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Neo Learn

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Abstract

Neo Learn is an artificial intelligence–driven adaptive learning platform developed to assist students in mastering complex subjects such as Formal Languages and Automata Theory (FLAT), Design and Analysis of Algorithms (DAA), and Aptitude. The system integrates Large Language Models (LLMs) and Natural Language Processing (NLP) techniques to deliver real-time responses, contextual explanations, and personalized academic guidance tailored to individual learning pace and requirements. To enhance conceptual understanding, the platform provides visualization support that transforms abstract topics—particularly automata and algorithmic concepts—into interactive diagrams and graphical representations. Additionally, Neo Learn includes an automated summarization module that condenses extensive academic materials into concise and structured key points, thereby improving revision efficiency. The platform also incorporates quizzes and assessment mechanisms to evaluate learner comprehension and reinforce knowledge retention. A dedicated progress monitoring component tracks user performance, identifies weaker areas, and provides data-driven insights for continuous improvement.

By combining intelligent tutoring, visualization, automated summarization, assessment tools, and performance analytics within a unified system, Neo Learn delivers a personalized and interactive learning experience. The proposed platform enhances student engagement, improves conceptual clarity, and supports efficient academic preparation across technical subjects.

Keywords-*Adaptive Learning, Artificial Intelligence, Large Language Models, Natural Language Processing, Personalized Learning, Educational Technology, Automated Summarization, Learning Analytics, Intelligent Tutoring Systems, Formal Languages and Automata Theory, Design and Analysis of Algorithms.*

Introduction

Neo Learn is an artificial intelligence–enabled adaptive learning platform developed to improve students' understanding of technically demanding subjects such as Formal Languages and Automata Theory (FLAT), Design and Analysis of Algorithms (DAA), and Aptitude. These domains are often considered difficult because they involve abstract reasoning, mathematical logic, and complex problem-solving techniques. The proposed platform addresses these challenges by integrating advanced technologies including Large Language Models (LLMs) and Natural Language Processing (NLP) to provide accurate, real-time, and personalized academic assistance. Through this intelligent support, learners receive explanations that align with their knowledge level and learning speed, thereby improving comprehension and retention.

The system adopts a learner-centered design in which educational content dynamically adapts according to individual progress and preferences. It offers step-by-step solutions, contextual explanations, and instant doubt clarification to help students understand complicated concepts more effectively. A notable feature of Neo Learn is its visualization capability, which converts theoretical and abstract ideas into diagrams, animations, and interactive representations. This functionality is particularly beneficial for subjects such as automata and algorithm design, where visual interpretation significantly enhances conceptual clarity. In addition, the platform incorporates an automated summarization module that transforms lengthy academic content into concise key points, enabling efficient revision and better time management.

Neo Learn further integrates interactive quizzes and assessment modules to evaluate student understanding and reinforce learning outcomes. The system also includes progress monitoring and performance analytics, allowing learners to track improvement, identify weak areas, and focus on targeted study strategies. By combining intelligent tutoring, visualization, summarization, assessment, and analytics within a unified framework, Neo Learn provides an engaging and personalized learning environment that promotes deeper understanding and improved academic performance.

Existing System

The current digital learning landscape is largely dominated by video-based educational platforms that provide structured content through lectures, assignments, and assessments. These platforms improve accessibility to educational resources and allow students to learn at their convenience.

However, most of them follow a standardized delivery approach in which the same content is presented to all learners regardless of their individual learning pace, background knowledge, or performance level. This uniform methodology limits personalization and reduces the overall effectiveness of learning experiences.

In addition to video-based systems, conversational artificial intelligence tools are increasingly used for doubt clarification and conceptual explanations. While these tools support interactive learning, they are generally not aligned with specific academic curricula and lack integration with structured assessment mechanisms. As a result, they function mainly as supplementary aids rather than comprehensive educational platforms. Similarly, standalone summarization tools assist students in condensing large volumes of academic material into shorter summaries. Although these tools improve revision efficiency, they operate independently and do not provide progress tracking or adaptive learning capabilities. The absence of integration among tutoring, summarization, and performance monitoring results in fragmented learning experiences that limit overall effectiveness.

Problems in Existing System

Existing learning systems suffer from several limitations that hinder effective knowledge acquisition. Many platforms lack personalization, offering identical content without considering individual learning needs or performance variations. Furthermore, real-time adaptive feedback is often unavailable, preventing students from understanding their strengths and weaknesses during the learning process. Another significant limitation is the absence of integration between various educational tools, such as tutoring systems, summarization modules, and assessment platforms, which leads to disconnected learning experiences. In addition, most systems are not fully aligned with academic curricula, making it difficult for students to prepare systematically for examinations. These platforms also fail to identify skill gaps and provide targeted recommendations for improvement. Moreover, learners often do not receive a structured roadmap that guides them through progressive learning stages, which can result in inefficient study patterns and reduced academic confidence.

Proposed System

The proposed system, NeoLearn, is an AI-driven adaptive learning platform designed to overcome the limitations of existing educational technologies. By leveraging Artificial Intelligence and Natural Language Processing, the platform functions as an intelligent tutor capable of providing personalized explanations and real-time academic support.NeoLearn also incorporates an automated summarization feature that converts extensive academic material into concise and meaningful key points, thereby simplifying revision. Additionally, the platform includes quizzes and assessment modules that enable learners to evaluate their knowledge and reinforce understanding. The integrated progress tracking and analytics component monitors performance, identifies weak areas, and supports data-driven learning strategies. By combining intelligent tutoring, visualization, summarization, assessment, and analytics within a single unified environment, NeoLearn delivers a personalized, interactive, and efficient learning experience that improves academic outcomes.

Requirement Analysis

Functional Requirements

The NeoLearn platform consists of two primary modules: the user module and the administrator module. The user module provides secure authentication features that enable students to log in and log out safely. Once authenticated, users can interact with the AI-based tutor by submitting subject-related queries and receiving instant explanations. The platform also allows learners to upload notes or academic documents, which are automatically summarized into concise key points for quick revision. To enhance conceptual clarity, particularly in Formal Languages and Automata Theory, the system supports visualization features that generate diagrams such as Deterministic Finite Automata (DFA) and Non-deterministic Finite Automata (NFA). Additionally, users can participate in quizzes to evaluate their understanding, and the system displays scores for self-assessment. The platform further provides access to progress reports, enabling students to track their learning performance over time.

Non-Functional Requirements

The NeoLearn system is designed to meet several non-functional requirements to ensure efficiency and reliability. Scalability is an important consideration, allowing the platform to support multiple users and handle concurrent AI-based queries without performance degradation. Usability is emphasized through a simple and intuitive interface that accommodates both students and administrators. Reliability is maintained by ensuring continuous system operation with minimal downtime and robust error-handling mechanisms. Security measures include secure authentication, encrypted data storage, and protected API communication to safeguard user information. Compatibility is ensured across Windows and Linux operating systems, as well as modern web browsers. Maintainability is achieved through a modular architecture that supports easy updates and debugging. Performance requirements focus on providing quick responses to user queries, typically within a few seconds, along with efficient rendering of visual diagrams. Accessibility is also prioritized

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through a responsive design that supports desktops, tablets, and mobile devices.

Computational Resource Requirements

Hardware Resources

The NeoLearn platform requires moderate hardware specifications for efficient operation. A processor equivalent to Intel i3 or higher is recommended to support system execution. A minimum of 4 GB RAM is required to ensure smooth multitasking and application responsiveness. Additionally, at least 40 GB of hard disk storage is necessary to accommodate application files, datasets, and user-generated content.

Software Resources

The system operates on Windows 10 or later versions, although it can also be deployed on other modern operating systems. The implementation utilizes Java as the primary programming language for backend development. Visual Studio Code is used as the integrated development environment for coding, debugging, and project management. These software resources collectively support the development and deployment of the NeoLearn platform.

Life Cycle Model

The NeoLearn project follows the Waterfall development model, which adopts a linear and sequential approach. The process begins with requirement analysis, where system functionalities and user expectations are clearly defined. This is followed by the system design phase, which outlines the architecture, including frontend, backend, and database components. During the implementation phase, individual modules such as authentication, AI tutoring, visualization, summarization, and assessment are developed according to the design specifications. The testing phase ensures that the system operates correctly by identifying and resolving functional and performance issues. After successful validation, the platform is deployed for user access. Finally, the maintenance phase involves continuous monitoring, updates, and enhancements to improve system performance and address user feedback. This structured approach ensures clarity, efficient planning, and systematic development.

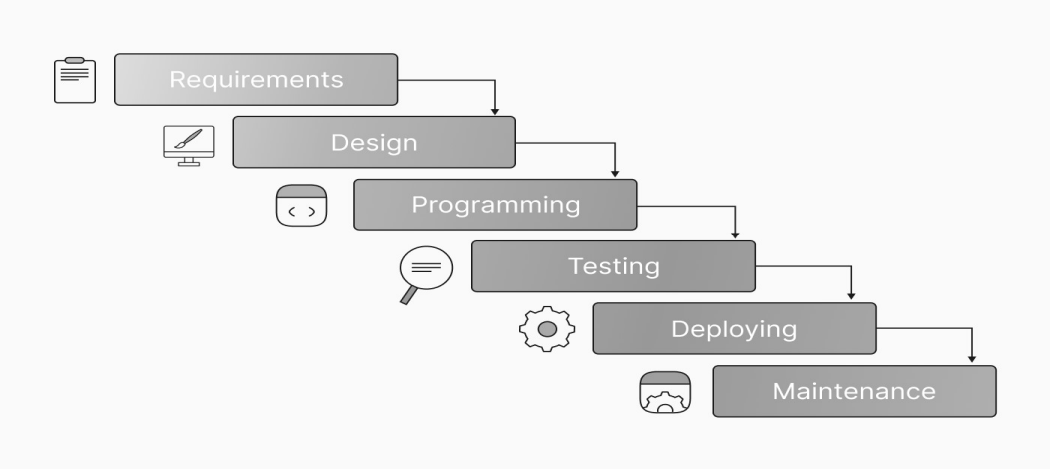

Fig 1 Life cycle model

Design

Architecture

Project architecture describes the structural organization of system components and the flow of request processing among them. It provides a formal representation of how different modules interact to perform system operations. The NeoLearn architecture is divided into software architecture and technical architecture, both of which contribute to the overall functionality and scalability of the platform.

Software Architecture

NeoLearn follows a modular software architecture in which major functionalities such as authentication, AI tutoring, visualization, summarization, quiz management, and performance analytics are implemented as independent components. This modular design enhances scalability, maintainability, and flexibility. The frontend is developed using technologies such as HTML, CSS, and JavaScript to provide an interactive user interface. The backend handles business logic and integrates AI-based services, while a database system is used to store user information, learning materials, and performance data. Communication between modules is achieved through RESTful APIs, ensuring seamless data exchange. Additionally, Natural Language Processing techniques are employed for query handling, summarization, and intelligent content generation. This architecture supports efficient system operation and future expansion.

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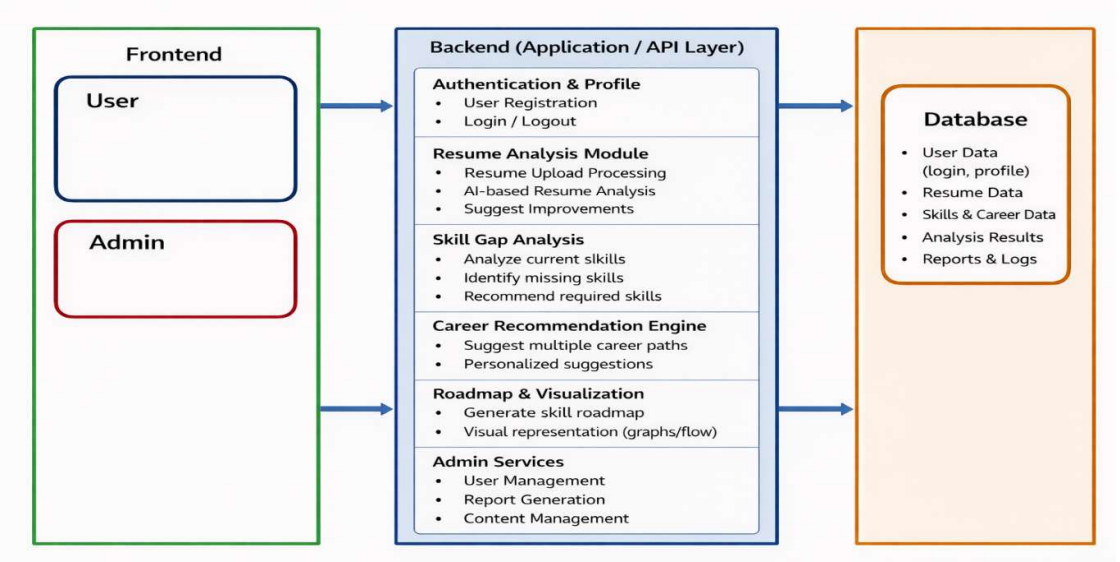

Fig. 2 Software Architecture

Technical Architecture

The NeoLearn platform adopts a client-server technical architecture consisting of three main layers: frontend, backend, and database. The frontend layer manages user interactions and sends API requests to the backend. The backend processes these requests, executes application logic, and interacts with AI services. The database layer stores user credentials, learning resources, quiz results, and performance analytics. This layered architecture ensures efficient data flow, improved security, and simplified maintenance. By separating presentation, logic, and data layers, the system achieves better performance and scalability.

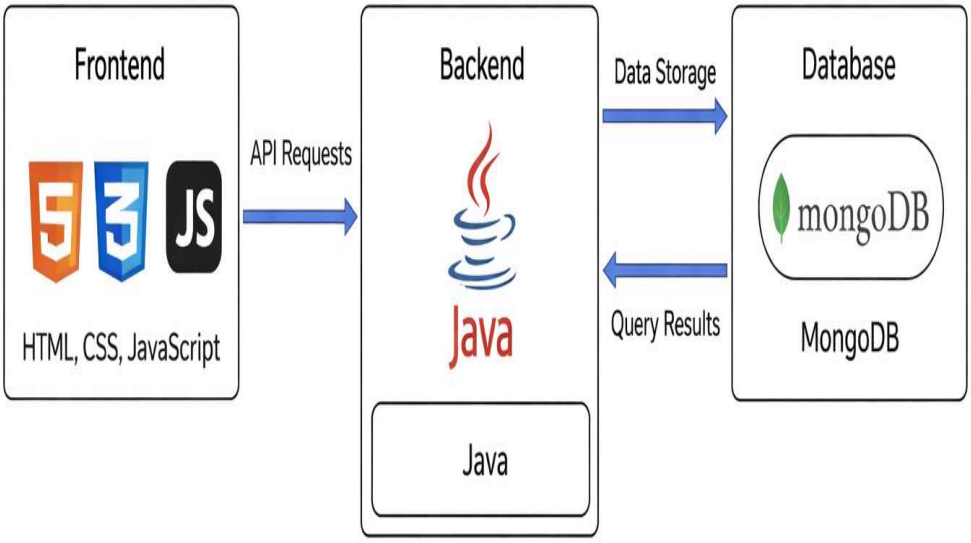

Fig.3 Technical Architecture

Implementation

The Random Forest algorithm is an ensemble learning technique that constructs multiple decision trees during training and combines their predictions to improve accuracy while minimizing overfitting. In the NeoLearn platform, this algorithm is used to classify students based on their learning performance and recommend appropriate learning resources. Each decision tree is trained using a random subset of the training dataset and a random selection of features, resulting in diverse decision patterns. When a new student's performance data—such as accuracy, error rate, and practice frequency—is provided, it is passed through all decision trees. Each tree independently predicts a category such as high performer, moderate learner,

or at-risk student. The final classification is determined through majority voting, where the class receiving the highest number of votes is selected as the final prediction. Based on this outcome, the system generates recommendations, such as suggesting easier exercises for weaker subjects or enabling visualization modules for improved understanding.

In addition to Random Forest, the NeoLearn system employs the K-Means clustering algorithm to group students based on learning behavior. K-Means is an unsupervised learning technique that partitions data into K clusters by minimizing the distance between data points and cluster centroids. Each student is represented using features such as quiz accuracy, average response time, practice frequency, and error rate. Initially, K centroids are selected, representing different learner categories. The algorithm calculates the Euclidean distance between each student's feature vector and the centroids. Students are assigned to the cluster with the smallest distance value. After assignment, centroids are recalculated as the mean of all data points within each cluster. This process continues iteratively until convergence. Through clustering, the system identifies learner groups and provides targeted learning suggestions for each category.

Testing

Software testing is an essential phase in the NeoLearn project to ensure that all modules operate correctly, efficiently, and securely. Since the platform manages student data and learning activities, it is important to verify system reliability and accuracy. The testing process focuses on validating key components, including the AI tutor, summarization module, quiz system, visualization features, and performance analytics. Each module is tested to confirm that it meets the specified functional requirements and produces expected outputs.The AI tutor module is evaluated to ensure that it generates accurate and relevant explanations in response to student queries. The summarization module is tested to verify its ability to convert lengthy academic content into concise key points. The quiz module is validated for proper question delivery, answer evaluation, and score calculation. Visualization features are tested to confirm that diagrams such as DFA and NFA are generated correctly. The performance analytics module is examined to ensure accurate tracking of user progress and identification of weak areas.In addition to module-level testing, backend testing is conducted to verify correct data processing and smooth communication between system components. Database testing ensures proper storage and retrieval of user data without loss or corruption. Security testing validates authentication mechanisms and protects sensitive information. Performance testing evaluates system responsiveness and ensures that multiple users can access the platform simultaneously without degradation in performance. These testing activities improve system reliability and overall user experience.

Stages of Testing

The testing process for NeoLearn follows a structured sequence of phases, including requirement analysis, test planning, test case development, test environment setup, test execution, and test closure.Test case development involves designing test scenarios with defined inputs, expected outputs, and execution steps. These test cases cover modules such as user authentication, AI responses, summarization accuracy, quiz evaluation, and visualization. The test environment setup phase configures the system using the required technologies and tools, ensuring realistic testing conditions. During test execution, all test cases are run, outputs are compared with expected results, and errors are identified and corrected. Finally, in the test closure phase, testing results are analyzed, reports are prepared, and the system is validated for deployment.

Types of Testing

NeoLearn incorporates both black-box and white-box testing techniques. Black-box testing evaluates system functionality without examining internal code structure. It focuses on validating inputs and outputs for different modules, ensuring that the application behaves as expected. White-box testing, on the other hand, analyzes internal logic and code structure. This method is typically applied at the unit level to verify individual components. Techniques such as statement coverage, branch coverage, and path coverage are used to ensure comprehensive testing of program logic.

Test Cases

Test cases are designed to validate different functionalities of the NeoLearn platform. These include testing user registration, login authentication, AI tutor responses, summarization accuracy, quiz evaluation, and progress analytics. Additional test cases evaluate system performance under multiple user requests and verify handling of edge cases such as invalid inputs and unauthorized access. The results indicate that all modules function correctly, producing expected outputs and maintaining system stability. The successful execution of these test cases confirms that the NeoLearn platform meets functional requirements and delivers reliable performance.

Screenshots

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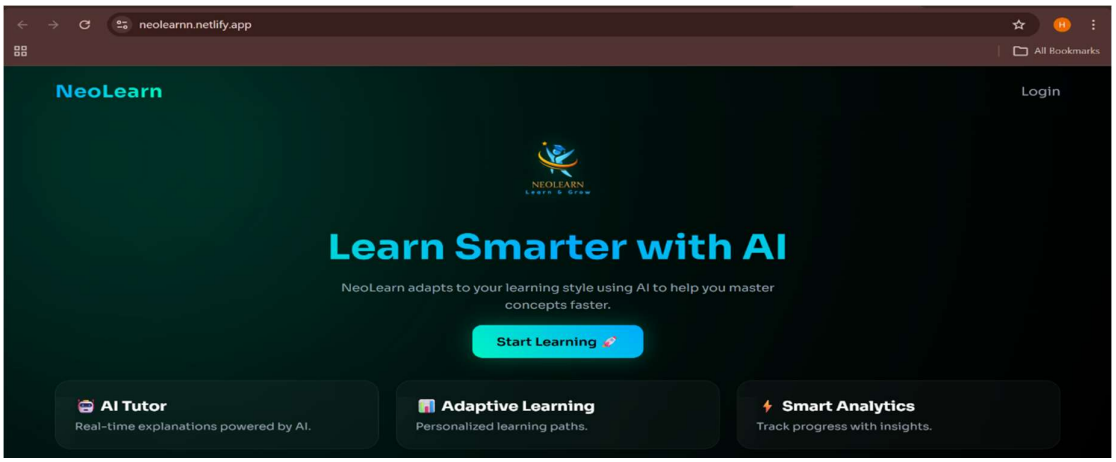
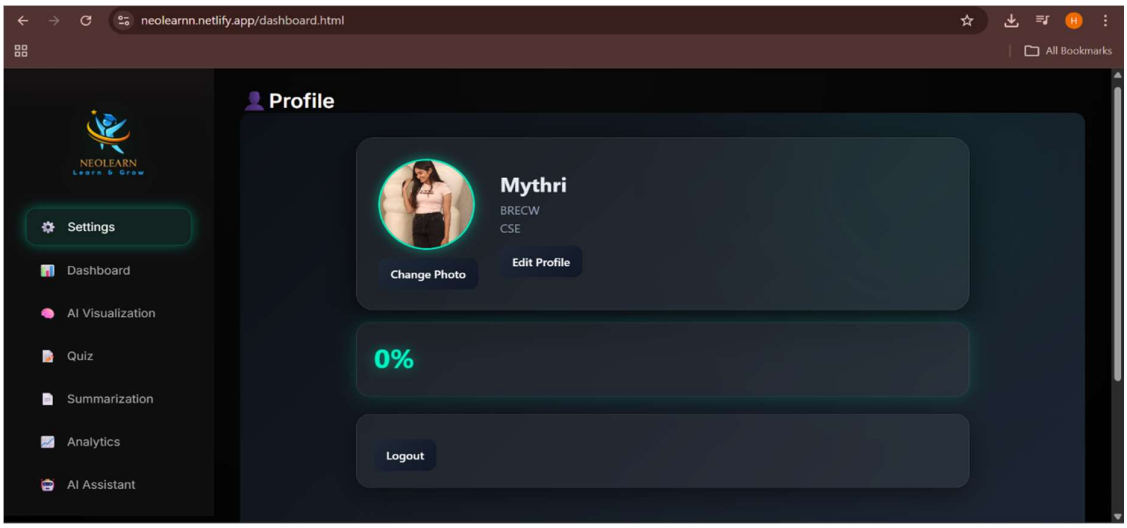
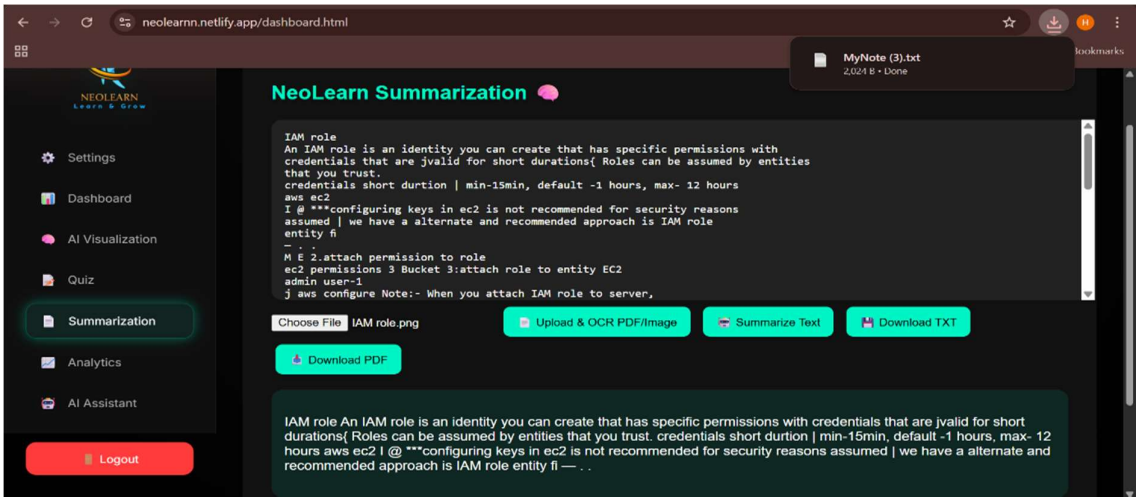


Screenshot 1 Welcome page



Screenshot 2 Profile page of Neo Learn



Screenshot 3 Summarized Text of the file uploaded

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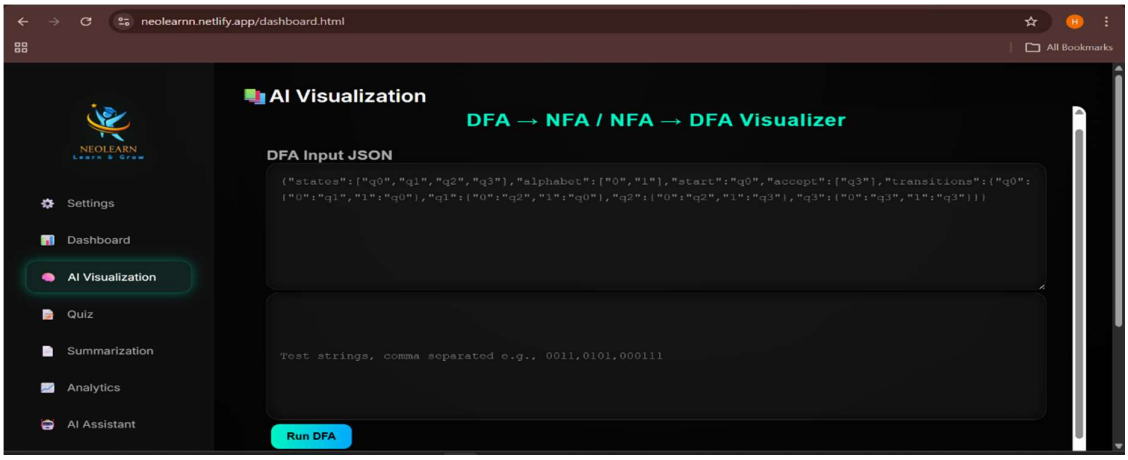
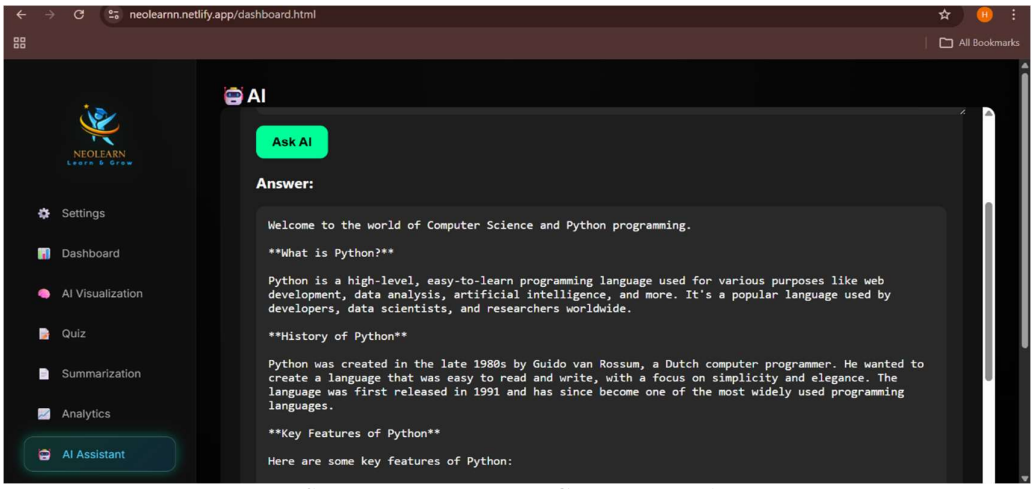


Screenshot 4 AI visualization page



Screenshot 5 Response Generated by AI

Conclusion

NeoLearn is an artificial intelligence–based adaptive learning platform designed to enhance students' understanding of complex academic subjects through personalized guidance and interactive learning tools. The system integrates intelligent tutoring, automated summarization, visualization modules, quizzes, and performance analytics within a unified environment. These features enable learners to receive contextual explanations, revise efficiently, and evaluate their knowledge through structured assessments. The inclusion of visualization components further supports comprehension of abstract topics, particularly in technical domains such as automata and algorithm design.

The platform also provides progress tracking and analytics, allowing students to monitor their performance and identify areas requiring improvement. By combining multiple educational functionalities into a single system, NeoLearn creates a dynamic and learner-centered environment that improves engagement and promotes effective knowledge acquisition. Overall, the proposed platform demonstrates the potential of artificial intelligence in delivering adaptive, efficient, and accessible learning experiences tailored to modern educational requirements.

Future Scope

Although the NeoLearn platform successfully integrates core learning functionalities, several enhancements can be implemented to further improve its capabilities. Future developments may include adaptive assessment mechanisms that automatically adjust quiz difficulty based on individual student performance. Advanced visualization techniques, including interactive simulations and real-time graphical representations, can be incorporated to enhance conceptual clarity for complex topics. Security features may also be strengthened by implementing advanced encryption methods and role-based access control to ensure safe handling of user data.

Additionally, deploying the system on cloud infrastructure can improve scalability and support a larger number of concurrent users. The integration of gamification elements such as rewards,

leaderboards, and achievement badges could increase student motivation and engagement. Voice-based interaction and multilingual support can further enhance accessibility for diverse users. These improvements will contribute to making NeoLearn a more robust, scalable, and intelligent learning platform capable of supporting a wide range of educational needs.

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