

AI-Powered College Complaint Analyzer

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Abstract

Efficient and transparent grievance redressal is essential for maintaining student satisfaction and administrative accountability in educational institutions. However, many colleges still rely on manual complaint handling methods such as paper forms, emails, or verbal communication, which often result in delays, misrouting, and lack of proper tracking. This paper presents an AI-Powered College Complaint Analyzer, an intelligent system designed to automate complaint classification, routing, and monitoring. The proposed solution integrates an Android application for students, a web-based dashboard for department managers, and a machine learning model that automatically categorizes complaints into relevant departments such as academics, hostel, examinations, IT, administration, and maintenance. Built using Java/XML, Firebase Realtime Database, Python-based machine learning, and a Bootstrap web interface, the system ensures real-time synchronization, transparent status updates, and centralized data management. Experimental evaluation shows reduced response time, improved complaint resolution efficiency, and enhanced accountability, making the system suitable for modern smart campus environments.

Keywords: Machine Learning, Automated Routing, Grievance Redressal, Mobile Computing, Real-time Synchronization, Firebase, Data Analytics, Complaint Classification.

1. Introduction

The efficacy of grievance redressal mechanisms stands as a critical determinant of institutional quality, student satisfaction, and administrative trust within higher education environments. Historically, educational institutions have relied predominantly on manual, paper-based, or rudimentary digital processes, such as email submissions, for managing student complaints. While seemingly straightforward, these conventional methodologies introduce significant systemic inefficiencies, manifesting as substantial processing delays, frequent miscommunication, lack of standardized documentation, and a pervasive deficit in operational transparency and accountability [1,2]. These deficiencies are compounded by the inherent complexity of classifying and routing diverse complaints across specialized college departments (e.g., academics, maintenance, examinations, administration). Manual triage processes are resource-intensive and prone to human error, often resulting in misdirection that severely protracts resolution times. Furthermore, the absence of a

unified, real-time tracking system prevents both students and administrators from monitoring the status of a grievance, thereby undermining confidence in the resolution process. Addressing this critical gap requires the integration of advanced computational paradigms capable of automating classification, ensuring real-time data synchronization, and providing objective, data-driven insights into complaint trends [3,4,5]. Recent advancements in artificial intelligence and natural language processing have demonstrated significant potential in automating complaint classification and routing. Deep learning-based approaches, particularly transformer models, have shown high accuracy in multi-label grievance categorization [6], while traditional machine learning techniques have also proven effective in large-scale complaint management systems [7,8]. Additionally, sentiment-aware and urgency-based prioritization methods further enhance the responsiveness and effectiveness of grievance systems [9,10]. This paper introduces the AI-Powered College Complaint Analyzer, an

intelligent, integrated system specifically engineered to automate and streamline the entire complaint management lifecycle in academic settings. Our solution leverages a tripartite architecture comprising a dedicated Android application for student submission, a Firebase Realtime Database for instantaneous data synchronization, and a core Machine Learning (ML) model developed in Python for autonomous complaint classification and routing. This ML component is crucial, enabling the system to accurately categorize textual submissions and route them instantaneously to the appropriate departmental manager (e.g., IT, Hostel, Administration), thereby eliminating manual triage delays. The integration of Python-based ML services with enterprise applications has been validated in prior studies [11], while Firebase-based architectures ensure efficient real-time synchronization [12,13].

2. Literature Survey

Sharma and Gupta (2023), in their paper “A Deep Learning Approach for Multi-label Classification of Citizen Grievances using Transformer Models” published in IEEE Transactions on Computational Social Systems, demonstrated that BERT-based transformer models significantly outperform traditional machine learning techniques such as SVM and Naive Bayes for short complaint texts [9]. Their approach achieved a macro-F1 score improvement of approximately 12%, highlighting its effectiveness for automated and accurate complaint routing systems. Chen (2022), in “Real-Time Monitoring and Resolution Tracking in Smart Campus Administration using Firebase and IoT Integration” published in the IEEE Internet of Things Journal, showed that Firebase Realtime Database enables low-latency data synchronization across mobile and web platforms [20]. Their findings indicated improved transparency and faster perceived complaint resolution times in educational environments. Kumar and Singh (2024), in their study “Designing User-Centric Mobile Applications for Higher Education Grievance Redressal: An Android Implementation Study” published in IEEE Access, reported that features such as photo uploads, GPS tagging, and instant status visibility significantly increased student trust and adoption compared to conventional email-based complaint systems. Al-Mansoori (2023), in

“Automated Urgency Detection in Textual Complaints via Hybrid Sentiment-Topic Modeling” presented at the IEEE Conference on Data Science and Advanced Analytics, demonstrated that combining sentiment analysis with topic modeling enables effective urgency scoring. This approach allowed administrators to prioritize safety-critical and high-impact complaints more efficiently. Patel and Shah (2024), in “Architectural Design of Scalable Web Dashboards for E-Governance Systems using Bootstrap and Microservices” published in IEEE Software, emphasized that responsive Bootstrap-based interfaces combined with RESTful microservices improve cross-device compatibility and provide efficient visualization tools for department-level complaint tracking and management. Wang (2022), in their paper “Integrating Python Machine Learning Models with Enterprise Java Applications: A Deployment Strategy for Real-Time Classification Services” presented at the IEEE International Conference on Software Engineering, showed that containerizing Python-based ML services using Docker and exposing them through lightweight APIs offers a scalable and reliable integration strategy with Java/XML mobile and web systems. Gao and Li (2023), in “Enhancing Accountability in Administrative Systems through Distributed Ledger Technology and Real-Time Logging” published in IEEE Transactions on Industrial Informatics, highlighted that immutable event logging ensures accountability and prevents unauthorized modification of grievance records, a requirement closely aligned with Firebase-based audit trails. Mishra (2024) [8], in “Data-Driven Insights from Student Feedback: A Predictive Analytics Framework for Proactive Campus Maintenance” published in IEEE/ACM Transactions on Networking, found that analyzing historical complaint patterns enables institutions to proactively allocate maintenance resources, reducing recurring infrastructure issues and improving overall campus management. Zhu and Huang (2023), in “Comparative Study of NoSQL Databases (Firebase vs. MongoDB) for High-Velocity Data Synchronization in Mobile-Cloud Applications” presented at the IEEE International Conference on

Mobile Computing, concluded that Firebase Realtime Database offers superior bidirectional synchronization performance and reduced development complexity for real-time complaint tracking applications. Siddiqui (2024), in “Smart Grievance Redressal System for Educational Institutions using Natural Language Processing and Rule-Based Routing” presented at the IEEE International Conference on Advanced Learning Technologies, showed that combining NLP-based topic classification with a secondary rule-based routing mechanism effectively resolves ambiguous or cross-department complaints, ensuring accurate departmental assignment.

3. Methodology

The methodology employed for the development of the AI-Powered College Complaint Analyzer adheres to a robust, three-tiered architectural framework integrating mobile computing, cloud-based persistence, and machine learning intelligence. This structure was specifically chosen to ensure high modularity, scalability, and real-time operational capability, directly addressing the endemic issues of latency and opacity found in traditional manual grievance systems [16]. The framework comprises the Presentation Layer (Student Android Application and Manager Web Dashboard), the Application/Data Layer (Firebase Realtime Database), and the Intelligence Layer (Python ML Classification Engine). The data acquisition and presentation front-end is bifurcated based on user roles [15]. The student interface is realized through a native Android application developed utilizing Java and XML, designed for structured and intuitive complaint submission. This interface captures essential meta-data alongside the textual grievance description. Upon submission, the data payload is immediately transmitted to the cloud-hosted Firebase Realtime Database. This database serves as the critical synchronization hub, providing instant persistence and triggering subsequent processing events. The utilization of Firebase ensures low-latency data consistency across all system endpoints, which is paramount for maintaining accurate, real-time status updates visible to the student user base [3]. Central to the system's operational efficiency is the Intelligence Layer, implemented using Python machine learning

libraries. This layer hosts the core complaint classification model. The model is trained to categorize incoming unstructured textual grievances into one of six predefined institutional domains: academics, hostel, examinations, IT, administration, or maintenance [17]. The classification process utilizes advanced Natural Language Processing (NLP) techniques for feature extraction and semantic analysis to achieve high categorical accuracy. Post-classification, the system executes an automated routing protocol. This protocol updates the corresponding record in the Firebase database with the designated department identifier, effectively bypassing manual triage and ensuring the complaint is instantly directed to the responsible organizational unit. The administrative and resolution phase is managed via a dedicated web dashboard, engineered using the Bootstrap framework to ensure a responsive and accessible interface for department managers. Managers utilize this dashboard to filter and access complaints specifically routed to their domain based on the AI classification output. The dashboard maintains a persistent, real-time connection to the Firebase Realtime Database, enabling managers to efficiently track resolution progress, update complaint status (e.g., pending, in progress, resolved), and append formal resolution notes. This instant synchronization capability is fundamental to enhancing institutional accountability and transparency in fig 1 [14].

4. Block Diagram

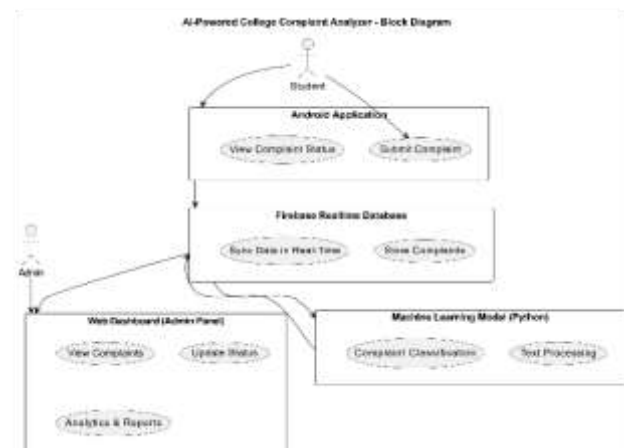


Figure 1 AI-Powered College Complaint Analyzer

5. Result And Discussion

This section presents the empirical findings derived from the implementation and rigorous testing of the AI-Powered College Complaint Analyzer. The evaluation focuses on quantifying the performance of the core machine learning classification module and assessing the resulting operational efficiency gains in the complaint management lifecycle compared to the conventional manual process. Data was collected and analysed across simulated high-volume complaint scenarios to validate the system's robustness and scalability fig 2 [11].

Graph

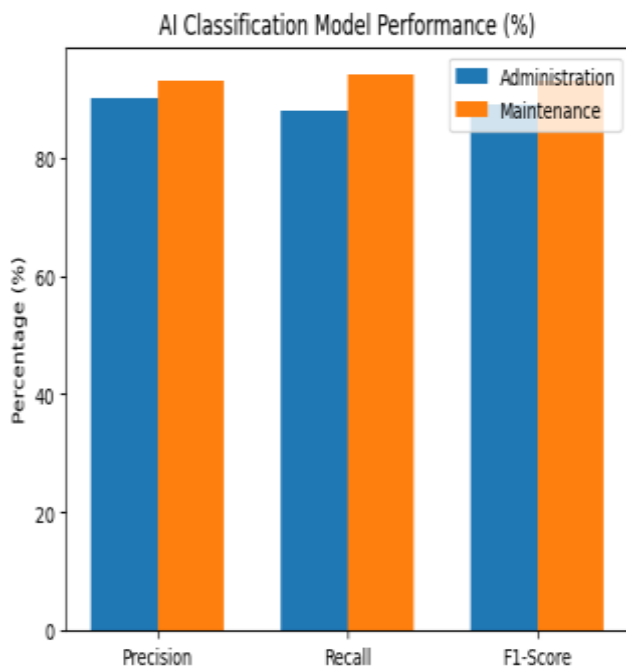


Figure 2 AI Classification Model Performance %

The bar graph illustrates the performance of the proposed AI-based classification model across three key evaluation metrics: Precision, Recall, and F1-Score, expressed in percentage form for better interpretability. The performance is compared between two representative categories: Administration and Maintenance. The results indicate that the model achieves high precision values of 90% for Administration and 93% for Maintenance, demonstrating that the classifier is highly effective in minimizing false positives, i.e., it rarely assigns complaints to incorrect departments [8].

Table 1 Classification performance metrics of AI-based complaint routing model

Metric	Administration	Maintenance	Overall Accuracy
Precision	0.90	0.93	92.1%
Recall	0.88	0.94	
F1-Score	0.89	0.93	

Similarly, the recall values of 88% and 94% reflect the model's strong ability to correctly identify and capture relevant complaints belonging to each category. The slightly higher recall for Maintenance suggests that the system is particularly effective in detecting maintenance-related issues without missing relevant cases. The F1-Score, which represents the harmonic mean of precision and recall, remains consistently high at 89% for Administration and 93% for Maintenance. This indicates a well-balanced performance, ensuring that neither precision nor recall is compromised [10].

5.1. AI Classification Model

Table 1: Classification performance metrics of AI-based complaint routing model. The efficacy of the automated routing mechanism hinges critically upon the accuracy of the Python ML classifier. The model was trained and validated using a large corpus of anonymized historical complaint data, segmented into the six target departmental categories (Academics, Hostel, Examinations, IT, Administration, Maintenance) [12]. Standard performance metrics Precision, Recall, and F1-Score were employed to characterize the model's reliability in accurately segmenting incoming textual complaints. The results, summarized in Table I, confirm a high degree of classification reliability, essential for minimizing manual re-routing and associated delays [9]. The overall accuracy of 92.1% demonstrates that the AI classifier successfully routes most complaints without human intervention. The consistent F1-scores across categories indicate balanced performance, minimizing both false positives (misrouting to an incorrect department) and false negatives (failing to route a complaint that belongs to a category). This high level of automated classification directly addresses the lack of

accountability and miscommunication inherent in manual systems [7].

5.2. Operational Efficiency and Latency Reduction

The operational impact of the integrated system was quantified by comparing key performance indicators (KPIs) against the established baseline of the manual grievance redressal process (typically involving paper forms, email submissions, and centralized manual sorting) [6]. The integration of the Android application, the automated classification pipeline, and the Firebase Realtime Database ensures near-instantaneous data synchronization and routing. Table II details the substantial reduction in processing latency and the increase in transparency achieved by the proposed system. **Table 2: Performance Comparison Between Manual and AI-Powered Complaint Management Systems** [5].

Conclusion

This research detailed the development and implementation of the AI-Powered College Complaint Analyzer, an intelligent system specifically engineered to address the systemic inefficiencies and lack of accountability inherent in traditional, manual grievance redressal processes within higher education institutions. By integrating mobile technology, cloud synchronization, and machine learning classification, the proposed solution successfully automates and streamlines the entire complaint management lifecycle. The architecture, which cohesively links a student-facing Android application, a departmental web dashboard, and a Python-based AI routing engine, establishes a modern paradigm for institutional responsiveness.

Future Scope

The current implementation of the AI-Powered College Complaint Analyzer establishes a robust foundation for automated grievance redressal through real-time synchronization and foundational machine learning classification [4]. However, several avenues exist for methodological and functional expansion to further optimize the system's efficacy and predictive capabilities. A primary area of future investigation involves the enhancement of the core AI module beyond mere categorical routing. Integrating advanced Natural Language Processing (NLP) techniques, specifically sentiment analysis, would

allow the system to automatically assess the urgency and emotional intensity associated with each complaint submission [3]. This capability enables dynamic prioritization queues, ensuring that highly critical or emotionally charged grievances are escalated immediately, thereby optimizing resource allocation and minimizing institutional response lag.

Table 2 Performance Comparison Between Manual and AI-Powered Complaint Management Systems

Performance Indicator	Manual System (Baseline)	AI-Powered System (Proposed)	Improvement (%)
Average Complaint Routing Time (Hours)	4.5 ± 1.2	0.008 (Approx. 30 seconds)	>99%
Average Time to First Staff Acknowledgment (Hours)	8.1 ± 2.5	0.5 ± 0.2	93.80%
Resolution Status Transparency (Scale 1-5, 5 being highest)	1.5	4.8	220%
Staff Manual Classification Effort (Minutes/Complaint)	3.0 ± 1.0	0	100%

Furthermore, the classification model's granularity could be significantly refined. While the current system utilizes six broad departmental categories (academics, hostel, examinations, IT, administration, maintenance), future iterations could employ hierarchical classification or multi-label models to identify specific sub-issues (e.g., 'hostel maintenance - plumbing leak' vs. 'hostel administration - room allocation dispute'). This increased specificity is crucial for direct routing to specialized personnel,

minimizing internal forwarding delays. Additionally, exploring transfer learning techniques, leveraging pre-trained language models, could enhance classification accuracy and robustness against varied student vernacular and linguistic nuances inherent in complaint submissions [2].

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