International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2025.076
e ISSN: 2584-2854
Volume: 03
Issue:03 March 2025
Page No: 481- 486

Educational Assistant for Visually Impaired People

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Abstract
Developing educational resources that are accessible and effective for visually impaired individuals remains a significant challenge. Traditional learning tools often lack the necessary features to accommodate their needs, resulting in limited educational opportunities and resources. The current gap in accessible educational tools hinders the ability of visually impaired individuals to learn independently and efficiently. To address this issue, we propose to develop a mobile application using Flutter, designed specifically to serve as an educational assistant for visually impaired people. This application will aim to provide an intuitive and user-friendly interface, leveraging voice commands, screen readers, and other assistive technologies to enhance the learning experience and ensure that visually impaired users can access educational content with ease.
Keywords: *Voice Interaction, Text to Speech, Natural Language Processing, Audio books*

1. Introduction
The proposed project aims to develop an accessible mobile application using Flutter to empower visually impaired individuals by enhancing their educational and daily activities. The application leverages advanced voice-user interfaces, assistive technologies, and AI-driven functionalities to address challenges in accessing educational resources and performing routine tasks independently. It offers features like text-to-audio conversion for transforming e-books and documents into audiobooks, voice-controlled web search for seamless information retrieval, and tools for creating, organizing, and bookmarking notes. The app integrates Optical Character Recognition (OCR) to convert physical documents into digital, audio-friendly formats and employs assistive AI for personalized user experiences. Developed for cross-platform compatibility, it ensures ease of use with a fully voice-activated interface and personalization options like audio speed and language preferences. This project marks a significant advancement toward creating an inclusive learning environment where visually Hsu et al. assessed the accessibility of educational websites for blind users, evaluating compliance impaired accessibility, navigation efficiency individuals can independently access resources and thrive.

2. Literature Review
In the literature review, we examined existing projects related to this topic to understand the behavior of current systems. G. Lathkar et al. reviewed mobile assistive technologies for visually impaired users, highlighting advancements in accessibility and their impact on user independence, with a focus on emerging assistive applications [1]. F. Oriani et al. developed a mobile web browser specifically designed for visually impaired users, enhancing web accessibility, navigation efficiency, and overall independence [2]. M. Rey-Galán et al. evaluated mobile applications for visually impaired individuals, identifying key areas for improving accessibility and usability to enhance user experience and inclusivity [3]. Additionally, M. Schmitz et al. introduced a smartphone-based indoor navigation system, conducting usability tests to improve navigation accuracy and user experience [4]. Furthermore, G. Kouroupetroglou et al. analyzed smartphone-based learning tools for visually impaired students, emphasizing inclusive design and accessibility features that enhance learning experiences [5]. H. Nicolau et al. examined the accessibility of e-learning platforms for blind users, identifying usability challenges and recommending improvements for a more inclusive online learning environment [6]. M. D. Dunlop et al. designed and

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tested a tactile tablet interface for blind users, focusing on improving interaction and accessibility through touch-based feedback [7]. Moreover, Y.-C. Hsu et al. assessed the accessibility of educational websites for blind users, evaluating compliance with established accessibility guidelines and identifying areas for improvement [8]. These studies collectively highlight the advancements, challenges, and potential improvements in assistive technologies for visually impaired individuals, emphasizing the need for user-centric designs that promote accessibility and inclusivity.

3. Module Implementation

In the educational assistant for visually impaired people, ensuring accessibility and effectiveness is essential, as traditional learning tools often lack necessary features, limiting independent learning. To address this, we developed a Flutter-based mobile application designed to assist visually impaired users. The app features an intuitive interface with voice interaction, text-to-speech, speech-to-text. By incorporating these technologies, our application provides an accessible and inclusive learning experience, empowering visually impaired individuals to engage with educational content more effectively.

3.1 Modular Architecture

In the Educational assistant for the visually impaired people, we developed an app. The app processes PDFs as input, analyzes their content, and delivers it through speech to assist blind users in understanding. Users can also ask queries related to the PDF, which are answered by an AI model, ensuring an accessible and interactive learning experience for visually impaired individuals.

3.2 Analyzing the Input

The input PDF file is processed to extract its text content using specialized libraries. The extracted text is then analysed by an AI model for understanding, including summarization, semantic analysis, or entity recognition by using Natural language processing. The process of extracting, analysing, and formatting text from a PDF file involves multiple technical steps. These steps ensure the information is processed effectively for downstream tasks like summarization and text-to-speech conversion, which are particularly beneficial for visually impaired users.

3.3 Explain the contents through speech

Text-to-Speech (TTS) converts the AI-generated explanation or summary into speech, making it accessible for visually impaired users. In Flutter, this is achieved using the flutter_tts package, which transforms text into natural-sounding voice output, enabling users to listen to content effortlessly and enhancing their learning experience.

3.4 Responding to User Queries

After explaining the contents, the app must accurately process user queries through speech. This involves converting speech to text, interpreting the query, processing it with an AI model, and delivering a response via speech.

4. System Architecture

Figure –1 The architecture of the system illustrates how various components interact to process and deliver educational content for visually impaired users. The flow begins with PDF input processing and proceeds through several stages, culminating in AI-driven query resolution and speech output. The system enhances accessibility by processing user-uploaded PDF documents. It extracts and analyzes content, generating a concise summary converted into speech for easy listening. Users can also ask queries related to the document, and the AI model retrieves and delivers responses through speech. This is particularly beneficial for visually impaired users, enabling independent access to text-based content. By integrating natural language processing and text-to-speech technology, the system improves document accessibility, promotes independent learning, and enhances user interaction. The AI-driven speech response ensures a seamless, engaging, accessibility and usability to enhance user experience and inclusivity interpreting the entrance and essential, as traditional learning tools often lack necessary features, limiting independent learning. To address this, we developed a Flutter-based mobile application designed to assist visually impaired users. The app features an intuitive interface accessibility, navigation efficiency challenges, and potential emphasizing of with voice interaction, text-to-speech, inclusive experience

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e ISSN: 2584-2854
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for all users. Figure 1 shows System Architecture

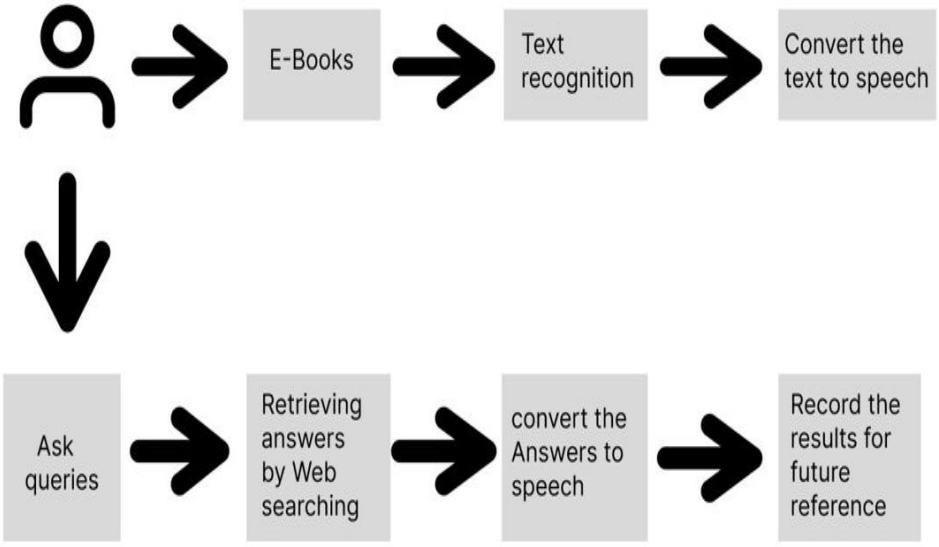

Figure 1 System Architecture

4.1 Get Input from User

The educational assistant processes e-books and PDFs through a user-friendly interface for visually impaired users.

- File Selection & Validation: Uses file_picker for browsing, ensures supported formats (PDF/ePub), and handles errors gracefully.
- File Parsing & Error Handling: Extracts text using syncfusion_flutter_pdf (PDF) and epubx (ePub), with try-catch blocks for errors.
- User Feedback: Displays progress indicators and provides speech confirmation upon successful file processing.

4.2 Analyze the content

The input PDF file is processed to extract its text content using specialized libraries. The extracted text is then analyzed by an AI model for understanding, including summarization, semantic analysis, or entity recognition by using Natural language processing. The process of extracting, analyzing, and formatting text from a PDF file involves multiple technical steps. These steps ensure the information is processed effectively for downstream tasks like summarization and text-to-speech conversion, which are particularly beneficial for visually impaired users. Here's a more detailed breakdown of the components:

- Text Extraction & Cleaning: Uses pdf_text for text-based PDFs and OCR tools for scanned ones, removing unnecessary symbols and structuring content for readability.
- NLP Analysis: Applies OpenAI's API for summarization, entity recognition, and sentiment analysis, ensuring secure and scalable processing.
- Formatting & Accessibility: Organizes text into sections, retains essential formatting, and optimizes it for text-to-speech conversion and better user interaction

4.3 Explain the contents through speech

The Flutter app integrates AI to extract, analyze, and explain PDF content through speech, enhancing accessibility for users.

- Text Extraction: Uses pdf_text to retrieve text from PDFs, ensuring proper structuring and readability for further processing.
- AI Processing: Implements an NLP-based AI model via OpenAI's API to analyze content, perform summarization, sentiment analysis, and answer user queries, making the extracted text more meaningful.

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- Text-to-Speech (TTS): Converts the AI-generated explanation into speech using flutter_tts, enabling a clear and interactive user experience.

4.4 Responding to User Queries

Voice-based interaction is crucial for accessibility-focused AI-driven apps, enabling users to query and receive responses through speech. The process involves multiple stages to ensure accurate interpretation and meaningful interaction.

- Speech-to-Text Conversion & Query Understanding: Uses speech_to_text to convert voice input into text, followed by NLP techniques for intent recognition, context understanding, and query rectification to improve accuracy. [9]
- Storing & Retrieving Conversations: Firebase stores user queries and AI responses, allowing retrieval based on time or keywords. Firestore or Realtime Database ensures real-time syncing of chat history for personalized interactions. [11]
- Text-to-Speech Playback: Retrieved chats are read aloud using flutter_tts, enabling users to listen to past interactions through voice commands like "Tell me what I asked yesterday," enhancing accessibility and engagement. [12]

5. Implementation of The System

This section outlines the step-by-step process of implementing the App, from text extraction to AI-driven analysis and speech-based interaction. Each phase is designed to enhance accessibility, ensuring seamless integration of NLP, text-to-speech, and real-time user engagement for an intuitive learning experience. [13]

5.1 Initial Setup

To set up the Educational Assistant App, start by installing Flutter & Dart and creating a new project using flutter create edu_assistant. Navigate into the project and add dependencies in pubspec.yaml for key functionalities. Use pdf_text for extracting text from PDFs, flutter_tts for text-to-speech conversion, and speech_to_text for processing voice input. Integrate Firebase (firebase_core, cloud_firestore) to store user queries and responses for retrieval. Configure API access for OpenAI to enable NLP-based content understanding. Set up Firebase authentication if user accounts are required. Finally, structure the UI with a simple home screen allowing users to upload PDFs and interact via voice. [14]

5.2 Work Flow

The following steps outline the operation of the Educational Assistant App, ensuring efficient text extraction, AI-driven analysis, and interactive speech-based responses for visually impaired users.

- User Input & File Processing: Users upload e-books or PDFs through a user-friendly interface. The app validates file formats (file_picker), extracts text (syncfusion_flutter_pdf), and provides speech-based feedback. [15]
- Content Analysis & AI Processing: Extracted text is processed using NLP techniques via OpenAI's API for summarization, entity recognition, and sentiment analysis, ensuring meaningful content representation.
- Speech-Based Explanation & Interaction: AI-generated summaries are converted to speech using flutter_tts, and users can query the system via voice. Queries are processed (speech_to_text), stored in Firebase for retrieval, and played back when needed.

6. Results

The implementation of assistive technologies such as Optical Character Recognition (OCR), text-to-speech (TTS), and voice-user interfaces has significantly improved educational accessibility for visually impaired individuals. These innovations enable independent learning by converting text into audible formats, facilitating efficient interaction with educational materials. Personalized learning experiences through adaptive applications enhance comprehension and retention, while digital platforms help bridge educational gaps. As a result, visually impaired students experience improved academic performance, greater autonomy, and increased confidence in their learning abilities. Continuous advancements in accessible technology will further promote inclusivity and equal educational opportunities. Figure 1 illustrates the home page of the system, which features an "Upload PDF" button.

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By clicking this button, users are navigated to the upload page, as shown in Figure 2, where they can select and upload a PDF document. Once the PDF is uploaded, the system processes its content, generating a summary and converting it into speech. Figure 3 depicts the stage where the analyzed content is delivered to users through speech output. This seamless navigation ensures an intuitive user experience, enabling efficient document processing and accessibility, particularly benefiting visually impaired users through AI-driven text-to-speech technology. Figure 2 shows Home Page, Figure 3 shows Uploading PDF, Figure 4 shows Explaining PDF Contents Through Speech

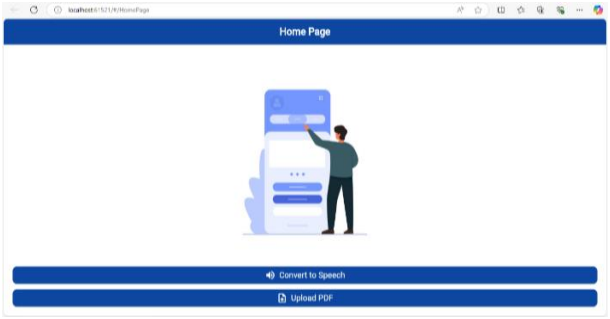

Figure 2 Home Page

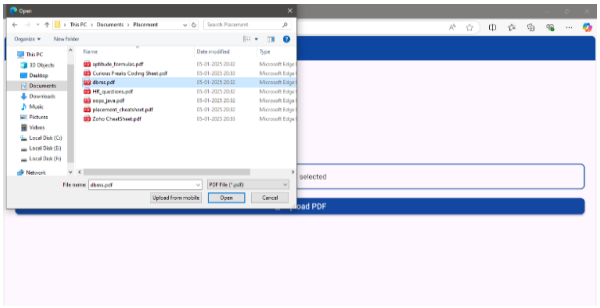

Figure 3 Uploading PDF

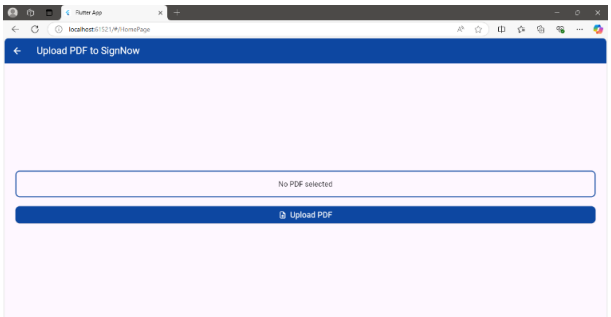

Figure 4 Explaining PDF Contents Through Speech

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