**Illumination: An AI-Driven Adaptive Mobile Learning Application**

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Abstract— This paper introduces Illumination, an AI-driven mobile learning app that delivers tailored learning content based on real-time adaptation of student performance and preference. It enables targeted recommendation to help students improve in the weak areas of their performance while still allowing the student's progress in the subjects they perform well in. With an intuitive performance dashboard, students using Illumination can view their learning process, get tailored feedback, and be guided through a personalized study path across a variety of subjects. Through its spaced repetition and reinforcement learning, Illumination boosts knowledge retention and engagement to provide support for individual success. The present paper explores machine learning algorithms, system architecture, and evaluation metrics that contribute to a dynamic and effective adaptive learning experience.

Keywords— **Adaptive learning, mobile application, personalized recommendations, machine learning, spaced repetition, reinforcement learning.**

1. Introduction

Personalized learning has recently become one of the most essential elements of educational technology. Illumination is an AI-driven mobile learning platform which uses adaptive algorithms for the presentation of tailored content, helping a student to identify and work on his or her areas of weakness, while also studying other subjects in which he or she excels. Illumination provides the use of reinforcement learning for dynamic adaptation of content, a performance dashboard for actionable insights, and spaced repetition for maximum retention.

This paper describes the architecture, algorithms, and functionality of Illumination that demonstrate how AI techniques improve learning content to be more personalized and effective. In such a way, Illumination seeks to make education more available, time-efficient, and student-oriented.

1. Literature Review

Personalized learning applications have recently gained significant attention with regard to improving educational outcomes. Evidence shows that technologies from adaptive learning reinforced by reinforcement learning, content-based filtering, and vectorization techniques such as Word2Vec are able to deeply engage students based on the modification of real-time complexity of the content.

Such reinforcement learning in the course of adaptive learning is usually applied to give an appropriate level of difficulty depending on learner performance. With the help of vectorization algorithms, such as Word2Vec, content-based filtering is able to suggest articles, quizzes, and other content relevant to learners similar to previously successful material. Such a combination of adaptive algorithms with user-oriented feedback fully corresponds to the contemporary trends of educational technologies, and is highly relevant for the needs of diverse learning.

1. **System** requirements

Illumination aims to offer a seamless learning experience through functional and technical requirements that meet adaptive learning objectives.

A. *Functional Requirements*

1. **Personalized Content Recommendations**: Content is recommended based on individual quiz results and areas of weakness.
2. **Spaced Repetition Scheduling**: The system schedules content reviews for optimal intervals to reinforce learning.
3. **Performance Dashboard**: The dashboard displays metrics such as quiz scores, time spent on content, and mastery by subject, helping students visualize their strengths and weaknesses.

B. *Technical Requirements*

1. **Machine Learning Algorithms**: Reinforcement learning and Word2Vec models are implemented to analyze quiz results and generate recommendations.
2. **User Interface**: A mobile-responsive, intuitive interface allows students to navigate content, view recommendations, and track progress effortlessly.
3. **Backend Infrastructure**: Using Fast API for machine learning processes, NodeJS for user management, MongoDB for data storage, and AWS for deployment, the backend ensures secure and scalable data management.
4. System **Architecture**

A diagram of a software system

Description automatically generated with medium confidence

Fig 1. Conceptual Architecture Diagram

The three major components comprise Illumination architecture: frontend, backend, and machine learning services.

* 1. *Frontend*

The front-end, developed on React Native, provides cross-platform functionality, while its intuitive design helps in the easy navigation of users through learning modules, quizzes, and progress dashboards.

* 1. *Backend*

It consists of machine learning task processing through Fast API and the interaction of clients/user management through NodeJS. MongoDB stores information about the users, quiz results, and learning material, while AWS hosts the application for high availability and scalability.

* 1. *Machine Learning*

The ML module utilizes reinforcement learning for adaptive content delivery and Word2vec for semantic similarity analysis, which will make recommendations based on student preference and performance.

1. **Algorithms**

In Illumination uses the Machine Learning Algorithms to render the system adaptive and personalized.

1. *Reinforcement Learning*

Illumination employs reinforcement learning for personalization: this dynamic RL algorithm adjusts the difficulty level with the performance of the student, such that high-scoring students gradually receive harder questions, while students who struggle with it get easier questions. That way, it keeps the students engaged and does not discourage them with either overly difficult or overly easy material.

1. ***Word2Vec for Content-Based Filtering***

Illumination implements the Word2vec model for extending content-based filtering. It will reimagine articles and learning content in vector space, including semantic relations such that recommendations of this kind of article will fall closer to students' past preferences or weak points in some area and hence will make the recommended content more relevant.

1. **Key Features**

1. ***Performance Dashboard***

The performance dashboard is a visual metric whereby students follow up on their progress academically: they can see the scores of their quizzes, the time spent with articles, and even their subject mastery, from which they can find out their weaknesses and their strong points, thus putting in more time where it is needed. Graphing progress yields visually actionable insights, enabling students to set reasonable performance improvement goals.

A screenshot of a phone

Description automatically generated

*(Figure 2: Example of Performance Dashboard Visualization)*

1. ***Spaced Repetition Scheduling***

Illumination reinforces long-term retention through the spacing effect and will schedule reviews of the content at optimum intervals based on performance on quizzes and prior interaction. That kind of scheduling reinforces key concepts at regular points in time to decrease memory decay and reflects cognitive science principles that foster long-term retention.

1. ***Dynamic Content Adjustment***

Illumination automatically adjusts the content through dynamic effects of individual learning curves thanks to its RL model. If students master certain areas, then more advanced topics just appear in a very smooth way; if they struggle, the app suggests more simple or review content. All this makes students constantly challenged but never overwhelmed.

1. **Testing and Evaluation**

Illumination continuously conducts extensive testing on its system for reliability and precision. Tests of greatness involve content recommendation relevance, efficacy of spaced repetition, and accuracy of data on the dashboard.

* 1. *Test Cases*

The key test cases will confirm the following Illumination functionalities:

1. **Personalized Content Recommendations:** Many of the tests reflect alignment in content recommendations based on quiz performance to find the weak areas.
2. **Spaced Repetition Scheduling:** Tests ensure that the reminders for content review pop up when it's optimal for better retention.
3. **Performance Dashboard Accuracy:** Tests confirm that the metrics present in the dashboard accord with a user's quiz results, time spent reading the articles, and subject mastery.
   1. ***Evaluation Metrics***

The efficiency improvement in performance in the quizzes taken, the engagement rate, and retention in the quizzes-the key indicators of the app's effectiveness. These are the metrics studied over time in determining the accuracy and impact of Illumination's adaptive learning model.

1. **Results and Discussion**

A diversified student pilot measured illumination to decide upon the effectiveness of adaptive learning. There is a trend of increased comprehension and retention in relatively weaker subjects; spaced repetition is included in the personalized content recommendations. The engagement has been maintained with the successful adaptation of content difficulty based on scores obtained at each quiz using the reinforcement learning model, without repetitive or overly challenging material.

These pilot study results point towards the efficiency of combined use of RL and Word2Vec in an adaptive application.

In fact, the entire exercise of integration of data and fine-tuning of ML models through rigorous iterative testing resulted in a far better responsiveness of the model and increased recommendation accuracy. This will continue in future iterations: refining the ML algorithms to derive greater personalization, with more content added for many more subjects.

1. **Testing and Evaluation**

Illumination is a unique mobile learning application that introduces personalized education to students for the first time through dynamic adaptation of content based on the needs and level of performance for each student. Illumination embeds reinforcement learning with Word2Vec and spaced repetition to produce obtained results with long-term knowledge retention. Results from our studies suggest that personalized learning apps, such as Illumination, may improve educational outcomes by making effective, student-centered learning adaptive across a wide range of learning environments. The further course of development will include the investigation of more AI techniques for even finer granularity, increase the base of subjects, and additional features promoting collaborative learning. Such additional functionality will help Illumination maintain leadership in adaptive mobile education.

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