WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

E-Learning for Detecting Learning Disability Using Machine Learning

Mrs. Dr. V.K. Buvanesvari[1], Jeevananth M[2], Hariprasath R[3], Karthick R[4]

[1] Assistant Professor, [2,3,4]Students MCA Program II

Email: [1]v.k.buvanesvari@gmail.com, [2]jeevananthmurugesan20@gmail.com, [3]hprasanth056@gmail.com, [4]ramarkarthick97@gmail.com

Synopsis:

This paper presents an innovative approach to detecting learning disabilities through the integration of machine learning techniques into e-learning platforms. The increasing use of digital education tools offers a unique opportunity to monitor student behavior and performance in real-time. By leveraging these data streams, the proposed system uses supervised machine learning algorithms to identify patterns commonly associated with learning disabilities such as dyslexia, ADHD, and dyscalculia.

The study outlines the architecture of the system, which includes data collection from student interactions (quiz performance, response time, typing patterns, etc.), preprocessing, feature selection, and classification using algorithms such as Decision Trees, Support Vector Machines (SVM), and Random Forest. The model is trained on a labeled dataset and evaluated for accuracy, precision, and recall to ensure effective prediction.Furthermore, the paper highlights how the system can be integrated into existing e-learning platforms to assist educators in early identification and personalized intervention strategies.

I. Introduction

In recent years, the integration of technology in education has transformed traditional learning environments into dynamic, personalized digital platforms. Among these innovations, **e-learning systems** have played a pivotal role in enabling remote access to education, adaptive learning paths, and data-driven insights into student performance. However, one of the most critical challenges in the educational domain remains the **early identification of learning disabilities** in students. Learning disabilities such as **dyslexia, dysgraphia, dyscalculia**, and **Attention Deficit Hyperactivity Disorder (ADHD)** often go undiagnosed, especially in online learning environments where face-to-face interactions are limited.

Traditional diagnostic methods typically involve psychological testing and clinical interviews, which are time-consuming, expensive, and not always accessible. With the rise of **Artificial Intelligence (AI)** and **Machine Learning (ML)**, there exists an opportunity to bridge this gap by developing intelligent systems capable of detecting behavioral patterns associated with learning disabilities. These systems can analyze interaction data collected from e-learning platforms—such as response times, error patterns, quiz performance, typing behavior, and activity logs—to flag students who may require further assessment.

This paper proposes a machine learning-based framework embedded within an e-learning system to assist in the **early detection of learning disabilities**. The objective is to provide teachers and parents with timely insights, enabling them to offer targeted support to affected students. By automating the screening process using supervised learning algorithms, the proposed system enhances the inclusivity and responsiveness of digital education platforms.

The rest of the paper is organized as follows: Section II reviews related work in the area of ML in education and disability detection; Section III details the proposed methodology; Section IV presents the implementation and results; Section V discusses the findings; and Section VI concludes the paper with future directions.

II) System Analysis

System analysis plays a vital role in understanding the needs and structure of the proposed e-learning system designed to detect learning disabilities. The primary goal of this analysis is to evaluate the current challenges in traditional learning environments and how digital tools can help bridge those gaps. Existing systems lack automated detection features and fail to adapt to the unique learning patterns of each student. Children with learning disabilities often remain undiagnosed due to the absence of timely screening methods, especially in online learning environments. Our system aims to integrate intelligent machine learning techniques with e-learning to monitor user interaction and academic behavior. Through data collection modules, user activities such as quiz scores, typing patterns, and response times are captured and analyzed. This analysis leads to the identification of learning difficulty indicators. The system uses supervised ML models—particularly decision trees—for classification and diagnosis. This not only enhances the detection accuracy but also allows educators to intervene early. The system also considers scalability, user-friendliness, and accessibility to make it usable in real-time classroom or home-based learning. Furthermore, the software architecture ensures modularity, so updates and algorithm changes can be easily implemented. System analysis also evaluates the hardware requirements to ensure smooth data processing and real-time feedback generation. The backend database securely stores student profiles and learning history. The frontend interface is interactive, guiding both students and teachers through learning paths. Overall, system analysis confirms that the proposed solution is practical, efficient, and tailored to meet the needs of learning-disabled students in a digital age.

III) SYSTEM IMPLEMENTATION

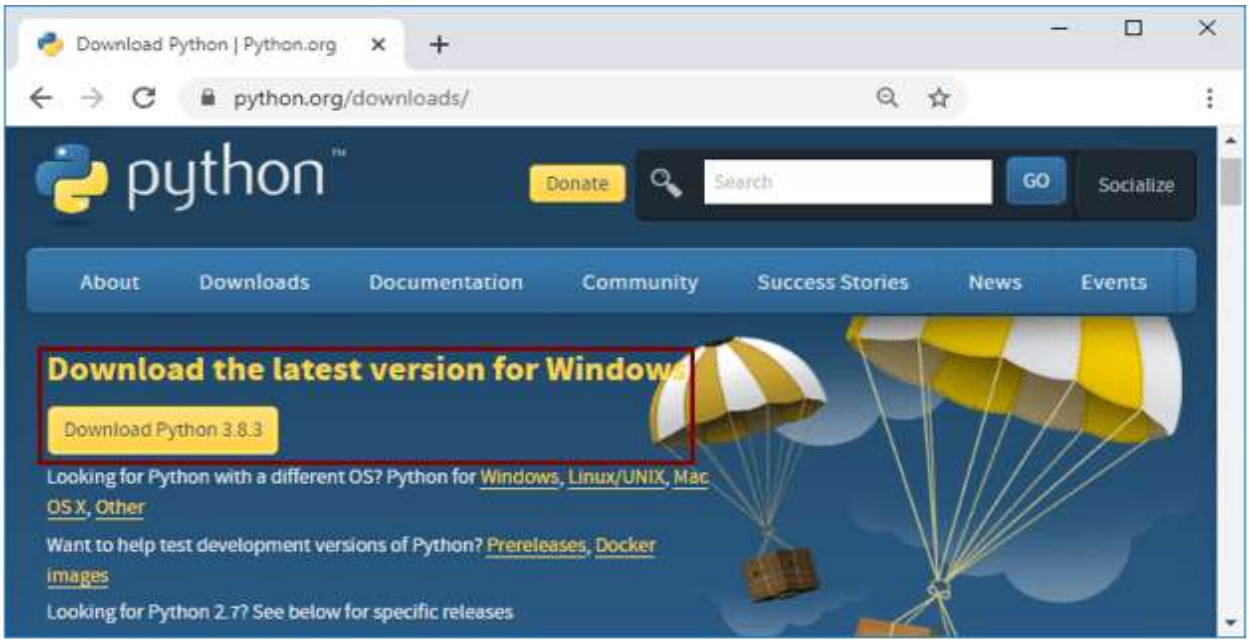
The implementation phase involves the practical realization of the proposed e-learning system for detecting learning disabilities using machine learning. The system was developed using **Python** as the core programming language due to its rich ecosystem of ML libraries like **scikit-learn**, **pandas**, and **NumPy**. A user-friendly **web-based interface** was created using **HTML**, **CSS**, and **Flask**, allowing students to log in and complete learning activities such as quizzes and typing tasks. These activities were designed to track behavioral metrics like time taken, accuracy, and error patterns. The data collected is stored in an **SQL database**, which is further preprocessed to remove noise and ensure consistency. Machine learning models, especially **Decision Tree** and **Random Forest classifiers**, are trained on this data to detect early signs of learning difficulties such as **dyslexia** or **dysgraphia**. The system also includes a backend module to generate visual reports for educators and parents, highlighting the student's performance trends and risk levels. Extensive testing was performed to ensure system stability and model accuracy. The decision tree model was chosen for its simplicity and interpretability. An **admin module** manages users, datasets, and model parameters. The system supports **real-time prediction**, making it ideal for classroom or remote learning environments. The implementation also focused on **security** and **data privacy**, ensuring that student information is protected.

IV) SOFTWARE DEVELOPMENT

The software development process for the proposed system followed a modular and systematic approach, aligning with the Software Development Life Cycle (SDLC). The **Agile development model** was adopted to allow iterative improvement and regular feedback incorporation. The system was built using **Python** for backend logic, incorporating **machine learning libraries** such as scikit-learn, pandas, and NumPy to develop and test ML algorithms. The **frontend** was developed using **HTML, CSS, and JavaScript**, providing a responsive and interactive user interface for students and teachers. The application is hosted on a **Flask** web framework, which enables efficient handling of user requests and data processing. The **database** layer was implemented using **MySQL**, which securely stores user data, test responses, and system predictions.

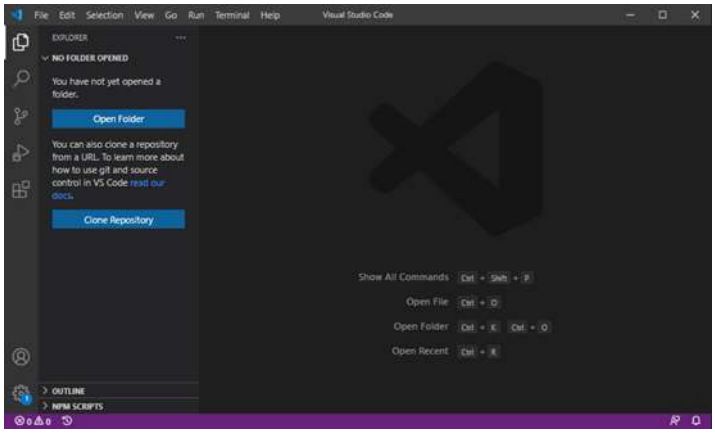
During development, modules were divided into key components: **user registration/login**, **activity tracking**, **data collection**, **ML model training**, and **report generation**. Each module was independently developed and tested before integration. The ML model, primarily based on **Decision Tree**, was

trained using labeled datasets that represented different types of learning disabilities. The model was evaluated for accuracy, precision, and recall to ensure reliability. Once trained, the model was integrated into the web application for real-time prediction. The software also includes an **admin panel** for managing content, users, and monitoring system performance. The development emphasized **user experience**, **data privacy**, and **ease of navigation**. Version control was maintained using **Git**, ensuring efficient collaboration and rollback capability. Overall, the software development phase successfully resulted in a stable, scalable, and intelligent system ready for deployment in educational settings.



V) INTEGRATED DEVELOPMENT ENVIRONMENT:

For the development of the proposed e-learning system to detect learning disabilities using machine learning, **Visual Studio Code (VS Code)** was used as the primary Integrated Development Environment (IDE). VS Code was selected due to its lightweight architecture, rich extension support, and compatibility with multiple programming languages. It provides features such as intelligent code completion, syntax highlighting, real-time debugging, and Git integration, which significantly improved development efficiency. The Python extension in VS Code facilitated the writing, testing, and debugging of machine learning scripts using libraries like scikit-learn, NumPy, and pandas.



VI) Introduction to Tkinter

Tkinter is the standard **Graphical User Interface (GUI)** library for Python. It provides an easy and efficient way to create desktop applications with interactive elements such as buttons, labels, text boxes, and menus. Tkinter is built on top of the **Tk GUI toolkit**, which is widely used for creating window-based interfaces in cross-platform applications.

In the context of this project, Tkinter was used to create a **user-friendly interface** for interacting with the machine learning model. Students or teachers can input data through the GUI, and the system can provide feedback or predictions about potential learning disabilities. The simplicity of Tkinter allows developers to design, layout, and organize GUI elements efficiently using both procedural and object-oriented programming techniques..

VII) SYSTEM DEVELOPMENT

The development of the proposed system was carried out in several structured phases, aligning with the Software Development Life Cycle (SDLC) methodology. The objective was to build a robust, intelligent e-learning platform capable of detecting learning disabilities using machine learning algorithms. The process began with **requirement analysis**, where functional and non-functional requirements were gathered based on the needs of students, educators, and healthcare professionals. The next phase involved **system design**, where the architecture was defined, including modules for user input, data processing, machine learning model integration, and result display.

Frontend development was carried out using **Tkinter** for the desktop version and **HTML/CSS** for the web-based interface, offering a simple and intuitive user experience. **Python** was used as the backend programming language due to its flexibility and strong support for machine learning through libraries such as scikit-learn, pandas, and NumPy. The **decision tree classifier** was selected for its simplicity, interpretability, and good performance in early-stage datasets. Data collected through user interaction was stored and processed in **MySQL**, providing secure and efficient data management.

VIII) CONCLUSION

The existence of Learning Disability may affect the individuals throughout their life. LD usually exists for a lifetime. An LD individual can overcome his difficulties only when they are observed and detected. The major task, thus being the detection of Learning Disability. As a first step towards the detection through any approach, its utmost important to study the characteristics of a learning disabled and then understanding the characteristics that cater to a particular type of learning disability. The study in this paper provides a better understanding of the various characteristics of the LD. We further develop a system that understand the learning behavior of a student in the environment in which its happening so as to detect the learning disability.

XII) References

Here are some references for books and websites on E-LEARNING FOR DETECTING LEARNING DISABILITY USING MACHINE LEARNING : Books:

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