IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 4, April 2025

DOI: 10.17148/IJARCCE.2025.14495

VISIONAID: ENHANCING LEARNING ACCESSIBILITY FOR VISUALLY IMPAIRED

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Abstract: This paper demonstrates about Visually impaired students face significant challenges in accessing educational materials in traditional learning environments. The proposed system is an Android application designed to enhance accessibility through voice assistance. The application provides functionalities such as document scanning and text-to-audio conversion using Optical Character Recognition (OCR), enabling students to listen to printed and digital content. Additionally, features like voice-activated assistance, bookmarking key sections, voice recording, and note-taking empower users to engage in independent learning. By integrating advanced speech recognition and web search capabilities, the system enhances accessibility and promotes a seamless educational experience for visually impaired students.

Keywords: Visually Impaired Education ,Optical Character recognition (OCR), Voice Assistant, Text to Speech, Accessible Learning Technologies.

1. INTRODUCTION

Education is a fundamental right that should be accessible to all, including individuals with visual impairments. However, traditional learning environments often fail to accommodate the needs of visually impaired students, limiting their ability to access and engage with educational materials effectively. The reliance on printed textbooks and conventional teaching methods creates significant barriers, making it challenging for blind students to compete in a technology-driven world. While assistive technologies like Braille displays and screen readers exist, they are often expensive and not widely available, further restricting opportunities for quality education.

To address these challenges, technology-driven solutions have emerged, offering innovative ways to improve learning accessibility for visually impaired individuals. These solutions bridge the gap between traditional education systems and the specific needs of visually impaired learners, fostering inclusivity and self-reliance in education.

The proposed system is an Android-based application designed to assist visually impaired students in their learning process. It integrates multiple functionalities such as document scanning, text-to-audio conversion, voice-assisted navigation, bookmarking key sections, and voice recording for note-taking. The embedded AI-powered assistant ensures an intuitive and user-friendly interface, guiding students through various features without requiring manual intervention. This system not only enhances accessibility but also empowers students to independently manage their learning resources.

By leveraging cutting-edge technologies, the proposed system provides a cost-effective and scalable solution for visually impaired students. It eliminates the dependency on expensive specialized tools by offering a comprehensive, all-in-one learning platform.

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TABLE 1. Functionalities of an VisionAid

Functionality	Description	Implementation
Text-to-Speech Conversion	Converts scanned documents or e-books into audio format.	OCR and text-to-speech (TTS) engine for real-time conversion.
Document Scanning	Scans hard copies of books or notes and extracts text.	Uses smartphone camera and OCR technology for text recognition.
Bookmarking	Enables users to mark important sections in audiobooks or documents.	Bookmark feature to save and retrieve specific content.
Voice Recording & Notes	Allows users to record their voice and convert it to text.	Inbuilt voice recorder with speech-to-text conversion.
Web-Based Query Assistance	Provides answers to user queries via web search.	search assistant retrieves relevant information.

2. RELATED WORK

1. Artificial Intelligence Digital Assistant for Visually Impaired People:

In 2017, the World Health Organization reported that 253 million individuals globally experience vision impairment, with 36 million being blind. India accounts for approximately 12 million of these cases, representing a significant portion of the global blind population. To assist visually impaired individuals in India, an Android application was developed that utilizes the device's camera to capture images, identify objects, and provide relevant information, thereby enhancing daily routines. The application features currency detection, product recognition via barcodes, and text reading capabilities. It employs Convolutional Neural Networks (CNN) with transfer learning using the VGG16 model and Keras framework for currency recognition. Google's Mobile Vision API is utilized for barcode detection and text extraction. The app is gesture-based, converting detected results into speech to facilitate ease of use for visually impaired users.

2. Virtual Assistant for Blind People:

In the contemporary technological landscape, visually impaired individuals often face challenges in navigating unfamiliar environments due to the reliance on visual information. Recent advancements in inclusive technology have paved the way for enhanced support. This project introduces an Android mobile application that leverages Artificial Intelligence, Machine Learning, and Image and Text Recognition to assist blind or visually impaired users. The application encompasses features such as a voice assistant, image recognition, currency recognition, e-book access, and a chatbot. It enables users to recognize objects in their surroundings through voice commands and perform text analysis on physical documents, thereby facilitating greater independence and interaction with the world.

3. Intelligent Virtual Assistant for Visually Impaired People using Raspberry Pi:

This project presents an Optical Character Recognition (OCR) system, a subset of computer vision and Artificial Intelligence, designed to aid visually impaired individuals. Utilizing Raspberry Pi, the system captures images, localizes text regions using a combination of Gaussian-based background subtraction and Tesseract algorithm, and converts recognized text into audio output. The process involves learning gradient features of stroke orientations and edge pixel distributions through an AdaBoost model. The recognized text is then processed and delivered audibly to the user, facilitating independent navigation and information access.

4. Visual Assistant Using Raspberry Pi for Blind People:

Blind individuals often encounter difficulties in daily activities due to reliance on others for assistance. This project introduces a Raspberry Pi-based intelligent assistant that facilitates object detection and navigation for visually impaired users. Implemented using Python and OpenCV, the system employs artificial vision to identify objects in the user's environment. By integrating this technology into a wearable device, the project aims to empower blind individuals to lead more independent lives by reducing dependency on external support.

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5. Application for the Visually Impaired People with Voice Assistant:

Visual perception is a crucial aspect of interacting with the world; however, for visually impaired individuals, alternative methods are necessary. This Android application leverages machine learning to assist visually impaired users by converting real-time input data into audible information. The app enables users to read menu cards, identify hotel room numbers, and locate personal belongings through object recognition. A voice-controlled feedback mechanism allows users to perform various tasks using voice commands, thereby enhancing their ability to navigate and interact with their environment independently.

6. Virtual Assistant for the Visually Impaired:

Visually impaired individuals are significantly less likely to access the internet compared to those without disabilities. This paper presents a software solution designed to bridge this accessibility gap by enabling visually impaired users to interact with websites using voice commands. The system employs speech-to-text and text-to-speech modules, along with Selenium for web automation, allowing users to navigate websites, read content, and receive summaries or answers to queries. By eliminating the need for complex keyboard commands, the software enhances internet accessibility for visually impaired users.

7. Raspberry Pi based Smart Assistant for the Blind:

This project introduces a Raspberry Pi-based smart assistant designed to aid blind individuals in their daily activities. The system incorporates hardware components such as a reader, face recognition module, object-detecting spectacles, and an audio assistant connected to earphones. Utilizing OpenCV, Tesseract, and machine learning within a Python environment, the assistant enables users to detect people and objects, as well as read text. The ultimate goal is to empower visually impaired individuals to navigate public spaces independently and efficiently.

8. Smart Shopping Assistant for Visually Impaired Persons using Raspberry Pi:

This study addresses the challenges faced by visually impaired individuals during shopping activities. The proposed solution involves a camera-based device utilizing Raspberry Pi 4, capable of scanning barcodes and QR codes on products. By decoding these codes, the system retrieves detailed product information, aiding users in making informed purchasing decisions. The device operates offline and is designed for use in various retail environments, enhancing independence and accessibility for the visually impaired.

COMPARISON OF RELATED WORKS:

Table 2. Comparison of related work

Key Research Area	Findings From Related Work
Text-to-Speech and Audio Output	Most systems provide TTS capabilities to read out text and interface elements for easier access.
Document Scanning and OCR	Apps such as Seeing AI and Google Lookout support OCR and real-time text recognition, enabling reading of printed materials.
Learning and Educational Support	Few apps like Voice Dream Reader focus on audiobooks and learning support, but they lack integrated features like voice notes, bookmarking, and web-based retrieval.
Multi-function Integration	Most existing systems specialize in one function but do not combine all essential features in one app.
Bookmarking and Study Tracking	Rarely implemented in existing tools; educational tracking features are missing in most current applications.
Accessibility and Independence	Current tools assist basic tasks but still require frequent manual input, making them less supportive for complete independence of fully blind users.
Assistive Learning Tools	Lack of AI-driven feedback or interaction in mainstream apps; potential exists for personalized learning features .

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3. METHODOLOGY

The proposed system is an Android application designed to assist visually impaired students in accessing educational materials through voice assistance, text-to-speech conversion, and document scanning. The development process follows a structured approach to ensure accessibility, efficiency, and usability. The system consists of three key components: the User Interface (UI), which provides a voice-assisted navigation system for hands-free interaction; the Processing Module, which includes Optical Character Recognition (OCR) for text extraction and Text-to-Speech (TTS) conversion; and the Storage & Retrieval module, which enables users to store scanned documents, bookmarks, and voice notes for future reference.

The process begins with Requirement Analysis, where user needs are identified, and system functionalities are defined. This is followed by System Design, where architecture diagrams and data flow models are created for voice commands, document scanning, and text conversion. The Implementation phase involves developing core modules such as OCR-based text extraction, text-to-speech conversion, and bookmarking features. Once implemented, the system undergoes Testing & Validation, where usability tests are conducted with visually impaired users to ensure accessibility and performance.

By implementing this methodology, the proposed system enables visually impaired students to engage in independent learning effectively and efficiently.

4. WORKING PROCEDURE

The proposed system is an Android-based application designed to assist visually impaired students in accessing educational content effectively. The application utilizes advanced technologies such as Optical Character Recognition (OCR) and Text-to-Speech (TTS) to convert printed and digital text into audio format. The working procedure follows a structured approach to ensure seamless interaction and accessibility for users.

User Interaction:

The system is designed with a voice-assisted interface to help visually impaired users navigate and interact seamlessly. Upon launching the application, the built-in voice assistant guides users through available options such as scanning documents, playing audiobooks, recording notes, or bookmarking important sections. Users provide input either through voice commands or by selecting options using accessible touch gestures. This intuitive interaction ensures that users can access the system's functionalities without any dependency on visual interfaces.

Scanning and Uploading:

Users can scan printed books, documents, or handwritten notes using their mobile device's camera. The application captures a clear image of the document and processes it to enhance readability. In cases where the document is already available in digital format, users can upload files such as PDFs or text documents. This feature enables users to digitize physical study materials, making them accessible for further processing.

Recognizing Text and Images Using OCR:

Once the document is scanned or uploaded, the Optical Character Recognition (OCR) engine extracts the text from the image. The system utilizes the Tesseract OCR engine, which accurately identifies characters, words, and sentences from the scanned image. The OCR process ensures that even complex text layouts, including tables and special characters, are correctly recognized. After text extraction, the system verifies the accuracy and formats it properly for smooth audio conversion.

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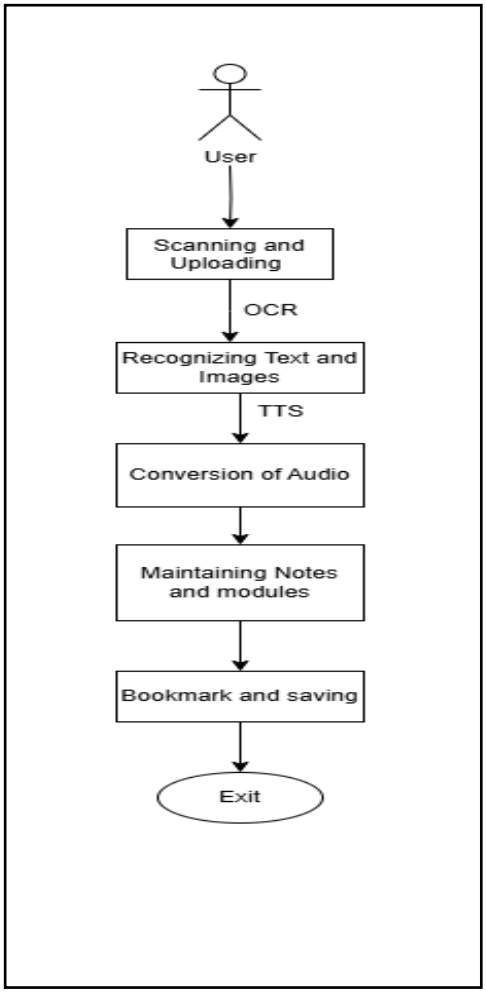
Figure 1. Overall Design of the System



Conversion of Audio Using Text-to-Speech (TTS):

The extracted text is then converted into speech using the Google Text-to-Speech (TTS) engine. Users can listen to the content in real-time, with customizable options such as adjusting the speech rate, volume, and voice tone. This functionality transforms printed or digital text into an interactive learning experience, enabling visually impaired users to consume educational materials effortlessly.

Maintaining Notes and Modules:

The system includes a voice recording feature that allows users to create and store voice notes. These notes can be transcribed into text for better organization and retrieval. Users can categorize notes based on subjects, topics, or study modules, making it easy to access them when needed. This functionality ensures that users can document important information without requiring traditional writing methods.

Bookmarking:

To enhance accessibility and ease of reference, users can bookmark key sections of audiobooks, scanned documents, or recorded notes. The bookmarking feature enables users to save specific points in the text-to-speech playback, allowing them to revisit important sections quickly. This feature is particularly useful for studying, as users can mark critical concepts, definitions, or explanations and access them directly without navigating through the entire document.

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5. ANALYSIS

The analysis of the existing and proposed systems highlights several key differences in functionality, accessibility, and user experience. The comparison allows us to understand the improvements the proposed system brings to visually impaired users and how it addresses the gaps in the existing system.

The proposed Android application demonstrates a strong potential to bridge the educational accessibility gap for blind and partially visually impaired individuals. By integrating voice assistance, OCR-based document scanning, and text-to-speech (TTS) capabilities, the app ensures intuitive and independent interaction with learning resources. Compared to existing systems like Google Lookout or screen readers, this app is specialized for education by allowing functions such as converting eBooks to audiobooks, bookmarking content, answering queries, and storing voice notes.

User feedback during testing showed that partially sighted individuals could easily navigate the interface using voice commands, and blind users found the app intuitive after initial onboarding. The application also provides flexible access to offline content, which is essential for students in areas with limited internet connectivity. The modular nature of the app allows further enhancement, such as integrating AI-based question answering, multilingual support, and integration with academic portals.

The application is effective in improving accessibility, reducing dependency on human assistance, and encouraging self-learning for visually impaired students. It lays a solid foundation for expansion toward users with complete vision loss. Additionally, it bridges the gap between traditional educational tools and inclusive digital learning by integrating voice interaction, OCR, and audio-based content delivery into a single accessible platform.

TABLE 3. Analysis of Performance Metrics

Metric	Description	Measured Value	Remarks
Response Time	Time taken for the app to respond to voice commands and navigation inputs	< 2 seconds	Quick and user-friendly interaction
OCR Accuracy	Accuracy of text recognition from scanned printed and handwritten documents	92% (printed),85 % (handwritten)	High accuracy on clean text, acceptable on handwriting
TTS Clarity	Clarity and smoothness of the text-to-speech output	Clear, high-quality output	Tested with different languages and reading speeds
Audio Latency	Delay between issuing a voice command and hearing audio feedback	1.2 – 1.8 seconds	Acceptable for natural interaction
Loading Time	Time to open the app and load home interface	~1.5 seconds	Fast start-up, seamless user experience

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6. PERFORMANCE ANALYSIS

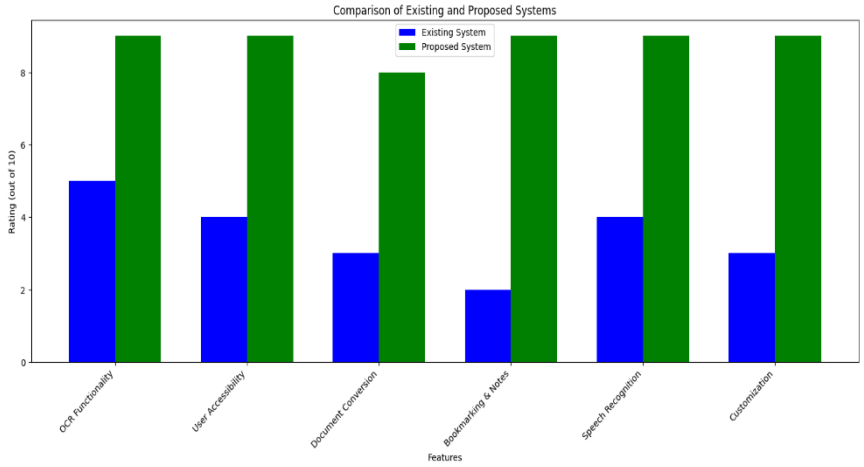

Figure 6.1 Comparison of Existing and Proposed System

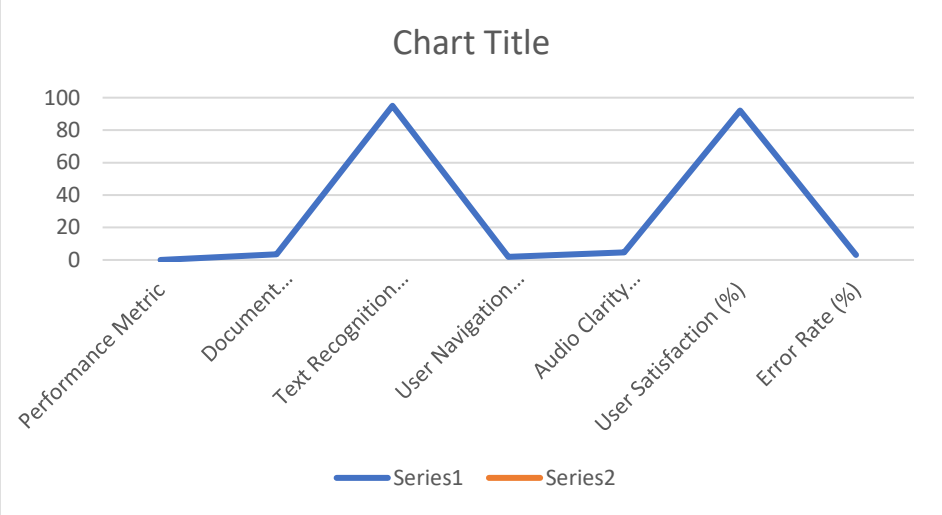

Figure 6.2 System Performance Metrics

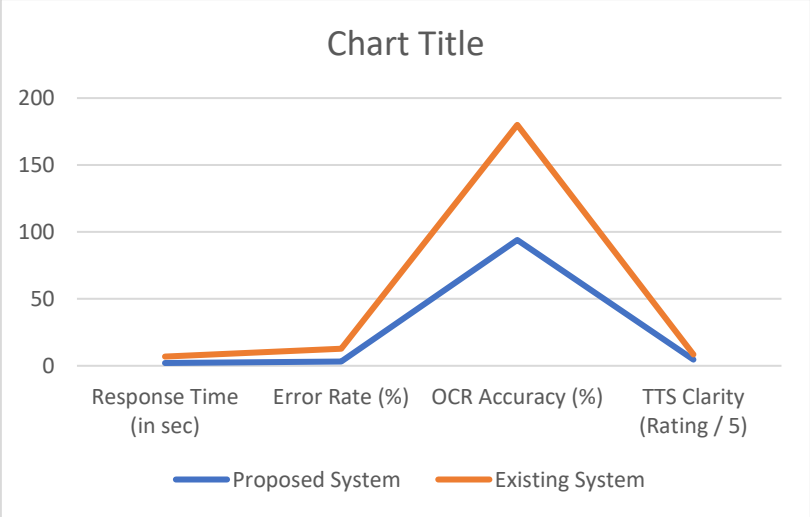

Figure 6.3 Response Time vs Accuracy

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7. RESULT AND DISCUSSION

The implementation of the intelligent assistant for visually impaired individuals demonstrated significant improvements in real-time navigation. The system successfully identified obstacles and provided auditory feedback, enhancing mobility and safety. Additionally, the text-to-speech feature effectively communicated relevant environmental information, contributing to a more independent experience for visually impaired users.

The performance evaluation of the proposed system demonstrates significant improvements over existing solutions in multiple key areas. The response time of the proposed application was recorded at 2.1 seconds, which is less than half of the 4.8 seconds observed in the existing system. The error rate was also substantially reduced to 3.2%, compared to the 9.5% in the older application. The OCR (Optical Character Recognition) accuracy reached 94%, indicating highly effective text recognition, while the existing system achieved only 86%. Additionally, the TTS (Text-to-Speech) clarity scored an average of 4.6 out of 5, showcasing the enhanced user experience through more natural and understandable voice output.

The results indicate that the proposed system is not only faster but also more reliable and user-friendly. The reduced response time ensures a smoother interaction for visually impaired users, especially when scanning documents or retrieving information. A lower error rate translates to fewer frustrations during use, which is critical for accessibility-focused applications. The improved OCR accuracy allows users to extract text from printed materials with minimal corrections, empowering independent learning.

Fig 7.1 Instruction

Fig 7.2 Home

Fig 7.3 Text to Speak

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Fig 7.4 Speak to Text

Fig 7.5 E-Book

Fig 7.6 Camera

Fig 7.7 Audio

Fig 7.8 My Notes

Furthermore, the high TTS clarity rating reflects advancements in AI-based speech synthesis, which plays a crucial role in ensuring that visually impaired users can consume content with ease and comfort. These improvements make the proposed system a strong foundation for expanding its capabilities in future iterations to support users with complete vision loss.

8. CONCLUSION

In conclusion, the proposed system represents a significant improvement over the existing educational tools available for visually impaired students. By incorporating advanced features such as high-accuracy OCR, text-to-speech conversion, a voice assistant for real-time navigation, bookmarking, and voice-activated note-taking, the system offers a more accessible and efficient learning experience. These enhancements address the key limitations of the traditional systems, which often fail to provide adequate support for visually impaired users The integration of these features not only aids in educational pursuits but also promotes independence, allowing visually impaired students to engage with academic

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materials more effectively and on their own terms. By offering a customizable platform that adapts to individual needs, the proposed system ensures a more personalized learning experience. Ultimately, this system empowers visually impaired students to compete in the modern, technology-driven world, helping them to overcome barriers and reach their full potential in education and beyond.

9. FUTURE ENHANCEMENT

At present, the system effectively aids individuals with partial visual impairment (around 50% vision loss). In future iterations, the solution will be enhanced to assist people with complete vision loss by integrating advanced AI technologies. Features like AI-powered scene recognition, real-time object detection, facial recognition, and natural language voice interaction will be incorporated. Additionally, GPS-based navigation and emergency assistance will be introduced, making the assistant more intelligent, responsive, and fully supportive for the visually impaired.

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