

Literature Survey: Road Damage Detection and Reporting System Using Computer Vision and Deep Learning

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Abstract: Road damage such as potholes, cracks, and waterlogging is a major problem affecting road safety, transportation efficiency, and infrastructure maintenance. Traditional road inspection methods generally depend on manual observation and periodic surveys, which can be time-consuming and difficult to scale. With the development of computer vision, image processing, machine learning, and deep learning, automated road-damage detection has become an important research area.

This survey compares three representative studies covering citizen-oriented pothole reporting, computer-vision methods for road imaging and pothole detection, and an HPC-enabled multi-model deep-learning approach for cracks, potholes, and waterlogging. The studies are compared in terms of problem, method, data or setting, findings, strengths, limitations, and practical applicability. The literature shows a progression from conventional image processing toward deep-learning-based multi-damage detection. However, challenges remain in environmental variation, dataset diversity, class imbalance, computational requirements, severity assessment, and integration of detection with GPS, databases, maps, and authority reporting..

Keywords: road damage detection; pothole detection; computer vision; deep learning; image processing; YOLO; GPS; road damage reporting.

I. INTRODUCTION

Road infrastructure plays an important role in transportation, economic activity, and public safety. Road surfaces can deteriorate because of traffic loads, weather conditions, water accumulation, poor construction, and inadequate maintenance. Common forms of road damage include potholes, longitudinal cracks, transverse cracks, alligator cracks, and waterlogging.

Traditional road-condition assessment generally depends on manual inspection. Although manual inspection can provide useful information, it requires considerable human effort and may not provide continuous monitoring. Automated road-damage detection using images and computer vision provides an alternative approach for identifying and documenting road defects.

The purpose of this survey is to compare selected research studies, identify the evolution of road-damage detection methods, and determine the research gap for a practical Road Damage Reporting System that combines automated detection, location information, severity assessment, database management, map visualization, and authority-oriented reporting.

II. SURVEY METHOD

This survey is a focused comparison of three representative studies rather than an exhaustive review of the complete road-damage literature. The studies were selected because they represent different layers of a practical road-damage



reporting system: citizen-based reporting and GPS, computer-vision technology selection, and modern multi-model deep-learning detection.

Topic and keywords: road damage detection, pothole detection, computer vision, image processing, deep learning, object detection, semantic segmentation, GPS-based reporting, and road condition monitoring.

Inclusion basis: studies addressing road-damage detection or reporting using image processing, computer vision, machine learning, or deep learning, with a reported method or evidence that can be compared.

Selected studies: Felix Enigo et al. (2016), Ma et al. (2022), and Verma et al. (2025).

Reading approach: each study was examined for its problem, methodology, data or image source, detected damage types, findings, strengths, limitations, and relevance to a practical reporting system.

III. LITERATURE REVIEW BY THEME

3.1 Crowdsourcing-Based Pothole Detection and Reporting

Felix Enigo et al. proposed a crowdsourcing-based online petitioning system for pothole detection using the Android platform in 2016. The system uses a smartphone camera and GPS so that a user can capture a damaged-road image, record its location, and upload the image and coordinates to an online server database. The processed result is represented through a map-based interface.

The image-processing pipeline uses grayscale or binary conversion, median filtering, Canny edge detection, dilation, and a Count-based Pothole Detection Algorithm (CPDA) to reduce false detections caused by road grains and other objects. Its main strengths are low-cost implementation, use of commonly available smartphones, GPS-based location information, and direct connection between citizens and authorities. Its main limitation is dependence on visual road conditions, which restricts generalization to highly variable environments.

3.2 Computer Vision for Road Imaging and Pothole Detection

Ma et al. presented a state-of-the-art review of computer vision for road imaging and pothole detection in 2022. The review covers two-dimensional image processing, three-dimensional road-surface reconstruction, machine learning, and deep learning. Traditional two-dimensional methods generally use preprocessing, segmentation, feature extraction, edge detection, contour analysis, and post-processing.

Three-dimensional approaches such as stereo vision and laser scanning provide geometric information about road-surface defects, but they can require specialized equipment and greater computational resources. The review demonstrates the transition from manually designed image features toward machine-learning and deep-learning methods that can learn useful visual features directly from training data.

3.3 HPC-Enabled Multi-Model Deep Learning

Verma et al. proposed an HPC-enabled deep-learning multi-model pipeline for road-damage detection in 2025. The system focuses on potholes, waterlogging, longitudinal cracks, transverse cracks, and alligator cracks. Instead of forcing all damage types into one model, the approach uses task-specific models. Crack detection uses a YOLOv11x-based model enhanced with GhostConv, while potholes and waterlogging are processed using segmentation models.

The study uses a subset of RDD2022 for crack detection and additional image data for potholes and waterlogging. Image preprocessing and augmentation are used to improve robustness under different lighting and surface conditions. The study reports overall crack precision of 0.63, recall of 0.44, and mAP50 of 0.49. The results also show that class imbalance and limited representative samples can reduce performance for particular damage classes.



IV. LITERATURE REVIEW MATRIX

Study	Problem	Method	Data / Setting	Key Finding	Limitation / Gap
Felix Enigo et al., 2016 [1]	Pothole detection and citizen reporting	Android, GPS, image processing, CPDA	Smartphone images with GPS; online server	Low-cost pothole reporting with location information	Limited generalization under varied road and visual conditions; mainly potholes
Ma et al., 2022 [2]	Review of road imaging and pothole detection	2-D image processing, 3-D reconstruction, ML and DL	Road-imaging research literature	Provides broad technology overview and shows transition toward ML/DL	No single complete reporting implementation; approaches vary in cost and resources
Verma et al., 2025 [3]	Multi-type road-damage detection	YOLO-based object detection, segmentation, HPC	RDD2022 subset plus pothole/waterlogging images	Supports cracks, potholes and waterlogging using multi-model detection	Class imbalance, limited data and computational requirements

V. COMPARATIVE SYNTHESIS

The three studies address road-damage monitoring at different levels. The 2016 study focuses on citizen reporting and pothole detection using a smartphone and GPS. The 2022 review covers the wider technology landscape, including two-dimensional and three-dimensional computer vision, machine learning, and deep learning. The 2025 study focuses on automated multi-damage detection using task-specific deep-learning models and high-performance computing. Where they differ: the first study emphasizes practical reporting, the second provides a technology review, and the third emphasizes modern automated detection.

Data used: smartphone road images and GPS in [1], a broad body of road-imaging research in [2], and RDD2022 plus additional image data in [3].

Detection capability: conventional image processing is comparatively simple but less adaptive; deep learning can learn complex visual features but requires suitable labelled data and computation.

Practical action: existing work demonstrates detection and/or location reporting, but there is scope to connect detection directly to severity assessment, database storage, map visualization, and authority workflows.

VI. RESEARCH GAP AND POSITIONING OF THE PROPOSED SYSTEM

Existing research has addressed image-based pothole detection, broad computer-vision methods, and multi-model deep-learning detection. However, limited attention is given to integrating these capabilities into one practical road-damage reporting workflow. The main gaps identified are:

Environmental variation: lighting, weather, camera angle, shadows, and road-surface conditions can reduce detection reliability.

Dataset limitations: deep-learning models require sufficiently large and diverse labelled datasets for good generalization.



Class imbalance: different damage classes may have unequal training examples, which can reduce recall for less represented classes.

Multiple damage categories: systems may focus on potholes or cracks separately, while practical monitoring should handle several damage types.

Detection-to-reporting integration: there is scope to integrate image capture, AI detection, GPS, severity, database storage, map visualization, and authority notification.

Severity assessment: identifying the existence of damage is not sufficient for maintenance prioritization; size, area, type, and severity can also be considered.

The proposed Road Damage Reporting System is therefore positioned as an integrated workflow consisting of image acquisition, GPS location, preprocessing, AI-based damage detection, damage classification and severity assessment, database storage, map visualization, and authority reporting.

VII. CONCLUSION AND FUTURE SCOPE

This survey compared three representative studies related to road-damage detection and reporting. The literature demonstrates a clear progression from conventional image processing and crowdsourcing systems toward computer vision, machine learning, deep learning, and multi-model AI. The reviewed studies establish that smartphone-based reporting, GPS, object detection, and segmentation can contribute to automated road-condition monitoring.

At the same time, environmental variation, dataset diversity, class imbalance, computational requirements, multiple damage categories, severity assessment, and practical reporting remain important challenges. A useful future system should therefore combine AI-based detection with GPS location, database management, map visualization, severity information, and authority-oriented reporting. Future work can also evaluate the system using diverse road images and measure detection accuracy, robustness, reporting usefulness, and response prioritization.

REFERENCES

- [1] V. S. Felix Enigo, T. M. Vinoth Kumar, S. Vijay, and Prabu K. G., "CrowdSourcing based Online Petitioning System for Pothole Detection using Android Platform," *Procedia Computer Science*, vol. 87, pp. 316–321, 2016, doi: 10.1016/j.procs.2016.05.167.
- [2] Y. Ma et al., "Computer vision for road imaging and pothole detection: a state-of-the-art review of systems and algorithms," *Transportation Safety and Environment*, vol. 4, no. 4, tdac026, 2022, doi: 10.1093/tse/tdac026.
- [3] P. Verma, S. Chaturvedi, S. Sivakumar, and G. Sajeevan, "HPC-enabled Deep Learning Multi-model for Road Damage Detection," *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. X-5/W2-2025, pp. 701–704, 2025, doi: 10.5194/isprs-annals-X-5-W2-2025-701-2025.

