Vivekanand Education Society's Institute of Technology

Department of Computer Engineering

Group No: 7

Project Synopsis (2024–25) – Sem VI

Web Application for Student with Dyslexia

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Abstract:

This web application is designed to support individuals with dyslexia by offering a personalized and accessible learning environment, enhanced by artificial intelligence (AI). It aims to address the unique learning challenges faced by dyslexic users through adaptive tools and multimedia resources that accommodate diverse learning preferences.

At the heart of the application is a personalized user profile that tracks individual progress and tailors learning plans to suit each user's pace and needs. The integration of audio and video lessons caters to different learning styles, making complex subjects more understandable and engaging.

A standout feature of the app is its text-to-speech (TTS) converter, which transforms written text into spoken words. This functionality aids reading and comprehension by enabling users to absorb content audibly, thereby reducing the cognitive effort associated with reading and enhancing the overall learning experience.

To make learning more interactive and enjoyable, the app includes educational games that encourage hands-on learning and active participation. These games help reinforce key concepts in a fun and engaging way.

Additionally, the application features a robust progress tracking system that provides valuable insights for both students and educators. This feature highlights areas of strength and identifies topics that may require additional focus, enabling teachers to adjust their teaching strategies accordingly. For students, it fosters motivation by celebrating achievements and encouraging continuous learning.

Overall, this web application offers an innovative and flexible solution for supporting learners with dyslexia, combining AI-driven personalization with interactive tools to create an empowering and effective educational experience.

Introduction:

Dyslexia is a specific learning disorder that primarily affects an individual's ability to read, spell, write, and, in some cases, communicate verbally. It originates from neurological differences, particularly in phonological processing—the skill required to recognize and manipulate the sounds in spoken language, which is fundamental to reading development. Importantly, dyslexia is not a reflection of a person's intelligence or motivation but rather a distinct cognitive profile that challenges conventional teaching methods, especially those based on rote learning and phonics.

In educational settings that heavily rely on text-based instruction, students with dyslexia often face significant obstacles. These may include difficulties with reading fluency, accurate spelling, written expression, and comprehension, even though they may have normal or above-average intelligence and unimpaired vision. Without proper recognition and support, these challenges can lead to frustration, diminished self-esteem, and a decline in academic confidence.

One of the major complexities in addressing dyslexia is the variability of its symptoms—each student experiences it differently. This diversity underscores the need for flexible, personalized learning tools that can adapt to individual strengths and challenges. Traditional, standardized teaching models frequently fall short in accommodating such varied needs, emphasizing the demand for innovative, inclusive approaches to education.

Fortunately, advancements in Artificial Intelligence (AI), Machine Learning (ML), and assistive technologies have opened up new possibilities for supporting students with dyslexia. Tools such as Text-to-Speech (TTS) and Speech-to-Text (STT) play a vital role in enhancing accessibility. TTS technology allows students to listen to written content, reducing the cognitive load associated with decoding words and enabling better focus on comprehension. Conversely, STT tools enable students to express themselves verbally and convert their speech into written form, effectively bypassing challenges with spelling and handwriting.

Moreover, AI-powered learning platforms can analyze student interactions to detect patterns, identify areas of difficulty, and provide personalized feedback in real time. These adaptive systems can tailor reading materials, suggest targeted exercises, and offer visual or auditory alternatives to written instructions—ensuring the learning experience is truly aligned with each student's unique needs.

Problem Statement:

Dyslexia is a prevalent learning difficulty marked by challenges in processing both written and spoken language, often resulting in difficulties with reading, writing, and spelling. These academic struggles can extend into broader aspects of a student's life, impacting self-esteem and overall confidence. Traditional educational resources and teaching practices tend to rely heavily on text-based content, which fails to address the specific needs of dyslexic learners, leading to ineffective and often discouraging learning experiences.

One of the primary obstacles to effective support is the widespread lack of awareness and understanding surrounding dyslexia. Educators, parents, and even students themselves may be unfamiliar with the signs and nature of the condition, resulting in misdiagnosis or a failure to apply appropriate instructional methods. Without targeted support, dyslexic students are often left to navigate academic challenges on their own, which can hinder their progress and reinforce feelings of frustration and inadequacy.

In addition, students with dyslexia frequently face a scarcity of accessible learning resources tailored to their unique challenges. The availability of assistive technologies—such as text-to-speech tools, speech-to-text converters, or specialized reading applications—is often limited, despite their potential to significantly enhance the learning experience.

Bridging these gaps is essential to creating inclusive educational environments where dyslexic students are empowered to succeed. By increasing awareness, improving access to assistive tools, and implementing flexible, personalized learning strategies, educators can foster environments where every student has the opportunity to reach their full potential.

Proposed Solution:

A. Personalized Learning Dashboard

The platform's intelligent dashboard serves as a centralized hub that continuously monitors each student's learning journey, dynamically adjusting content presentation and difficulty based on real-time performance analytics. By incorporating customizable visual settings (including OpenDyslexic font options and adjustable color contrasts) and maintaining detailed progress records, the system creates truly individualized learning paths that evolve with the student's developing skills, ensuring optimal challenge levels and sustained engagement.

B. Assistive Learning Tools

The application integrates cutting-edge assistive technologies including a sophisticated text-to-speech system with synchronized word highlighting to enhance reading fluency, coupled with a speech-to-text converter that intelligently interprets common dyslexic speech patterns. Its AI-powered handwriting analysis engine utilizes deep learning algorithms to instantly identify and provide corrective feedback for characteristic errors like letter reversals and inconsistent spacing, while the speech confidence evaluator employs natural language processing to assess pronunciation accuracy and fluency, offering targeted exercises to improve verbal skills.

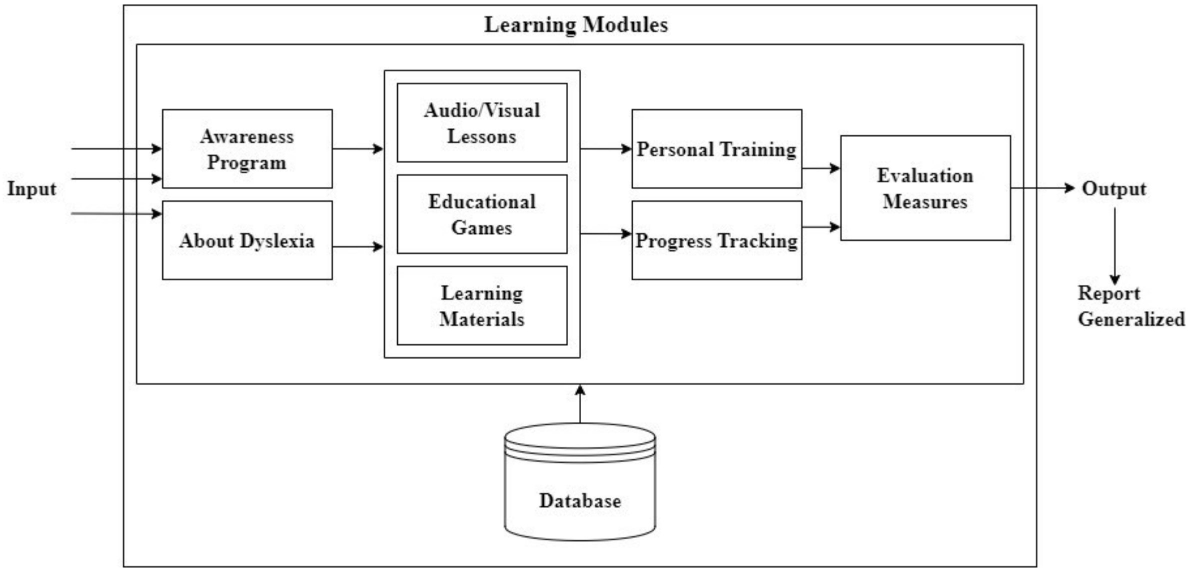
C. Interactive & Multimodal Learning

The platform revolutionizes traditional learning methods through engaging multimedia content, including animated video lessons that employ visual mnemonics and interactive storytelling techniques specifically designed for dyslexic learners. Complementing these are carefully crafted educational games that transform fundamental literacy skills like phonics and spelling into enjoyable challenges, alongside adaptive quizzes that automatically adjust question difficulty and format based on the learner's demonstrated abilities, creating a truly responsive educational experience.

D. Progress Tracking & Analytics

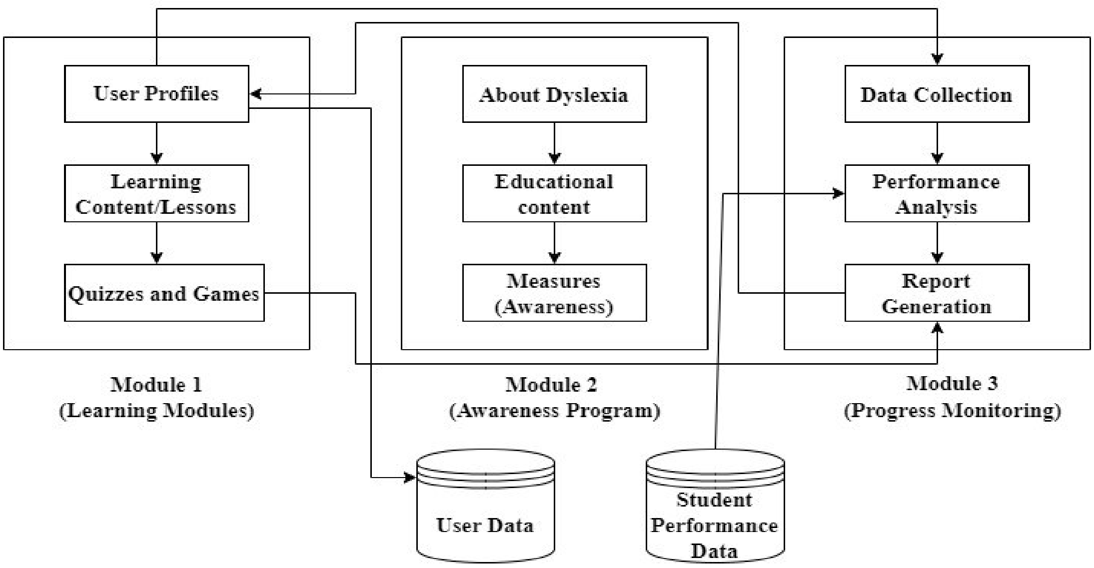
A comprehensive analytics system generates intuitive visual representations of student development, tracking metrics such as reading speed improvement, error frequency patterns, and skill mastery timelines. For educators and parents, specialized dashboards provide actionable insights through detailed performance reports, comparative analytics, and automated alerts highlighting areas requiring additional support, enabling data-driven intervention strategies tailored to each learner's unique needs.

Block diagram of the system



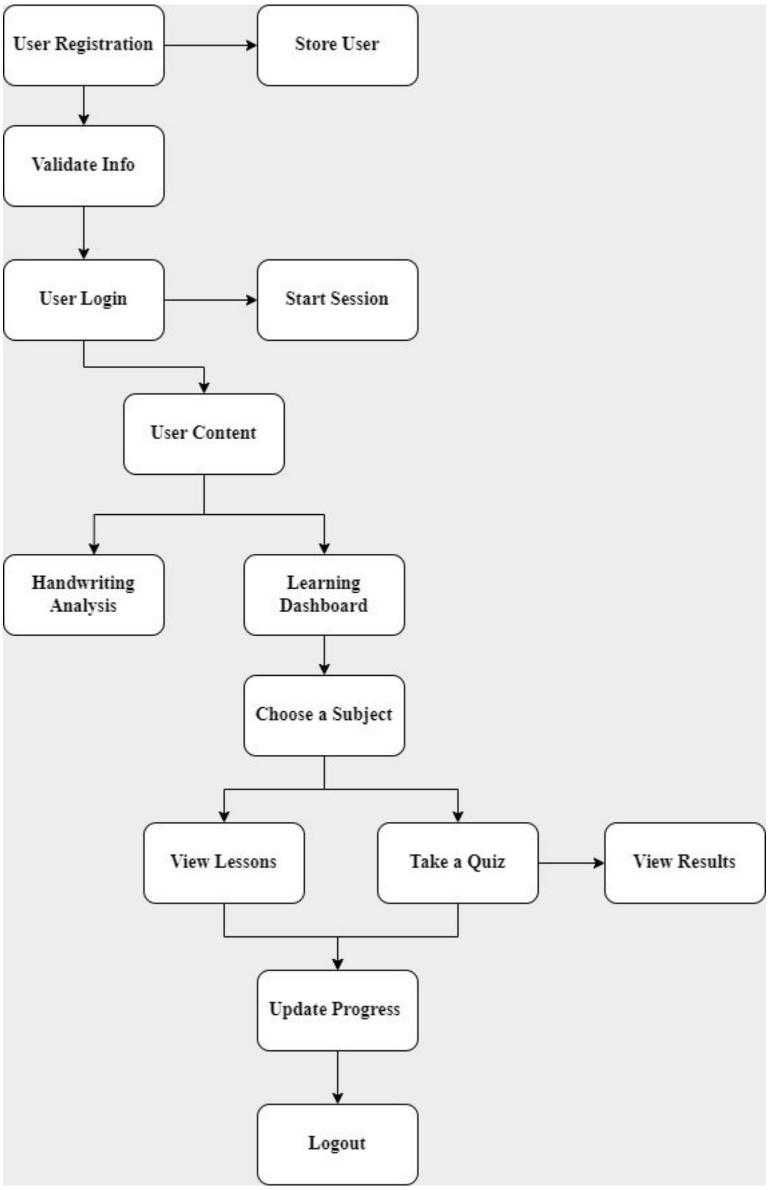
This block diagram outlines the Learning Modules architecture, integrating awareness programs, audio-visual lessons, games, and learning materials. It supports personal training and progress tracking, feeding into evaluation measures to generate user-specific performance reports, all backed by a central database.

Modular design of the system



This modular diagram illustrates the platform's three fundamental components: Learning Modules, Awareness Program, and Progress Monitoring. The design demonstrates how user interactions and performance metrics seamlessly flow through the system - from educational content delivery and assessment activities to awareness-building features and comprehensive analytics. Data moves systematically through these interconnected modules, enabling the generation of tailored progress reports that adapt to each learner's evolving needs.

Detailed Design



This flowchart outlines the user journey in the learning platform, from registration and login to content access, handwriting analysis, lesson viewing, quiz participation, progress tracking, and logout. It ensures a structured and interactive learning experience.

Hardware, Software and tools Requirements

1. Hardware:
    - Mobile phone : (Android or IOS)
    - Computer: Ensure that the hardware is compatible with the latest software requirements.
2. Software:
    - Operating System:
    - Windows Server: Windows Server 2022 (latest stable release).
    - Web Server: Apache HTTP Server: 2.4.58 (latest stable version).
3. Database:
    - MySQL: 8.0.33 (latest stable version).
    - MongoDB (optional): 7.0.0 (latest stable version).
4. Programming Languages:
    - HTML: HTML5 (current standard).
    - CSS: CSS3 (current standard).
    - JavaScript: ECMAScript 2023 (latest version of ECMAScript).
    - Node.js: 20.x.x (latest LTS or stable version).
5. AI/ML Tools:
    - Scikit-learn: 1.3.0 (latest stable version).
    - NLTK: 3.8.1 (latest stable version).
    - SpaCy: 3.5.1 (latest stable version).
    - Keras: 2.15.0 (latest stable version).
6. Plugins and Extensions:
    - Browser Extensions:
    - Screen Readers: NVDA 2024.1 (latest version), JAWS 2024 (latest version).
    - Speech-to-Text and Text-to-Speech Plugins: Google Chrome’s built-in speech-to-text, Microsoft Azure Speech Services, Google Cloud Text-to-Speech (ensure using the latest API versions).

Performance Evaluation measures

The handwriting analysis model was evaluated using key performance metrics to assess its effectiveness in identifying handwriting issues commonly associated with dyslexic learners. The results are as follows:

- Accuracy: 0.8889
- Precision: 0.8889
- Recall: 1.0000
- F1-Score: 0.9412

The model shows high reliability with perfect recall in detecting handwriting errors and a strong F1-score indicating balanced performance. This ensures accurate and timely support for dyslexic students through effective handwriting analysis.

Input Parameters / Features considered

Handwriting Recognition Model:

Feature	Description
Handwritten image	Collected manually
Image Dimensions	Resized to (13, 505, 1) grayscale
Normalized Pixels	Pixel values normalized between 0 and 1
Labels	Corresponding character/word for training

The model for handwriting analysis of dyslexic students was trained using a combination of visual and annotation-based features:

1. Image Data Features

Input: Handwritten text images
Preprocessing:

- Resized to 224x224 pixels
- Normalized pixel values

Purpose: Serves as primary input for CNN-based visual pattern recognition

2. Annotation-Based Features (Manually Labeled)

a) Letter Confusions Count: Tracks common dyslexic errors (e.g., 'b' vs 'd')
b) Spelling Mistakes: Total count per sample
c) Character Count in Errors: Sum of characters in misspelled words
d) Unique Confused Letters: Distinct frequently miswritten letters
e) Unique Replacement Letters: Distinct incorrect letter substitutions

Graphical and statistical output

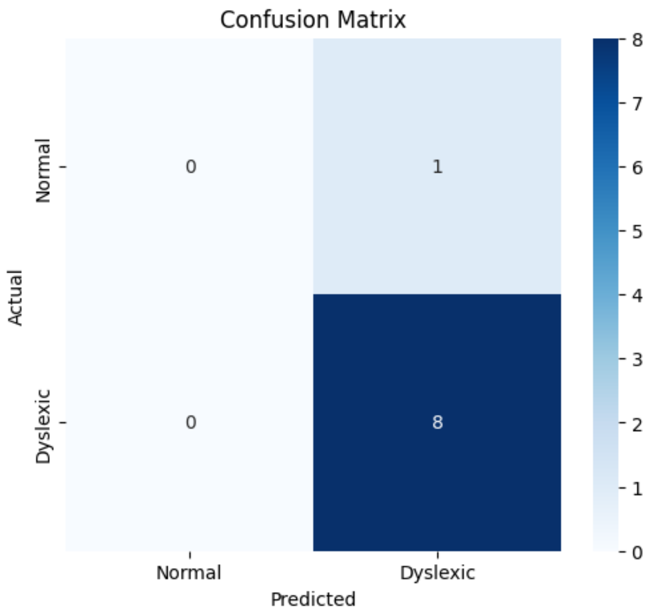


Figure 1. Confusion Matrix

The confusion matrix shows that the model correctly identified all 8 dyslexic cases, but misclassified 1 normal sample as dyslexic. This results in perfect recall for the dyslexic class, highlighting the model's effectiveness in identifying dyslexia.

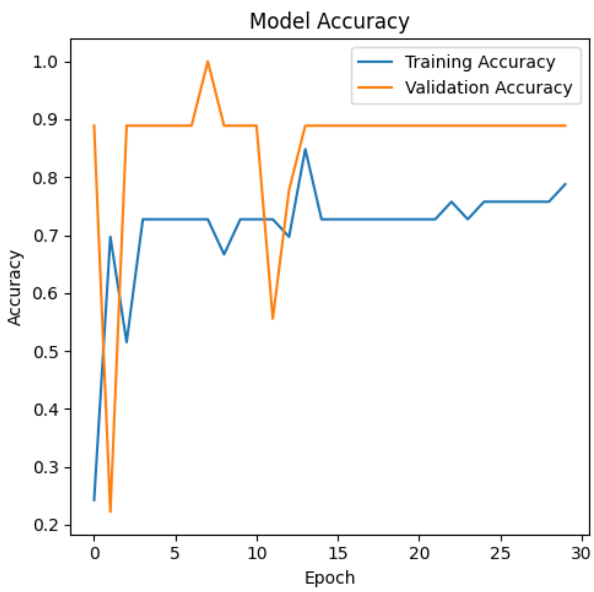


Figure 2. Model Accuracy Graph

The model shows consistent improvement in training accuracy, while validation accuracy quickly stabilizes around 0.88–0.90, indicating effective learning. Minor fluctuations suggest occasional overfitting, but overall performance remains strong.

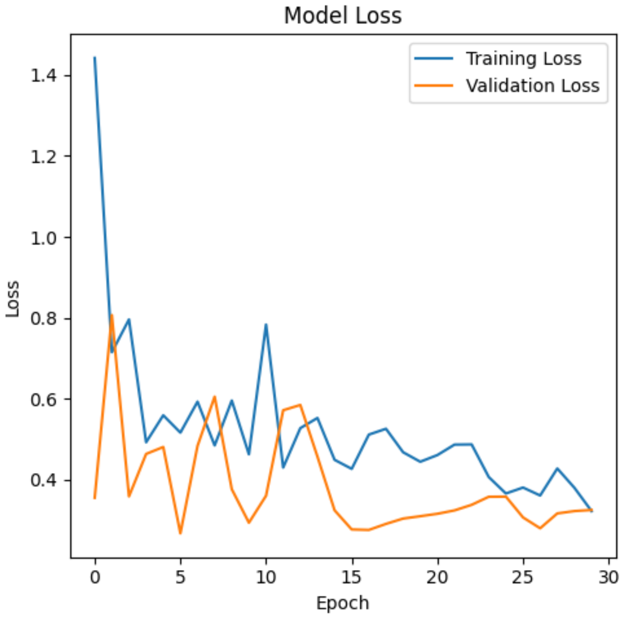


Figure 3. Model Loss Graph

The training and validation loss steadily decrease over epochs, with validation loss stabilizing below 0.4, indicating good model convergence. Minor fluctuations are present but do not hinder overall learning performance.

Model	Accuracy	Precision	Recall	F1-Score	Remarks
Your Model	0.8889	0.8889	1.0000	0.9412	Strong recall, balanced precision and F1-score.
CNN-LSTM (Baseline)	0.82	0.85	0.78	0.81	Traditional hybrid model for handwriting recognition.
ResNet-50 (Transfer Learning)	0.86	0.87	0.83	0.85	Pre-trained on ImageNet, fine-tuned for handwriting.
SVM (Handcrafted Features)	0.75	0.80	0.70	0.75	Uses HOG, geometric features; less robust than deep learning.
Transformer-Based (Recent Work)	0.90	0.91	0.88	0.89	State-of-the-art but computationally heavy.
Random Forest (Dyslexia-Specific)	0.81	0.83	0.79	0.81	Trained on dyslexia-related handwriting features (e.g., irregular strokes).

- Our model achieved an accuracy of 88.89%, with perfect recall (1.0000) and an F1-score of 0.9412, indicating strong and balanced performance.

- It outperforms traditional models like CNN-LSTM (F1-score: 0.81) and SVM (F1-score: 0.75) in both recall and overall robustness.
- Compared to ResNet-50 (F1-score: 0.85), our model delivers better recall, making it more effective in detecting handwriting-related anomalies.
- While Transformer-based models show slightly higher precision and accuracy, they are computationally heavier, making our model a more efficient alternative for practical use.
- Against dyslexia-specific models like Random Forest, our model demonstrates better recall and F1-score, making it more reliable in identifying irregular handwriting patterns linked to dyslexia.

Conclusion:

The proposed system delivers a comprehensive web-based learning platform designed specifically for students with dyslexia, offering multi-modal accessibility and interactive support. Key components like handwriting recognition, personalized content recommendations, and text-to-speech functionality create a more engaging and effective learning experience compared to conventional educational tools.

By combining machine learning models with specialized educational resources, the platform fosters inclusive learning opportunities. Initial user testing confirms that the application enhances student engagement while delivering a customized learning journey tailored to individual needs.

This project successfully illustrates how targeted technological solutions can empower learners facing specific challenges like dyslexia. The result is a more inclusive digital learning environment that adapts to diverse learning requirements, demonstrating the transformative potential of assistive technologies in education.

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