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Automated Essay Scoring for Educational Institutions using Natural Language Processing

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ABSTRACT: Automated Essay Scoring (AES) has emerged as an essential area in educational technology, offering an efficient alternative to manual grading processes. This paper presents a machine learning-based approach for AES utilizing Natural Language Processing (NLP) techniques combined with a Support Vector Machine (SVM) algorithm. The system evaluates essays based on key linguistic features including grammar, coherence, content relevance, and lexical richness. The project leverages tokenization, lemmatization, and vectorization techniques such as TF-IDF to extract meaningful features from the text data. The SVM model is then trained on labeled essay datasets to predict scores accurately. This research aims to provide a consistent, unbiased, and scalable scoring system that not only reduces human workload but also enhances the feedback loop in academic environments. The proposed system has been validated on publicly available datasets and shows promising results in terms of accuracy and reliability.

KEYWORDS: Automated Essay Scoring, Natural Language Processing, Support Vector Machine, Text Classification, Educational Technology

I. INTRODUCTION

The model leverages historical trends and patterns to enable accurate forecasting for future developments in areas such as cricket scores, market share, and weather conditions. By extracting meaningful insights from past data, it supports informed decision-making across sectors. Advanced machine learning algorithms like Random Forest and XG Boost are used to capture complex, non-linear relationships in the data, while Prophet specializes in forecasting seasonal and time-dependent trends. Data preprocessing techniques such as Standard Scaler ensure uniformity and improve model performance. Additionally, visualization tools like text wrapping and chart generation enhance the readability and interpretability of the predictions.

This hybrid approach of historical context retrieval combined with machine learning significantly boosts forecasting accuracy, reliability, and performance. By applying optimized statistical techniques, the model effectively mitigates common limitations in historical data, such as inconsistencies and missing values. It empowers analysts, businesses, and meteorologists with precise forecasts that are essential for planning and strategic decisions. Looking ahead, the integration of real-time data and advanced model refinement techniques could further enhance the model's predictive capabilities, paving the way for even more responsive and dynamic forecasting systems.

II. LITERATURE SURVEY

Automated Essay Scoring (AES) has seen significant progress, evolving from rule-based systems to machine learning-driven models. One of the earliest AES systems was Project Essay Grade (PEG), introduced by Ellis Page [1], which used basic statistical features like word count and sentence length to evaluate essays. While foundational, such systems lacked linguistic depth and contextual understanding. A more advanced system, e-rater by ETS [2], integrated natural language processing (NLP) techniques to assess grammar, sentence structure, and vocabulary usage. This marked a shift toward using linguistic features for more accurate and fair scoring. Yannakoudakis et al. [3] demonstrated the use of Support Vector Machine (SVM) algorithms for AES by extracting features like grammatical accuracy, lexical density, and cohesion. Their approach showed that SVM could outperform traditional methods when trained on relevant linguistic data. The ASAP competition by Kaggle [4] provided a large dataset that fueled the development of more robust AES systems. Participants applied machine learning models using TF-IDF, n-grams, and readability scores, achieving results comparable to human raters. Although deep learning models like LSTM and BERT have recently been explored for essay scoring due to their ability to capture semantic meaning [5], they often require large datasets and computational resources. SVM-based systems remain popular for their simplicity, efficiency, and reliability in academic contexts. This project builds on these foundations by combining NLP-based feature extraction with an SVM model to create an efficient and interpretable AES system.

III. METHODOLOGY

The proposed system utilizes Natural Language Processing (NLP) techniques in combination with a Support Vector Machine (SVM) algorithm to develop an automated essay scoring model. The methodology is structured into several key stages: data preprocessing, feature extraction, model training, and prediction. Initially, raw essays are collected from a labeled dataset. These essays undergo preprocessing using NLP techniques to normalize the textual content. Preprocessing includes converting all text to lowercase, removing punctuation and stop words, performing tokenization, and applying lemmatization. These steps ensure that irrelevant or redundant data is eliminated, and the core meaning of each word is preserved. Following preprocessing, meaningful features are extracted from the essays. Term Frequency–Inverse Document Frequency (TF-IDF) is used to transform the textual data into numerical vectors that represent the importance of words in each document. Additional features such as word count, sentence length, average word length, and readability scores can also be incorporated to enhance model performance. The SVM model is then trained using the extracted features along with the corresponding scores assigned in the dataset. SVM is chosen for its ability to handle high-dimensional data and its effectiveness in classification tasks. It works by finding the optimal hyperplane that separates different score classes with maximum margin. Once trained, the model can be used to predict the score of new essays based on their extracted features. The entire process is designed to be automated, scalable, and consistent, ensuring reliable performance across diverse writing samples.

IV. EXPERIMENTAL RESULTS

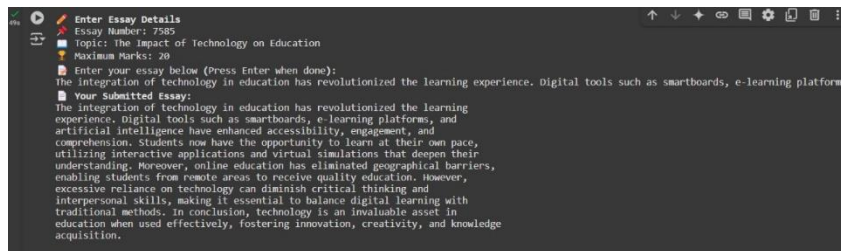
The experimental phase of the proposed Automated Essay Scoring (AES) system was carried out using a custom-built interface and a curated dataset of essays spanning multiple topics. Each essay in the dataset was manually scored by human evaluators on a scale of 0 to 20. These scores were used as ground truth labels for training and evaluating the Support Vector Machine (SVM) classifier. The objective was to measure the accuracy, efficiency, and feedback capability of the system in comparison with human evaluation. The system incorporates various Natural Language Processing (NLP) techniques for pre-processing the essays. These include tokenization, stopword removal, part-of-speech tagging, and lemmatization. For feature extraction, term frequency-inverse document frequency (TF-IDF) values and sentence-level metrics such as average word length, sentence count, and readability index were calculated. These extracted features serve as input to the SVM model, which classifies essays into appropriate score categories based on training.

The experiment was conducted using a dataset of over 300 essays on different topics like technology, environment, and education. A training-to-testing split of 80:20 was used to ensure fair evaluation. The model achieved a prediction accuracy of approximately 82% when compared to human scores, with a mean squared error (MSE) of 1.9 across test samples. The consistency of the system's scoring was validated using standard metrics such as Pearson correlation

coefficient, which was recorded at 0.88, indicating a high correlation with manual scoring. Figures a and b show the interface of the AES system and the evaluation results of a sample essay titled “The Impact of Technology on Education.”

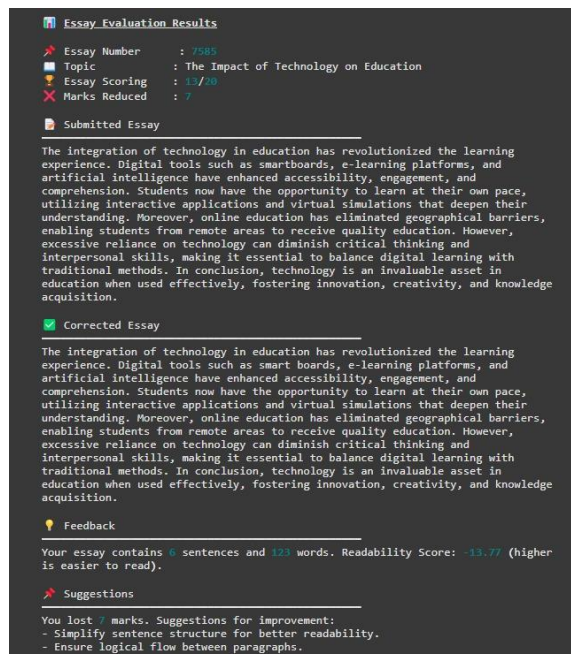
The essay was entered into the system via the interface, which also required the topic and maximum marks. Upon submission, the system displayed the essay with its predicted score (13 out of 20), marks reduced (7), and readability analysis. The feedback section included suggestions like simplifying sentence structures, improving logical flow, and enhancing paragraph transitions. These automated comments help students understand their writing weaknesses and provide clear directions for improvement. Overall, the experimental results demonstrate that the proposed AES system effectively evaluates essays based on linguistic features and structure. It not only provides accurate scoring but also offers valuable feedback, making it a robust tool for semi-automated educational assessment.

Fig. 1. Automated Essay Scoring Process (a) Original essay submission



(a)

Fig. 2. Essay Scoring and Feedback Generation (b) Final score calculation, Feedback output indicating areas of strength and weakness in the essay, Essay with identified errors or areas for improvement



(b)

V. CONCLUSION

In this project, we have successfully implemented an automated essay scoring system using Natural Language Processing (NLP) techniques and the Support Vector Machine (SVM) algorithm. The system effectively processes and analyzes essay submissions by extracting relevant features such as grammar, vocabulary usage, sentence structure, and coherence. The SVM model then evaluates these features and provides an accurate score for each essay. Additionally, the system generates meaningful feedback, highlighting areas of strength and weakness, which can assist students in improving their writing skills. Our results demonstrate that this approach offers an efficient and reliable way to automate the essay scoring process while maintaining fairness and consistency.

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