Civic Sphere

Smart Urban Problem Reporting and Management

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***Abstract*—Rapid Civic densification has increased the complexity of managing civic infrastructure and enforcing public regulations. Metropolitan hubs often struggle with crumbling transit networks, inadequate lighting, and refuse management issues. This paper presents a citizen-centric urban issue management platform that combines community participation with artificial intelligence (AI) to support timely, transparent, and data-informed governance. Residents can report infrastructure faults or regulatory violations by uploading geo-tagged images, textual descriptions, or endorsing existing complaints. AI-based image analysis helps identify issue categories, while natural language processing enhances report clarity. Predictive models estimate the likelihood of issue escalation, enabling preventive intervention. A centralized administrative dashboard allows authorities to prioritize actions based on urgency, severity, and public feedback, while route optimization improves administrative effectiveness. Citizens can monitor the progress of resolutions and earn incentive-based social contribution credits for meaningful participation. By integrating crowd-sourced inputs with intelligent analytics, the proposed system strengthens collaboration between citizens and authorities, promoting safer and more sustainable urban environments.**

I. Introduction

Civic densification has significantly transformed modern cities, bringing both economic growth and increased pressure on public infrastructure and regulatory systems. As urban populations continue to rise, city administrations face persistent challenges such as damaged road networks, insufficient public lighting, inefficient waste disposal practices, and a growing number of traffic-related violations [1]. These issues not only disrupt daily life but also increase the risk of accidents and long-term infrastructure degradation. Traditional civic Legacy municipal reporting protocols and systems are often limited in effectiveness due to delayed responses, fragmented workflows, and minimal transparency [11]. In many cases, citizens submit complaints without receiving timely updates, while authorities lack structured mechanisms to analyze complaint severity or urgency. As a result, Trivial physical flaws in the city often go ignored until they manifest as life-threatening dangers. Furthermore, limited opportunities for sustained citizen engagement reduce accountability within urban governance frameworks. The increasing availability of smartphones, location-aware services, and artificial intelligence technologies provides an opportunity to redesign how urban problems are reported and managed [6],[10]. Digital platforms that enable citizens to contribute real-time, location-specific information can significantly enhance situational awareness for city administrators [2],[3]. When combined with AI-based image interpretation and predictive analytics, these platforms can automate issue categorization, estimate future risk, and support informed decision-making. This paper presents a community-driven urban issue management system that combines citizen participation with intelligent data analysis to improve urban monitoring and response processes[2]. The proposed solution enables residents to submit geo-tagged complaints with visual evidence, support existing reports through public voting, and track resolution progress. At the same time, AI modules analyze submitted data, enhance report quality, and assess escalation risks, while a centralized administrative interface supports prioritization and resource allocation. Through continuous information exchange between citizens and authorities, the system aims to improve transparency, responsiveness, and long-term urban sustainability.

II. Related Work

Research in smart city development has resulted in various digital solutions aimed at improving urban issue reporting and service delivery [2],[11]. Initial efforts focused on web-based portals that enabled citizens to submit complaints regarding public infrastructure and municipal services. Although these systems improved accessibility, they often lacked intelligent prioritization, automated verification, and real-time feedback mechanisms [2],[7]. The widespread adoption of smartphones led to the emergence of mobile-based civic engagement platforms that support image-based and location-aware reporting. These applications enhanced spatial accuracy and reduced reporting delays; however, they typically relied on manual inspection by authorities,limiting scalability in large urban areas [4],[9]. More recent studies have investigated the application of artificial intelligence for urban monitoring tasks. Computer vision techniques have been employed for detecting road defects, waste accumulation, and traffic violations, while machine learning models have shown effectiveness in automating issue classification [4],[6],[12]. Nevertheless, many existing solutions address isolated problem domains rather than offering an integrated urban management framework. Predictive analytics has also been explored to assist urban planning by analyzing historical complaint records and traffic trends. While useful for long-term forecasting, such approaches often operate independently of real-time citizen reporting [5],[8], reducing their effectiveness in immediate response scenarios. Compared to prior work, the proposed system unifies crowd-sourced reporting, AI-driven analysis, predictive risk estimation, and administrative decision support within a single platform. This integrated approach enables responsive, transparent, and scalable urban issue management.

III. System Architecture

The proposed system adopts a layered and modular architecture to support seamless interaction between citizens, intelligent analytics components, and municipal authorities. The design integrates mobile and web-based interfaces with backend services and AI modules to facilitate real-time issue reporting, automated analysis, and efficient resolution tracking.

A. User Interaction Layer

The interaction layer provides citizens with access through mobile and web-based applications, enabling them to report urban issues, submit visual evidence, and monitor complaint status with minimal effort. Users submit complaints by uploading images, providing brief descriptions, and capturing GPS-based location data. The interface also allows users to view nearby reported issues, upvote existing complaints, and track the resolution status of previously submitted reports. This layer focuses on usability, accessibility, and real-time feedback to encourage active citizen participation.

B. Data Acquisition and Management Layer

All user-submitted data, including images, textual descriptions, location information, and voting metrics, is securely transmitted to the backend server. This layer is responsible for data validation, storage, and management. A centralized database maintains structured records of complaints, user activity, and historical resolution data. Proper indexing and access control mechanisms are employed to ensure data integrity, scalability, and privacy.

C. AI Analysis Layer

The artificial intelligence layer processes incoming complaint data and automates issue understanding and prioritization. Computer vision algorithms scan user-submitted visual data and pinpoint structural anomalies and public failures. Natural language processing techniques refine and summarize textual descriptions to improve clarity and consistency [6],[12],[13]. Additionally, predictive models evaluate the likelihood of issue escalation by examining severity indicators, location patterns, and historical trends. This layer's outputs support early risk identification and guide decisions.

D. Application and Service Layer

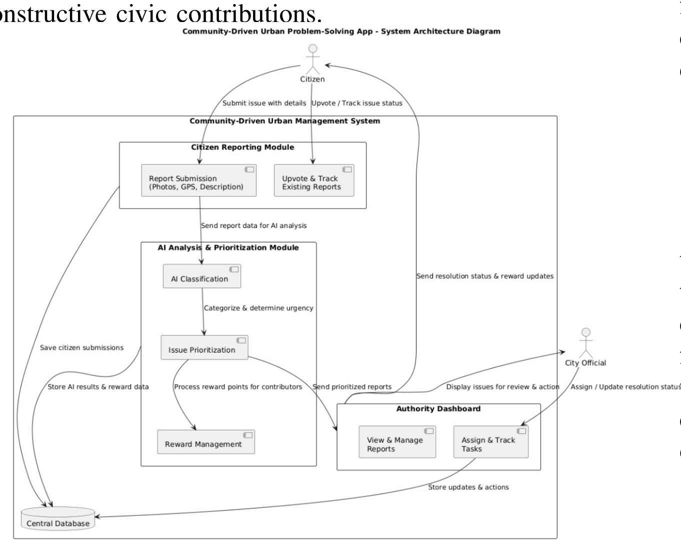
The application layer acts as the core processing unit that coordinates communication between system components. It manages complaint workflows, integrates AI analysis results, updates issue status, and handles notifications. This layer also enforces business logic, including complaint categorization, priority scoring, and reward allocation through Social contribution credits. APIs are utilized to ensure seamless interaction between frontend applications, AI modules, and administrative tools.

E. Administrative Dashboard Layer

City officials and authorized personnel access the system through a centralized administrative dashboard. This interface provides real-time insights into reported issues, including severity levels, public votes, and AI-generated risk assessments [6],[11]. Officials can prioritize tasks, assign resources, optimize maintenance and enforcement routes, and update resolution progress. Visualization tools such as maps, charts, and alerts support data-driven decision-making and administrative effectiveness.

F. Communication and Feedback Layer

The communication layer ensures continuous information exchange between citizens and authorities. Automated notifications inform users about complaint acceptance, progress updates, and resolution outcomes. Feedback mechanisms enhance operational openness and responsibility, while the reward system encourages sustained participation by recognizing constructive civic contributions.



IV. Methodology

The methodology of the proposed Community Driven Urban Problem Solving system focuses on enabling real-time issue reporting, intelligent analysis, and efficient resolution through a structured and modular workflow. The system combines user-generated data with artificial intelligence techniques and centralized administrative control to ensure accuracy, responsiveness, and transparency.

A. Issue Reporting and Data Collection

The workflow initiates when residents report civic issues or regulatory violations using the system's mobile or web interface. Users capture images of the problem, provide short textual descriptions, and record GPS-based location details automatically. Users may also support existing complaints by upvoting them, which contributes to public priority scoring. This step ensures reliable, location-specific, and evidence-backed data collection.

B. Data Preprocessing and Validation

Roboflow Detection Transformer (RF DETR) object detection framework is used for training the computer vision component of the proposed system. An annotated image dataset was prepared using this. The dataset focuses on common urban safety and infrastructure issues and includes four primary categories: road accidents, tree fall incidents, pothole detection, and fire accidents. Approximately 3,500 labeled images were collected and annotated to ensure accurate object recognition and classification. These images represent different environmental conditions, viewing angles, and lighting variations to improve the model's accuracy. The annotated dataset was then used to train a single RF DETR model capable of identifying and distinguishing between the four classes of urban issues. This dataset preparation strategy enables the model to effectively recognize multiple types of urban hazards from citizen-submitted images and supports automated issue classification within the platform. The final output of the dataset holds 78% of threshold confidence.

C. AI Based Issue Classification

Preprocessed images are analyzed using computer vision techniques to identify infrastructure defects or detect regulatory violations [4],[13]. Simultaneously, natural language processing is applied to refine and summarize textual descriptions for improved clarity. Based on visual and textual analysis, the system automatically classifies the issue into predefined categories such as road damage, waste issues, traffic violations, or public safety concerns.

D. Predictive Risk Assessment

To support proactive decision making,Anticipatory analytics determine the probability of a reported incident deteriorating without immediate attention [5],[8]. Factors such as issue severity, location sensitivity, historical occurrence patterns, and public voting trends are considered. This step helps identify problems that may evolve into serious hazards if not addressed promptly, allowing authorities to intervene early.

E. Priority Scoring and Workflow Management

Each reported issue is assigned a dynamic priority score derived from AI-based severity analysis, escalation risk, and citizen votes. The application layer manages the complaint life cycle by updating status stages such as reported, under review, assigned, in progress, and resolved. This structured workflow ensures systematic handling of all reported issues.

F. Administrative Action and Route Optimization

Authorized officials access the system through a unified administrative dashboard where prioritized issues are displayed with analytical insights and geographic visualization. The system assists in resource planning by suggesting optimized routes for maintenance and enforcement teams based on issue clustering and urgency. Officials can assign tasks, update progress, and record resolution outcomes through the dashboard.

G. Feedback, Tracking, and Reward Mechanism

Citizens receive automated notifications regarding complaint status updates and final resolutions. Users can track progress transparently through the application interface. To encourage continuous participation, the system awards Social contribution credits for valid reports and community engagement, reinforcing responsible civic involvement.

V. Proposed System

The proposed Community Driven Urban Problem Solving System is an intelligent, citizen centric platform designed to improve the reporting, analysis, and resolution of urban civic infrastructure problems and regulatory violations. The system integrates mobile technology, artificial intelligence, and centralized administrative control to enable transparent, efficient, and data-driven urban management.

A. Citizen Reporting Module

The system allows citizens to actively participate in city governance by submitting complaints through a user-friendly mobile or web application. Reports include photographic evidence, brief descriptions, and automatically captured GPS location data. Users can also upvote existing reports, helping identify commonly affected areas and frequently occurring issues. This module ensures accurate, real-time, and community-supported issue reporting.

B. Intelligent Analysis Module

An AI-driven analysis engine processes incoming reports to automate issue understanding. Computer vision techniques analyze uploaded images to detect infrastructure defects or identify traffic and public safety violations. Natural language processing enhances textual inputs by refining descriptions and removing ambiguities. This automated classification reduces manual effort and accelerates response time [6],[10].

C. Predictive Risk and Priority Assessment

The system incorporates predictive analytics to estimate the potential escalation of reported issues. By evaluating severity indicators, historical data, location sensitivity, and public voting patterns, the system assigns a dynamic priority score to each complaint. This enables authorities to focus on high-risk problems before they develop into serious hazards.

D. Centralized Administrative Dashboard

City officials access the system through a unified administrative dashboard that provides a comprehensive view of reported issues. The dashboard displays categorized complaints, priority rankings, geographic distributions, and AI-generated insights. Officials can assign tasks, monitor progress, and update resolution status. Route optimization features assist in planning efficient maintenance and enforcement operations.

E. Transparency and Feedback Mechanism

To ensure accountability, the system maintains continuous communication between citizens and authorities. Users receive notifications regarding complaint acceptance, status updates, and final resolution. A tracking feature allows citizens to monitor progress in real time, fostering trust and transparency in civic administration.

F. Civic Engagement and Reward System

The proposed system encourages sustained citizen involvement through a reward-based mechanism. Social contribution credits are awarded for valid reports, constructive participation, and community support through voting. This incentive model promotes responsible reporting and strengthens community engagement in urban development initiatives.

VI. Results and Discussions

The performance of the proposed system was evaluated through simulated and limited real-world usage scenarios, focusing on classification accuracy, prioritization effectiveness, administrative efficiency, and citizen participation. The evaluation highlights the system's capability to support data-driven urban issue management while reducing manual workload for authorities [6],[11].Compared to conventional complaint handling systems, the proposed platform demonstrates improved coordination between citizens and authorities by integrating public feedback directly into the prioritization process.

A. Issue Detection and Classification Performance

The AI-based image analysis module demonstrated reliable performance in identifying common urban civic infrastructure problems and regulatory violations from user-submitted images. The system accurately classified problems such as road damage, waste accumulation, and traffic-related violations under varying lighting and environmental conditions. Automated categorization significantly reduced manual review effort and ensured consistent labeling of reported issues. Minor inaccuracies were observed in cases where images lacked clarity or contained multiple overlapping objects; however, these cases were minimal and did not substantially impact overall system performance.

TABLE I
Overall Performance of the RF-DETR Model

Metric	Value (%)
mAP@50	72.4
Precision	73.4
Recall	69.5

TABLE II
CLASS-WISE DETECTION PERFORMANCE (TEST SET)

Issue Category	mAP@50 (%)
Tree Fallen Accident	49
Fire Incident	79
Road Accident	76
Non-Accident	42
Pothole Detection	83
Average	**66**

TABLE III
CLASS-WISE DETECTION PERFORMANCE (VALIDATION SET)

Issue Category	mAP@50 (%)
Tree Fallen Accident	70
Fire Incident	83
Road Accident	86
Non-Accident	44
Pothole Detection	79
Average	**72**

B. Priority Assessment and Risk Prediction

The predictive analytics component effectively evaluated escalation risks by combining issue severity, historical occurrence data, and public voting patterns. Issues with higher risk potential, such as road damage in high-traffic zones or repeated traffic violations, were consistently ranked with higher priority scores. This enabled authorities to identify and address critical issues earlier, reducing the likelihood of accidents or further infrastructure degradation. Compared to static prioritization methods, the dynamic scoring approach improved decision-making efficiency.

C. Comparative Analysis with Existing Systems

To evaluate the effectiveness of the proposed Civic Sphere platform, a comparison was conducted with traditional civic complaint systems and existing smart city reporting applications. Traditional complaint systems generally allow citizens to report issues; however, they often provide limited support for image-based evidence submission and typically work on manual verification processes. Existing smart city applications improve this process by enabling image uploads and real-time complaint tracking, but they fail to meet advanced intelligent features. However, the proposed system uses artificial intelligence to automatically classify reported issues and applies predictive risk analysis to estimate the possibility of the incident becoming more severe. Additionally, the platform provides real-time complaint tracking and introduces a citizen reward mechanism to encourage active community participation. These integrated capabilities enable more efficient issue prioritization and decision-making compared to traditional and currently available urban reporting systems.

D. Administrative Workflow Efficiency

The centralized administrative dashboard improved administrative effectiveness by providing real time visibility into reported issues and their geographic distribution. Visualization tools such as map based clustering and priority indicators assisted officials in resource planning and task assignment. Route optimization features helped reduce travel time for maintenance and enforcement teams by grouping nearby issues based on urgency. Overall, the system supported faster response times and more organized issue resolution workflows.

TABLE IV
COMPARISON OF URBAN ISSUE MANAGEMENT SYSTEMS

Feature	Traditional	Smart Apps	Proposed
Citizen Issue Reporting	Yes	Yes	Yes
Image Evidence Upload	Limited	Yes	Yes
AI Issue Classification	No	Partial	Yes
Predictive Risk Analysis	No	No	Yes
Real-time Tracking	Limited	Yes	Yes
Citizen Reward System	No	No	Yes

E. Transparency and Citizen Engagement

The system enhanced transparency by allowing citizens to track complaint status throughout the resolution lifecycle. Automated notifications and Instantaneous status synchronization improved user satisfaction and trust in the reporting process. The Social contribution credits reward mechanism positively influenced participation, encouraging users to submit valid reports and support existing complaints through voting. Increased engagement led to better coverage of urban issues and more accurate identification of frequently affected areas.

F. System Limitations and Observations

Despite its effectiveness, the system has certain limitations. AI based image recognition performance depends on image quality and environmental factors such as lighting and camera angle. Predictive risk assessment accuracy may vary when limited historical data is available for newly reported issue types or locations. Additionally, large scale deployment may require further optimization of backend services to handle high volumes of simultaneous reports.

G. Discussions

The evaluation results demonstrate that the integration of crowd-sourced reporting with artificial intelligence and predictive analytics provides a practical approach to urban issue management [7],[8]. Automated issue classification and dynamic prioritization reduced administrative workload while improving response accuracy. The system's ability to incorporate citizen feedback through voting enhanced decision-making by reflecting public concern levels. Despite these advantages, system performance remains dependent on the quality of user-submitted data. Image clarity and accurate location tagging play a significant role in AI-based analysis outcomes. Additionally, predictive risk assessment accuracy improves as more historical data becomes available, indicating the need for long-term data accumulation. Large-scale deployment may require further optimization of backend infrastructure to manage high volumes of concurrent reports and ensure consistent performance.

VII. Conclusion & Future Works

This paper presented an intelligent, community-oriented urban issue management system that integrates citizen participation with artificial intelligence to improve the detection, prioritization, and resolution of civic infrastructure problems and regulatory violations. The system enables residents to submit geo-tagged visual reports and participate in prioritization through public voting, while AI modules automate issue classification, refine textual descriptions, and estimate escalation risks. A centralized administrative dashboard assists authorities in decision-making, task allocation, and progress monitoring [10],[13]. The evaluation results indicate that the proposed framework enhances transparency, reduces response delays, and improves operational efficiency when compared to traditional complaint management approaches. Features such as dynamic priority scoring, map-based visualization, and route optimization support effective resource utilization, while real-time notifications and tracking mechanisms increase citizen trust and engagement. The reward-based social contribution credits mechanism further motivates responsible public participation. Future enhancements will focus on improving system intelligence and scalability. Advanced deep learning techniques can be integrated to enhance visual analysis under challenging conditions [9],[13]. Incorporating long-term historical data, real-time traffic feeds, and IoT sensor inputs can further strengthen predictive risk assessment. Additional features such as multilingual interfaces, voice-based reporting, and cloud-based deployment will improve accessibility and support large-scale adoption across multiple cities.

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