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# Detecting Nuances in Hybrid AI-Generated Academic Essays

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**Abstract: This research paper focuses on detecting nuances in hybrid AI-generated academic essays by identifying subtle differences between human-written, AI-generated, and partially edited content. With the growing use of AI tools in education, traditional detection systems often fail to recognize essays that are generated by AI and later modified by humans. The proposed system uses Natural Language Processing and machine learning techniques to analyze writing style, sentence patterns, linguistic features, and factual consistency. It also generates a Naturalness Score to measure human-likeness. The system aims to improve detection accuracy, reduce false results, and support academic integrity in modern educational environments.**

***Keywords:*** *Essay Submission, Text Preprocessing, Linguistic Analysis, Stuctural Analysis, Fact Verification, Feature Extraction and Combination, Machine learning Classification, Content Classification, Naturalness Score Generation, Report Generation and Log Storage.*

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## I. INTRODUCTION

The rapid advancement of Artificial Intelligence has significantly transformed the field of academic writing. Modern Large Language Models such as ChatGPT and similar tools can generate essays, assignments, and research content within seconds. While these technologies provide valuable support for brainstorming, drafting, and improving written communication, they have also created serious concerns regarding originality, authorship, and academic integrity. Educational institutions now face increasing difficulty in determining whether submitted work is written by students or generated using AI systems.

Most existing AI detection tools are designed to identify fully AI-generated content by analyzing common patterns such as repetitive phrasing, predictable sentence structures, and lexical uniformity. However, these systems often fail when students use AI to create a draft and then manually edit, paraphrase, or refine the text. Such mixed content is known as hybrid AI-generated content and is much harder to detect because human modifications can hide obvious machine-generated patterns.

This research paper focuses on detecting nuances in hybrid AI-generated academic essays by identifying subtle differences between human-written, AI-generated, and partially edited text. The proposed system uses Natural Language Processing, stylometric analysis, and machine learning techniques to examine writing style, sentence rhythm, vocabulary diversity, and factual consistency. It also generates a Naturalness Score to measure how human-like the content appears. The objective of this research is to improve detection accuracy, reduce false classifications, and support fairness and trust in academic evaluation systems.

## II. LITERATURE SURVEY

Ryan & McKenna (2023): Focusing on academic science writing, this study demonstrates that structural analysis—specifically sentence and paragraph length variability—can achieve over 99% detection accuracy. It proves that AI writing is often more "uniform" than human writing.

Calhoun et al. (2025): This experimental study evaluates the effectiveness of humans and detection software in spotting AI text. The results show that both groups struggle significantly, with human accuracy often falling to the level of random chance, indicating a high difficulty in distinguishing modern LLM output from human work.

Georgiou et al. (2025): By utilizing automated linguistic extraction, this research highlights a "stylometric gap." AI-generated text is characterized by high noun density and complex vocabulary, whereas human writing consistently features more pronouns and function words.

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Fleckenstein et al. (2025):This survey focuses on university lecturers and reveals that educators are only slightly better than chance at identifying AI text. The study suggests that as AI quality improves, traditional academic assessment methods become increasingly vulnerable to undetected AI usage.

Al-Makhadmeh & Turab (2025): The authors propose a "Naturalness Score" metric. By measuring lexical diversity and syntactic complexity, their model successfully classifies student essays as human or AI with high precision, providing a new path for automated grading security.

Doru et al. (2025): Analyzing medical student essays, this study finds that experts do not usually catch AI through factual errors. Instead, they rely on identifying stylistic repetition and specific linguistic patterns that feel "mechanical."

Vashistha et al. (2026):This research identifies qualitative "red flags" reported by professors. These include a suspicious lack of any grammatical errors, overly "dense" or flowery phrasing, and the hallmark AI error of providing fabricated or non-existent citations.

Alshahrani & Al-Mekhlafi (2026): This comparative study of ChatGPT, Gemini, and BingAI found that human writing is consistently distinguished by longer sentences and a higher frequency of singular, unique word choices compared to the more "averaged" output of LLMs.

Yan et al. (2026): An assessment of the tool GPTZero shows that while it is highly effective at catching pure AI text, it has a high "false positive" rate, often incorrectly flagging human-written essays (especially those by non-native speakers) as AI.

Hessler et al. (2026): This rapid literature review categorizes detection cues into surface, discourse, and predictability features. It concludes that while many markers exist, the lack of a consistent "gold standard" remains a major hurdle for reliable AI detection in schools.

## III. RESEARCH GAP

Several studies have explored detecting AI-generated academic writing, but challenges remain. Calhoun et al. (2025) showed that both humans and tools struggle to identify AI text, while Georgiou et al. (2025) focused on linguistic features but lacked deeper analysis. Ryan and McKenna (2023) used structural patterns effectively, yet only on pure AI text. Al-Makhadmeh and Turab (2025) introduced a Naturalness Score, and Yan et al. (2026) highlighted issues like false positives. However, most research ignores hybrid content. To address this gap, this project proposes a system combining linguistic, structural, and factual analysis to classify text as human, AI, or hybrid more accurately.

## IV. WORKING FLOW OF SYSTEM

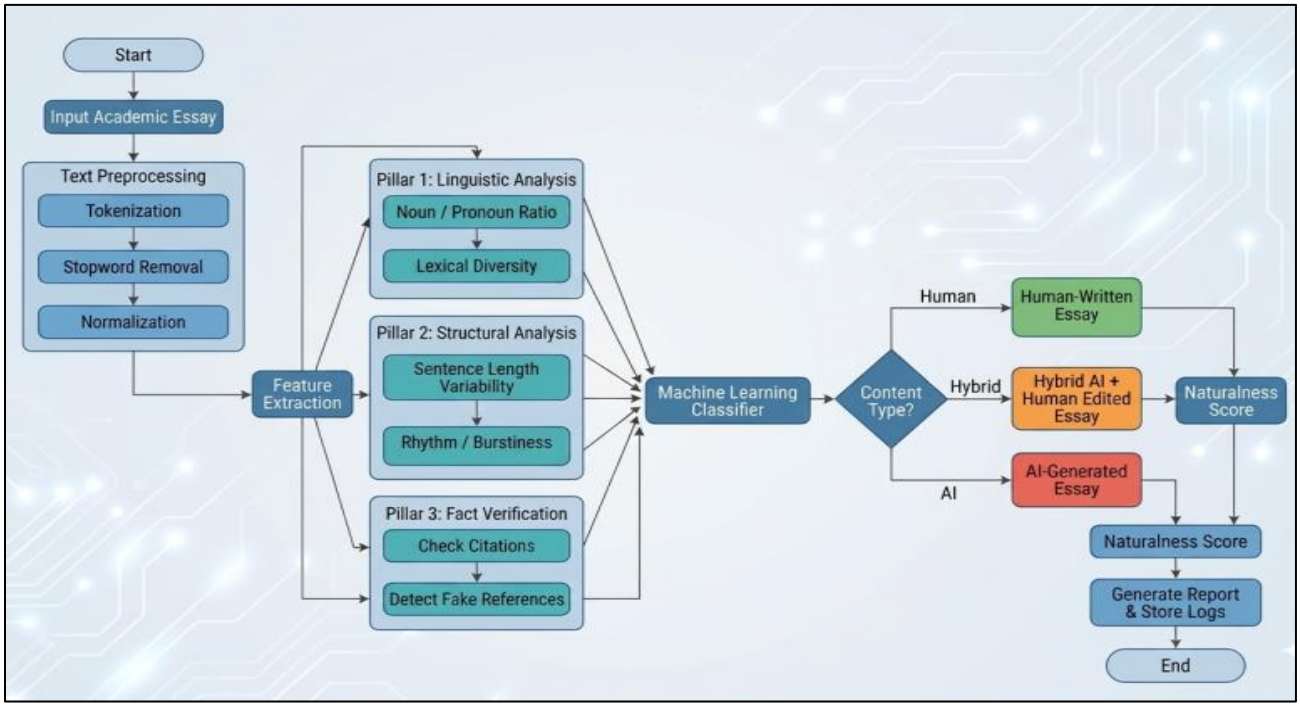


Fig 1 Working Flow of System

➢ *Essay Submission*

The working process begins when the user uploads or enters an academic essay into the system. The essay may be completely human-written, fully AI-generated, or partially edited hybrid content. Once submitted, the system stores the text temporarily for analysis and starts the detection process automatically.

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- *Text Preprocessing*

After receiving the essay, the system performs preprocessing to clean and organize the text. The essay is divided into words and sentences, unnecessary stopwords are removed, and the content is converted into a standardized format. This step improves data quality and prepares the text for accurate feature analysis.

- *Linguistic Analysis*

The system then analyzes the writing style of the essay. It checks vocabulary usage, noun-pronoun ratio, lexical diversity, grammar consistency, and writing patterns. Human-written text usually contains more natural variation, while AI-generated content often follows repetitive and predictable language structures.

- *Structural Analysis*

Next, the system studies the structural flow of the essay. It evaluates sentence length variability, paragraph organization, rhythm, and burstiness. Human writing generally contains irregular sentence patterns and natural flow, whereas AI-generated text tends to be smoother and more uniform.

- *Fact Verification*

The system verifies citations, references, and factual information present in the essay. AI-generated essays may include fake references or incorrect citations. This process checks whether the cited books, journals, or articles actually exist and whether the information is reliable.

- *Feature Extraction and Combination*

After completing all analyses, the system extracts important linguistic, structural, and factual features from the essay. These features are combined together to create a complete writing profile that represents the overall behavior and characteristics of the text.

- *Machine Learning Classification*

The combined features are passed to a machine learning classifier trained using human-written, AI-generated, and hybrid essay datasets. The classifier compares the extracted patterns with learned models and predicts the category of the essay.

- *Content Classification*

Based on the analysis results, the system classifies the essay into one of three categories: Human-Written Essay, AI-Generated Essay, or Hybrid AI + Human Edited Essay. This helps identify whether AI assistance was used in the writing process.

- *Naturalness Score Generation*

The system then generates a Naturalness Score that measures how human-like the essay appears. A higher score indicates natural human writing characteristics, while a lower score suggests stronger AI-generated patterns.

- *Report Generation and Log Storage*

Finally, the system generates a detailed analysis report containing classification results, writing pattern analysis, detected issues, and the Naturalness Score. The reports and logs are securely stored for future reference, monitoring, and academic evaluation purposes.

## V. PROCESS

The proposed system is developed to detect human, AI-generated, and hybrid content through a structured process. First, text data is collected and preprocessed by removing stopwords, normalizing, and tokenizing it. Then, important features such as linguistic patterns, sentence structure, and factual accuracy are extracted. The system calculates a Naturalness Score to measure how human-like the text appears. A machine learning classifier analyzes these features and categorizes the text into human, AI, or hybrid. Finally, the system generates the result along with a detailed report and stores it for future reference, ensuring accurate and efficient detection of AI-influenced writing.

## VI. FEATURES

Detecting Nuances in Hybrid AI-Generated Academic Essays includes several important features that help identify subtle differences between human-written and AI-assisted content. The system can classify essays into three categories: human-written, fully AI-generated, and hybrid AI plus human-edited text. It uses Natural Language Processing to preprocess text and extract useful patterns. Linguistic analysis checks vocabulary usage, grammar style, noun-pronoun ratio, and lexical diversity. Structural analysis studies sentence length variation, writing rhythm, and paragraph flow. Fact verification detects fake citations or incorrect references. A machine learning classifier improves accuracy in prediction. The system also provides a Naturalness Score to measure how human-like the writing appears, generates reports, stores logs, and helps maintain academic integrity.

## VII. APPLICATIONS

- *Education Sector*

Detects AI-generated or hybrid assignments, essays, and research papers in schools and colleges.

- *Universities & Examinations*

Helps maintain fairness in online exams, project submissions, and assessments.

- *Research Institutions*

Verifies originality of research papers, journals, and technical documents.

- *Publishing Industry*

Checks authenticity of articles, blogs, books, and news content before publication.

- *Recruitment & HR*

Validates resumes, cover letters, and online test answers submitted by candidates.

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- *Content Writing Industry*
  Ensures originality and quality of website content, marketing text, and reports.

- *Corporate Sector*
  Verifies internal reports, proposals, and business communication documents.

- *Online Learning Platforms*
  Integrates with LMS systems to monitor student submissions automatically.

- *Legal & Compliance*
  Helps verify authenticity of official documents and written statements.

- *Social Media & Forums*
  Detects AI-generated spam, misleading posts, or automated content.

## VIII. ADVANTAGES

- *Improved Accuracy*
  Detects human-written, AI-generated, and hybrid content more accurately.

- *Supports Academic Integrity*
  Helps prevent misuse of AI tools in assignments and exams.

- *Detects Hybrid Content*
  Identifies essays that are AI-generated but later edited by humans.

- *Finds Subtle Patterns*
  Recognizes hidden writing differences that normal detectors may miss.

- *Naturalness Score*
  Provides a score showing how human-like the essay appears.

- *Reduces False Results*
  Lowers chances of wrongly marking genuine student work as AI-generated.

- *Saves Time for Teachers*
  Automates essay checking and reduces manual effort.

- *Generates Reports*
  Creates useful reports and stores logs for future reference.

- *Fair Evaluation*
  Ensures equal and transparent assessment of student submissions.

- *Useful in Many Fields*
  Can be used in education, publishing, recruitment, and content verification.

## IX. FUTURE SCOPE

- *Advanced Deep Learning Models*
  Use transformer-based AI models for higher detection accuracy.

- *Real-Time Detection*
  Provide instant checking while the user is typing or submitting content.

- *Multilingual Support*
  Detect AI-generated and hybrid text in multiple languages.

- *Integration with LMS Platforms*
  Connect with educational systems like Moodle, Google Classroom, and Blackboard.

- *Plagiarism + AI Detection*
  Combine plagiarism checking with AI content detection in one system.

- *Explainable AI Reports*
  Show clear reasons why the content is marked as Human, AI, or Hybrid.

- *Mobile Application*
  Develop Android and iOS apps for easy access.

- *Continuous Learning System*
  Regularly update the model with new AI writing patterns and tools.

- *API Services*
  Provide APIs for colleges, companies, and websites to integrate the system.

- *Enhanced Security*
  Add data encryption, secure storage, and privacy protection features.

## X. CONCLUSION

Detecting Nuances in Hybrid AI-Generated Academic Essays provides an effective solution for identifying subtle differences between human-written, AI-generated, and partially edited hybrid content. By using Natural Language Processing, stylometric analysis, structural pattern evaluation, and machine learning techniques, the system improves detection accuracy compared to traditional AI detectors. It also generates a Naturalness Score to measure how human-like the writing appears. This approach helps maintain academic integrity, fairness, and originality in educational environments. The proposed system is practical, scalable, and useful for schools, colleges, universities, publishers, and organizations facing challenges in AI-assisted content verification.

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