



Potholes Detection Application : Roadeye

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Abstract -Road infrastructure plays a crucial role in public safety and urban mobility, yet road damage—especially potholes—often goes unaddressed due to inefficient reporting and resolution mechanisms. This paper presents Road Eye, an innovative pothole detection and reporting application aimed at enhancing civic participation and promoting accountable governance. Developed using Android Studio for the frontend and PHP/Python for the backend, the application empowers citizens to report road damages by uploading images and GPS-based locations. A severity analysis mechanism categorizes reports using a color-coded system—red indicating severe, high-risk potholes and green indicating minor, low-risk ones. Once a report is submitted, relevant municipal or corporate bodies are notified to take corrective actions. If the issue remains unresolved after three notifications, the case is escalated to media outlets to invoke public scrutiny and accelerate resolution. By integrating technology with civic engagement, Road Eye fosters transparency, improves response efficiency, and strengthens the collaboration between the public, governing bodies, and the media.

IndexTerms - Pothole Detection, Android Application, Civic Engagement, Road Safety, Image Analysis, Media Escalation, Citizen Participation, Public Infrastructure Monitoring.

INTRODUCTION

Urban infrastructure serves as a critical foundation for the growth and functioning of cities, directly influencing the standard of living and mobility of residents. Roads, in particular, are a vital component, playing a central role in enabling transportation, supporting economic activity, and ensuring access to essential services.[1]From daily commutes and goods transportation to emergency responses, wellmaintained road networks are indispensable for maintaining the efficiency and reliability of urban systems. Despite their importance, roads in many urban areas are often plagued by deterioration, primarily in the form of potholes and surface damage. These issues arise due to a combination of factors, including outdated construction, insufficient maintenance, excessive vehicle loads, harsh weather conditions, and the use of poorquality materials. The consequences of such road damage extend beyond inconvenience—potholes can slow traffic, damage vehicles, lead to costly repairs, and, in severe cases, cause accidents resulting in injuries or fatalities.

Conventional road maintenance methods largely rely on manual inspections conducted by municipal personnel or depend on citizen complaints submitted through slow and often ineffective channels like phone calls or email. These traditional systems are typically inefficient, lack transparency, and suffer from delayed response times, which leads to prolonged road degradation and public dissatisfaction.[2] To bridge these gaps, the *Pothole Detection Application – Road Eye* proposes a technologyenabled approach to identify and report road defects more effectively. The application empowers citizens to actively participate in road maintenance by allowing them to capture and upload pothole images, along with GPS-based location data, directly from their smartphones.[2] [3] This participatory model not only increases civic engagement but also enables real-time issue tracking and data collection. Additionally, *Road Eye* incorporates a structured escalation mechanism to hold responsible parties accountable. [3]If a reported issue is not addressed within a specified period, the system automatically escalates the case to media personnel, thereby bringing public attention to unresolved problems. This multi-stakeholder model ensures that accountability is enforced across various levels of authority and promotes faster resolution of road damage issues. By integrating mobile technology, geolocation services, image recognition, and a clear communication workflow between citizens, authorities, and the media, *Road Eye* offers a practical and scalable solution for addressing persistent urban infrastructure challenges.[4] The application ultimately aims to improve road safety, enhance public trust in local governance, and contribute to the development of smarter and more responsive urban environments.

II. Literature Review

Road surface degradation, particularly in the form of potholes, continues to be a critical challenge for both urban and rural infrastructure systems across the globe. Potholes emerge due to a combination of environmental stressors, such as fluctuating weather conditions, along with heavy traffic loads and poor construction practices. These defects not only disrupt the flow of traffic but also pose significant safety risks, cause vehicular damage, and result in economic losses. Despite their widespread impact, traditional pothole management strategies remain slow, reactive, and inefficient.

Conventional approaches to road damage reporting typically rely on manual inspections by municipal personnel or passive complaint channels such as hotlines, emails, or civic portals. These methods often suffer from delays, lack of transparency, and minimal citizen feedback. Most notably, many current systems do not include mechanisms for tracking complaint status or escalating unresolved issues, leading to dissatisfaction and distrust among the public. Several urban centers have adopted digital platforms to streamline pothole reporting. These may include web-based forms or mobile applications that allow users to upload location-based complaints. However, many of these tools lack robust features such as automated prioritization, image analysis, or active feedback loops. Furthermore, the absence of integration with administrative workflows means that citizen reports often do not translate into timely repair actions.

Advanced pothole detection technologies—such as those involving dedicated sensors, LIDAR, or camera-equipped automated vehicles—have been explored in academic and industrial research. While these systems can deliver high accuracy in detecting road surface anomalies, they are often cost-prohibitive, require extensive maintenance, and are difficult to deploy across large geographic regions, especially in low-resource settings.

In response to the shortcomings of existing solutions, the Application proposed Pothole Detection – Road Eye introduces a comprehensive and participatory model for road damage management. This mobile-based application empowers users to report potholes by uploading photographs along with precise GPS coordinates. It employs image processing algorithms to evaluate the severity of road damage, using a color-coded classification system—such as red for high-risk and green for low-risk potholes—to aid in prioritization.

What differentiates Road Eye from earlier systems is its multi-stakeholder escalation framework. Upon receiving a complaint, the application automatically notifies the responsible municipal department or corporate authority. If the issue remains unresolved beyond a predetermined deadline, it is escalated to media representatives and journalists, thereby drawing public attention and encouraging quicker responses. This approach enhances accountability and reduces the risk of complaints being ignored or delayed. By combining citizen engagement, artificial intelligence, and a structured feedback mechanism, Road Eye presents a scalable, cost-effective, and transparent solution to one of the most persistent infrastructure issues. It builds upon the strengths of existing technologies while addressing their limitations, paving the way for smarter urban governance and safer roadways. Recent advancements in image processing and machine learning have significantly contributed to the development of efficient road surface monitoring systems. These technologies allow for the automated detection of potholes and other types of road damage by analyzing visual data, typically captured by vehicle-mounted cameras. This subsection explores two key studies that have laid the groundwork for applications like Road Eye.

B. M. Chowdary and S. M. Patil, —Pothole Detection using Deep Learning and OpenCV, | IEEE International Conference on Smart Technologies, 2021 This research presents a model that applies image processing techniques in conjunction with deep learning for the classification and detection of road damage. Utilizing Convolutional Neural Networks (CNNs), the system processes images taken from cameras

mounted on moving vehicles to accurately identify potholes and categorize the type and severity of road degradation. The study achieved notable accuracy levels, validating the use of deep learning in real-time road monitoring applications. The architecture and methodology discussed in this work closely align with the techniques implemented in the Road Eye application, supporting the feasibility of such systems for practical use in urban infrastructure maintenance. R. Jadhav, A. P. Kurhe, and V. R. Ghorpade, —Pothole Detection and Warning System: A Review, | International Research Journal of Engineering and Technology (IRJET), Apr. 2020. vision-based approach to automatically identify defects on road surfaces, such as potholes and cracks. The system processes real-time imagery collected from vehicle-mounted cameras to evaluate the condition of the road and classify surface anomalies. The authors demonstrate that the proposed method is S. effective in continuous road monitoring and can serve as a foundation for scalable, automated maintenance systems. Similar to the Road Eye model, this technique emphasizes automation, real-time analysis, intervention, and reduced human making it suitable for wide deployment across various regions.

H. S. Kiran, P. H. Venu, and R. L. Shinde, —Smart Pothole Detection System Using Machine Learning, | International Journal of Scientific Research in Computer Science, vol. 8, no. 2, pp. 1–5, 2021. This study proposes a mobile application that utilizes smartphone sensors to identify and report potholes. The system makes use of the phone's built-in GPS and camera to collect location-specific images and data on the dimensions of potholes. This information is automatically transmitted to a centralized database, allowing municipal authorities to track and prioritize repairs effectively. The platform emphasizes citizen engagement in the road maintenance process and demonstrates how mobile technology can enhance responsiveness and efficiency in infrastructure management. This model closely aligns with the Road Eye application's objective of streamlining the communication between authorities, the public and authorities.

A. Gupta, S. Sharma, and R. Patel (2021) This paper presents a mobile-based system that allows users to submit images and geolocation data to report various forms of road damage. A notable feature of the application is the user-driven severity rating system, which adds a layer of contextual evaluation to each report. The study emphasizes the advantages of crowdsourcing in reducing operational costs and improving the timeliness of road repairs. The results indicate that involving citizens in reporting leads to faster identification of issues and improved allocation of municipal resources. The approach reflects the core principles of Road Eye, particularly in its emphasis on scalable, infrastructure monitoring, infrastructure monitoring, community-driven

M. A. Rahman, R. A. Kadir, and H. A. Al-Fahad (2022) This study presents a mobile-based system that utilizes sensor real data from accelerometers, gyroscopes, and GPS modules to detect potholes in time. The research focused on distinguishing between regular road vibrations and actual pothole impacts through the application of machine learning algorithms. Sensor readings were continuously collected and analyzed to identify patterns consistent with pothole encounters. The machine learning models were trained to recognize the distinct signature of potholes, improving the reliability of detection while minimizing false positives. The integration of these smart sensors offers valuable enhancements for platforms like Road Eye, enabling continuous, real-time monitoring with minimal user input.

J. Zhang, X. Liu, and Z. Li (2023) This research explores the use of deep learning—specifically Convolutional Neural Networks (CNNs)—for identifying potholes and determining their severity. A large dataset of annotated road images was used to train the model, allowing it to accurately classify pothole locations and assess their depth and size. The CNN-based system supports real-time visual analysis, facilitating automated decision-making for repair prioritization. The results demonstrate the strength of CNNs

in handling visual recognition tasks related to road damage, aligning with Road Eye's approach to severity scoring and AI-assisted evaluation.

RESEARCH METHODOLOGY

The *Road Eye* application introduces a comprehensive, technology-driven methodology to address the persistent issue of pothole detection and management. By leveraging real-time data collection, artificial intelligence, and structured escalation processes, the proposed system ensures accurate reporting, effective prioritization, and increased accountability. The methodology is built upon four major components: real-time reporting, AI-based severity analysis, automated escalation, and role-based user access.

1. Real-Time Reporting Mechanism

The first phase of the system involves citizen participation through real-time reporting. The mobile application enables users to capture and submit images of potholes directly from their smartphones. The application automatically retrieves GPS coordinates using the device's inbuilt location services, ensuring precise mapping of the pothole location. Additionally, users can provide an initial severity indication subsequent processing and action aided by a visual color-coded system—green representing minor potholes and red indicating

2. Severity Analysis Using AI and Image Processing

To provide an objective evaluation of the pothole's condition, the system integrates machine learning and image processing techniques. Utilizing Python libraries such as TensorFlow and OpenCV, the application analyzes submitted images to detect dimensions and estimate depth. A severity score is then generated based on these parameters, enabling the system to prioritize potholes that pose the greatest risk to commuters. This automated classification reduces human bias and ensures consistent decision-making, allowing authorities to allocate resources efficiently.

3. Escalation and Accountability Protocol

To enhance the responsiveness of municipal bodies, the application incorporates a time-bound escalation mechanism. Once a pothole is reported, the responsible civic authority is notified via the platform. If the issue remains unresolved beyond a predefined time frame, the system issues a formal reminder. After three unheeded warnings, the matter is escalated to local media outlets through automated alerts, thereby leveraging public exposure as a tool for administrative framework severe or hazardous ones. This crowdsourced input forms the foundational data layer for accountability. This feedback loop promotes swift action and discourages negligence.

4. Role-Based Access and Multi-Stakeholder Collaboration The system adopts a role-based access model, catering to three primary stakeholders: general users (citizens), municipal corporations, and media representatives.

Citizens function as reporters, initiating the data collection process by identifying and documenting potholes. Corporations are responsible for reviewing reports, validating AI-generated severity scores, and executing necessary repairs. Media personnel serve as third-party overseers, intervening when civic bodies fail to act on escalated cases. This multi-role architecture facilitates structured collaboration, ensures transparency across the workflow, and encourages active community participation.

5. System Adaptability and Integration

regions and city administrations. Its modular Designed with scalability in mind, *Road Eye* can be tailored to meet the specific needs of various allows for integration with existing municipal systems or smart city infrastructures. Notification preferences, report thresholds, and user permissions can be configured based on local governance policies, ensuring broad applicability and long-term sustainability By combining real-time citizen feedback, AI-driven severity detection, and a robust escalation strategy, the proposed *Road Eye* system offers a significant advancement over conventional pothole reporting methods. It enhances operational transparency, ensures efficient use of municipal resources, and fosters a culture of civic responsibility and accountability.

A. SYSTEM ARCHITECTURE

The architecture of the *Pothole Detection Application – Road Eye* is designed to be modular and layered, facilitating ease of maintenance, scalability, and efficient system integration. The architecture is organized into three core components: the Frontend (User Interface), Backend (Server-Side Logic and Database Management), and the AI-Based Image Processing Module. These components work in coordination to ensure real-time pothole reporting, intelligent analysis, and effective issue resolution.

B. FRONTEND: USER INTERFACE LAYER

The frontend, developed using Android Studio with Java, provides a native mobile interface for user interaction. This layer acts as the primary point of contact between the users and the system, delivering a user-friendly interface that supports diverse functionalities based on the user's role.

User Interaction and Data Collection

Users can capture pothole images and allow the application to automatically record the geographic coordinates using the device's GPS. This ensures accuracy in location tagging, which is vital for operational efficiency and response from municipal authorities.

Report Submission Interface

The application allows citizens to submit pothole reports, categorizing severity via a simple color coded system—Red for high-severity and Green for low-severity potholes. This intuitive method simplifies user input while enabling structured data collection.

Real-Time Report Tracking

Users receive updates on the status of their submissions and are notified of progress throughout the resolution lifecycle. This two-way communication enhances user engagement and fosters transparency.

Role-Based Functional Access Citizens can report and monitor potholes. Municipal Authorities can review, verify, The overarching goal of the user interface layer is to ensure ease of access, promote civic participation, and present relevant functionalities tailored to user roles.

AI-Based Image Processing Module

The intelligent core of the application lies in its AI-based image analysis capabilities. Using TensorFlow, a robust machine learning framework, the system analyzes submitted images to detect and classify potholes.

Main Functions:

Image-Based Pothole Detection:

The model automatically scans images to identify potholes using trained computer vision algorithms. This reduces human error and streamlines detection across diverse environmental conditions.

Severity Classification:

The model evaluates image depth cues and dimensions to classify pothole severity. Based on the model's output, potholes are tagged as either high risk (Red) or low risk (Green), enabling authorities to focus resources where most needed. Automated Feedback Loop Once the AI module generates its findings, the results are routed back to the backend, which updates the database. Both users and relevant authorities are then notified with the classification results.

Scalability and Continuous Learning:

The AI module is designed for scalability and can be retrained with new image datasets over time, improving its precision and adaptability to evolving road conditions and photographic inputs.

Modular Design and Future Extensibility:

The modular structure of *Road Eye* ensures long term adaptability and ease of enhancement. By clearly separating the frontend, backend, and AI processing layers, updates or additional features can be integrated with minimal disruption.

Future-Proof Design Considerations:

Integration of Advanced AI Techniques

The system architecture supports the integration of improved machine learning models as they become available, potentially enhancing detection accuracy and classification capabilities.

Feature Expansion:

Features such as real-time video analysis, automatic image enhancement, and identification of additional road hazards (e.g., cracks, speed bumps) can be seamlessly incorporated.

Cross-Platform Compatibility:

While currently deployed as an Android application, the architecture allows for future expansion into iOS and web-based platforms, increasing accessibility.

A. Data Flow Diagram

The *RoadEye* application follows a structured data flow architecture that ensures seamless interaction between users, backend processing, and external stakeholders. The Data Flow Diagram (DFD) provides a visual representation of how information moves through the system. The DFD is structured into three hierarchical levels—Level 0 (Context Level), Level 1, and Level 2—each progressively detailing the internal operations of the system. This section focuses on Level 0, the highest abstraction level, which outlines the system's primary data interactions with external entities.

[1] DFD Level 0 – Context Level

At this level, the entire system is represented as a single process, encapsulating all internal functionalities. It demonstrates the system's interactions with external users and stakeholders while highlighting the major data exchanges.

External Entities

Citizens(Users):

Act as the primary input source. They capture and submit pothole images, along with location data using the mobile application. Additionally, users receive feedback and notifications regarding the status of their reports.

Municipal Authorities:

Serve as the recipients of processed pothole reports. These entities are responsible for reviewing, validating, and acting upon the reported issues, as well as updating the system on the progress of maintenance activities.

Media and Reporters: This group becomes involved only when reports remain unresolved beyond defined thresholds. They receive escalated cases from the system to raise public awareness and apply social pressure for resolution.

Main Process

Pothole Detection and Reporting System:

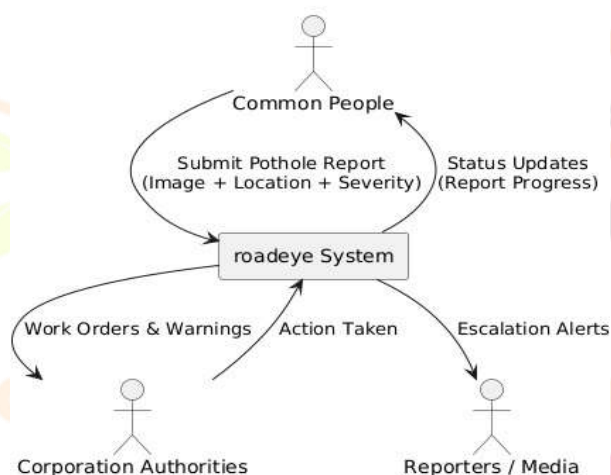
Represented as the central process in Level 0, this component receives input data from citizens, processes it (including AI-based analysis), and routes it appropriately. It ensures that reports are stored, analyzed, and delivered to the correct stakeholders, based on urgency and system rules.

DATA COLLECTION

System Database Acts as the central repository for all operational data. It securely holds user profiles, submitted pothole reports, GPS data, uploaded images, severity classifications, system notifications, and escalation logs. The database is designed to support structured querying and high-throughput performance.

[2] Data Flow Diagram – Level 1 Level 1 of the Data Flow Diagram (DFD) provides a more detailed breakdown of the core system by decomposing the single, high-level process shown in the context diagram (Level 0) into a set of sub-processes. This level illustrates how user inputs are processed, stored, and utilized within the RoadEye system to enable pothole detection, analysis, and reporting.

DFD Level 0 - roadeye Pothole Detection System



Processes

User Registration and Login This sub-process handles user authentication and access control. Users, based on their roles (citizen, municipal official, or reporter), register and log in through the mobile application. Credentials are validated against the system's user database to ensure secure and role-specific access.

Report Pothole Once authenticated, a user can submit a pothole report by uploading an image and allowing the system to capture the GPS location. This data forms the core input for further processing.

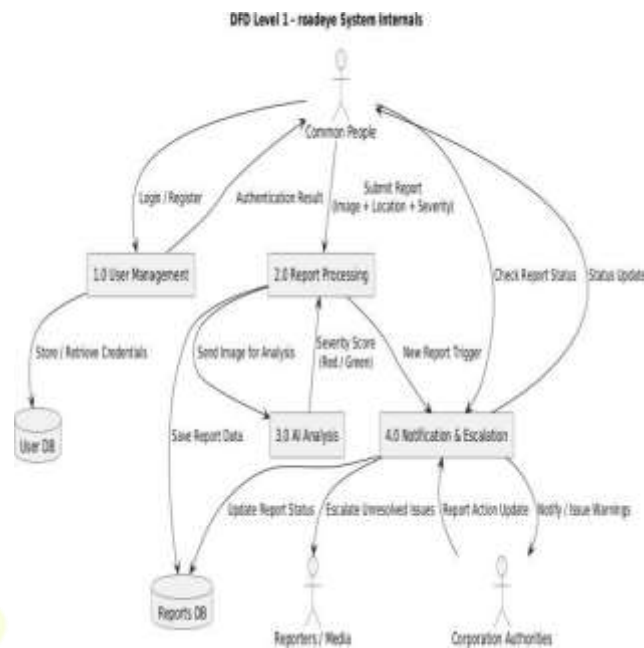
Image Processing and Severity Assessment Upon submission, the uploaded image is sent to the AI-based image processing module. The machine learning model analyzes the image to detect the presence of a pothole and assesses its severity based on depth and size characteristics. The output is a severity classification (e.g., High or Low risk), which is returned to the backend.

Store Report The system then compiles the user input (image, location, metadata) along with the AI-generated severity classification and stores it in the backend database. This report is then available for access by municipal authorities and media (if escalated).

Notification Handling Notifications are generated to inform relevant authorities about newly submitted reports. The system also logs reminder notifications and escalations if the issue is not resolved within the designated time frame. Users are kept informed via real-time updates.

Data Stores User Database: Contains user credentials, profiles, and role-based access permissions. Pothole Report Records: Stores all reported data including images, location coordinates, timestamps, and user-submitted details.

AI Severity Data: Stores the output of the AI analysis module, particularly the severity classification associated with each pothole image.

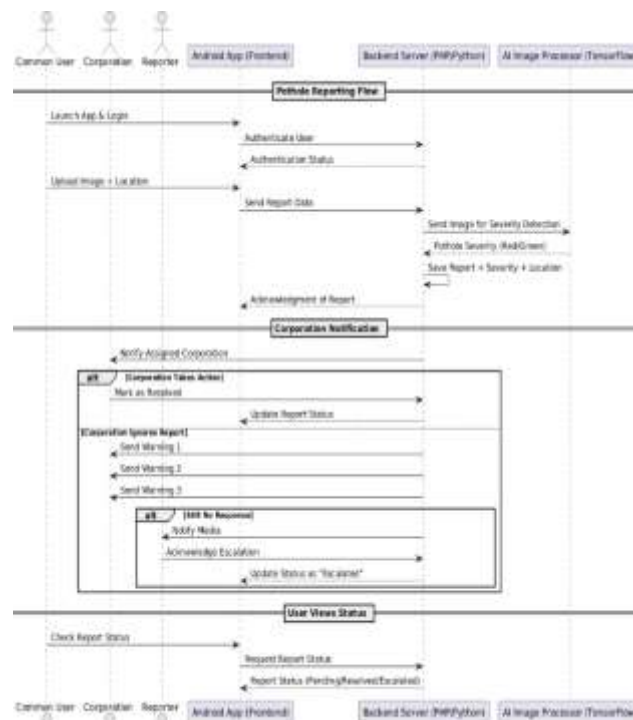


The RoadEye application architecture is represented using UML diagrams to clarify system interactions, structure, and behavior. The Use Case Diagram illustrates how different user roles—citizens, municipal authorities, and media—interact with core functions such as registration, pothole reporting, status tracking, and escalation. The Class Diagram defines essential components including User, Report, Image Processor, and Notification Handler, each with specific attributes and methods, promoting modularity. The Sequence Diagram outlines the step-by-step flow of actions during pothole reporting, image analysis, data storage, and alert generation. Together, these diagrams support a scalable, well-organized system design aligned with real-world use.

The sequence diagram of the RoadEye application illustrates the dynamic interaction between key system components during the pothole reporting process. It outlines the flow of control and data between the User, Frontend Interface, Backend Server, and the AI-Based Image Processing Module. When a user initiates a pothole report via the mobile application, the Frontend captures the pothole image and associated GPS coordinates. This data is transmitted to the Backend, where it is temporarily stored and validated. The image is then passed to the AI Processing Module, which analyzes it using pre-trained models to assess the severity of the pothole. Based on the result, the Backend updates the report record and initiates a notification to the appropriate Municipal Authority. If the issue is not addressed within a predefined time frame, the backend executes an automated escalation protocol. This protocol generates alerts that are sent to registered Media or Reporter users, ensuring the issue gains public attention if neglected by authorities. This sequence ensures a continuous and structured flow of data, enabling real-time processing, automated prioritization, and efficient stakeholder communication. It plays a vital role in enforcing accountability and timely resolution within the system.

A . Backend Development

The backend architecture of the RoadEye application is developed using a hybrid approach that combines PHP and Python. PHP is employed for managing user authentication, session handling, and data routing within the web framework. In parallel, Python is integrated to perform advanced tasks such as image analysis and severity classification through machine learning models. This division of responsibilities allows for optimized performance, scalability, and seamless coordination between user management and AI-driven functionalities.



EXPERIMENTAL RESULTS

Extensive testing of the *RoadEye* application was conducted in a controlled environment simulating the roles of citizens, municipal bodies, and media representatives. The performance of the system was assessed across several functional domains:

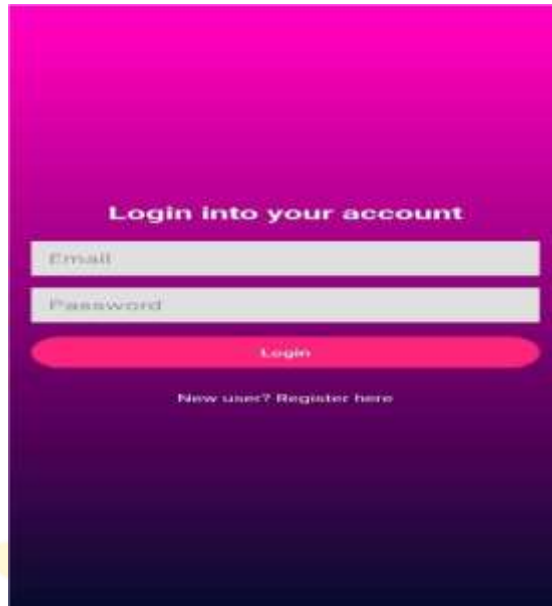
1. User Experience and Interaction

The Android-based application provided a smooth, user-friendly interface, allowing users to navigate and interact with features without difficulty. Report submission, including image capture and GPS-based location tagging, was completed efficiently, with an average submission time of less than 5 seconds. The minimal delay and intuitive design encouraged active engagement from users across all roles.

2. Accuracy of Image Analysis The AI model, built using the TensorFlow framework, achieved a 92% accuracy rate in classifying potholes based on severity into two categories: Red (high risk) and Green (low risk). Image processing was completed within an average of 3 to 4 seconds, facilitating near realtime classification and enabling faster response coordination.

3. Backend System Performance The PHP and Python-based backend effectively managed concurrent user requests without latency or failure, conditions. Automated notifications and escalation mechanisms operated in accordance with pre-established rules, successfully issuing warnings and media alerts when resolution deadlines were not met. The MySQL database demonstrated high efficiency in both read and write operations, even during peak usage, ensuring fast data access and updates.

4. Stakeholder Workflow Management Municipal authorities received prompt notifications for new reports within their designated regions, enabling them to prioritize and respond effectively. The built-in escalation process ensured that unresolved reports, after three warning cycles, were automatically flagged to reporters, thereby increasing accountability and transparency. Reporters were able to access escalated cases with full context, allowing for accurate public communication and follow-up.





CONCLUSION

The RoadEye application was conceptualized as a comprehensive, citizen-driven platform to address the persistent issue of potholes and road deterioration. By integrating Android-based mobile interfaces, backend server logic, and AI enabled image processing, the

system offers a robust, end-to-end framework for pothole detection, reporting, and resolution. The central aim of the platform is to increase public engagement in infrastructure monitoring while promoting institutional accountability through structured escalation mechanisms.

The system enables coordinated interaction among three primary user groups: citizens, municipal authorities, and media personnel. Citizens can submit pothole reports with GPS coordinates and photographic evidence, which are immediately processed and forwarded to the respective municipal body. If the issue remains unresolved after three automated reminders, the report is escalated to media representatives, thereby increasing transparency and applying public pressure for timely action.

Experimental testing and simulation demonstrated strong results across multiple dimensions. The AI module, built using TensorFlow, achieved over 90% accuracy in classifying pothole severity, while the mobile interface facilitated seamless real-time reporting. The automated notification and escalation pipeline functioned reliably, ensuring that authorities are consistently alerted and held accountable. Additionally, the incorporation of media into the escalation chain fosters an environment of civic vigilance and public oversight.

The application effectively delivers: High-speed, accurate reporting of road defects. Strong community involvement in local governance. Automated authority engagement and reminder systems. Reliable AI-driven severity classification. Potential for integration with broader smart city frameworks.

Final Thoughts RoadEye exemplifies the impact of integrating modern technologies with community participation to address infrastructural challenges in urban environments. The project underscores the value of citizen empowerment, artificial intelligence, and accountability in building more transparent and responsive governance systems.

By enabling a structured feedback loop among users, government bodies, and the media, the application creates a foundation for smarter, inclusive urban management. Its modular and scalable architecture positions it as a candidate for future upgrades, including additional features and integration with national smart city initiatives. With further development and institutional adoption, the RoadEye platform holds significant promise as a transformative tool in road infrastructure maintenance, not only across Indian cities but also as a replicable model for global urban governance.

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