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AI Based Smart Civic Complaint Management System

Dr. Suganthi C[1], Anusuya S[2], Dhanusha V[2], Janani M[2]

Associate Professor, Department of Computer Science and Engineering, Muthayammal Engineering College, Rasipuram, Namakkal, Tamil Nadu, India[1]

UG Scholar, Department of Computer Science and Engineering, Muthayammal College of Engineering, Rasipuram, Namakkal, Tamil Nadu, India[2]

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ABSTRACT: Rapid urbanization has significantly increased civic infrastructure challenges such as waste management inefficiencies, water leakages, road damages, and sanitation issues. Conventional civic complaint management systems rely heavily on manual processes, leading to delayed responses, inefficient classification, lack of transparency, and poor coordination between citizens and municipal authorities. To overcome these limitations, this paper proposes an AI-Based Smart Civic Complaint Management System that leverages Artificial Intelligence (AI), Machine Learning (ML), Natural Language Processing (NLP), and image processing techniques to automate and optimize the complaint handling process.The proposed system enables citizens to submit complaints through a digital platform using text descriptions, images, and location details. NLP techniques are employed to preprocess textual data, and Machine Learning algorithms such as TF-IDF with Logistic Regression are used for accurate complaint classification. A duplicate detection mechanism based on cosine similarity is incorporated to identify and eliminate redundant complaints. Predictive analytics techniques are also utilized to analyze historical data and forecast recurring civic issues, enabling proactive governance.The system enhances operational efficiency, reduces administrative workload, improves transparency through real-time tracking, and strengthens citizen engagement. It provides a scalable and intelligent solution for smart city applications, contributing to effective urban management and improved public service delivery.

KEYWORDS: Artificial Intelligence, Machine Learning, Natural Language Processing, Smart City, Complaint Management System, Image Processing, Predictive Analytics.

I. INTRODUCTION

The rapid growth of urban populations has significantly increased the demand for efficient civic infrastructure and public services. Cities today face numerous challenges such as waste management inefficiencies, water leakage, road damage, sanitation issues, and other public grievances. With the expansion of urban areas, the volume and complexity of civic complaints have increased substantially, making it difficult for municipal authorities to manage and resolve issues effectively using traditional methods.Conventional civic complaint management systems are largely dependent on manual processes such as phone calls, emails, or paper-based submissions. These complaints are typically recorded, categorized, and forwarded to the relevant departments by administrative personnel. This process often involves multiple intermediaries, leading to delays, miscommunication, and inefficiencies. Furthermore, these systems lack transparency, making it difficult for citizens to track the status of their complaints. As a result, public dissatisfaction increases, and trust in governance systems is reduced.

Another major limitation of existing systems is the absence of intelligent automation. Complaints are not automatically classified or prioritized based on their severity or type, which results in inefficient allocation of resources. Critical issues such as water leakage or road hazards may not receive immediate attention, while less urgent complaints may consume valuable time and effort. Additionally, duplicate complaints are common in traditional systems, leading to redundancy and increased workload for authorities.With the advancements in Artificial Intelligence (AI) and Machine Learning (ML), there is a significant opportunity to transform civic complaint management systems into intelligent, automated platforms. AI techniques enable the processing of large volumes of data, extraction of meaningful insights, and automation of repetitive tasks. Natural Language Processing (NLP), a subset of AI, plays a crucial role in understanding and analyzing textual complaint data submitted by citizens. By converting unstructured text into structured information, NLP techniques facilitate accurate classification and interpretation of complaints.Machine Learning algorithms can be utilized to automatically classify complaints into predefined categories such as garbage management, water supply issues, road damage, and sanitation problems. This reduces the dependency on manual

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intervention and improves classification accuracy. In addition, image processing techniques, particularly Convolutional Neural Networks (CNN), can be used to analyze images submitted along with complaints. This enables the system to verify the authenticity of complaints and identify the type of issue visually, further enhancing the accuracy of the system.Another important aspect of modern complaint management systems is the ability to detect duplicate complaints. Using similarity measures such as cosine similarity, the system can compare new complaints with existing ones and identify duplicates. This prevents redundant entries, reduces system congestion, and ensures efficient utilization of resources. Furthermore, prioritization mechanisms can be implemented to assign urgency levels to complaints based on their severity and impact. This ensures that critical issues are addressed promptly, improving overall service efficiency.

In addition to automation and classification, predictive analytics plays a vital role in enhancing governance. By analyzing historical complaint data, the system can identify recurring issues and predict future trends. Techniques such as time series analysis and regression models can be used to forecast potential civic problems, enabling authorities to take proactive measures rather than reactive actions. This contributes to better planning, resource allocation, and long-term urban development.The proposed AI-Based Smart Civic Complaint Management System aims to address the limitations of traditional systems by integrating AI, ML, NLP, and image processing techniques into a unified framework.

The system provides a digital platform for complaint submission, automated classification, duplicate detection, prioritization, routing, and real-time tracking. It enhances transparency by allowing citizens to monitor the status of their complaints and receive timely updates. Additionally, it improves coordination between departments by ensuring that complaints are routed to the appropriate authorities without delay.The significance of this system lies in its ability to improve efficiency, reduce administrative workload, and enhance citizen satisfaction. By automating key processes and enabling data-driven decision-making, the system supports the development of smart cities and modern governance models. It also promotes accountability and transparency, which are essential for building trust between citizens and authorities.In conclusion, the integration of Artificial Intelligence and Machine Learning in civic complaint management systems represents a transformative approach to urban governance. The proposed system not only addresses the shortcomings of existing methods but also introduces advanced capabilities such as predictive analytics, intelligent classification, and automated routing. This makes it a scalable and efficient solution for managing civic issues in rapidly growing urban environments.

II. LITERATURE SURVEY

This work proposes a machine learning-based complaint management system that automates the classification of civic complaints using algorithms such as Logistic Regression. The system improves response efficiency and reduces manual workload by categorizing complaints into predefined classes[3]. However, it does not include mechanisms for duplicate complaint detection or image-based verification, which limits its ability to handle real-world scenarios effectively.

This study explores deep learning techniques such as Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), and transformer models for text classification[8]. The models demonstrate high accuracy in processing large volumes of textual data, making them suitable for analyzing civic complaints. However, the approach requires high computational resources and is not optimized for lightweight, real-time civic complaint systems.

This paper provides a comprehensive overview of AI applications in smart cities, including governance, transportation, and infrastructure management. It highlights how AI can improve decision-making and service delivery. [9]However, the study lacks a detailed implementation model specifically for civic complaint management and does not address automation in complaint handling.

This research introduces a multimodal approach combining Natural Language Processing (NLP) and image processing using Convolutional Neural Networks (CNN). The system enhances complaint validation by analyzing both text and images, improving accuracy and authenticity[12]. However, it does not incorporate predictive analytics or prioritization mechanisms, which are essential for efficient complaint handling.

III. PROBLEM STATEMENT

Rapid urbanization has led to a substantial increase in civic issues such as waste management inefficiencies, water leakage, road damage, and sanitation problems. Existing civic complaint management systems rely heavily on manual

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processes, including phone calls, emails, and paper-based submissions. These systems suffer from several limitations such as delayed response times, inefficient complaint classification, lack of transparency, and poor coordination between departments.

Additionally, traditional systems lack intelligent mechanisms for automatic complaint categorization, prioritization, and duplicate detection. As a result, similar complaints are often processed multiple times, leading to redundancy and increased workload. Critical issues are not prioritized effectively, causing delays in resolving high-impact problems. Furthermore, the absence of data-driven analytics prevents authorities from identifying recurring patterns and predicting future issues.

Therefore, there is a need for an intelligent, automated, and scalable system that can efficiently manage civic complaints by leveraging Artificial Intelligence (AI), Machine Learning (ML), and Natural Language Processing (NLP) techniques. The proposed system aims to address these challenges by automating complaint classification, detecting duplicates, prioritizing issues, and enabling proactive decision-making.

3.1 Proposed System

The proposed AI-Based Smart Civic Complaint Management System is designed to overcome the limitations of traditional complaint handling mechanisms by integrating Artificial Intelligence (AI), Machine Learning (ML), Natural Language Processing (NLP), and image processing techniques. The system aims to automate the entire complaint management lifecycle, improving efficiency, accuracy, and transparency in urban governance. The system begins with a Complaint Submission Module, where citizens can submit complaints through a user-friendly digital interface. Users can provide details such as textual descriptions, images, and location information. This ensures easy accessibility and structured data collection.

The submitted data is then processed in the Data Preprocessing Module, where NLP techniques such as tokenization, stopword removal, and normalization are applied to clean and transform the textual data. Feature extraction is performed using TF-IDF to convert the text into numerical form suitable for machine learning models. Image data, if provided, is preprocessed using basic image processing techniques. The core functionality of the system lies in the Complaint Classification Module, which utilizes Machine Learning algorithms such as Logistic Regression or Naïve Bayes to automatically categorize complaints into predefined classes such as waste management, water supply, road damage, and sanitation issues. This reduces manual intervention and improves classification accuracy.

For image-based complaints, the system incorporates a CNN-based Image Analysis Module that analyzes visual data to identify the type of issue and verify complaint authenticity. This multimodal approach enhances reliability and reduces false reporting.To improve system efficiency, a Duplicate Detection Module is implemented using cosine similarity to compare new complaints with existing ones. If a complaint is identified as a duplicate, it is flagged, preventing redundant processing and reducing system workload.

The Prioritization and Routing Module assigns priority levels (high, medium, low) based on the severity, type, and location of the complaint. The system then automatically routes the complaint to the appropriate municipal department, ensuring faster and more efficient resolution. Additionally, the system integrates a Predictive Analytics Module, which analyzes historical complaint data to identify recurring patterns and predict future civic issues. This enables proactive decision-making and better resource allocation. Finally, the Response and Feedback Module provides real-time updates to users regarding the status of their complaints. Citizens can track progress, receive notifications, and provide feedback after resolution, thereby enhancing transparency and user satisfaction. Overall, the proposed system provides a scalable, intelligent, and automated solution for civic complaint management, contributing to the development of smart and efficient urban governance systems.

3.2 System Architecture

The system architecture of the proposed AI-Based Smart Civic Complaint Management System is designed as a multi-layered framework that integrates user interaction, data processing, machine learning, and decision-making components. The architecture ensures efficient complaint handling, automation, and real-time response.

1.User Layer (Input Layer)

The system begins with the user layer, where citizens interact with the application through a web-based interface. Users can submit complaints by providing:

- Text description of the issue

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- Image (optional)
- Location details

This layer acts as the entry point of the system and ensures accessibility and ease of use.

1. Data Processing Layer

- Once the complaint is submitted, it is processed in the **data processing layer**, which prepares the input data for analysis.
- Text data is processed using NLPtechniques such as tokenization, stopwordremoval, andnormalization
- TF-IDF is used to convert text into numerical features
- Image data is preprocessed using image processing techniques

1. Machine Learning Layer

- The processed data is passed to the machine learning layer, which performs intelligent analysis.
- **Text Classification Model:** Uses TF-IDF with Logistic Regression to categorize complaints
- **Image Analysis Model (CNN):** Identifies issues from images and verifies complaint authenticity

2. Decision Making Layer

- This layer handles complaint validation and processing decisions.
- Duplicate Detection Module: Uses cosine similarity to identify repeated complaints
- Prioritization Module: Assigns priority levels (High, Medium, Low)
- Routing Module: Sends complaints to the appropriate department

3. Analytics Layer

The system includes a predictive analytics component that analyzes historical complaint data.

- Identifies recurring issues
- Predicts future problems
- Supports proactive governance

4. Output Layer

The final layer provides results to users and authorities.

- Displays complaint status
- Sends notifications
- Collects user feedback

This layer ensures transparency, accountability, and improved user experience.

3.3 Data Flow Diagram

A Data Flow Diagram (DFD) is a modeling tool used to represent the flow of data between processes, data stores, and external entities within a system.

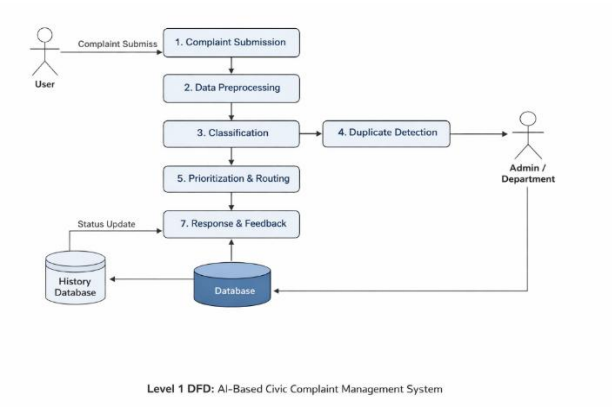

Figure:1 Data flow Diagram

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IV. METHODOLOGY

The proposed AI-Based Smart Civic Complaint Management System follows a structured and systematic workflow to automate the complaint handling process. The methodology consists of multiple stages, including complaint submission, data preprocessing, classification, duplicate detection, prioritization, and feedback. Each stage plays a crucial role in ensuring efficient and accurate complaint management. Initially, in the complaint submission stage, users submit their complaints through a web-based interface by providing details such as text description, optional image, and location information. This ensures that complaints are captured in a structured and accessible format.

In the **data preprocessing stage**, the submitted complaint data is cleaned and prepared for analysis. Natural Language Processing (NLP) techniques such as tokenization, stopword removal, and normalization are applied to the textual data. Feature extraction is performed using TF-IDF to convert text into numerical form suitable for machine learning models. If images are included, basic preprocessing techniques such as resizing and filtering are applied.

4.1 System Modules

The proposed AI-Based Smart Civic Complaint Management System is composed of multiple interconnected modules that collectively enable efficient complaint handling, classification, and resolution. Each module performs a specific function within the system architecture, ensuring automation, accuracy, and scalability.

4.2.1 Complaint Submission Module

The Complaint Submission Module serves as the interface between citizens and the system. It allows users to submit complaints through a web-based platform by providing textual descriptions, optional images, and location details. This module ensures structured data acquisition and facilitates seamless interaction between users and the system.

4.2.2 Data Preprocessing Module

The Data Preprocessing Module is responsible for transforming raw input data into a structured format suitable for analysis. Textual data is processed using Natural Language Processing (NLP) techniques such as tokenization, stopword removal, and normalization. Feature extraction is performed using Term Frequency–Inverse Document Frequency (TF-IDF). Image data, if available, undergoes preprocessing steps such as resizing and normalization to prepare it for further analysis.

4.2.3 Machine Learning Module (Text Classification)

This module employs Machine Learning algorithms to classify complaints into predefined categories such as waste management, water supply, road damage, and sanitation issues. The system utilizes TF-IDF features along with classifiers such as Logistic Regression or Naïve Bayes to achieve accurate and efficient classification. This automation reduces manual intervention and enhances system performance.

4.2.4 CNN Model (Image Analysis)

The CNN Model Module processes image-based complaints using Convolutional Neural Networks. It analyzes visual inputs to identify the type of issue and validate complaint authenticity. This multimodal approach improves classification reliability and supports accurate decision-making.

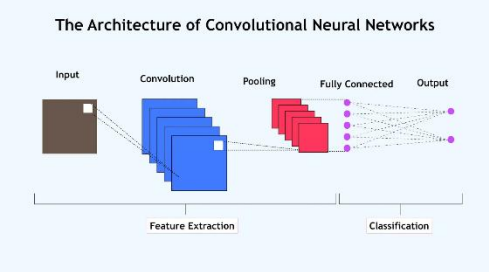

Figure 5.2 CNN Model

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4.2.5 Complaint Classification Module

The Complaint Classification Module consolidates the outputs from the machine learning models and assigns the final category to each complaint. This module ensures consistency and correctness in classification, which is essential for downstream processing such as routing and prioritization.

4.2.6 Duplicate Detection Module

The Duplicate Detection Module identifies redundant complaints by comparing new submissions with existing records. It utilizes cosine similarity measures to detect similarity between complaint descriptions. If the similarity exceeds a predefined threshold, the complaint is flagged as a duplicate, thereby reducing redundancy and optimizing system efficiency.

4.2.7 Prioritization and Routing Module

This module assigns priority levels (high, medium, or low) to complaints based on their severity, category, and location. It then automatically routes the complaints to the appropriate municipal departments. This ensures timely resolution of critical issues and efficient resource allocation.

4.2.8 Predictive Analytics Module

The Predictive Analytics Module analyzes historical complaint data to identify recurring patterns and trends. Using predictive models such as regression or time-series forecasting (e.g., ARIMA), the system can anticipate future civic issues. This enables proactive governance and supports data-driven decision-making.

4.2.9 Response and Feedback Module

The Response and Feedback Module provides real-time updates to users regarding the status of their complaints. It also allows users to submit feedback after issue resolution. This module enhances transparency, accountability, and user engagement within the system.

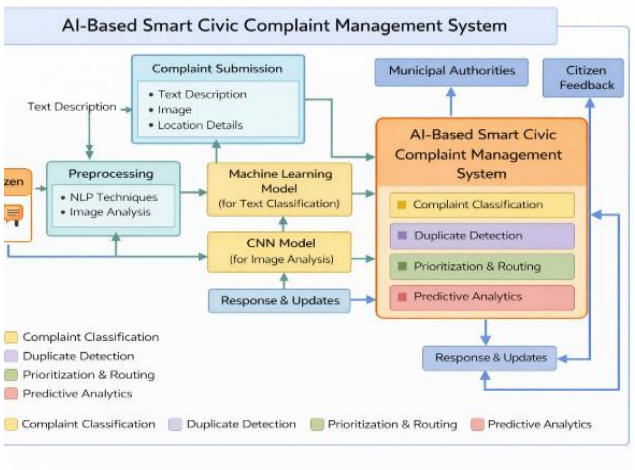

Figure 2: Block Diagram of Civic Complaint System

4.3 Mahine Learning Algorithm (Complaint Classification)

Machine Learning algorithms are used to automatically classify civic complaints into predefined categories such as garbage management, water supply issues, road damage, and sanitation problems. In the proposed system, algorithms such as Logistic Regression or Naïve Bayes are applied on TF-IDF feature vectors obtained from complaint text. These models learn patterns from training data and predict the appropriate category for new complaints. This automatedclassification reduces manual effort, improves accuracy, and ensures efficient complaint handling.

4.3.1 Naïve Bayes Theorem

Naive Bayes is a supervised Machine Learning algorithm used for classification tasks, especially suitable for text data such as civic complaints. It is based on Bayes' Theorem and assumes that the features are conditionally independent given the class label.

The algorithm is based on the following formula:

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$P(C \mid X) = \frac{P(X|C) \cdot P(C)}{P(X)}$

Where:

- $P(C \mid X)$= Posterior probability of class Cgiven input X
- $P(X \mid C)$= Likelihood of input Xgiven class C
- $P(C)$= Prior probability of class □
- $P(X)$= Probability of input data

4.4 Natural Language Processing (NLP)

Natural Language Processing (NLP) is used to extract meaningful information from the textual descriptions provided by users. Since complaint data is unstructured, NLP techniques such as tokenization, stopword removal, stemming, and feature extraction (TF-IDF) are applied to preprocess the text. This process converts raw text into structured numerical data, which can be used by machine learning models for classification and analysis. NLP improves the understanding of user input and enhances system accuracy.

4.4.1 Term Frequency – Inverse Document Frequency (TF-IDF)

TF-IDF is a statistical technique used to convert textual data into numerical form so that it can be processed by Machine Learning algorithms. In the proposed AI-Based Smart Civic Complaint Management System, TF-IDF is used to transform complaint descriptions into feature vectors for classification.

It helps identify the importance of a word in a document relative to a collection of documents (corpus).

Term Frequency measures how frequently a word appears in a document.

$$□□(□, □) = \frac{□(□,□)}{\sum□(□,□)} \quad (2)$$

Where:

- □(□, □)= Number of times term □appears in document □
- $\sum$□(□, □)= Total number of terms in document □

4.5 Image Processing (CNN-Based Analysis)

Image processing techniques are used to analyze images submitted along with complaints. The system employs Convolutional Neural Networks (CNN) to extract visual features from images and classify the type of issue, such as potholes, garbage accumulation, or water leakage. The CNN model consists of convolution, pooling, and fully connected layers that help in identifying patterns in images. This module also verifies the authenticity of complaints, reducing false reporting and improving reliability.

4.6 Predictive Algorithm

Predictive algorithms are used to analyze historical complaint data and identify patterns and trends. Techniques such as **time series forecasting (ARIMA) or regression models** are applied to predict future civic issues.

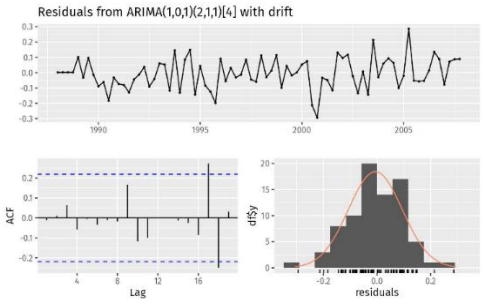

Figure 5.6 Predictive Forecast

For example, the system can forecast areas with frequent complaints or predict seasonal problems. This enables authorities to take proactive measures, optimize resource allocation, and improve overall governance.

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4.7 Performance Metrics

To evaluate the effectiveness of the proposed AI-Based Smart Civic Complaint Management System, standard classification metrics such as Accuracy, Precision, Recall, and F1-Score are used. These metrics help measure the performance of the machine learning model in classifying civic complaints correctly.

A. Accuracy

Accuracy represents the overall correctness of the model in predicting complaint categories.

$$\text{Accuracy} = \frac{\square\square + \square\square}{\square\square + \square\square + \square\square + \square\square}$$

Where:

- **TP** = True Positive
- **TN** = True Negative
- **FP** = False Positive
- **FN** = False Negative

B. Precision

Precision measures how many of the predicted positive complaints are actually correct.

$$\text{Precision} = \frac{\square\square}{\square\square + \square\square}$$

C. Recall

Recall measures how many actual positive complaints are correctly identified.

$$\text{Recall} = \frac{\square\square}{\square\square + \square\square}$$

D. F1-Score

F1-Score is the harmonic mean of precision and recall.

$$\text{F1-Score} = \frac{2 \times (\square\square\square\square\square\square\square\square\square \times \square\square\square\square\square\square)}{\square\square\square\square\square\square\square\square\square + \square\square\square\square\square\square}$$

V. RESULTS AND CONCLUSION

The proposed AI-Based Smart Civic Complaint Management System was developed and evaluated to analyze its effectiveness in automating complaint handling and improving service efficiency. The system integrates Machine Learning, Natural Language Processing (NLP), and image processing techniques to classify complaints, detect duplicates, assign priority, and provide real-time feedback.The complaint classification module demonstrated high accuracy in categorizing complaints into predefined classes such as garbage, water supply, road damage, and sanitation. Using TF-IDF with Logistic Regression (or Naïve Bayes), the system achieved improved classification performance compared to manual categorization. The use of NLP preprocessing techniques significantly enhanced feature extraction and reduced noise in textual data.

The duplicate detection module, implemented using cosine similarity, effectively identified redundant complaints. This reduced unnecessary data storage and minimized repeated processing, thereby improving system efficiency and reducing administrative workload. The prioritization and routing module successfully assigned appropriate priority levels (high, medium, low) based on complaint type and severity. Critical issues such as water leakage and road damage were prioritized and routed to the respective departments, resulting in faster response times.

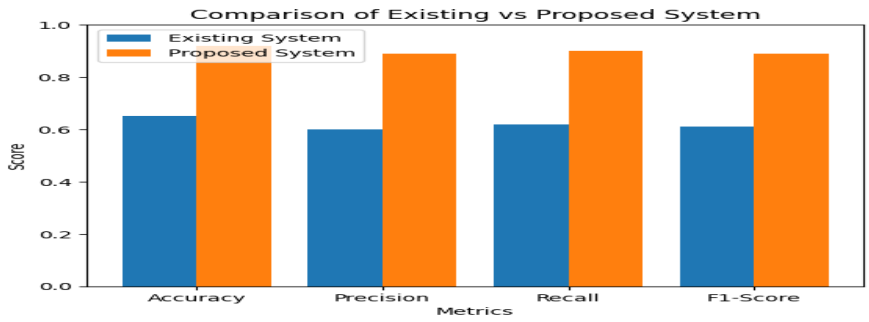

Figure: 6.1 Comparison of Existing and Proposed

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The integration of the CNN-based image analysis module enabled the system to verify complaint authenticity and classify issues based on images. This improved reliability by reducing false or irrelevant complaints and supporting multimodal analysis.

The predictive analytics module, implemented using ARIMA or regression techniques, analyzed historical complaint data to identify patterns and forecast future civic issues. This allowed authorities to take proactive measures, improving resource allocation and planning.

Overall, the system demonstrated significant improvements in terms of efficiency, accuracy, and transparency. Compared to traditional systems, the proposed solution reduced response time, minimized manual intervention, and enhanced citizen engagement through real-time updates and feedback mechanisms.

Metric	Existing System	Proposed System
Accuracy	0.65	0.92
Precision	0.60	0.89
Recall	0.62	0.90
F1-Score	0.61	0.89

Table:1 Comparison Table of Existing and Proposed

The performance comparison between the existing system and the proposed system is illustrated in Fig. X. The proposed system significantly outperforms the traditional system across all evaluation metrics. The accuracy improved from 65% to 92%, while precision, recall, and F1-score also showed substantial improvements. This demonstrates the effectiveness of integrating AI, ML, and NLP techniques in enhancing complaint management efficiency.

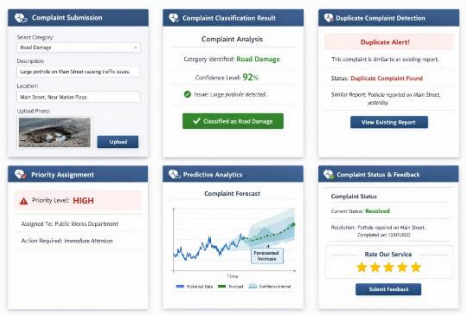

Figure:6.2 AI Civic Complaint Management Interface

5.1 Conclusion

In this paper, an AI-Based Smart Civic Complaint Management System has been proposed and implemented to address the limitations of traditional complaint handling systems. The system integrates Machine Learning, Natural Language Processing, image processing, and predictive analytics to automate complaint classification, detect duplicates, prioritize issues, and provide real-time updates.

The experimental results demonstrate that the proposed system achieves high accuracy in complaint classification and significantly reduces response time compared to existing systems. The integration of CNN-based image analysis enhances complaint verification, while predictive algorithms enable proactive decision-making.

Overall, the system improves efficiency, transparency, and citizen engagement, making it a scalable solution for smart city applications. The proposed approach contributes to modern urban governance by enabling intelligent and data-driven complaint management.

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5.2 Future Scope

The proposed AI-Based Smart Civic Complaint Management System can be further enhanced by integrating advanced technologies to improve its efficiency and scalability. Future work may include the integration of Internet of Things (IoT) sensors to automatically detect civic issues such as garbage overflow, water leakage, and road damage without manual complaint submission.

Additionally, the system can be extended to support multilingual complaint processing using advanced Natural Language Processing (NLP) models, enabling users to submit complaints in regional languages. The development of a mobile application with GPS-based tracking can further improve accessibility and user engagement.

Furthermore, integrating Geographic Information Systems (GIS) can help visualize complaint hotspots and assist authorities in efficient decision-making. The use of advanced deep learning models can also improve classification accuracy and prediction performance.

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