A Comprehensive E-Learning Platform developed using MERN-Stack with Automated Grading Functionalities

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Abstract - *The digital revolution is transforming the educational landscape, and engineering education is no exception. While traditional methods provide a strong foundation, they often struggle to adapt to the diverse learning styles and needs of contemporary students. Furthermore, manual assessment methods, particularly for essay-based assignments, create bottlenecks in the learning process. Time-consuming grading delays valuable feedback, hindering student progress and engagement.*

This research presents a novel solution: a comprehensive e-learning platform specifically designed for engineering education, integrated with an Automated Essay Scoring (AES) system powered by machine learning. The platform leverages the MERN stack (MongoDB, Express.js, React.js, and Node.js) to provide a user-friendly and interactive learning environment. The innovative AES component utilizes a pre-trained Long Short-Term Memory (LSTM) network trained on a relevant engineering essay dataset. This allows the platform to generate automated essay scores, streamlining the assessment process for instructors and facilitating the timely delivery of feedback to students. This not only enhances instructor efficiency but also fosters a more engaging and effective learning experience.

Key Words: E-learning platform, MERN stack, Automated Essay Scoring (AES), Machine Learning, Engineering Education, Assessment, Feedback

1.INTRODUCTION

The landscape of engineering education is undergoing a dynamic transformation. Traditional methods, while laying a strong foundation, often lack the flexibility and personalization needed to cater to the diverse learning styles and needs of today's students. Furthermore, the reliance on manual assessment practices, particularly for essay-based assignments, can create bottlenecks in the learning process. Time-consuming grading delays the delivery of valuable feedback, hindering student progress and engagement.

This research addresses these challenges by proposing the development of a comprehensive e-learning platform specifically designed for engineering education. This platform leverages the power of the MERN stack (MongoDB, Express.js, React.js, and Node.js) to provide a user-friendly and interactive learning environment. But its true innovation lies in the integration of an Automated Essay Scoring (AES) system powered by machine learning. By utilizing a pre-trained Long Short-Term Memory (LSTM) network, this platform can generate automated essay scores, significantly streamlining the assessment process for instructors. This not only saves valuable time but also allows for the provision of more timely feedback to students, fostering a more effective and engaging learning experience.

The following sections will delve deeper into the details of this proposed platform. We will explore the benefits of e-learning platforms in engineering education, examine relevant research on AES, and provide a comprehensive breakdown of the system's architecture and functionalities. Furthermore, the methodology for data preprocessing, machine learning model development, and web application creation will be presented. Finally, the evaluation methods for both platform usability and AES model accuracy will be outlined.

2. LITERATURE REVIEW

E-learning Platforms in Engineering Education

The growing demand for accessible and flexible learning opportunities has fuelled the development and implementation of e-learning platforms in engineering education. Studies have consistently demonstrated the positive impact of these platforms on various aspects of the learning process.

- Alsawadi et al. (2019) conducted a study investigating the effectiveness of a web-based learning environment for teaching undergraduate engineering courses. Their findings revealed significant improvements in student learning outcomes compared to traditional lecture-based methods.
- Sun et al. (2020) explored the use of a blended learning approach that combined online modules with traditional classroom instruction for an engineering mechanics course. The results indicated that the blended learning approach led to increased

student engagement and improved performance compared to the traditional approach.

- Zhang et al. (2018) examined the impact of a mobile learning platform on student motivation and self-directed learning in engineering education. Their research showed that the platform fostered a more learner-centered environment, promoting student autonomy and motivation in the learning process.

These studies highlight the potential of e-learning platforms to enhance the educational experience for engineering students by providing flexibility, accessibility, and interactive learning opportunities.

Automated Essay Scoring (AES) in Engineering Education

While e-learning platforms offer numerous benefits, traditional assessment methods, particularly for essay-based assignments, can pose challenges. The implementation of AES offers a promising solution to address these challenges.

- Zervan et al. (2019) investigated the use of AES for evaluating engineering ethics essays. Their research demonstrated that AES models could achieve a level of accuracy comparable to human graders, suggesting their potential as a valuable assessment tool.

- Yoon & Powers (2018) explored the application of AES for assessing open-ended problem-solving skills in engineering courses. Their findings indicated that AES models were effective in identifying key elements of students' problem-solving approaches within essays.

- Liu & Zhao (2020) examined the use of AES to provide students with immediate feedback on their writing. The study demonstrated that students who received automated feedback alongside human grading exhibited improvements in their writing skills over time.

These studies showcase the potential of AES in engineering education for streamlining the assessment process, providing timely feedback to students, and evaluating specific skills within essays. However, it is crucial to acknowledge that AES models are still under development, and ongoing research is needed to address limitations, such as the ability to capture the nuances of human language and complex arguments often found in engineering essays.

Integration of E-learning Platforms and AES

The proposed research builds upon the strengths of both e-learning platforms and AES by integrating them into a comprehensive system specifically designed for engineering education. This integration has the potential to create a more efficient and effective learning environment.

- Wang et al. (2021) explored the development of an e-learning platform with integrated AES for a language learning course. Their study demonstrated that the platform provided a user-friendly interface for both students and instructors, while the AES component offered valuable feedback to students on their writing skills.

- Chen et al. (2020) proposed a framework for an adaptive learning platform that utilized AES to personalize learning experiences based on student performance in essay assessments. Their research suggests that such integration can provide targeted feedback and learning materials to address individual student needs.

3. PROPOSED SYSTEM

The proposed e-learning platform consists of three main components:

Front-end: Developed using ReactJS, providing a user-friendly interface for students and instructors to interact with the platform.

Back-end: Built using NodeJS and ExpressJS, handling server-side logic and communication with the database.

Database: Utilizes MongoDB, a NoSQL database, to store course content, user data, and assessment results.

Fig - 1: Class diagram

A. Core Functionalities (MERN Stack):

- User authentication and registration for students and instructors
- Course creation and management by instructors
- Course enrollment and content access for students
- Online assessments, including essay submissions

- Progress tracking and reporting for students and instructors

B. Integration of Automated Essay Scoring (AES):

- The platform utilizes a pre-trained LSTM network to score student essays.
- The model is trained on a relevant engineering essay dataset, such as "The Hewlett Foundation: Automated Essay Scoring Dataset" by ASAP (https://www.kaggle.com/c/asap-aes).
- Instructors can choose to utilize the AES score alongside their own human evaluation.
- The platform can flag essays with significant discrepancies between the AES score and the instructor's score for review.

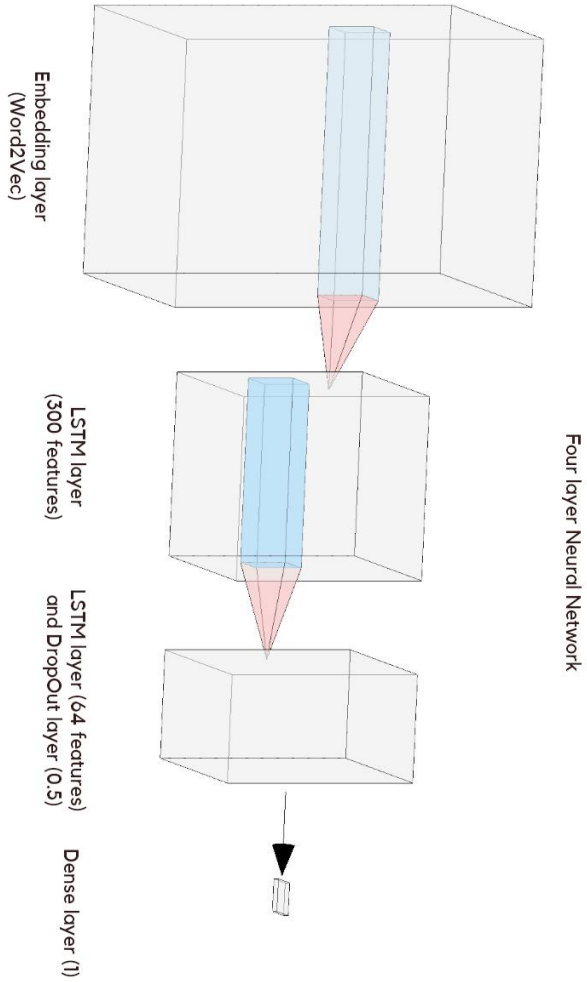

Fig – 2: Four Layered Neural Network

C. Results:

Step 1:

Fig – 3: Interface for automated grading

Step 2:

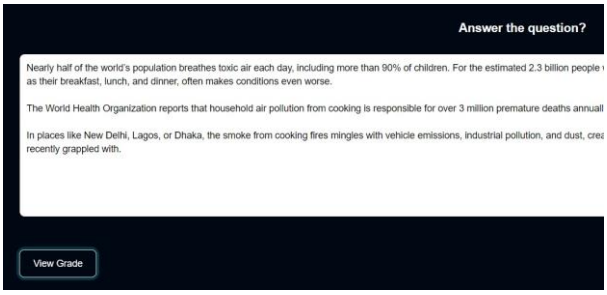

Fig 4: Enter your text for auto-grading

Step 3 :

Fig 5: Result of auto grading

4. SYSTEM ARCHITECTURE

The proposed e-learning platform with AES adopts a client-server architecture, consisting of the following components:

Web App (Client-side):

Developed using ReactJS, this component provides a user-friendly graphical interface for students and instructors to interact with the platform. Students can access course materials, submit essays, and view their grades with the platform.

Instructors can create and manage courses, view student submissions, and assign grades.

API (Server-side):

Built using Node.js and Express.js, this component acts as an intermediary between the web app and the backend services.

It handles user authentication, authorization, and communication with the database and machine learning models.
The API receives essay submissions from the web app, preprocesses the essays using techniques like stop word removal and text normalization, and sends them to the machine learning model for scoring.

It also retrieves grades and feedback from the model and sends them back to the web app for display.

Database (Backend):

MongoDB, a NoSQL database, is used to store various types of data, including:

1. User accounts and roles (students and instructors)
2. Course content (lectures, assignments, etc.)
3. Student essays and grades
4. Machine learning model parameters

Machine Learning Model:

- A pre-trained Long Short-Term Memory (LSTM) network is employed to perform automated essay scoring.
- This model is trained on a relevant engineering essay dataset, such as "The Hewlett Foundation: Automated Essay Scoring Dataset" by ASAP (https://www.kaggle.com/c/asap-aes).
- The LSTM network analyzes the essays and generates scores that reflect the quality of the writing.

External Storage (Optional):

The system may integrate with an external storage service for storing large files, such as multimedia course content.

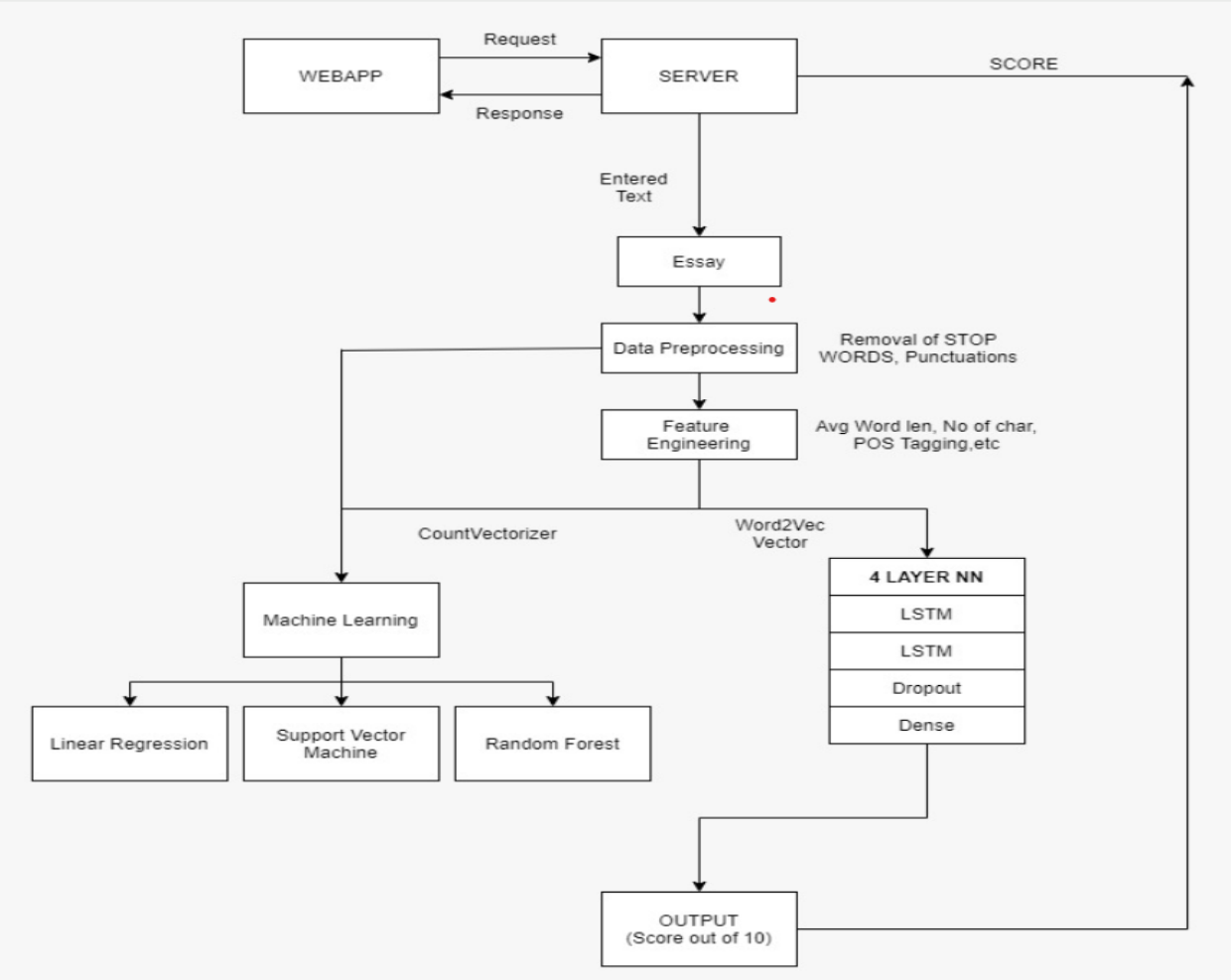

Fig-6: Flow diagram

5. METHODOLOGY

A. Data Preprocessing

- Standard preprocessing steps are applied, including null value imputation and feature selection.
- Techniques are implemented to address skewness in the data and improve model performance.
- Essay cleaning is performed to remove unnecessary symbols, stop words, and punctuation.
- Additional features are considered, such as sentence count, word count, and average word length.
- Techniques for part-of-speech tagging and misspelling detection are explored for further feature extraction.

B. Machine Learning Model Development

- Initial exploration involves applying machine learning algorithms like linear regression, Support Vector Regression (SVR), and Random Forest to the pre-processed data.
- Feature engineering is performed by incorporating additional features identified during preprocessing.
- A deep learning approach is implemented using a recurrent neural network (RNN) with an LSTM architecture.
- The LSTM network is trained with word embeddings generated by a Word2Vec model.
- The model is optimized using appropriate loss functions and optimizers.

C. Web Application Development

- A web application is developed using the Flask framework to deploy the trained model.
- The application provides a user interface for instructors and students to interact with the platform.
- Instructors can create and manage courses, while students can enroll in courses, submit essays, and receive feedback.
- The AES functionality is integrated into the essay submission process, providing instructors with the option to utilize the generated score.

6. EVALUATION

- The platform's usability and effectiveness will be evaluated through user testing with students and instructors.
- The accuracy of the AES model will be assessed using standard metrics on a held-out test set.

7. CONCLUSION

The development of a comprehensive e-learning platform with AES for engineering education offers a significant advancement in educational technology. This platform empowers students with a flexible and engaging learning environment while providing instructors with tools to streamline assessment and provide timely feedback. Future enhancements may include:

- Integration of adaptive learning algorithms for personalized learning paths.
- Gamification elements to enhance student motivation

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BIOGRAPHY

Prof. Pramila M. Chawan, is working as an Associate Professor in the Computer Engineering Department of VJTI,Mumbai. She has done her B.E.(Computer Engineering) and M.E.(Computer Engineering) from VJTI College of Engineering, Mumbai University. She has 28 years of teaching

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