pi camera for capturing book pages that will be converted to text. The text will be sent to text to audio converter, where the speaker installed in the Raspberry Pi will play the audio. Tesseract and Flite software are used to implement image-to-text conversion and text-to voice conversion. The software can be accessed through internet using IEEE802.11 standard connectivity, embedded in Raspberry Pi.

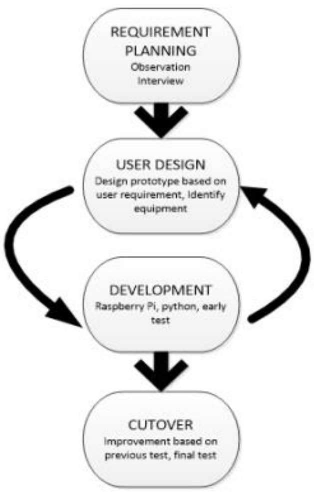

Fig.1. Rapid Application Development Phase.

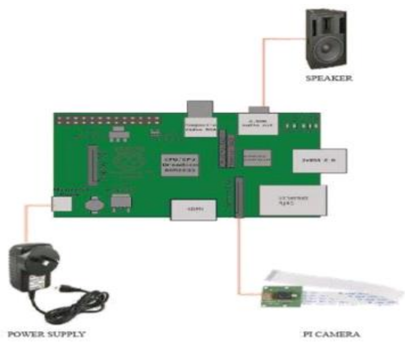

Fig.2. Physical Design of developed book reader.

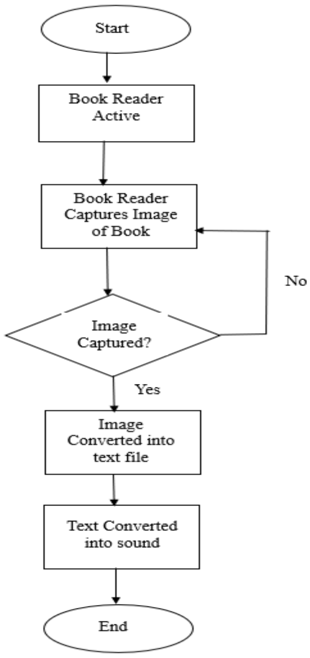

Fig.3. Flow chart of book reader using Raspberry Pi Project.

B. Implementation:

This stage consists of three steps; hardware setup, software setup and book reader setup. The required software and hardware are shown in Table 1.

TABLE I. HARDWARE AND SOFTWARE REQUIREMENT FOR THE DEVELOPED PROTOTYPE

Hardware	Software
• Raspberry Pi Model B	• Python
• Micro SD 32GB	• Flask
• USB Mouse	• Open CV
• USB Keyboard	
• Monitor with HDMI	
• Power Supply	
• USB Wi-Fi	
• Pi Camera	
• Stand	
• Speaker	

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Fig. 4. show hardware setups for the developed book reader. The hardware listed in Table 1 is setup for development purpose only. The finalized prototype only consists of Raspberry Pi embedded with camera, SD card, Wi-Fi and power supply/power bank as illustrated in Fig. 4.

Fig.4. Hardware Setup for Development Purpose.

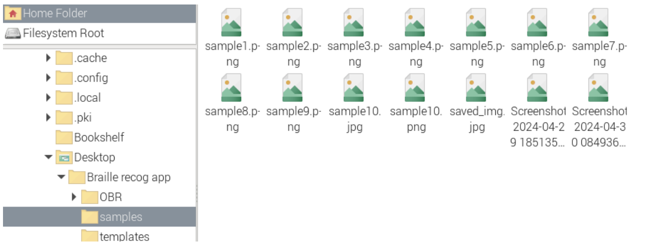

Fig.5.Collection of Captured Image.

For book reader setup, python programming has been used as shown in Fig. 5. The embedded camera is used to capture the image of the book. The captured image is sent to PyTesseract that recognizes the word in the image and converts it into text file. Then PyTTS will read the text file and the text file will be converted to voice and played by speaker.

4. RESULTS AND ANALYSIS:

A. Results

The images are captured in the real time and the braille characters are captured by plotting the regions the characters are fetched it is converted into a text file and the text file is converted to voice output.

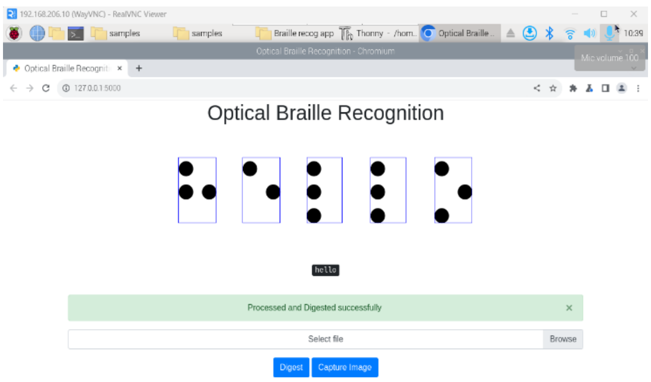

Fig.6. Image captured in real time and the generated output

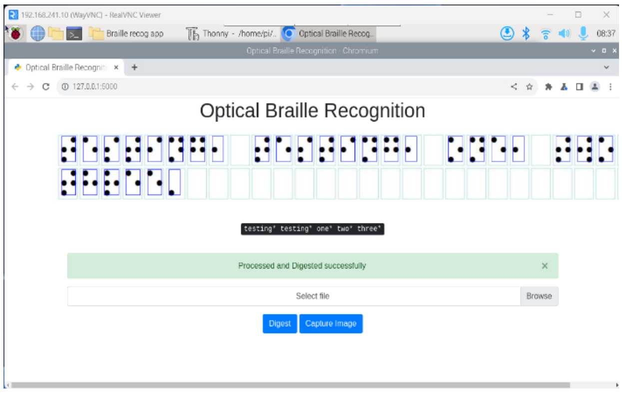

Fig.7. Output for the uploaded Image.

B. Analysis

The accuracy is calculated for the obtained results. By uploading the images to the Raspberry Pi, the accuracy obtained is 100% where we get the exact output for the uploaded images and the graph is plotted as shown in Fig.8.

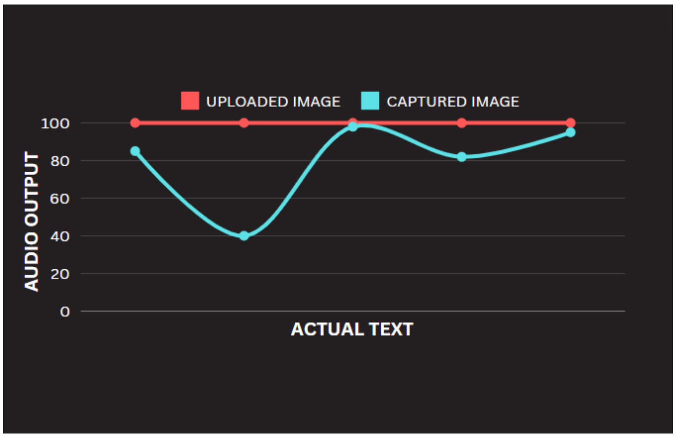

Fig.8.Graph Plotted

The accuracy is calculated for the captured images and the graph is plotted where we get 80% accurate results for it. To achieve the 100% accuracy for captured image the intensity of light should be more and the camera should be placed properly.

5. CONCLUSION:

The Smart Book Reader is an innovative device aimed at assisting visually impaired individuals by removing the requirement to learn braille. This enhancement boosts reading speed and makes literature more accessible. By addressing the difficulties associated with braille education, it ensures equal access to books for the blind. The device represents a significant technological advancement, utilizing deep learning and advanced image processing within its Optical Book Reader (OBR) module to accurately translate English text into audio. Overall, it promotes inclusivity by eliminating obstacles and enabling visually impaired users to access information independently and with ease.

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