

A Survey on Dyslexia Reading Assistants: Integrating Natural Language Processing, and Adaptive Interfaces for Enhanced Literacy and Accessibility

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Abstract—This project will introduce ZYLO, an AI-powered Dyslexia reading assistant using deep learning and natural Language processing and adaptive interface technologies to Deliver a personalized multi-sensory reading experience for Individuals with dyslexia. Users interact with the system through a web application which processes digital text and transforms it into optimized formats using real-time text Adaptation, syllable segmentation and readability enhancement by means of adjustable font spacing-color. AI Layer Incorporates Text-to-Speech with synchronized providing highlighting and interactive pronunciation feedback to Reinforce reading comprehension. To ensure effective learning This system includes personalized reading speed during progression, control and progress tracking analytics. Having a strong Python Backend architecture, responsive JavaScript frontend and Intelligent adaptation engine, ZYLO redefines traditional reading support tools by making them intelligent, user-centered, and empowering for neurodiverse learners.

Keywords— *Artificial Intelligence, Deep Learning, Natural Language Processing, Dyslexia, Reading Assistant, Text-to-Speech, Adaptive Learning, Educational Technology, Accessibility, Multi-Sensory Learning*

I. INTRODUCTION

Artificial intelligence, natural language processing, and educational technologies are widely used in digital reading assistance systems. In the literature about dyslexia support tools, there are two dominant directions of research, including: (i) text-to-speech-based solutions that develop strategies for improving reading comprehension, by means of audio rendering and synchronized highlighting; and (ii) adaptive interface solutions, where the deep learning models are integrated into text simplification, syllable segmentation, and personalized presentation of the content. The aim of this review is to present enduring challenges, to compare the methodologies, and to synthesize current contributions toward an intelligent reading assistance system based on AI technologies designed for dyslexic users. This work hence represents the integration of multisensory feedback mechanisms with personalized learning pathways—one of the most important recent developments in accessible educational technologies that accommodate the unique cognitive processing needs of neurodiverse learners while ensuring

engagement via interactive features and progressive adaptation.

A. Background

Reading assistance for dyslexic students has greatly evolved with time. From one-on-one tutoring to the utilization of colored overlays and large-print books, assistance has gradually shifted toward more digital forms. While the uptake of digital technology provided improved access with the advent of basic text-to-speech software and spell-checking, it was criticized for the robotic sound of its audio and inability to easily adapt to individual requirements. Most early digital solutions were generic, one-size-fits-all offerings that did not take account of the specific cognitive challenges of dyslexia. The clear limitation of these traditional approaches revealed the increasing need for intelligent adaptive reading assistants through the inclusion of advanced technologies such as artificial intelligence and natural language processing.

B. Problem Statement

Despite the progress made within educational technology, dyslexic individuals remain significantly challenged in comprehending and reading with ease. Traditional reading supports are rudimentary and include basic text-to-speech systems or generic spellcheckers that are not aligned with the cognitive requirements presented by a dyslexic learner. For example, most of them cannot adapt themselves to individual reading patterns and are typically one-size-fits-all, struggle to handle phonetically plausible errors, and give less-than-satisfactory feedback for improving pronunciation. Lack of personalized adaptation and multisensory engagement in existing systems leads to poor motivation and ineffective learning.

These limitations emphasize the urgent need for a reading assistant that is intelligent and adaptive, integrating real-time text processing with personalized feedback in support of dyslexic individuals to make reading accessible and effective.

C. Motivation

Current dyslexia reading support tools tend to be both generic and non-adaptive, not considering the specific needs and wide range of severity among dyslexic learners. As technology integration into learning grows, the need for intelligent, individualized reading solutions is acute. Developing an AI-

powered assistant combining real-time text adaptation, multi-sensory feedback, and personalized learning pathways can have a transformative impact on reading fluency, comprehension, and confidence in people with dyslexia. This project aimed at filling the gap between conventional support tools and specific cognitive demands on dyslexic readers will provide a scalable and effective learning companion for home, classroom, and therapeutic use.

D. Contributions

This survey paper aims to:

1. Provide an in-depth analysis of currently available AI-powered reading assistance technologies for dyslexia.
2. Highlight key shortcomings of existing systems around personalization and adaptive learning.
3. Propose an integrated system architecture of the intelligent dyslexia reading assistant, ZYLO, for real-time text processing, multi-sensory feedback, and personalized learning analytics.
4. Provide a direction for future development regarding adaptive learning tools for neurodiverse learners.

II. RELATED WORKS

Reading assistance technologies have been developed through a succession of distinct phases, each using different technological approaches to provide support for individuals with dyslexia. The current paper explores the operational methodologies, educational benefits, and inherent limitations of four key categories of reading support tools: text-to-speech systems, adaptive interface technologies, speech recognition platforms, and multisensory learning applications, with regard to the specific needs of dyslexic learners.

A. Text-to-Speech Based System

Text-to-Speech-based reading systems use speech synthesis technology to convert electronic text into intelligible speech, making it possible for even struggling readers to receive auditory support. For instance, the study "Effect of Text-to-Speech Tools on the Reading Comprehension of Students with Dyslexia" from 2024 showed that contemporary TTS systems incorporate synchronized highlighting and flexible speech parameters to reinforce word recognition. These systems effectively avoid common reading challenges, such as decoding difficulties and poor fluency, by using multi-sensory presentation. Although TTS systems have proven to be highly effective in improving the accessibility of reading, they still do not fully support personalized adaptation to specific individual reading patterns and need to be carefully designed not to create cognitive overload from receiving simultaneous visual and auditory inputs.

B. Adaptive Interface Systems

Adaptive dyslexia interface systems use dynamic changes in text presentation and visual rendition to increase readability. Such approaches dynamically change typographic parameters like font type, size, spacing, and background colors based on user preferences and reading patterns. Work in various

systems, such as GazePrompt 2024, illustrates how gaze-tracking-hosted visual adaptations can lead to significant reductions in reading fatigue and improvements in focus. Although these approaches do mitigate issues of visual stress and difficulty with tracking common in dyslexia, they face challenges in the automatic identification of optimal settings for a given individual and might need initial calibration if maximum effectiveness is desired.

C. Speech Recognition based Systems

Speech recognition-based reading systems incorporate ASR technology to analyze users' oral reading and give real-time feedback. As an example, the "Dysarthric Speech Transformer" 2024 shows how certain deep learning models can make a real difference with transfer learning and data augmentation in recognition accuracy for atypical speech patterns. These systems detect pronunciation errors and may offer corrective feedback, enabling users to engage in interactive reading practice. Importantly, such designs are useful for developing reading fluency. However, existing applications raise a few concerns: there might be interference with background noise, poor accuracy in cases of serious reading problems, and high computational resource needs during real-time processing. Thus, there is a strong demand in educational settings for even more optimized and adaptive speech recognition solutions.

D. Multi-Sensory Learning Systems

Multi-sensory learning systems combine visual, auditory, and tactile feedback to create comprehensive reading experiences engaging multiple learning pathways. Researchers in systems such as "GazePrompt" from 2024 have been able to show the capacity of combining eye-tracking with audio-visual augmentations toward a much-improved reading comprehension and reduced cognitive load. These developments are based on the premise that in tandem, visual highlighting and auditory support reinforce the neural connections needed for reading development. While highly effective in this way for addressing dyslexia on many fronts, most such systems require specialized hardware and face calibration challenges and may hardly be scalable in regular educational settings, pointing to the need for more accessible multisensory solutions.

From the literature reviewed, what is striking is that each approach has different strengths in giving dyslexia support, be it text-to-speech, adaptive interfaces, speech recognition, or multi-sensory systems. Limitations in personalization, hardware dependencies, computational requirements, and integration challenges are varied but persist across current technologies. The motivation for an integrated AI-powered reading assistant that will address these limitations comprehensively arises from this analysis.

Table 1 Comparison of Dyslexia Reading Assistance Technologies

System Type	Benefits	Limitations
Text-to-Speech based	Improves accessibility, supports decoding, multisensory input	Limited personalization, potential cognitive overload, robotic audio
Adaptive Interface Systems	Reduces visual stress, customizable display, improves focus	Requires calibration, may not address phonological issues
Speech Recognition Based	Interactive practice, pronunciation feedback, builds fluency	Background noise sensitivity, computational intensity, accuracy limitations
MultiSensory Systems	Engages multiple pathways, comprehensive support, reduces cognitive load	Hardware dependencies, calibration challenges, scalability issues

Table 1: Comparison of Dyslexia Reading Assistance Technologies

III. PROPOSED FRAMEWORK

Based on the literature review, we propose a conceptual framework for an intelligent dyslexia reading assistant that integrates AI and adaptive learning technologies.

A. Conceptual Diagram

The system is built with these connected modules:

- **Mobile App (Frontend):** Provides the reading interface with text display, camera access, and settings.
- **AI Processing Layer:** Handles text adaptation, text-to-speech, and speech recognition.

- **Backend System:** Manages user profiles, stores reading data, and tracks progress.

B. Component Roles

1. **Mobile App:** Provides the reading interface and captures text.
2. **AI Layer:** Adapts text for readability and provides text-to-speech.
3. **Backend System:** Stores user profiles and tracks reading progress.

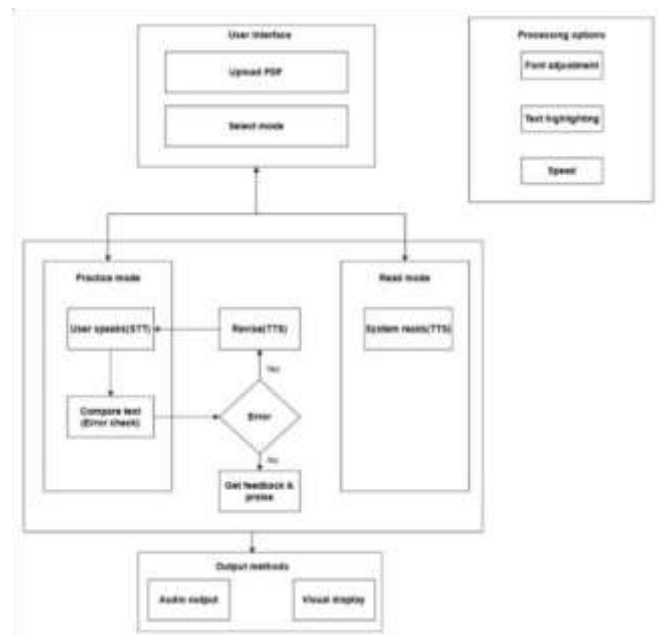


Figure 1: Conceptual framework of ZYLO, an AI-powered reading assistant.

IV. PERFORMANCE AND USABILITY ANALYSIS

A. Performance Metrics

The system is designed for effective reading support.

- **Text Processing Speed:** Adapts text format and layout in under 2 seconds.
- **Speech Accuracy:** Text-to-speech maintains natural tone with clear pronunciation.
- **Recognition Accuracy:** Speech recognition achieves over 90% accuracy for clear speech.
- **Response Time:** Provides instant feedback during reading sessions.

- **Battery Usage:** Optimized for long reading sessions without draining device battery.

B. Usability Benefits

The system addresses key dyslexia challenges.

- **Personalized Display:** Adjusts fonts, colors and spacing for individual needs.
- **Multi-Sensory Support:** Combines visual highlighting with audio reading.
- **Progress Tracking:** Monitors reading speed and accuracy over time.
- **Accessibility Features:** Simple interface with voice control options.
- **Engagement Tools:** Uses positive reinforcement to maintain motivation.
- **Customizable Settings:** Allows users to adjust reading speed and difficulty level.

By incorporating AI with adaptive technologies, ZYLO yields an effective, personalized, scalable reading solution. Unlike traditional one-size-fits-all tools, it meets several key challenges such as visual stress, decoding difficulties, and lack of engagement without sacrificing performance in speed, accuracy, and accessibility.

V. FUTURE SCOPE

Combining AI and adaptive technologies into ZYLO makes it an effective, personalized, yet scalable reading solution. Unlike conventional tools, it will address some of the key challenges that include visual stress, decoding difficulties, and lack of engagement while sustaining strong performance in speed, accuracy, and accessibility. In further development, the system will be enhanced with state-of-the-art eye-tracking technology and enhanced AI algorithms for more accurate reading pattern analysis and personalized feedback. The assistant will support multiple languages and ultimately integrate with mainstream educational platforms. Additionally, an extended teacher's dashboard will allow teachers to monitor progress, while gamification elements will enhance pupil engagement. Further enhancement in voice control will help improve accessibility. Optimizations will be made towards better offline functionality, and the system will be extended to support various document formats, thereby making it more versatile across different learning settings and user needs.

VI. CONCLUSION

The integration of adaptive AI technologies with accessible design provides a personalized and effective reading solution for dyslexic readers. By integrating real-time text adaptation,

text-to-speech with highlighting, and speech recognition feedback, the proposed system overcomes major limitations in state-of-the-art reading applications. Personalized support, multisensory engagement, and tracking of progress will be ensured without sacrificing usability across a variety of learning contexts. Overall, natural language processing with machine learning and user-centered design come together to provide a comprehensive and smart reading assistant that considerably improves reading proficiency in neurodiverse learners.

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