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Xai-Based Rural Complaint Prioritization & Resolution System

Souvik Mandal[1], Vishwa A H[2], B Mahesh A[3]
[1]Assisstant professor, Dept. of ECE, SRM Institute of Science & Tech., Kattankulathur, Tamilnadu, India.
[2,3]UG Scholar, Dept. of ECE, SRM Institute of Science & Tech., Kattankulathur, Tamilnadu, India.
EmailID: *souvikm@srmist.edu.in [1], vh9997@srmist.edu.in[2], ma6923@srmist.edu.in[3]*

Abstract
The rural infrastructure issues like lack of water supply, road damage, sanitation problems and power failures have a strong impact on the quality of life in the rural settlements. The old grievance management systems are manual and do not have an effective system to prioritize complaints and resources allocation. The paper describes the RuralTrust AI, an intelligent AI based complaint management and decision support system, which will enhance rural governance by conducting automated complaint analysis and predictive analytics.The suggested system will combine Natural Language Processing (NLP), sentiment analysis, multi-label classification of complaints, and a machine learning-based urgency score to classify and rank citizen complaints automatically. The site is deployed on a full-stack application comprising of React-based citizen interfaces, Node.js-based backend service, and MongoDB cloud database infrastructure. More sophisticated functions of the system are also the detection of duplicates of complaints, the forecasting of the trends in complaints, the recommendation of the resource allocation based on the AI, and tools to simulate the impact of the policies on the government officials in making decisions.It has been shown through experimental assessment that the system will make the complaint handling more efficient, allow prioritizing the critical infrastructure problems faster and improve the transparency of the governance. The suggested platform shows how AI-based governance systems can be used to enhance the delivery of services to people in rural areas.

Keywords: *Artificial Intelligence, NLP, Sentiment Analysis, Complaint Classification, Predictive Analytics, Smart Governance, Decision Support System*

1. Introduction
Over the last few years, the efficiency of the system of the public services has increased due to the development of digital technologies and artificial intelligence. Management of grievances is significant in ensuring that governance is maintained through transparency and accountability. Poor infrastructure facilities like lack of water supply, broken roads, sanitation system, power outages, and access to health services are commonly under-addressed in the rural areas because of ineffective systems of reporting and monitoring complaints. The common method of complaint management approach is based on manual documents and physical access to local administrative offices. Such systems are not associated with real-time monitoring, a systematic analysis of complaints, and therefore, the government authorities cannot recognize the pressing issues and distribute the resources effectively. This has seen most complaints being left unattended or taking a long time to be attended to thereby leaving the rural citizens dissatisfied. Due to the accelerated development of artificial intelligence and data analytics, nowadays, intelligent governance systems can process high amounts of complaint information automatically. Using Natural Language Processing (NLP) methods enables systems to read and understand text complaints, classify infrastructure problems, and decide the urgency of the problem by analyzing the complaint content. Governments can also utilize these technologies to prioritize critical issues and act in a more efficient way. The paper will suggest RuralTrust AI, a smart complaint management system that aims at enhancing rural governance by automated complaint analysis and

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decision support systems. The system combines artificial intelligence methods, including complaint classification, sentiment analysis, urgency scoring, and predictive analytics, to help government authorities find out where critical infrastructure problems exist. There is also a government dashboard on the platform which visualizes the statistics and trends of complaints, so that the decisions of the government can be made better and the resources could be allocated. The suggested system is expected to increase transparency, make the complaint resolution system more efficient and effective, and reinforce the relations between the citizens and the government officials in rural areas.

2. Related Works

Digital grievance management platforms have been of great concern in the recent years where governments strategize to enhance transparency, efficiency, and responsiveness in the systems of delivering public services. There are multiple studies about the application of artificial intelligence and data analytics to citizen complaints and better decision-making in governance systems. A thorough research on intelligent complaint management systems based on the use of machine learning techniques was conducted by J. Chen and L. Zhang which investigated methods of automatic classification of complaints and revealed key issues in the work with big amounts of textual feedback provided by citizens [1]. An example is an AI-based redressal platform of public grievances, which is suggested by R. Kumar and P. Singh and in which the natural language processing is used to classify complaints and issue priority alerts to the government authorities, which prove to be more responsive in the municipal governance system [2]. The online complaint management system developed by S. Patel and M. Shah to smart cities is a combination of web-based reporting and automated tracking of complaints and administrative dashboard. The system allows the government officials to track the status of complaints as well as analyze the distribution of the issues in various infrastructural sectors [3]. K. Ramesh and S. Arul have suggested a digital grievance portal that would enable the citizens to post complaints via mobile interface and also allow administrators to monitor complaints in terms of central databases and reporting tools [4]. The natural language processing has been commonly utilized in the analysis of citizen feedback and textual grievance information as well. A. Gupta and V. Sharma developed an open-source machine learning-based system of complaint classification based on text mining and sentiment analysis, classifying citizen complaints into various infrastructure categories, including transportation, sanitation, and the water supply [5]. Equally, T. Nguyen and H. Tran had created an automated framework of complaint classification with deep learning models to determine the topics of complaints and determine the level of urgency based on the intensity of sentiment [6]. A number of researches have also been directed at decision-support in public administration. P. Roy and S. Bhattacharya offered an intelligent governance platform, which incorporates predictive analytics, to detect infrastructure issues patterns and guide authorities in terms of resource planning [7]. L. Wang and Y. Zhao are the authors of a big data analytics platform to govern cities that offers a framework to analyze citizen feedbacks in various sources to identify common problems in urban services [8]. Besides classifying complaints, duplicate detection and clustering of complaints have also been considered to minimize grievance management system redundancy. A semantic similarity-based complaint detection system was suggested by R. Mehta and S. Kulkarni; this framework clusters similar complaints together with sentence embeddings and cosine similarities [9]. M. Ali and K. Rahman came up with a complaint clustering system that detects patterns in citizen complaints and assists government officials in identifying a pattern of infrastructure issues in certain geographical regions [10]. More current developments are also concerned with incorporating predictive models with governance platforms. J. Lee and S. Park suggested a predictive system of monitoring public services based on past historical data on complaints to predict infrastructure problems and help the authorities in making proactive decisions [11]. A. Verma and R. Gupta created a machine learning-driven governance analytics system that was able to determine factors of infrastructure risk and forecasted complaint surges in urban settings [12]. Even with such developments, a significant number

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of the current systems are involved in registering complaints and data storage, but not much can be done in terms of intelligent analysis and predictive decision support. The proposed RuralTrust AI system can overcome these shortcomings by embedding automated complaint categorization, sentiment-based urgency ranking, duplicate complaint identification, and predictive analytics into a single governance platform to help authorities to deal with rural infrastructure problems in a more efficient way.

3. Proposed System

The suggested RuralTrust AI system is aimed at enhancing the system of rural governance through the provision of an intelligent complaint management and decision-support system, allowing citizens to be connected to the government authorities. The infrastructure enables citizens to make complaints in the form of lack of water supply, broken roads, sanitation, electricity breakdowns, healthcare facility problems, and waste management by using a digital web platform. After a complaint is made, the system stores the information about the complaint in a centralized database and sends the description of the complaint to an artificial intelligence process unit to be analyzed automatically. Fig. 1 and Fig. 2 are the prototype and the general block diagram of the system.

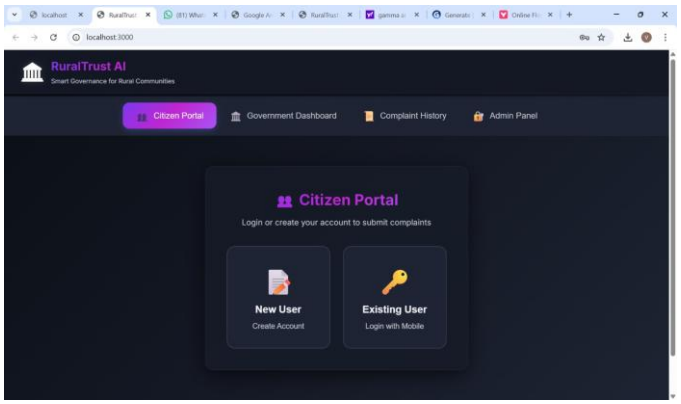

Figure 1 Dashboard of the citizen portal

The process of analyzing complaints is carried out with the help of Natural Language Processing (NLP). The text of the complaint is initially preprocessed with the help of tokenization, text normalization, and elimination of the stop-word to prepare the data to be analyzed further in fig 1. The complaint is then classified into the various infrastructure sectors that it pertains to using a multi-label classification model into water supply, electricity, road maintenance, sanitation, healthcare, street lighting, and waste management. This computerized classification enables the government authorities to be able to determine the kind of problem being reported in a short time. The system also classifies the complaints and also conducts sentiment analysis to ascertain the intensity of the emotion of the complaint. Sentiment score gives an idea of urgency of the issue reported by the citizen. The system takes the sentiment score and the preset infrastructure category priorities and risk-related keywords and uses them to compute an urgency score. According to this urgency score, complaints are automatically marked prioritized whereby critical issues can be addressed faster by the concerned authorities in fig 2.

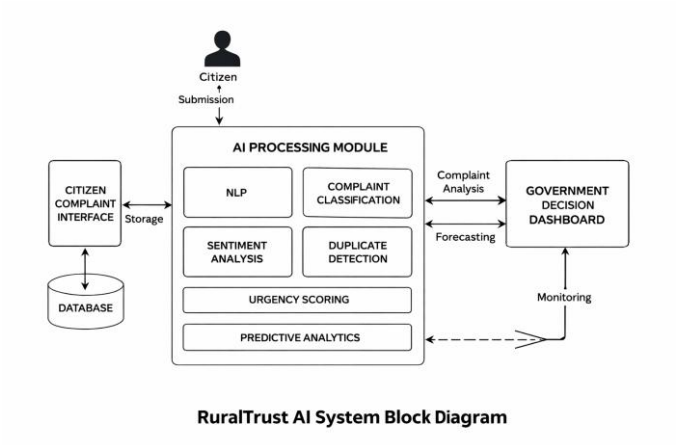

Figure 2 Block Diagram of the RuralTrust AI

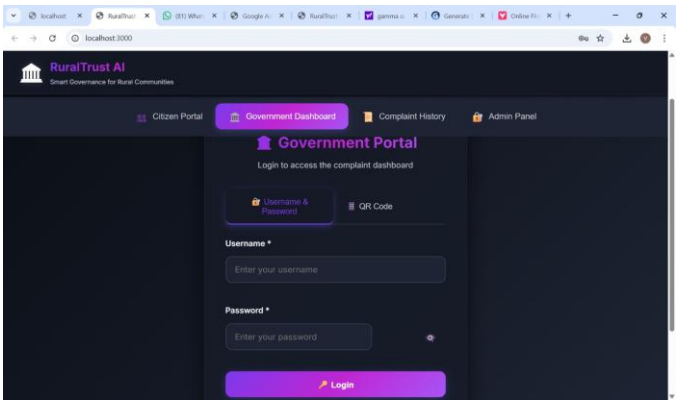

Figure 3 Government portal Dashboard

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The system also has a duplicate complaint detection system which notifies the same infrastructure problem based complaints. The descriptions of the complaints are transformed into sentence embeddings and similarity scores are generated with the help of cosine similarity. When there are several complaints that are related to the same issue in a particular location, the system is able to cluster them to eliminate unnecessary processing and assist administrators concentrate on addressing the main problem that is impacting various citizens in fig 4.

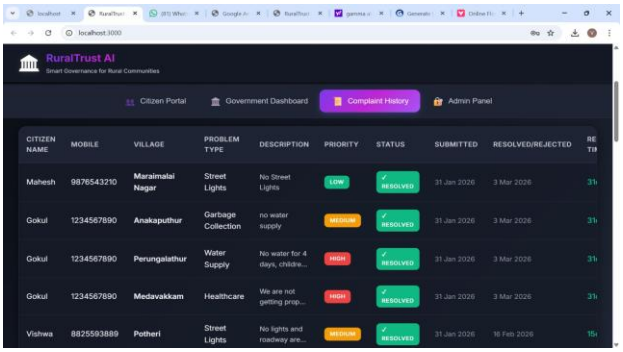

Figure 4 Complaint History Dashboard

The system is accessible to the government authorities via an administrative dashboard, which shows real-time complaint analytics and infrastructure insights. The dashboard will show data on the distribution of complaints by categories, urgency level, and patterns of complaints by various villages or regions. Predictive analytics are also part of the system, which examines historical complaint records and predicts the possible infrastructure challenges in fig 5.

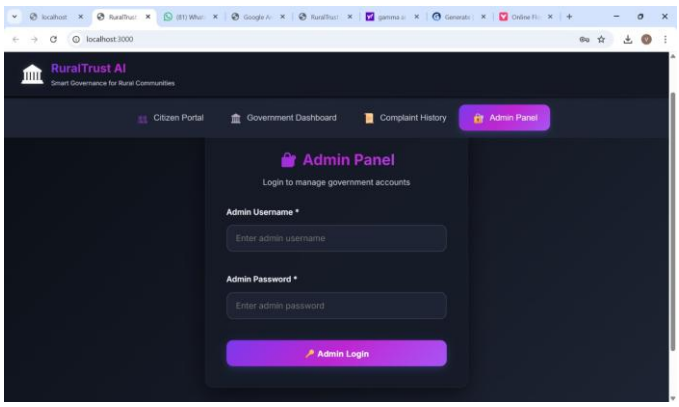

Figure 5 Admin Panel Dashboard

The entire platform is deployed with the help of a full-stack architecture based on React-based frontend interface, a set of Node.js and Express backend services, and MongoDB cloud database, allowing effective interaction between the citizens and the government representatives and facilitating the intelligent analysis of complaints and the decision-making process.

4. Results And Discussion

To test the effectiveness of the proposed RuralTrust AI complaint management system in automating complaint classification, prioritization, and administrative decision support, it was implemented and evaluated. The assessment aimed at estimating the work of the AI-based complaint analysis pipeline, duplicate complaints detection, urgency scoring system, and dashboard analytics. The simulated rural complaint datasets that were used to test the system included several types of infrastructure like water supply, electricity, road damage, sanitation, healthcare, and waste management. It was tested both individually in the modules of AI and on the whole system performance. Experimental findings show that the presented system can correctly categorize complaints and pinpoint priority problems as well as deliver valuable information to government officials.

Performance of Complaint Classification:

The complaint classification module was tested to determine its capacity to classify textual complaints correctly into the appropriate infrastructure sectors. The system implemented Natural Language Processing, to preprocess the description of complaints and conduct multi-label classification. In the process of testing, the model was able to classify the complaints based on pre-defined categories that included water supply, road damage, sanitation, and electricity problems. The classification model was found to be highly accurate when determining the appropriate complaint category even in cases where the description of the complaint had informal or mixed language expression. This ability will go a long way in minimizing the amount of manual work that government officials will have to conduct in order to process and categorize the complaints of citizens.

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4.1.Complaint Classification Performance

The evaluation of the complaint classification module assessed its capability to classify textual complaints into the right infrastructure sectors correctly. The system applied Natural Language Processing methods to pre-process the descriptions of complaints and conducts multi-label classification. In the process of testing, the model was able to classify complaints into the predetermined categories that included water supply, road damage, sanitation, and electricity issues. The classification model was found to be very accurate in determining the appropriate category of complaint despite the presence of informal or mixed words in the description of the complaint. This will greatly save on the manual workload that the government officials would need to sift through and classify the citizen complaints in fig 6.

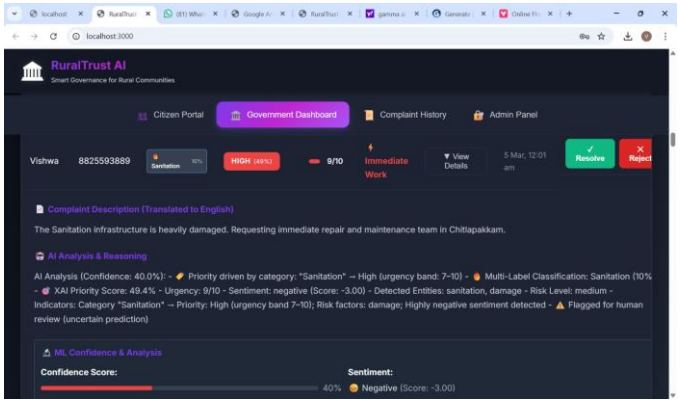

Figure 6 Natural Language Processing techniques to preprocess the complaint descriptions

4.2. Urgency Scoring and Sentiment Analysis.

The system was also found to be effective in the determination of the urgency level of complaints based on sentiment analysis. Sentiment analysis module measured the emotional tone of the complaint descriptions and produced sentiment scores which are used to demonstrate the severity of the issue raised by the citizen. These scores were added to the predetermined infrastructure category priorities and risk-related keywords to calculate an urgency score of every complaint. Critical infrastructure issues like healthcare crises or water supply disruptions were automatically given priority and identified as possible administrative matters that needed immediate administrative action in fig 7.

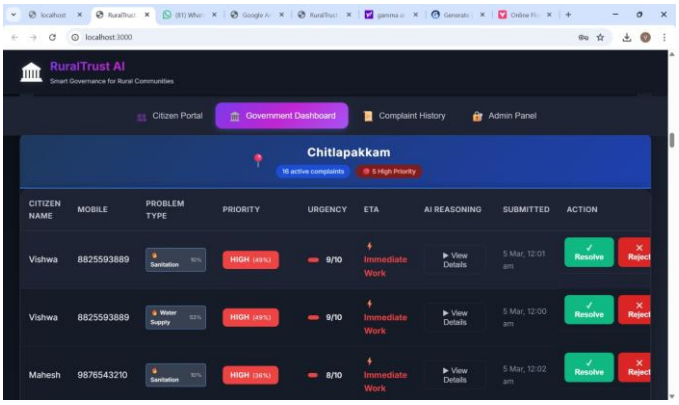

Figure 7 Visualization of Urgency Scoring

4.3. Duplicate Complaint Detection

In practical grievance management systems, the same infrastructure problem in a particular locality may be reported by several citizens. To resolve this issue, the RuralTrust AI system has added a duplicate complaint detection system that uses sentence embeddings and cosine similarity. When the system was tested, it was able to identify complaints that raised the same issue and cluster them as duplicate entries in fig 8.

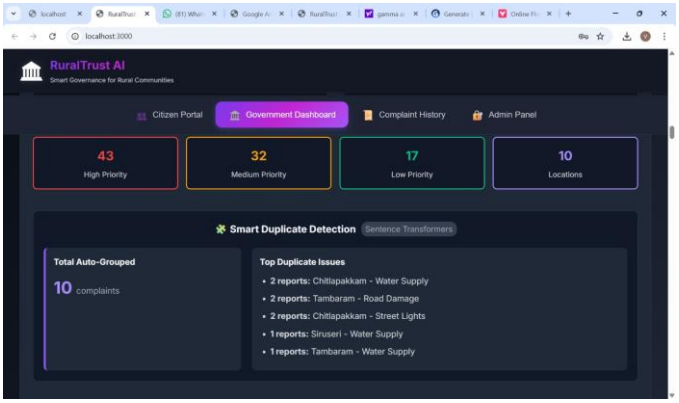

Figure 8 Smart Duplicate detection

4.4. Predictive Complaint Trend Analysis

The system also makes use of predictive analytics to study previous complaint records and detect recurring patterns in public issues. By carefully analyzing historical data, the model can anticipate possible infrastructure-related problems that may arise in

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certain areas. This ability to forecast potential issues allows government authorities to act in advance rather than waiting for the situation to worsen. As a result, officials can plan timely maintenance, improve infrastructure management, and allocate necessary resources more effectively to prevent larger problems from developing.

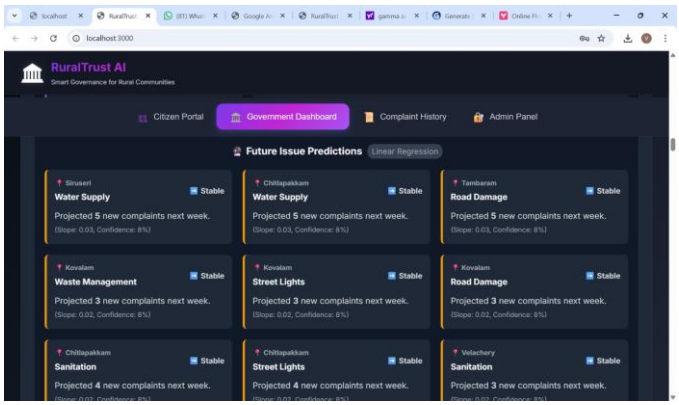

Figure 9 Dashboard of prediction of future issues

4.5. System Performance and Practical Considerations

During the evaluation stage, the system showed consistent and dependable performance. However, when implemented in real-world environments, some practical challenges may occur. For instance, differences in how citizens describe their complaints, the use of multiple languages, and missing or incomplete information in submissions could influence the accuracy of the classification process. Additionally, integrating real-time data from several villages or districts may create scalability issues, requiring efficient database management and improved server performance. Even with these challenges, the RuralTrust AI system represents a considerable advancement compared to traditional manual grievance handling methods. By automating complaint analysis and supporting data-driven decision-making, the system helps authorities manage public grievances more efficiently.

4.6. Comparison with Existing Systems

When compared to conventional complaint management platforms, the proposed system offers several advanced features within a single integrated framework. These include automated classification of complaints, urgency assessment based on sentiment analysis, detection of duplicate complaints, and predictive analysis of emerging issues. Many existing systems mainly concentrate on registering complaints and tracking their status, without providing deeper analytical insights or decision-support tools. In contrast, the RuralTrust AI platform combines intelligent analytics with administrative dashboards, allowing authorities to quickly identify pressing infrastructure problems and respond to citizens' concerns in a more timely and effective manner.

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