Automated Petition Analysis and Categorization System Using Machine Learning for Efficient Grievance Redressal

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Abstract: The Petition Analysis and Categorization System leverages machine learning and automation to streamline petition handling for government agencies and businesses. By utilizing BERT for department classification, Random Forest for urgency detection, and K-Means clustering to identify recurring petitions, the system minimizes redundancy and enhances efficiency. Additionally, LSTM models monitor unresolved cases, ensuring timely follow-ups. Real-time notifications are facilitated through the Twilio API, keeping petitioners and officials updated on petition status. To optimize data management, petitions are stored as images in MySQL, enabling quick retrieval and classification. With a user-friendly web interface, the system ensures transparency, accountability, and faster resolution of public grievances while reducing manual effort and improving response times.

I. INTRODUCTION

An innovative way to automate and simplify the handling of petitions in government agencies and organizations is the Petition Analysis and Categorization System. Although petitions frequently raise important issues that need to be addressed right away, manual processing can result in inefficiencies, delays, and poor management. This system effectively categorizes, ranks, and monitors petitions using automation and machine learning, guaranteeing a methodical and open resolution procedure. It increases the overall effectiveness of petition handling by reducing human interaction and streamlining workflow.

The fundamental component of this system is an AI-driven classification mechanism that uses BERT to assign petitions to the relevant departments, Random Forest to prioritize urgent cases, and K-Means clustering to identify recurring problems. In order to ensure prompt follow-ups, it also uses LSTM models to monitor situations that remain unsolved. Data administration is streamlined by storing petitions as photos in a MySQL database. Officials and petitioners can receive real-time progress updates thanks to the system's integration of the Twilio API for automated alerts.
Organizations may drastically cut down on processing time, increase transparency, and better address public issues by putting this approach into place. The petitions may be submitted, tracked, and managed with ease thanks to the user-friendly web interface, which guarantees accountability throughout the process. The solution also assists authorities in identifying recurrent petition tendencies through data-driven insights, allowing for proactive decision-making. All things considered, this method updates the petition management process, making it more effective, dependable, and significant in resolving public complaints.

II. RELATED WORKS

Petition management is a crucial aspect of governance and administrative processes, allowing individuals to report grievances and request actions from relevant authorities. Traditionally, petitions are manually sorted and reviewed, a process that is not only time-consuming but also prone to human error. With the increasing number of petitions received daily, manual handling has become inefficient, leading to misclassification, processing delays, and unaddressed grievances.

To overcome these challenges, artificial intelligence (AI) and machine learning (ML) techniques have been widely explored for automating petition classification and management. Natural Language Processing (NLP) techniques, such as deep learning-based text classification and clustering, have proven effective in analyzing unstructured petition texts, ensuring accurate categorization, prioritization, and tracking. Additionally, machine learning models can detect recurring issues and prioritize urgent cases, improving efficiency and response times. The integration of automated notifications further enhances transparency by keeping petitioners and authorities informed about case statuses.

Numerous studies have examined various AI-based approaches with the goal of automating petition classification. Conventional methods used keyword matching and rule-based algorithms, which had trouble with linguistic and contextual variances. Deep learning methods, especially transformer models like BERT (Bidirectional Encoder

Representations from Transformers), have become the focus of more recent research because of their exceptional ability to comprehend the context of textual input.

Studies in legal document classification have demonstrated the effectiveness of deep learning models in categorizing petitions and legal texts. For instance, research has shown that BERT-based classifiers outperform conventional models such as Support Vector Machines (SVM) and Naïve Bayes in legal text classification tasks. Other researchers have proposed using Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), achieving high accuracy in categorizing legal and administrative documents. These approaches highlight the potential of deep learning in automating petition classification, reducing human intervention, and improving accuracy.

Effective petition management requires distinguishing between urgent and non-urgent grievances to ensure timely responses. Traditional urgency detection relied on manual review processes, which were subjective and inconsistent. Machine learning models, such as Random Forest classifiers and neural networks, have been employed to analyze petition texts and determine urgency based on predefined criteria.

Government agencies and organizations often receive a large number of petitions that address similar concerns, resulting in duplicated efforts and inefficiencies in case resolution. To manage this redundancy effectively, automated clustering techniques can be employed to group related petitions, allowing authorities to handle them collectively rather than addressing each one separately.

To efficiently manage recurring petitions, clustering techniques can be used to group similar grievances, reducing redundancy in case handling. Methods such as K-Means, DBSCAN (Density-Based Spatial Clustering of Applications with Noise), and hierarchical clustering have been widely applied to categorize related complaints. Instead of manually reviewing each petition, these algorithms analyze patterns in text data to identify petitions with common issues. Integrating word embeddings with clustering models further enhances accuracy by capturing semantic relationships between words, enabling better grouping of similar cases. This automated approach reduces administrative workload, improves resource allocation, and ensures that officials can focus on addressing widespread concerns collectively. As a result, grievance management systems become more efficient, allowing for faster resolutions and improved responsiveness to public issues.

BERT-based text classification is one of the system's essential elements; it guarantees that petitions are accurately categorized into ten department-specific tables in MySQL databases. BERT has a higher classification accuracy than conventional keyword-based classification since it incorporates contextual meaning. The system can rapidly convert and handle petitions that are supplied as text or graphics. This method guarantees that every petition reaches the right department for response, minimizes human intervention, and lowers misclassification mistakes.

The system uses Random Forest-based urgency detection to identify and prioritize grievances requiring immediate action. It analyzes text patterns, sentiment, and key terms to classify petitions as urgent, ensuring swift processing. This feature is crucial for addressing public safety concerns, environmental hazards, and infrastructure emergencies. Additionally, the system tracks unresolved petitions in real time, enabling timely follow-ups and enhancing accountability. Traditional tracking methods often rely on manual updates, leading to inefficiencies. To overcome this, the system integrates LSTM (Long Short-Term Memory) networks, which analyze historical petition updates to predict delays. By combining Random Forest for urgency classification and LSTM for ongoing tracking, the system improves efficiency, responsiveness, and transparency, ensuring a faster and more reliable grievance resolution process.

Research in case tracking has explored time-series prediction models that estimate resolution times based on historical petition data. By training LSTM models on past petition records, these systems can predict whether a case is likely to remain unresolved, enabling proactive intervention. The use of deep learning for petition tracking helps governments and organizations identify bottlenecks in the resolution process and allocate resources more effectively to address delayed cases.

Providing timely updates on petition status is a critical aspect of transparent grievance redressal. Traditional communication methods often involve manual email or phone notifications, which are time-consuming and prone to delays. AI-powered solutions, particularly automated messaging systems, have been developed to streamline petition updates and improve engagement.

Advancements in API-driven communication have revolutionized the way petitioners receive updates on their cases. Automated notification systems, powered by services like Twilio, enable instant delivery of SMS and email alerts, keeping individuals informed about changes in petition status. By providing real-time updates, these systems help reduce uncertainty and enhance public confidence in grievance resolution processes. Additionally, the incorporation of AI-driven chatbots and virtual assistants allows users to check petition progress effortlessly, eliminating the need for manual inquiries. This technology-driven approach enhances efficiency, transparency, and user engagement in petition management systems.

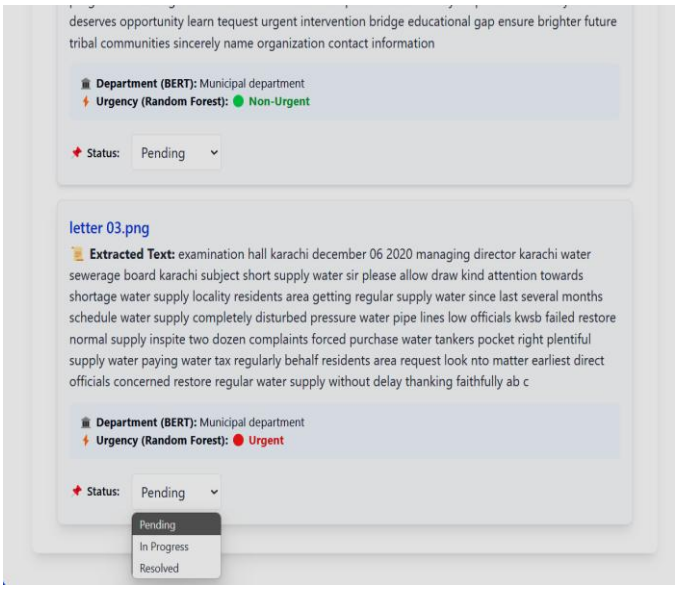
The application of AI and machine learning in petition

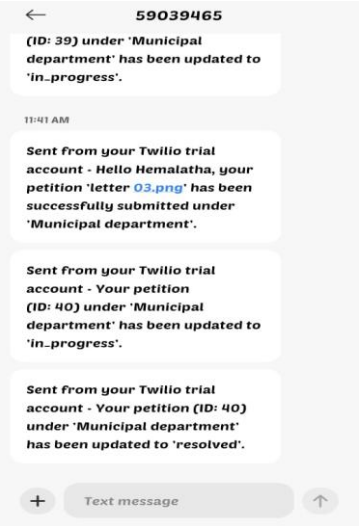
management has significantly improved classification accuracy, urgency detection, clustering efficiency, and case tracking. By leveraging advanced NLP techniques such as BERT for categorization, Random Forest for urgency detection, K-Means for clustering, and LSTM for tracking, modern grievance redressal systems ensure faster resolutions, reduced manual workload, and improved public trust.

Future research directions include the exploration of hybrid transformer models such as GPT-4 and RoBERTa for enhanced text classification. Additionally, integrating multimodal processing techniques that analyze text, voice, and images could further enhance petition classification accuracy. As AI-driven systems continue to evolve, their adoption in governance and administrative processes will play a crucial role in ensuring efficient, transparent, and accountable grievance management.

Furthermore, real-time analytics dashboards powered by AI-driven insights can be developed to help authorities track petition trends and allocate resources effectively. The incorporation of explainable AI (XAI) techniques will ensure transparency by making petition classification decisions more interpretable. As AI-driven systems continue to evolve, their adoption in governance and administrative processes will play a crucial role in ensuring efficient, transparent, and accountable grievance management, ultimately leading to better public service delivery and citizen engagement

SAMPLE OUTPUT IMAGES





III. METHODOLOGY

Module 1: Petition Submission Module: This module allows users to submit petitions online, supporting both text-based input and document uploads (PDF, DOCX). It incorporates OCR (Optical Character Recognition) to extract text from uploaded documents, improving accessibility. Submitted petitions are then stored securely in a structured database for further processing.

Module 2: Petition Categorization Module: This module utilizes BERT (Bidirectional Encoder Representations from Transformers) to analyze petition content and automatically assign it to the appropriate department. By leveraging NLP techniques, the system ensures that petitions are correctly classified, reducing misrouting and manual workload.

Module 3: Urgency Detection Module: This module employs Random Forest algorithms to determine the priority level of each petition. By analyzing keywords, sentiment, and context, it categorizes cases as urgent or non-urgent, ensuring that critical issues receive immediate attention while routine cases follow standard processing.

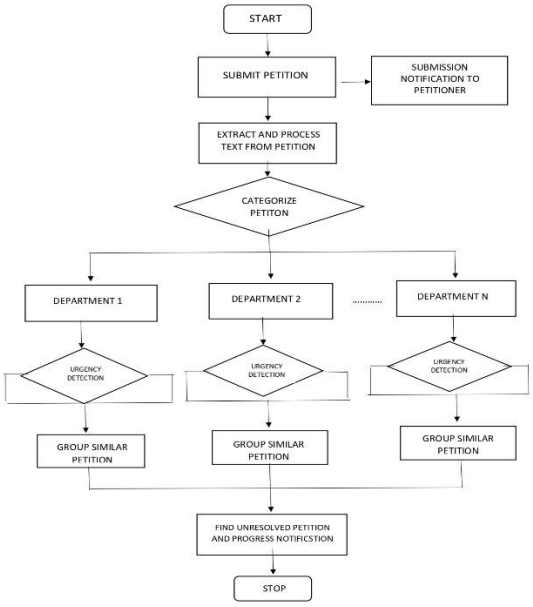
Module 4: Repetitive Petition Detection Module: This module uses K-Means clustering to identify similar petitions submitted by multiple users. By grouping repetitive grievances, the system helps to authorities address widespread issues collectively, preventing redundant case handling, and optimizing resource allocation.

Module 5: Petition Tracking and Notification Module: This module integrates LSTM models to track unresolved petitions and analyze case updates over time. Automated real-time notifications via Twilio API keep both petitioners and officials informed about petition progress. Alerts are sent through SMS and email, ensuring transparency and timely follow-ups.

The Petition Analysis and Categorization System is designed to automate the process of petition management using advanced machine learning (ML) and natural language processing (NLP) techniques. The methodology is structured into multiple stages, including data collection, preprocessing, classification, clustering, urgency detection, tracking, and notification systems**.** These stages ensure that petitions are efficiently categorized, prioritized, and monitored for resolution.

The system gathers petition data exclusively from online submissions through the dedicated website. Since petitions are entered in a structured format, there is no need for Optical Character Recognition (OCR) to process scanned documents or emails. Once submitted, the data is securely stored in a MySQL database, where petitions are categorized into

department-specific tables for efficient organization. This structured storage approach allows for quick retrieval, enhanced security, and seamless access to petition records, ensuring smooth processing and management of grievances.



FLOWCHART

The system begins by collecting petitions exclusively through image uploads**,** allowing users to submit grievances in JPG, PNG, or scanned PDF formats**.** These images, which may contain handwritten or printed text, are processed using Optical Character Recognition (OCR) to convert them into machine-readable text. This approach ensures that even petitions submitted in non-digital formats can be analyzed effectively. Once the text is extracted, it is securely stored in a MySQL database, where petitions are systematically categorized into department-specific tables.

To ensure timely responses, the system incorporates an urgency detection mechanism powered by the Random Forest algorithm. This model evaluates the content of petitions by identifying key terms, sentiment scores, and contextual indicators that signify urgent matters. Based on the analysis, petitions are categorized as either urgent, which includes cases requiring immediate action such as public safety risks or infrastructure failures, or non-urgent, which covers grievances that can be processed within standard timelines. By automating urgency classification, the system efficiently identifies and prioritizes critical petitions, ensuring swift intervention and reducing delays in addressing time-sensitive issues.

Grievance systems in government and organizations often receive multiple petitions related to the same issue from different individuals. Handling each of these separately can result in duplication of efforts and inefficient use of resources. To overcome this, the system utilizes K-Means clustering, an unsupervised machine learning algorithm, to group petitions with similar content. By analyzing text patterns, word relationships, and contextual meaning, the model detects petitions that address identical or closely related concerns. This enables authorities to manage recurring issues more effectively, allowing them to resolve widespread grievances collectively rather than handling each one individually.

Timely resolution of petitions is essential for maintaining transparency and public confidence in the grievance management system. To achieve this, the system utilizes a Long Short-Term Memory (LSTM) model, which continuously monitors unresolved petitions and analyzes their status over time. By identifying potential delays, the model flags cases that require follow-ups, ensuring that no grievance is overlooked. Additionally, the system incorporates automated notifications through the TWILIO API, which sends real-time SMS and email alerts to both petitioners and officials. These notifications provide updates on petition submission, department assignment, urgency classification, case progress, and final resolution. By integrating automated tracking and communication, the system improves efficiency, accountability, and stakeholder engagement, ensuring that petitioners remain informed throughout the resolution process.

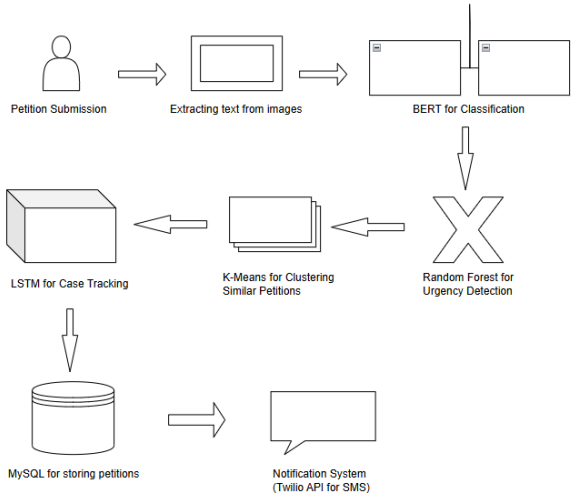
The system enhances grievance redressal by automating petition classification, urgency detection, and resolution tracking, ensuring faster and more accurate processing. By reducing manual intervention, it streamlines petition handling, prioritizes urgent cases, and efficiently manages recurring grievances.

IV.CONCLUSION

The Petition Analysis and Categorization System introduces an AI-driven approach to automating petition classification, urgency detection, repetitive grievance identification, and case tracking. Traditional petition handling methods are often slow, inefficient, and prone to errors, resulting in delayed resolutions and mismanagement of grievances. By integrating machine learning models such as BERT, Random Forest, K-Means clustering, and LSTM networks, the system enhances efficiency, accuracy, and transparency in grievance redress. The dedicated web-based submission portal ensures a streamlined process where petitions are exclusively submitted through image uploads, and OCR technology extracts relevant text for further analysis.

A major advantage of this system is its ability to categorize petitions into relevant departments using BERT, reducing misclassification and manual workload. Additionally, the Random Forest model analyzes textual patterns and sentiment to determine whether a petition is urgent or non-urgent, ensuring that time-sensitive grievances receive immediate attention. The system also employs K-Means clustering to detect similar petitions, grouping repetitive grievances into a single case, which prevents redundant case handling and allows authorities to address widespread issues collectively. This optimized resource allocation improves overall system efficiency.

SYSTEM ARCHITECTURE



Tracking unresolved cases is another key feature of this system. LSTM models are used to monitor petition status over time, predict potential delays, and ensure timely follow-ups. Traditional grievance tracking methods rely on manual updates, making them susceptible to inefficiencies and oversight. With automated tracking and predictive analytics, authorities can proactively manage unresolved cases, leading to faster resolutions and increased accountability. Additionally, the system integrates real-time notifications using the TWILIO API, keeping both petitioners and officials informed about status updates via SMS and email alerts.

This project contributes to the advancement of AI-driven governance systems, showcasing how natural language processing (NLP) and machine learning can transform petition management. Future improvements will focus on expanding dataset diversity to improve model accuracy, integrating multimodal processing (text, image, and voice analysis) for better petition understanding, and incorporating Explainable AI (XAI) techniques to enhance transparency in classification decisions.

As the system develops, it could be a widely used approach to data-driven, transparent, and effective grievance handling. Automating the processing of petitions reduces delays, speeds up response times, and increases public confidence and government accountability, all of which contribute to a more efficient grievance resolution process.

By leveraging automation and artificial intelligence, the system minimizes human intervention while ensuring accurate petition classification, efficient resource management, and timely grievance resolution. Its scalable and adaptable architecture allows for future enhancements, such as multilingual support and integration with advanced analytics tools. As governments and organizations move towards digital transformation, this system serves as a reliable and intelligent solution for improving transparency, responsiveness, and public trust in grievance redressal mechanisms.

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