POTHOLEPRO: AN INTELLIGENT SYSTEM FOR POTHOLE DETECTION AND COMPLAINT REGISTRATION USING DEEP LEARNING

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Abstract
Pothole Complaint Registration aims to develop a web application for registering pothole complaints using deep learning models to detect and classify road surface issues. Leveraging the TensorFlow framework, the application will incorporate a Convolutional Neural Network (CNN) algorithm for efficient pothole detection. The application allows users to upload images of roads, which are analyzed by the CNN model to detect potholes. In addition to detection, the system features an automated email notification service that alerts relevant authorities when a dangerous pothole is identified. The frontend of the application will be designed using HTML, CSS, and JavaScript, providing an intuitive and user-friendly interface for users to upload images of potholes. The backend system will process these inputs, identifying potholes using deep learning techniques. The CNN architecture will enable rapid detection of potholes in the images. Once a pothole is detected, the system will register the complaint in SQLite database, allowing for structured data management and easy retrieval. This information can then be accessed by local authorities or road maintenance teams for timely action. This project demonstrates the application of solving real-world problems and enhancing public infrastructure maintenance.

Keywords: Pothole Complaints, Deep Learning, Image Processing, Road Maintenance, Traffic Safety.

I.INTRODUCTION

Potholes continue to pose a major threat to road infrastructure worldwide, contributing to frequent traffic disruptions, vehicle damage, and serious safety hazards for daily commuters. Addressing these issues in a timely and

effective manner is essential not only for public safety but also for minimizing.Traditional pothole detection and repair methods are often reactive, manual, and inefficient—relying heavily on human effort, which can lead to delays and inconsistent results. To overcome these challenges, this project introduces a Pothole Complaint Registration System, a smart, web-based solution that harnesses the power of deep learning and real-time image analysis to modernize how pothole-related issues are reported and resolved.

At the core of the system is a Convolutional Neural Network (CNN), implemented using the TensorFlow framework, which enables automatic and highly accurate detection of potholes in user-submitted images. The CNN model delivers fast and precise image classification, eliminating the need for manual inspections and ensuring that only valid complaints are processed. The user interface, built with HTML, CSS, and JavaScript, offers a smooth and intuitive experience where users can easily upload road images. Once an image is submitted, the backend system processes it through the CNN model, and if a pothole is detected, the complaint is logged into a centralized SQLite database.

This intelligent automation not only streamlines the complaint registration process but also empowers municipal authorities with organized, actionable data, enabling quicker repairs and more strategic resource allocation. By merging artificial intelligence with practical civic engagement, the system represents a forward-thinking approach to urban infrastructure maintenance.

It ensures faster response times, improved road quality, and a significant step toward building smarter and safer.

II.BACKGROUND

A.Literature Review

Several studies have proposed innovative methods for pothole detection using deep learning and sensor-based technologies. One approach integrates ultrasonic sensors and GPS with a CNN-based deep learning model (CNN-DL) to detect potholes and humps, outperforming traditional methods like Kirchhoff’s Theory and KNN by providing high accuracy and real-time analysis, though it demands high computational power and robust infrastructure. Another solution utilizes smartphone sensors (accelerometer and gyroscope) and machine learning algorithms such as Random Forest and RetinaNet for both sensor-based and image-based detection, coupled with a web portal for automated complaint redressal and forecasting using SARIMA. A third method employs a dual mechanism using SSD for camera-based detection and a Deep Feed Forward Neural Network for sensor data, integrated into a mobile app with real-time map updates, offering a user-friendly and zero-cost solution but facing challenges like battery consumption and data privacy. Lastly, YOLOv4 is applied to an annotated image dataset for real-time, high-accuracy pothole detection from images and videos, proving effective but requiring significant computational resources and high-quality datasets. Together, these systems highlight the potential of deep learning and mobile technology to enhance road safety and maintenance efficiency.

B.Survey

Recent advancements in pothole detection leverage deep learning and sensor-based technologies to enhance road safety and maintenance efficiency. A notable study proposed a CNN-based Deep Learning (CNN-DL) model integrated with ultrasonic sensors and GPS to detect potholes and humps in real-time, outperforming traditional methods like Kirchhoff’s Theory and KNN in terms of accuracy and adaptability, though it requires high computational power and infrastructure. Another solution uses civilians' smartphones to gather accelerometer and gyroscope data and applies machine learning classifiers such as Random Forest and RetinaNet for accurate pothole identification and prioritization of complaints via a web portal. This system also includes time-series forecasting with SARIMA to predict pothole occurrences, offering a cost-effective and scalable approach despite concerns over data privacy and infrastructure needs. A third study introduces a dual mechanism combining SSD (Single Shot MultiBox Detector) and Deep Feed Forward Neural Networks within a smartphone app, enabling real-time mapping and detection through both image and sensor data, thereby ensuring cross-verification and robustness, albeit with challenges like sensor noise, lighting conditions, and high battery usage.

Finally, the YOLOv4-based model is trained on annotated images and video frames to detect potholes with high precision and real-time performance, achieving promising IoU scores, though it depends heavily on computational resources and dataset diversity. Collectively, these methods demonstrate the growing role of AI, mobile sensing, and real-time systems in creating accurate, scalable, and efficient pothole detection and reporting frameworks, with potential applications in civic infrastructure, autonomous navigation, and smart transportation.

C.Aim and Objective

The motivation for this project stems from the persistent inefficiencies in traditional pothole management methods, which often rely on manual inspections and delayed resolutions. These outdated practices frequently lead to worsening road conditions, escalating repair costs, and significant safety hazards for commuters. Recognizing these shortcomings, the Pothole Complaint Registration System was conceived to leverage advancements in technology for a more efficient and accurate solution. The system aims to automate pothole detection and complaint registration using deep learning algorithms, particularly CNNs integrated with the model. This approach ensures high accuracy and rapid detection, reducing the time and effort required for manual interventions while minimizing human error. By automating these processes, the system addresses the immediate need for faster identification and resolution of road issues. Moreover, the inclusion of a structured SQLite database provides a robust mechanism for storing and analyzing complaints, enabling authorities to identify patterns and implement proactive maintenance strategies. This not only addresses existing road issues but also helps prevent future ones. Another key driver of this project is its inclusivity. With an intuitive, user-friendly interface built using HTML, CSS, and JavaScript, the system ensures accessibility for all users to report potholes effortlessly. Ultimately, the project seeks to improve road infrastructure, enhance public safety, and contribute to community resilience through a practical, technology-driven solution.

The Pothole Complaint Registration System is designed with several key objectives aimed at addressing road maintenance challenges effectively. The system focuses on automated detection by leveraging Convolutional Neural Networks (CNNs) accurate identification of potholes from user-uploaded images. This automation eliminates the need for manual inspection and accelerates the detection process. Additionally, the project emphasizes efficient complaint management through a structured SQLite database, which systematically registers and stores complaints, ensuring easy retrieval and tracking for authorities. A user-friendly interface, built with HTML, CSS, and JavaScript, ensures accessibility for all users, enabling them to report potholes effortlessly. Beyond immediate detection and reporting, the system offers proactive maintenance insights by organizing data to help authorities analyse trends in pothole occurrences, allowing for efficient resource allocation and targeted maintenance plans. Furthermore, the project is designed with scalability and integration in mind, enabling future extensions to detect other road anomalies or integrate with mobile applications for broader accessibility. By fulfilling these objectives, the system provides a seamless solution for pothole detection, complaint management, and road maintenance, ultimately enhancing public safety and infrastructure quality.

D.Requirements:

1. The system requires a processor of **Intel i5 or above** for efficient performance.
2. A minimum of **4GB RAM** is necessary to support the application smoothly.
3. The project is developed using the **Python programming language**.
4. The front-end interface is developed using web technologies to ensure seamless user interaction with the system.
5. The backend integrates machine learning models to automate pothole detection and enhance complaint management.

III.PROPOSED SYSTEM

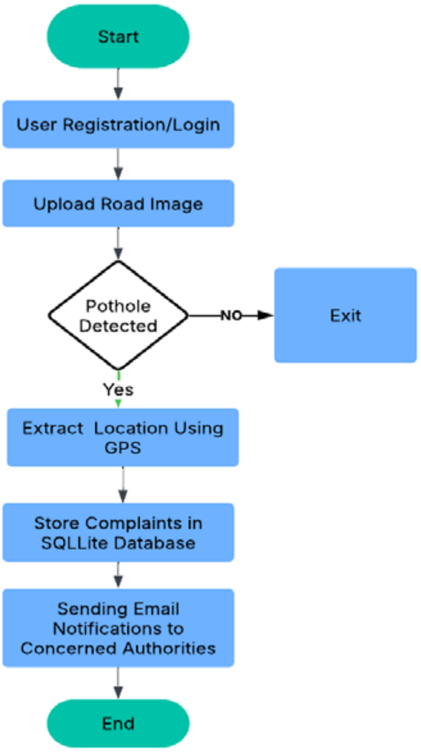

Fig. 1. System Flowchart of Pothole Detection

The Pothole Complaint Registration system is a comprehensive solution designed to enhance road safety and infrastructure maintenance by automating the detection and reporting of potholes. Utilizing advanced deep learning techniques, the system allows users to upload road surface images, which are then analyzed using a Convolutional Neural Network (CNN) model built on the TensorFlow framework. This model excels in image processing and is capable of accurately detecting potholes even in complex road conditions. Once a pothole is identified, the system automatically registers the complaint into an SQLite database, storing details such as location, severity, and timestamp for easy access by maintenance authorities. Additionally, the system includes an automated email notification feature that alerts the relevant officials with complete pothole information, ensuring timely response and repair. The frontend, developed using HTML, CSS, and JavaScript, provides a user-friendly interface that simplifies the image upload and complaint submission process. On the backend, the system efficiently manages image processing, database updates, and email notifications to maintain seamless functionality. Key advantages of the system include the reduction of accidents by enabling early detection of potholes, real-time alerts to drivers about road hazards, and potential integration with vehicle control systems for automatic speed regulation in the presence of potholes. Overall, the system significantly improves road condition monitoring and ensures safer travel for all road users.

The proposed system is a comprehensive pothole detection and complaint registration platform that leverages the power of deep learning and modern web technologies. By integrating a Convolutional Neural Network (CNN) model, the system ensures highly accurate and real-time identification of potholes from images submitted by users. It simplifies the reporting process by allowing users to upload images directly through a user-friendly web interface, and it handles backend processing to identify potholes, extract location data, and notify concerned authorities.

To ensure the complaints are actionable, the system uses GPS data or manual location input to pinpoint the exact position of each pothole. This geolocation information, along with other relevant metadata such as the timestamp and severity, is stored securely in an SQLite database. Automated email alerts are sent to municipal or road maintenance teams to ensure prompt attention and resolution of the reported issues.

Future enhancements can include mobile app integration, SMS alerts, route optimization for drivers based on pothole data, and real-time dashboards for government monitoring, making the system even more powerful and impactful in promoting road safety and infrastructure management.

IV.SYSTEM METHODOLOGY

The methodology begins with **system analysis**, where the project evaluates existing systems to identify their strengths and weaknesses. Previous methods, such as Deep Residual Neural Networks and architectures like AlexNet and Squeeze Net, were reviewed for detecting plant diseases in these systems often struggled with low accuracy on complex field images, lacked hyperparameter tuning, and did not employ preprocessing techniques like residual connections or data augmentation, leading to reduced performance.

This analysis informed the development of the proposed system, **PiTLiD**, which aims to overcome these limitations by leveraging transfer learning and the Inception-V3 CNN model to handle small datasets effectively.

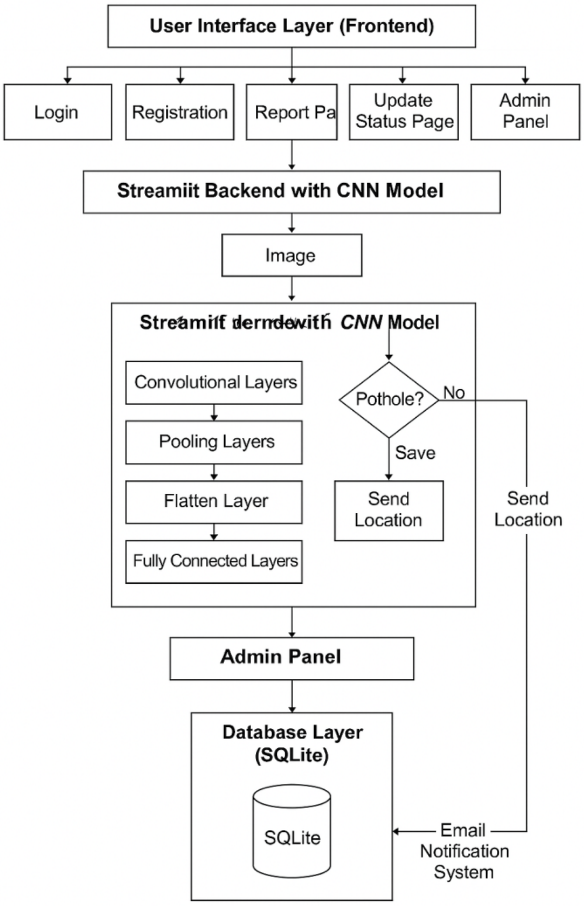

Fig. 2. System Architecture

A.User Interface

The user interface of the Pothole Complaint Registration system is designed to provide a seamless and intuitive experience across multiple sessions. Users begin by registering and logging in securely with their credentials, granting them access to report potholes by uploading images. These images are analyzed by a backend CNN model, and if a pothole is detected, users are redirected to complete the report by adding details such as title, description, location coordinates, and email. The system stores this information and sends automated email notifications to contractors registered by the admin.

Fig. 3. User Interface

B.User Reporting page

The Report Page is a core feature of the Pothole Complaint Registration System, enabling users to easily report pothole incidents. After logging in, users are directed to this page where they can upload an image of the pothole-affected road. Once the image is submitted, it is automatically sent to the backend, where a Convolutional Neural Network (CNN) model processes the image to detect whether it contains a pothole. If a pothole is identified, the image is returned to the report page, where users can enter additional details such as a title, description, latitude, longitude, and their email address. Upon clicking the “Post Issue” button, the system stores all the details in an SQLite database and instantly sends automated email notifications to all contractors or authorities registered in the admin panel. This real-time notification mechanism ensures that the right personnel are promptly informed about new pothole complaints, facilitating faster action and enhancing road safety.

The Report Page in the Pothole Complaint Registration System allows users to submit pothole-related issues efficiently. After logging in, users upload an image of the damaged road, which is analyzed using a CNN-based deep learning model to confirm pothole presence. If detected, users enter details such as a title, description, coordinates, and email ID before clicking “Post Issue.” This saves the complaint in a SQLite database while simultaneously notifying registered contractors via email, including location details for swift action. The system ensures accurate complaint tracking, accelerates response time, and enhances municipal road safety and maintenance.

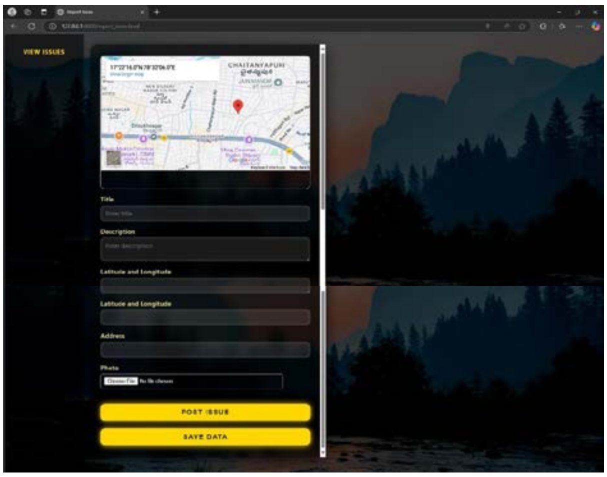

Fig. 3.User Reporting Page

C.Location Sharing Section

From Figure.6. aduring the Send Location phase, users report potholes by sharing their location with contractors. They enter latitude and longitude manually or use device geolocation for automatic input. The system compiles this data along with the complaint details into a formatted message. This message is then automatically emailed to all registered contractors for quick processing. Faster identification ensures efficient repairs and improves overall road safety. The streamlined communication helps in prompt pothole fixes and better infrastructure maintenance.

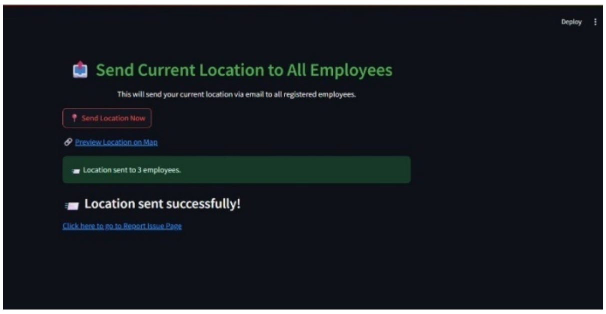

Fig. 4. a. Location Sharing

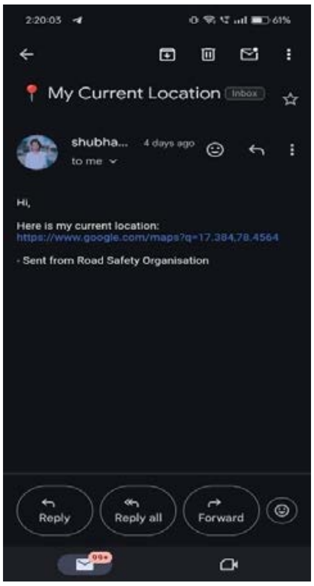

Fig. 4. b. Email notification to contractor

From Figure.6. b the system sends an email notification to users confirming the submission of their current location. The email includes a Google Maps link to the shared location, ensuring easy access for contractors. The sender is identified as the Road Safety Organization, reinforcing credibility. This notification helps users track their report, improving transparency and communication. It ensures that the responsible contractors receive precise location data for quicker pothole repairs. Ultimately, this process enhances road safety and infrastructure efficiency.

D. Issue Update and Resolution Session

From Figure.7. a on the Upload Resolution Page, contractors submit the resolved pothole image along with relevant details. They provide their name, email, and any additional remarks regarding the repair. The system ensures that the uploaded image is verified and stored in a cloud database for future reference. This process enhances transparency, allowing users to track the repair status efficiently. By maintaining a record of completed repairs, authorities can assess road maintenance effectiveness.Ultimately, this system streamlines pothole resolution, improving road safety and infrastructure management.

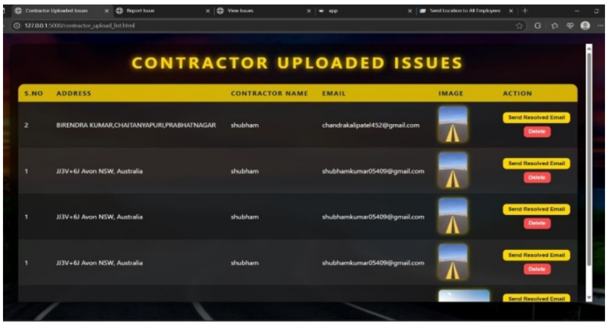

Fig .5.a . Issue Update

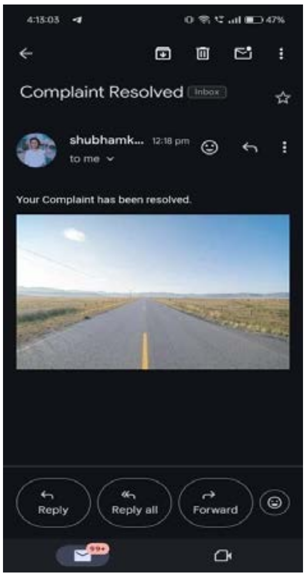

Fig .5.b.Email Notification

From Figure 7. b on the Resolution Page, contractors upload pothole resolution data, including the resolved image and repair details. When they click "Send Resolution," the system automatically sends an email notification to the complaint raiser’s email. The email includes the resolved image of the pothole along with a confirmation message stating that the issue has been fixed. This ensures transparency in the repair process and keeps users informed about the status of their complaint. The streamlined communication helps maintain efficient infrastructure management, improving road safety and user trust.

E. Database Management System

Throughout the system, an SQLite database serves as the primary data storage solution. It stores all critical information, including user credentials, pothole complaints, employee details, and status updates on reported issues. SQLite is chosen for its lightweight nature, ease of integration, and efficient handling of data, ensuring that information is reliably saved and quickly accessible across all sessions in the system.

F.Convolutional neural networks

Step 1: Image Preprocessing

1.1 Image Resizing: Resize all input images to a fixed dimension (e.g., 128×128 pixels) to ensure uniformity.

1.2 Normalization: Normalize pixel values to the range [0, 1] by dividing by 255 to improve training efficiency.

1.3 Augmentation (optional): Apply transformations such as rotation, flipping, and zooming to augment the training dataset and improve generalization.

Step 2: Dataset Splitting

The dataset is split into two main parts: 80% for training the CNN model and 20% for validation to monitor performance and prevent overfitting. This ensures the model learns effectively while being evaluated on unseen data.

Step 3: Model Architecture (CNN

3.1 Layer: Accepts input images of shape (128, 128, 3).

3.2 Convolutional Layer 1: Apply multiple (e.g., 32) filters of size 3×3withReLU activation.

3.3 Max Pooling Layer 1: Reduce spatial dimensions using 2×2 pooling.

3.4 Convolutional Layer 2: Apply 64 filters of size 3×3 with ReLU activation.

3.5 Max Pooling Layer 2: Another 2×2 max pooling to further reduce dimensions.

3.6 Convolutional Layer 3: Apply 128 filters of size 3×3 with ReLU activation.

3.7 Flatten Layer: Convert 2D matrix to 1D vector.

3.8 Output Layer: Use a dense layer with SoftMax activation corresponding tothe number of Pothole classes (e.g., 38).

Step 4: Model Training

4.1 Train the CNN model on the training dataset using a defined numberof epochs and batch size.

4.2 The CNN model is trained on the training dataset using a defined number

of epochs (e.g., 20–30) and batch size (e.g., 32). During each epochperformance is validated using the validation set, allowing monitoring accu- racy and loss.

Step 5: Model Deployment

5.1 Save the trained model (.h5 format).

5.2 Integrate the model into a Streamlit-based web application.

5.3 Accept user image input, perform preprocessing, run prediction, and display results in real-time.

Step 6: Pothole Validation (Optional Pre-Check)

6.1 Check if the uploaded image is likely to be a pothole image using color analysis (e.g., dominant green area in HSV color space).

6.2 Reject non-pothole or road images before running prediction.

VII. RESULTS AND DISCUSSIONS

Convolutional Neural Network (CNN) technology with a user-friendly web-based platform, offering a reliable and accessible approach to identifying and reporting potholes. This chapter highlights the practical outcomes of implementing the system and compares it against various methodologies discussed in the literature.

The CNN model used in this project was trained on labeled road surface images to differentiate between pothole and plain road classes. The dataset underwent preprocessing including resizing (128x128), normalization, and augmentation for better generalization. The model achieved high training and validation accuracy, with performance evaluated using metrics such as precision, recall, and F1-score. Upon successful detection, the system transitions into a reporting module that captures details such as title, description, GPS coordinates, and user email.

Unlike hardware-intensive solutions that rely on ultrasonic sensors and GPS integration, this system is lightweight and deployable on any web browser through Streamlit. It significantly lowers infrastructure cost while retaining high accuracy in pothole detection. Additionally, it simplifies the user experience by enabling straightforward image uploads and automated location sharing.

The backend integrates a SQLite database for securely storing user reports and system data. Automated email notifications, triggered upon successful complaint submission and resolution, ensure timely communication between users and registered contractors. The modular architecture supports expansion into mobile platforms and predictive analytics, creating room for future enhancements.When compared to existing systems using accelerometers and classifiers like Random Forest or SSD+sensor hybrids, the current implementation avoids issues like sensor noise, excessive battery usage, and data privacy risks. The CNN-based Static

image classification is less resource-intensive while offering sufficient real-time accuracy. Moreover, while YOLOv4 provides high-speed detection in video feeds, it demands greater computational resources; this project, however, provides a more practical solution for civic deployment.

VI. APPLICATIONS KEY FEATURES ACHIEVED

The Pothole Detection and Complaint Registration System revolutionizes urban road maintenance by leveraging CNN-based image recognition and a user-friendly platform. Citizens report potholes by uploading images, which the system analyzes to verify presence, reducing false reports and accelerating

response times. With real-time geolocation sharing and automated notifications, contractors and authorities receive instant alerts, ensuring rapid action and improved public safety. The system operates on a scalable, modular architecture, allowing future enhancements such as vehicle camera monitoring, mobile app integration, and IoT connectivity. By automating detection and reporting, it eliminates manual inefficiencies, prioritizes repairs based on severity, and optimizes maintenance resources. Seamless integration with government infrastructure fosters collaborative urban management, enhancing operational efficiency. This ensures potholes are addressed promptly, leading to safer and more efficient transportation.

Advanced data analytics embedded within the system provide actionable insights to predict pothole occurrences and allocate maintenance budgets effectively. Robust security and privacy protocols safeguard user data while maintaining transparency and accountability in reporting. The automated detection process ensures accurate classification of potholes, reducing response delays and optimizing repair schedules. AI-driven image recognition strengthens identification, minimizing errors and enhancing road safety measures. The system empowers communities by providing real-time tracking and status updates, ensuring contractors complete repairs efficiently. By prioritizing infrastructure management, it contributes to smarter, more sustainable urban development. Ultimately, the Pothole Detection System exemplifies how AI and technology can transform city maintenance, fostering safer roads and improved transportation networks

VII. CONCLUSION

The Pothole Detection and Complaint Registration System is an advanced AI-driven solution that integrates CNN-based image recognition with a user-friendly web interface to streamline urban road maintenance. By detecting potholes from images, the system reduces human error, accelerates reporting, and ensures organized tracking via a SQLite database. Real-time location sharing and automated email notifications facilitate swift action by contractors, improving road safety. Designed for scalability, the system supports future upgrades like mobile app integration, IoT connectivity, and pothole severity assessment, optimizing repair prioritization. Embedded data analytics help allocate maintenance budgets efficiently, while robust security protocols safeguard user data, ensuring transparency and accountability. Its automated workflow eliminates delays, enabling prompt responses to road hazards. Leveraging machine learning algorithms, the system refines pothole classification for enhanced decision-making. By transforming urban transportation, it contributes to safer, smarter, and more efficient cities, demonstrating the power of AI in modern infrastructure management.

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