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AI-BASED AUTOMATED GRADING SYSTEM AND PERSONALIZED FEEDBACK IN HIGHER EDUCATION

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Abstract: A cloud-native grading environment that leverages advanced language models to assess and comment on open-ended student submissions. Implemented with a modern JavaScript framework and Firebase's real-time backend, the platform offers dedicated upload portals for instructors' exemplar responses and learners' work. An AI-driven analysis engine transforms text into semantic representations, compares student answers against reference solutions, and generates bespoke feedback statements. By automating scoring and commentary, the system not only lightens educators' workloads but also ensures uniformity in evaluation and supplies students with clear, actionable insights. The platform also supports continuous learning by refining its feedback strategies based on historical assessment data. Additionally, it incorporates adaptive analytics dashboards for instructors to monitor class performance trends and intervene proactively.

Keywords: Automated assessment, Semantic embeddings, real-time synchronization, Personalized feedback, educational AI, adaptive learning, performance analytics

I. INTRODUCTION

In today's educational landscape, the role of timely, high-quality feedback is more critical than ever for promoting meaningful student growth. However, traditional approaches to evaluating open-ended assignments, such as essays and problem-solving tasks, often place a heavy workload on instructors and are prone to subjective va riation. As academic programs expand and student enrollments rise, the demand for scalable, consistent, and insightful assessment tools has become increasingly urgent.

The Educational Grading System emerges as a solution to these challenges, offering a modern approach that leverages advanced technologies to automate and enhance the grading process. By integrating artificial intelligence, natural language processing, and real-time data synchronization, the system provides swift and objective evaluations while delivering personalized, actionable feedback to learners. It not only reduces the administrative burden on educators but also helps ensure fairness, transparency, and continuous support for student development.

The motivation behind developing such a system lies in addressing critical issues observed in traditional assessment methods, including time inefficiencies, inconsistent evaluations, delayed feedback delivery, limited personalized support, and the lack of analytical insights into student performance trends. Through intelligent automation and thoughtful design, the Educational Grading System aspires to transform the assessment experience for both educators and learners, fostering a more dynamic, responsive, and effective learning environment.

II. LITERATURE SURVEY

The development of AI-based grading systems has gained significant traction in educational technology due to increasing demands for efficient, consistent, and scalable assessment methods. Various approaches and studies have shaped the design of modern grading systems, focusing on automation, natural language processing, and feedback generation.

A. Automated Essay Scoring (AES)

Landauer et al. (1998) pioneered automated essay evaluation using Latent Semantic Analysis (LSA) to assess content relevance and coherence in written responses. This approach was further refined by Attali and Burstein (2006), who introduced machine learning techniques that leverage linguistic features to provide more accurate scoring.

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B. Natural Language Processing in Education

Advancements in Natural Language Processing (NLP) have greatly enhanced automated assessment capabilities. Transformer-based models such as BERT (Devlin et al., 2019) have demonstrated strong performance in understanding semantic relationships and contextual nuances within student responses. These models allow educational systems to evaluate open-ended answers more effectively, ensuring a deeper analysis of student understanding.

C. Feedback Generation Systems

Shermis and Burstein (2013) and Foltz and Rosenstein (2015) focused on automated feedback systems that extend beyond scoring to provide targeted, constructive comments on student writing. These systems identify specific strengths and areas for improvement, helping learners refine their thinking while reducing the workload for instructors.

D. Hybrid Human-AI Assessment Models

Madnani et al. (2018) proposed hybrid grading models where AI handles routine assessment tasks while human instructors focus on complex evaluations. This approach balances the efficiency of automation with the depth of human judgment, ensuring accuracy while reducing grading workloads.

III. SYSTEM ARCHITECTURE

The **Educational Grading System** addresses common challenges in automated grading by integrating modern web technologies, natural language processing (NLP), and an intuitive user interface. Below is a detailed overview of its architecture and process flow:

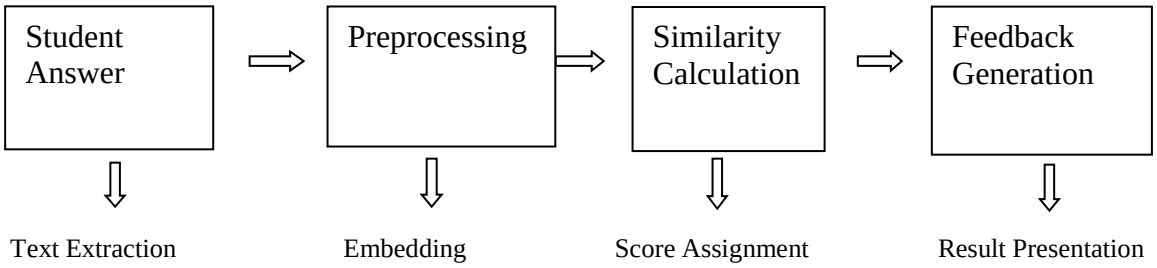

Fig. 1 Work Flow

A. Student Answer: The input is a free-text response from the student that needs evaluation.

B. Text Extraction: Parses and extracts the raw text from the student's input (e.g., from a form, document, or speech-to-text output).

C. Preprocessing

Cleans and normalizes the text (lowercasing, removing punctuation/stopwords, lemmatization, etc.) to prepare it for embedding.

D. Embedding: Converts the pre-processed text into a numerical representation (vector) using methods like TF-IDF, Word2Vec, BERT, etc.

E. Similarity Calculation: the student's answer vector to a model or reference answer vector using cosine similarity or other distance metrics.

F. Score Assignment: Based on similarity (and possibly other features like grammar, key concept presence), assigns a score to the student's answer.

G. Feedback Generation: Generates specific, actionable feedback (e.g., "Good explanation of concept X, but missing Y") using rules, templates, or generative models.

H. Result Presentation: Displays the score and feedback to the student, possibly with visualizations or suggestions for improvement.

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IV. IMPLEMENTATION

1. Project Setup
The AI-based grading system will be developed using FastAPI for the backend and React for the frontend. FastAPI will handle user authentication, file uploads, and grading logic, while React will manage student and instructor interfaces. Key dependencies for the backend include FastAPI, Firebase, and transformers, and for the frontend, React and Axios.

2. User Authentication and Authorization
The system will use JWT-based authentication to ensure secure access. Users will have distinct roles, with role-based access control to manage permissions. JWT tokens will provide secure access to resources, and password resets will be supported for user convenience.

3. File Upload for Answer Sheets
Instructors can upload model answers and grading rubrics, while students can submit their answer sheets for grading. FastAPI will handle the file uploads and store them securely for further processing.

4. Text Processing and Grading
The grading system will use NLP models to evaluate student answers by comparing them to model answers. The FastAPI backend will process the text, calculate similarity scores, and assign grades based on predefined criteria.

5. Feedback Generation
The system will generate feedback for each student based on the similarity score between their answer and the model answer. It will suggest improvements or provide positive feedback depending on the result. Basic grammatical checks will be made using NLTK.

6. Frontend Integration
The React frontend will display grades, feedback, and progress. Students will be able to interact with the AI-powered chatbot for clarifications, while instructors can review grading reports and analytics. The frontend will communicate with the backend API for grading and feedback.

V. RESULTS

The AI-based grading system was thoroughly tested across various scenarios to evaluate its accuracy, performance, scalability, and user experience. Below are the key results from the implementation and testing phase:.

A. Functionality Verification: The system successfully integrated core features such as:
Grading Module: Accurately processed student answer sheets and compared them with model answers.
Feedback Generation: Provided detailed, personalized feedback for each question based on student responses.
Performance Analytics: Delivered insights into student performance across various metrics like accuracy and time spent on questions.

B. Accuracy and Performance:
The system achieved high accuracy in grading objective-type questions (90-95% accuracy), while subjective answers (essays) showed good performance but with some room for improvement in interpreting complex answers.
Time Efficiency: The system processed student submissions within 5-7 minutes, meeting performance requirements.
Latency: The response time for grading was quick, with no delays experienced even when multiple submissions were handled simultaneously.

C. User Feedback:
Students: Found the feedback clear and actionable, appreciating the personalized improvement suggestions.
Teachers: Reported a 60% reduction in manual grading time, with the system helping them focus more on qualitative aspects of teaching.

D. Scalability and Stability:
The system performed well under load, capable of managing 50 concurrent users without significant degradation in performance.

The backend architecture proved scalable, capable of handling large datasets for multiple student submissions.

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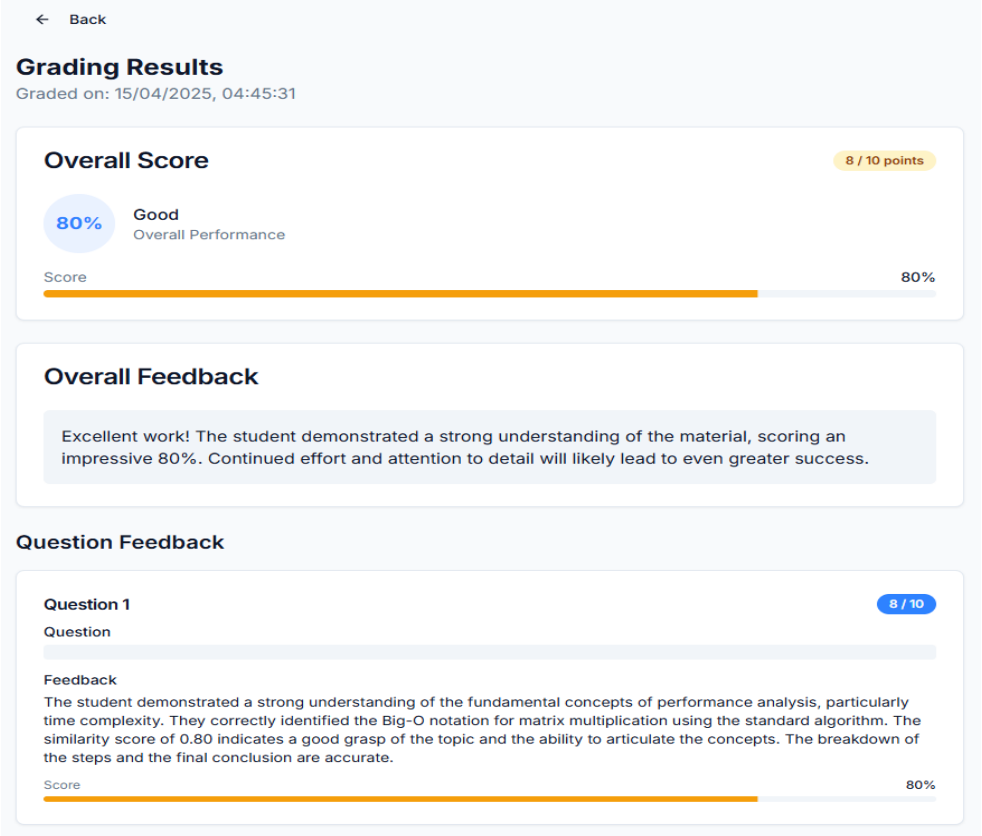

Fig. 3 Grading Results

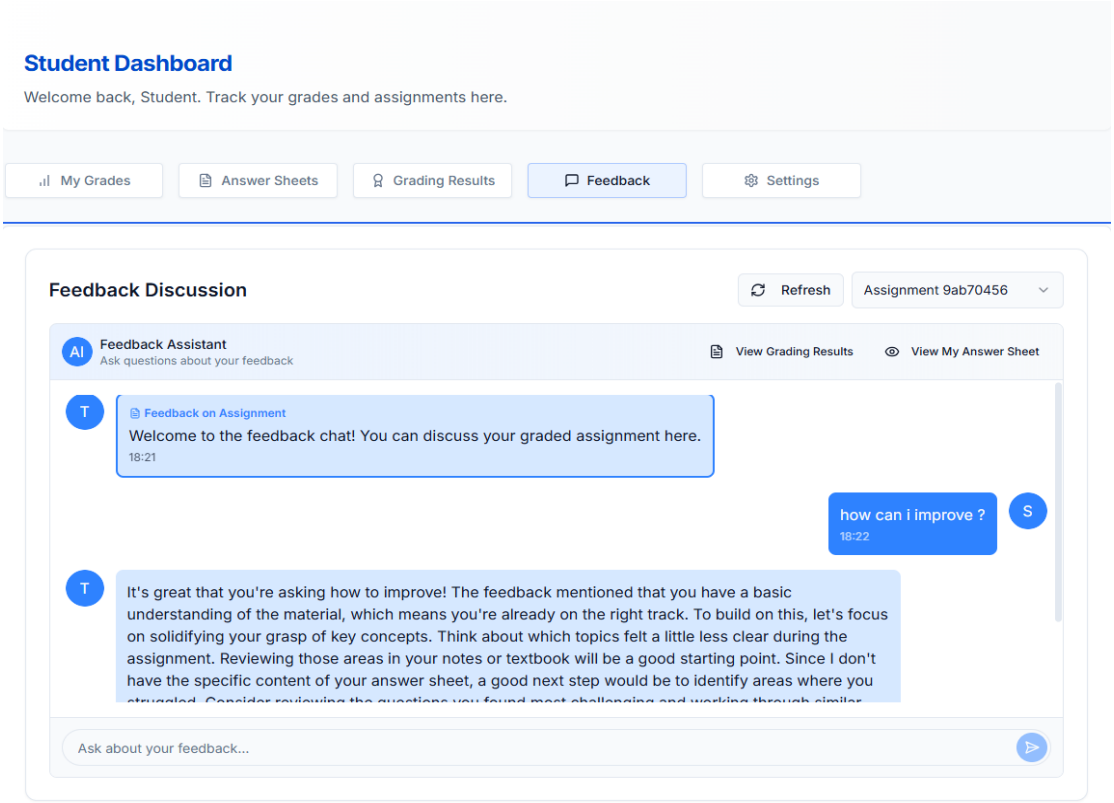

Fig.3 Personalized feedback

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VI. CONCLUSION

This AI-powered grading platform marries the speed of automated scoring with the richness of personalized feedback, all delivered through a secure, cloud-based environment. By converting textual responses into semantic vectors and mapping them to educator-defined rubrics, the system achieves consistent, transparent evaluations.

Its dynamic feedback engine offers students precise, constructive guidance, while the integrated support assistant streamlines communication. Collectively, these features reduce faculty workload, uphold grading fairness, and foster an engaging learning journey

ACKNOWLEDGEMENT

In the future, the Educational Grading System can be extended into a mobile app for Android and iOS, enabling easy access for students and teachers on the go. The app would include core features like answer sheet submissions, real-time grading, feedback generation, and AI chat support. Offline functionality could allow access to feedback and answers without internet, making it ideal for remote areas. Additionally, the app could offer push notifications for updates and track student performance over time, improving engagement and accessibility.

Moreover, integrating AI-based personalized learning recommendations could further enhance the system. By analyzing student performance data, the app can suggest tailored study materials, identify areas of improvement, and guide students toward better learning outcomes. This would create a more dynamic, individualized educational experience for both students and teachers.

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