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RoadShield AI: An Intelligent Road Damage Detection and Maintenance Prioritization System Using YOLOv8

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ABSTRACT

Road damage such as potholes, cracks, and surface erosion can reduce road safety and affect the quality of transportation infrastructure. Traditional road inspection methods generally depend on manual observation, which can require considerable time and human effort. To address these limitations, this paper presents RoadShield AI, an intelligent road damage detection and maintenance prioritization system based on computer vision and deep learning. The proposed system uses the YOLOv8 object detection model to identify three major categories of road damage: potholes, cracks, and surface erosion. For every detected damage region, the system extracts the damage type, confidence score, bounding-box coordinates, width, height, and approximate damaged area. Based on the estimated damaged area, the detected damage is categorized into Low, Medium, or High severity. The severity level is then converted into a corresponding repair priority: Normal, High, or Urgent. A dashboard is provided to present the detection results, severity levels, repair priorities, and overall maintenance information in an understandable form. Unlike conventional road damage detection approaches that mainly concentrate on identifying defects, RoadShield AI extends the analysis toward severity assessment and maintenance prioritization. The proposed approach can therefore support road inspection and help maintenance teams identify road sections that require greater attention.

Keywords: Road Damage Detection, YOLOv8, Computer Vision, Pothole Detection, Crack Detection, Surface Erosion, Severity Estimation, Repair Prioritization, Deep Learning, Maintenance Dashboard

1. INTRODUCTION

Road infrastructure is essential for safe transportation and the movement of people and goods. However, continuous traffic, weather conditions, aging, and poor maintenance can lead to common road damages such as potholes, cracks, and surface erosion. Early identification of these defects is important to prevent further deterioration.

Traditional road inspection mainly depends on manual observation, which can be time-consuming and require considerable manpower. Computer vision and deep learning provide an opportunity to automate this process. YOLO-based object detection models have been widely explored for road damage detection, including YOLOX-based pothole detection, the CRDDC 2022 road damage detection challenge, and improved YOLOv8-based approaches.

However, existing approaches mainly focus on detecting and classifying road damage rather than determining its severity and maintenance priority. To address this gap, RoadShield AI uses YOLOv8 to detect potholes, cracks, and surface erosion, followed by damage-area analysis, severity estimation, and repair prioritization. The results are presented through a dashboard to support easier road maintenance decision-making.

2. METHODOLOGY

The proposed RoadShield AI system follows a sequential workflow for detecting road damage and determining its maintenance priority. The methodology consists of image acquisition, image preprocessing, road damage detection, damage analysis, severity estimation, repair prioritization, and dashboard generation.

2.1 Image Acquisition

Road images are provided as input to the system for automated inspection. The images may contain different types of road damage such as potholes, cracks, and surface erosion. The uploaded image is passed to the detection module for further processing.

2.2 Image Preprocessing

The input image is prepared for detection using basic image processing techniques. OpenCV is used to handle image loading and preprocessing operations. The image is resized according to the input requirements of the YOLOv8 model, enabling consistent processing during detection.

2.3 Road Damage Detection

YOLOv8 is used as the primary object detection model in RoadShield AI. The trained model identifies three categories of road damage: Pothole, Crack, and Surface Erosion. For each detected region, the model generates a bounding box and confidence score indicating the predicted damage type and detection confidence.

2.4 Damage Analysis

After detection, the bounding-box coordinates are used to obtain the width and height of each damaged region. The approximate damaged area is calculated from these dimensions. The system stores the damage type, confidence score, bounding-box coordinates, width, height, and calculated area for further analysis.

2.5 Severity Estimation

The estimated damaged area is used to classify the detected defect into three severity levels: Low, Medium, and High. Different area thresholds are applied according to the type of road damage. Smaller detected regions are categorized as Low severity, moderate regions as Medium severity, and larger regions as High severity.

2.6 Repair Prioritization

The severity level is converted into a repair priority to support maintenance decision-making. The system follows the following priority mapping:

Severity	Repair Priority
Low	Normal
Medium	High
High	Urgent

This enables maintenance personnel to identify which detected road damages require greater attention.

2.7 Dashboard Generation

The final detection and analysis results are presented through a Streamlit-based dashboard. The dashboard displays the detected damage types, confidence scores, severity levels, repair priorities, and damage analysis information. This provides a simple interface for understanding road conditions and supports maintenance planning.

2.8 Overall Methodology

The complete workflow of RoadShield AI can be represented as:

Road Image → Image Preprocessing → YOLOv8 Detection → Damage Analysis → Severity Estimation → Repair Prioritization → Dashboard Generation

3. RESULTS AND DISCUSSION

The developed RoadShield AI system was evaluated using road images containing different types of surface damage. The system successfully processes an input image through the complete workflow of detection, damage analysis, severity estimation, and repair prioritization.

3.1 Road Damage Detection

The trained YOLOv8 model detects three road damage categories: Pothole, Crack, and Surface Erosion. For each detected region, a bounding box is generated along with the predicted damage type and confidence score. The bounding-box coordinates are further used for calculating the approximate damaged area.



Fig. 1. Input road image

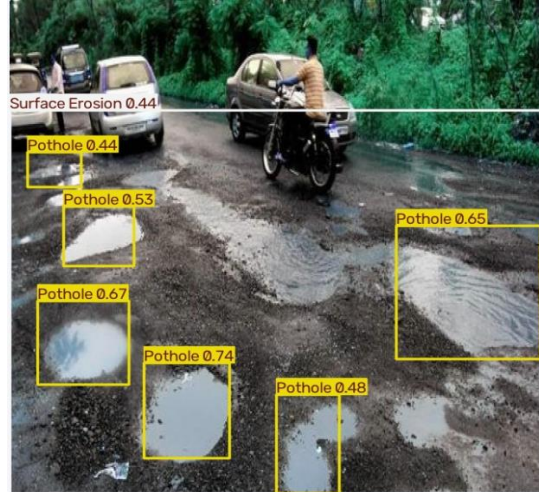


Fig. 2. YOLOv8 Detection Output

3.2 Severity Estimation

The detected damage regions are analyzed based on their approximate area. According to the predefined thresholds, each damage instance is categorized as Low, Medium, or High severity. This provides additional information beyond simply identifying the presence of road damage.

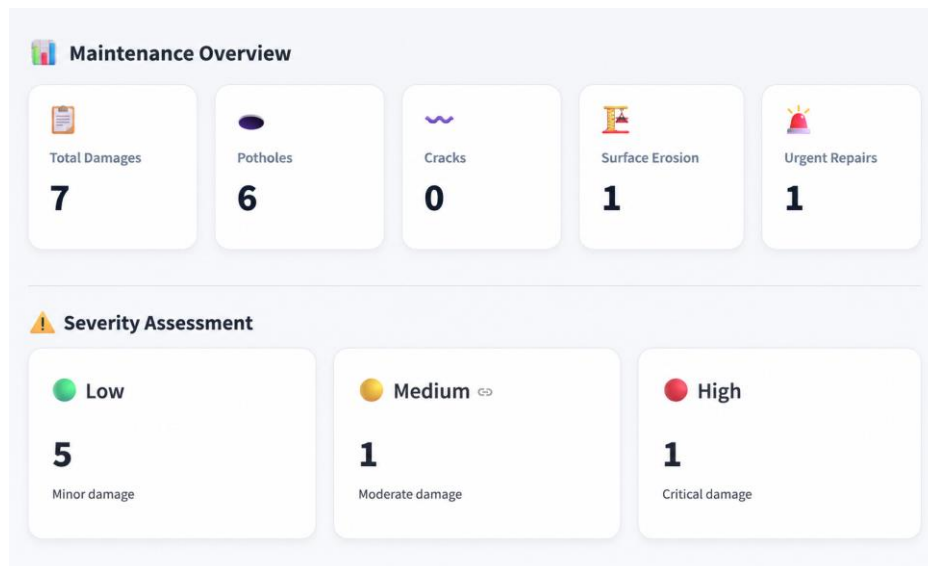


Fig. 3. Severity Assessment

3.3 Repair Prioritization

The severity result is converted into a corresponding repair priority. Low-severity damage is assigned Normal priority, medium-severity damage is assigned High priority, and high-severity damage is assigned Urgent priority. This allows maintenance personnel to distinguish between defects requiring routine attention and those requiring immediate action.

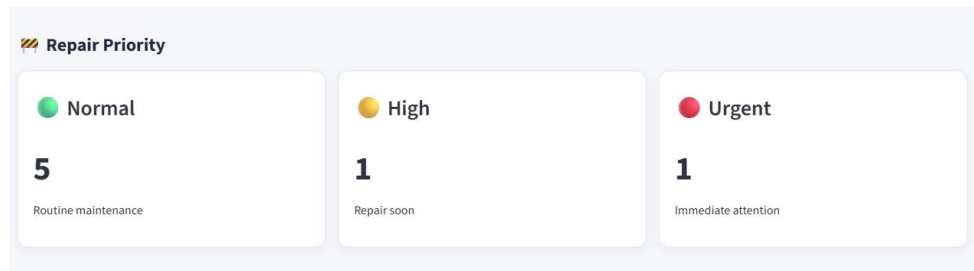


Fig. 3. Repair Priority

3.4 Dashboard Results

The results are presented through a Streamlit dashboard. The dashboard provides information about the detected damage type, confidence score, severity level, repair priority, and damage analysis. The visual presentation makes the inspection results easier to understand and can support maintenance teams in identifying areas that need attention.

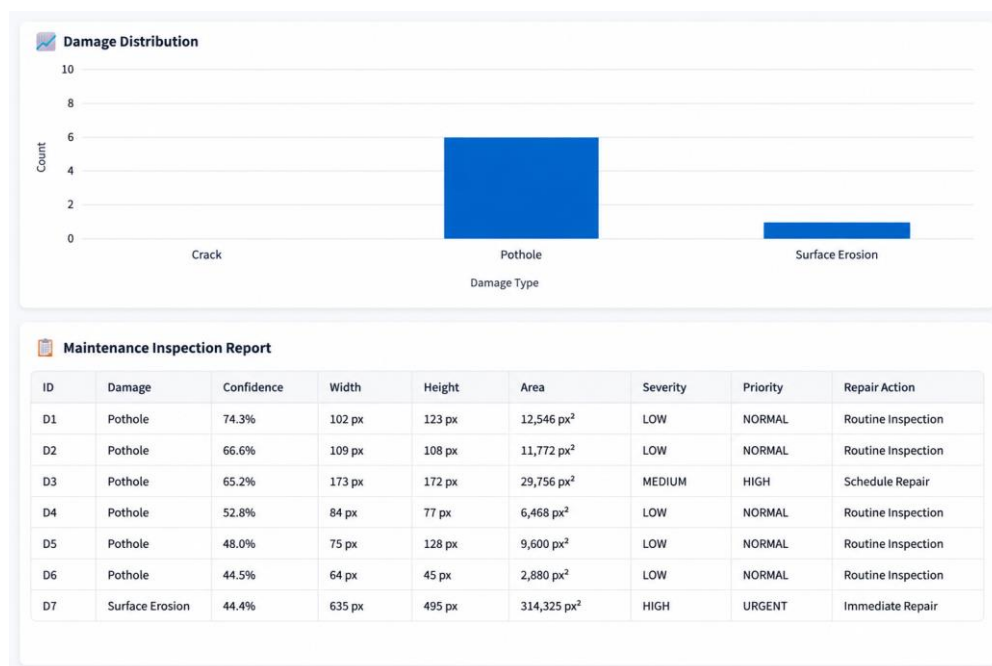


Fig. 4. Dashboard Results

3.5 Discussion

The results demonstrate that RoadShield AI extends conventional road damage detection by incorporating severity assessment and repair prioritization. Instead of providing only the location and type of a defect, the system converts detection results into actionable maintenance information. Therefore, the proposed workflow can serve as a decision-support mechanism for road inspection and maintenance planning.

4. CONCLUSION

RoadShield AI provides an intelligent approach for automated road damage inspection and maintenance prioritization. The system uses YOLOv8 to detect potholes, cracks, and surface erosion from road images and analyzes the detected regions using bounding-box information. Based on the estimated damage area, the system assigns a severity level as Low, Medium, or High. These severity levels are then converted into Normal, High, or Urgent repair priorities. The results are presented through a dashboard, making the inspection information easier to understand and supporting maintenance decision-making. Thus, RoadShield AI extends conventional road damage detection by integrating damage analysis, severity estimation, repair prioritization, and dashboard visualization into a single system.

5. FUTURE ENHANCEMENTS

- **GPS-Based Road Mapping:** Detected road damages can be mapped using GPS coordinates to identify their locations.
- **Mobile Application:** A mobile application can be developed for field-based road inspection and real-time image uploading.
- **Automated Reporting:** The system can generate downloadable inspection reports containing damage, severity, and repair-priority information.

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