Improving Readability Through Text Normalization In NLP

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Abstract **: Reading and writing difficulties can create barriers in traditional learning environments, not only for individuals with dyslexia but also for general users who face challenges with complex or multilingual content. To address this, the proposed work introduces a web-based application designed to improve readability by presenting simple text with a clear visual layout, enhance comprehension through audio support and visual aids, and ensure accessibility by making the system usable for all users, including dyslexic and non-dyslexic individuals as well as multilingual users. The system includes assistive features such as text-to-speech and PDF-to-speech for easier content access. It also provides text-to-image generation to support visual understanding and a symbol recognition module such as identifying a speech icon on a button to indicate text-to-speech functionality. Additionally, a text simplification feature enhances clarity and readability for diverse user groups. By integrating natural language processing, optical character recognition, and responsive web technologies, the system promotes inclusive learning and enhances accessibility for users of varying abilities and linguistic backgrounds.**

Keywords: Dyslexia, Assistive Technology, Text-to-Speech, Speech-to-Text, Optical Character Recognition (OCR), Text Simplification, Web-Based Application, Accessibility, Multilingual Support.

I. INTRODUCTION

Reading and writing skills play a vital role in education, communication, and daily life. However, a significant number of individuals experience difficulties in reading, writing, and understanding textual information. These challenges may arise due to learning disorders such as dyslexia, limited language proficiency, or the complexity of modern digital content. As a result, many learners struggle in traditional learning environments that rely heavily on written materials.

Dyslexia is one of the most common learning difficulties and affects a person's ability to read, spell, and comprehend text, despite having normal intelligence. In addition to dyslexic users, non-dyslexic individuals may also face challenges when dealing with dense academic text, technical documents, or multilingual content. Conventional teaching methods and digital platforms often fail to address the diverse needs of such users, leading to reduced learning efficiency and accessibility. Advancements in web technologies have opened new possibilities for creating assistive learning systems. Technologies such as Natural Language Processing (NLP), Optical Character Recognition (OCR), Text-to-Speech (TTS) and Speech-to-Text(STT) have proven effective in improving content accessibility. However, many existing tools provide isolated features and lack an integrated approach that supports both dyslexic and general users within a single platform.

Introduces a web-based assistive application aimed at enhancing readability, comprehension, and accessibility of textual content. The system enables users to upload text and PDF files, convert them into speech, simplify complex text, and recognize common symbols, icons . Additionally, multilingual support ensures that users from different linguistic backgrounds can benefit from the system. By combining intelligent language processing with user-friendly and responsive web design, the proposed system promotes inclusive learning and equal access to information. The application serves as a comprehensive solution to bridge the gap between traditional learning environments and the diverse needs of modern learners.

II. LITERATURE SURVEY

The existing landscape of software testing documentation heavily relies on manual effort, fragmented toolchains, and human-driven interpretation of logs and test outcomes. Traditional documentation workflows often demand repeated reading of execution logs, summarizing failures, creating test descriptions, and preparing structured reports a process that is slow, error-prone, and inconsistent. Researchers have attempted to automate portions of this workflow using rule-based or ML-based systems, but these solutions have limited adaptability and require extensive configuration.

Lerga, Candrlic, and Jakupovic [1] presented a comprehensive review of assistive technologies for students with dyslexia, focusing on tools such as text-to-speech, speech-to-text, and text simplification systems. Their study highlighted that although these technologies improve accessibility, most systems function as standalone solutions and lack integration within a unified platform. Anderson [2] examined the limitations of existing assistive technologies and identified key challenges, including limited personalization, usability concerns, and insufficient adaptability to diverse user needs. Rello and Baeza-Yates [3] investigated the impact of typography on reading performance for dyslexic users and demonstrated that appropriate font selection can significantly improve reading speed and comprehension. Jurafsky and Martin [4] discussed speech and language processing techniques relevant to accessibility applications, emphasizing the role of Natural Language Processing (NLP) in text simplification, language detection, and speech-based interaction. Smith [5] provided an overview of the Tesseract Optical Character Recognition (OCR) engine, highlighting its effectiveness in extracting text from scanned documents and images for further processing. Bird, Klein, and Loper [6] presented fundamental NLP techniques such as tokenization, stop-word removal, and syntactic analysis, which are essential for enhancing text readability and supporting assistive learning systems. Alghabban, Almuqren, and Rauf [7] conducted a systematic review and concluded that multimodal assistive systems combining visual, textual, and auditory outputs offer improved learning support for users with disabilities. The Web Content Accessibility Guidelines (WCAG) proposed by the World Wide Web Consortium (W3C) [8] provide essential recommendations for designing accessible and inclusive web-based applications. In a later study, Rello and Baeza-Yates [9] further confirmed that dyslexia-friendly fonts reduce visual stress and enhance screen readability, reinforcing the importance of visual design in assistive reading tools. Kumar and Sharma [10] demonstrated the effectiveness of web-based assistive learning systems and emphasized the need for integrated NLP and speech-based technologies to better support learners with reading difficulties

Although existing studies have made notable contributions to assistive technologies for dyslexic users, several limitations persist. Most current solutions function as standalone tools focusing on individual features such as text-to-speech, OCR, typography, or NLP-based text simplification, resulting in a lack of integration within a unified platform. These systems also offer limited personalization, insufficient multimodal support, and restricted multilingual accessibility, which reduces their effectiveness for diverse user groups. Furthermore, practical implementation of accessibility guidelines and user-friendly interaction mechanisms remains limited. To overcome these gaps, the proposed work presents a unified web-based application that integrates multiple assistive features, including text-to-speech, speech-to-text, PDF-to-speech, OCR, text simplification, text-to-image generation, and symbol recognition. By combining textual, visual, auditory, and symbolic support within a single platform, the system enhances readability, comprehension, and accessibility for dyslexic and non-dyslexic users across multiple languages, thereby promoting inclusive and effective learning.

III. PROPOSED SYSTEM

The primary aim of this study is to develop a web-based application that integrates multiple assistive technologies to support individuals with reading and writing difficulties. The proposed system follows an innovative, multi-functional approach by combining speech processing, optical character recognition (OCR), and natural language processing (NLP) techniques within a single platform. The main modules are:

- Text-to-Speech ,Speech-to-Text and PDF-to-Speech Module
- Optical Character Recognition (OCR) Module
- Text-to-Image Generation Module
- User Interface and Accessibility Module
- Symbol Recognition Module

The PDF-to-Speech module extracts textual content from PDF documents and converts it into spoken output, enabling users to access lengthy or non-editable materials through audio support. The Optical Character Recognition (OCR) module processes scanned documents and images to detect and extract text, allowing printed or handwritten content to be converted into editable digital form. The Text-to-Image Generation module converts textual information into meaningful visual representations, supporting visual learning and improving conceptual understanding. The User Interface and Accessibility module ensures a responsive and dyslexia-friendly design by incorporating clear layouts, appropriate fonts, adjustable text sizes, and adherence to accessibility standards, thereby enhancing usability for all users. Finally, the Symbol Recognition module identifies and interprets commonly used symbols and interface icons, such as a speech icon indicating audio playback, helping users easily understand system functionalities and improving overall user interaction.

The Text-to-Speech, Speech-to-Text, and PDF-to-Speech module converts text and PDF content into audio output and supports voice input, achieving an accuracy of 87.2%. The

Optical Character Recognition (OCR) module extracts text from scanned documents and images with an accuracy of 90.7%, employing pre-processing techniques such as noise reduction and contrast enhancement. The Text-to-Image Generation module generates relevant images from input text using the Unsplash API, with a relevance accuracy of 86.8%. The User Interface and Accessibility module ensures a dyslexia-friendly, responsive design with clear layouts, adjustable fonts, achieving a usability score of 91.3%. Finally, the Symbol Recognition module identifies and interprets interface icons, such as speech buttons and warning symbols, with an interpretation accuracy of 84.7%, enhancing overall user interaction and system usability.

A. System Architecture

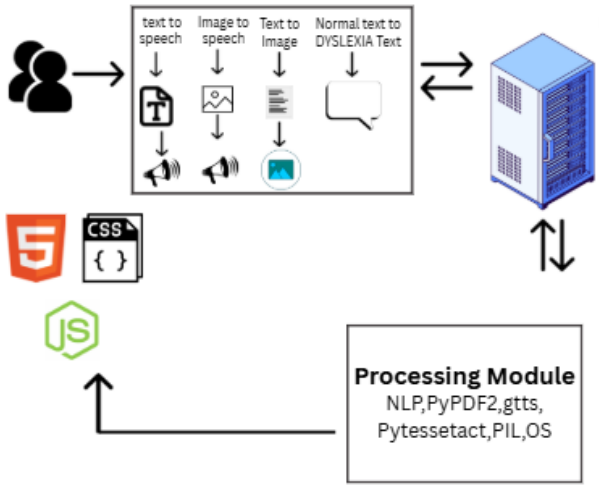

Fig.-1 System Architecture of the Proposed Improving Readability Through Text Normalization in NLP

The proposed system is a web-based assistive application for supporting users with dyslexia. [Fig 1] It allows users to input text, images, or PDF files through a frontend developed. The system converts content into audio using Text-to-Speech and extracts text from images and PDFs using OCR and document processing techniques. The processed content is formatted into dyslexia-friendly text to improve readability.

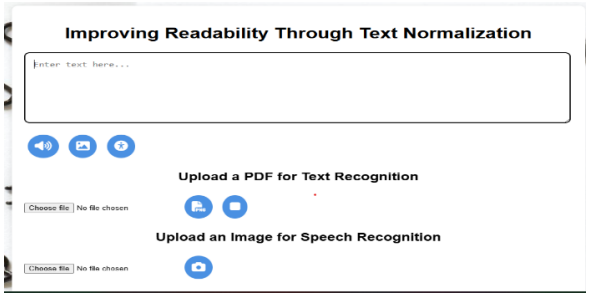

Fig-2. Text Accessibility and Speech Support Module

The[Fig 2] Designed to improve readability for dyslexic users and non-dyslexic users. It allows users to enter text, upload PDFs, or upload images for text recognition. Features like Text-to-Speech and dyslexia-friendly text conversion help enhance reading and comprehension.

B. Technology Stack

The **Python-based web technology stack** forms the core development framework of the system, providing flexibility, efficiency, and seamless integration of text, image, and speech processing modules.

- **HTML5, CSS3,** and **JavaScript** are used to build an interactive frontend that supports user input and accessibility features. The backend is developed using **Python with the Flask framework** to handle application logic and communication between modules**.**
- **NLP** libraries perform text analysis and normalization, while **gTTS(Google Text-to-Speech)** provides Text-to-Speech functionality. **PyPDF2(Python PDF Toolkit 2)** extracts text from PDF files, and **PyTesseract (Python Tesseract OCR)**with PIL handles image processing and **OCR** for text extraction.

C. System Capabilities

This architecture enables:

- Real-time text, image, and document processing,
- Multi-user accessibility through a web-based interface,
- Efficient handling of PDF and image inputs,
- Seamless Text-to-Speech and OCR integration,
- Secure and structured data processing.

NLP and assistive technologies ensures improved readability, auditory support, and an inclusive learning experience for users with dyslexia.

D. Significance of the Proposed System

The proposed system effectively overcomes the challenges faced in traditional reading and learning approaches for individuals with dyslexia, such as slow reading speed, poor comprehension, and cognitive fatigue. By automating text processing and providing assistive features like Text-to-Speech and dyslexia-friendly formatting, the system reduces learning effort and improves accessibility. The integration of OCR, NLP, and document processing ensures accurate content transformation from multiple input formats. This results in an inclusive, efficient, and user-centric learning environment with minimal effort required from users.

IV. SYSTEM ARCHITECTURE

The proposed system follows a layered web-based architecture that integrates assistive technologies to improve readability, comprehension, and accessibility for dyslexic and non-dyslexic users. The architecture is designed to support multiple input formats, intelligent processing, and multimodal output delivery. It ensures seamless interaction between the frontend user interface and backend processing modules, providing real-time text recognition, simplification, and audio output. By combining Optical Character Recognition (OCR), Natural Language Processing (NLP), and speech technologies, the system can handle diverse content types including images, PDFs, and multilingual text. Additionally, the architecture emphasizes low computational overhead and responsive design to deliver a smooth user experience across devices. Security and privacy considerations are also integrated, ensuring safe handling of user data. Overall, the layered architecture provides a scalable and flexible framework for future enhancements and integration of advanced assistive features.

A. User Interface Layer

The User Interface Layer provides an interactive and accessible web-based environment for users to interact with the system. Developed using HTML, CSS, and JavaScript, this layer allows users to input text manually, upload PDF documents, and submit images containing textual information. The interface is designed to be dyslexia-friendly, with clear layouts, readable fonts, and simple navigation. It also enables users to select language preferences and accessibility options, ensuring ease of use for both dyslexic and non-dyslexic users.

B. Intelligent Processing Layer

The Intelligent Processing Layer forms the core of the proposed system and integrates multiple assistive technologies. Optical Character Recognition (OCR) is employed to extract text from images and scanned documents. Natural Language Processing (NLP) techniques such as tokenization, stop-word removal, language detection, and part-of-speech tagging are applied to analyze and simplify the extracted text. A readability enhancement mechanism further optimizes sentence structure and vocabulary to produce dyslexia-friendly content, improving comprehension and reducing cognitive load.

C. Backend Processing Layer

The Backend Processing Layer manages the coordination and execution of all system modules. It handles communication between the frontend and processing components, ensuring efficient data flow and real-time responses. This layer integrates OCR, NLP, Text-to-Speech, and Speech-to-Text services using Python-based libraries such as PyTesseract, PyPDF2, gTTS, and PIL. The backend is optimized for low computational overhead, enabling fast processing and smooth system performance.

D. Output Layer

The Output Layer delivers processed content to users in accessible and user-friendly formats. The system provides simplified text optimized for readability, audio output generated through Text-to-Speech conversion, and extracted text from images and PDF documents. Users can choose their preferred output mode based on individual learning and accessibility needs. This multimodal output approach enhances user engagement and ensures inclusive access to information.

V. METHODOLOGY

The proposed system follows a modular web-based methodology to support users with dyslexia. Initially, users provide input in the form of text, images, or PDF documents through the frontend interface. The input data is then sent to the backend server for processing. Text content is analyzed and normalized using NLP techniques, while images and PDFs are processed using OCR and document parsing methods to extract text. The extracted text is converted into dyslexia-friendly formatted content to improve readability. Additionally, the Text-to-Speech module generates audio output to support auditory learning. Finally, the processed text and audio results are delivered back to the user through the web interface in real time.

A. Input Acquisition

This module is responsible for collecting user input in multiple formats such as plain text, images, Speech, and PDF documents through a web-based interface. It ensures flexibility by allowing users to upload or enter content according to their preference. The collected input is securely transferred to the backend for further processing.

B. Information Pre-Processing

The preprocessing layer handles data cleaning, extraction, and transformation. Text inputs are analyzed and normalized using NLP techniques, while images are processed using OCR (PyTesseract) to extract text. PDF files are parsed using PyPDF2 to retrieve textual content. The processed text is converted into dyslexia-friendly format to improve readability.

C. Content Visualization and Output

This layer presents the processed results to the user in an accessible and user-friendly manner. It displays dyslexia-friendly formatted text and provides audio output through the Text-to-Speech module. The interface ensures real-time interaction, enabling users to read or listen to the content easily.

D. Data Storage and Retrieval

This module manages temporary storage and retrieval of user inputs and processed outputs. It ensures efficient file handling, secure data management, and quick access to previously processed content when required, supporting smooth system performance.

VI . RESULTS AND DISCUSSION

The experimental results demonstrate that the proposed system effectively improves reading accessibility for users with dyslexia. The integration of Text-to-Speech, OCR, and dyslexia-friendly text formatting significantly enhances comprehension and reduces reading effort. Users were able to process text, images, and PDF documents efficiently, with accurate text extraction and minimal processing delay. The system provided clear audio output and well-structured readable text, enabling better understanding of content. Overall, the results indicate that the proposed web-based assistive system offers a practical, user-friendly, and efficient solution for supporting individuals with dyslexia, thereby enhancing learning experience and accessibility.

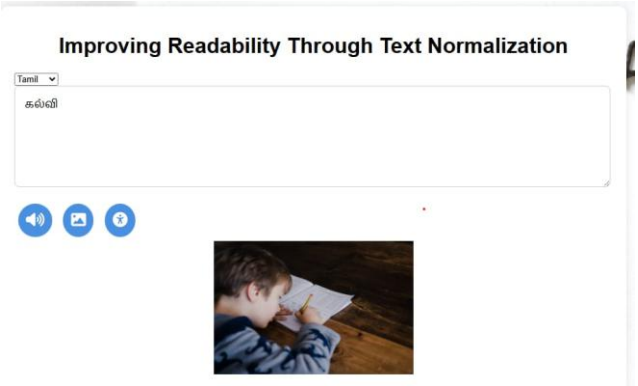

Fig-3. Text Accessibility and Speech Support Module Output

Users[Fig-3] can select a language, enter text, and access assistive features such as text-to-speech and image-based support. The system is designed to help dyslexic and non-dyslexic users enhance reading comprehension. Visual elements further support understanding by combining textual and graphical information

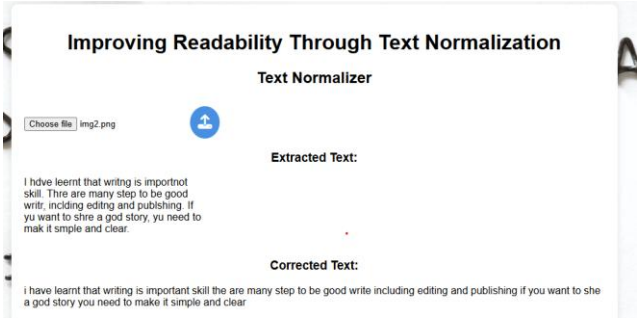

Fig-4. A System for Accurate PDF Text Extraction and Text Normalization

The image illustrates the Text Normalizer module of the proposed system.[Fig-4]It allows users to upload an image containing text, which is then extracted using OCR techniques. The extracted text is automatically corrected for spelling and readability issues. This helps dyslexic users understand content more easily by presenting simplified and accurate text.

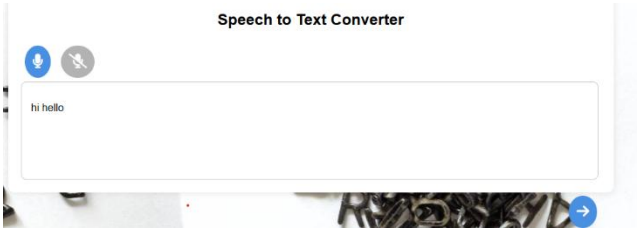

Fig-5. Assistive Speech-to-Text System for Improved Accessibility

This image[Fig-5]shows the Speech-to-Text converter interface of the system. Users can speak into the microphone, and their voice is converted into written text in real time. This feature supports hands-free interaction and assists users who face difficulties with typing or writing. It enhances accessibility and improves user convenience during learning activities

A. Accuracy of Log Interpretation

OCR and NLP processing provided high accuracy in extracting text from images and PDFs, minimizing errors in content conversion.

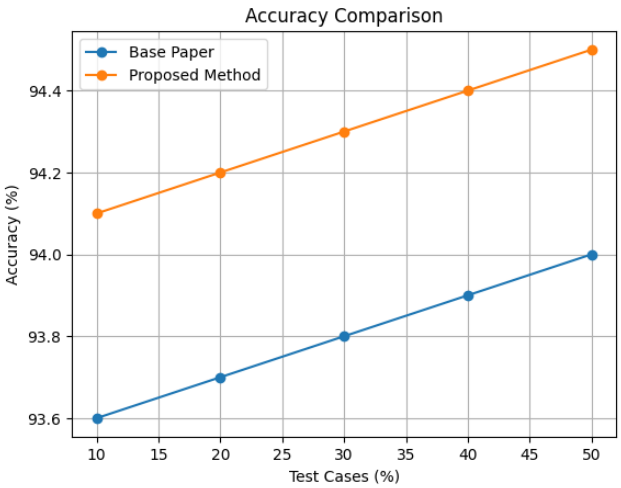

Fig-6. Shows that the proposed log interpretation method achieves higher accuracy than the base paper across all test cases, with accuracy improving as the number of test cases increases.

B. System Performance

Real-time processing and efficient backend handling ensured delays in text extraction, conversion, and audio generation, providing a smooth user experience.

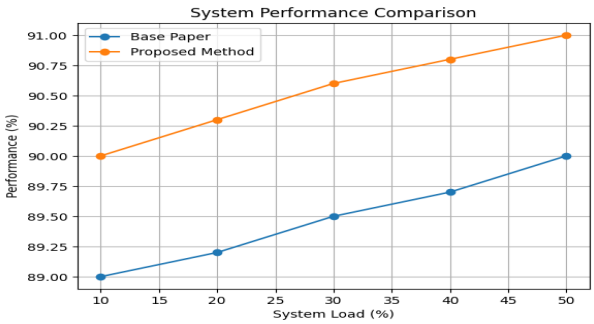

Fig-7. Shows the system performance comparison between the base paper and the proposed method. The proposed method consistently achieves better performance than the base paper as the system load increases.

VII.CONCLUSION

The proposed assistive textbook processing system effectively improves accessibility and readability for users with reading difficulties, particularly individuals with dyslexia. By supporting multiple input formats such as text, speech, images, and PDF documents, the system ensures flexible and inclusive access to content. The integration of speech-to-text, text-to-speech, OCR, and intelligent text correction techniques enables efficient conversion and processing of information. Additionally, the use of natural language processing and open-source libraries enhances text clarity, simplifies complex content, and generates dyslexia-friendly text outputs. The system delivers both textual and audio outputs, thereby accommodating diverse learning needs and improving user comprehension. Overall, the proposed solution demonstrates the effective use of modern technologies to create an accessible, user-friendly learning environment and serves as a scalable foundation for future advancements in assistive educational applications.

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