International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

Deep Learning – Based Automated Pothole and Road Crack Detection System

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ABSTRACT- ***Road surface damage such as Potholes and cracks is one of the major causes of road accidents, vehicle damage, and traffic congestion. Manual road inspection is time-consuming, costly, and often inaccurate. This project presents a Deep Learning-Based Automated Pothole and Road Crack Detection System that uses the YOLOv3-Tiny object detection algorithm and OpenCV to automatically detect potholes and road cracks from images. The proposed system is developed using Python, Flask, OpenCV, and YOLOv3-Tiny, Providing a web-based interface where users can upload road images for instant analysis. The trained deep learning model identifies damaged road regions with bounding boxes and confidence scores, helping road maintenance authorities detect defects efficiently. The system offers faster, accurate, and cost-effective road inspection, reducing manual effort and improving transportation safety.***

KEYWORDS: ***Deep Learning, YOLOv3-Tiny, OpenCV, Flask, Road Crack Detection, Pothole Detection, Computer Vision, Image Processing, Object Detection, Python.***

INTRODUCTION

Road conditions directly affect transportation efficiency and public safety. Damaged roads containing potholes and cracks increase the risk of traffic accidents, vehicle maintenance costs, and travel delays. Most municipalities still depend on manual inspections to identify damaged roads, making the process expensive and inefficient. Recent developments in Artificial Intelligence, Computer Vision, and Deep Learning have enabled automated road damage detection using digital images. Object detection algorithms can identify damaged road surfaces accurately and quickly.

RELATED WORK

Several researchers have proposed

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automated road damage detection systems using Artificial Intelligence and Deep Learning. Earlier systems used traditional image processing algorithms including Sobel filters, Canny edge detection, Hough Transform, and texture analysis to detect road cracks. These methods required manual parameter tuning and produced poor results under different environment conditions. Recent research focuses on deep learning object detection models such as faster R-CNN, SSD, YOLOv3, YOLOv4, and YOLOv5. Among these, YOLOv3-Tiny provides an excellent balance between detection accuracy and processing speed, making it suitable for real–time applications and low-cost hardware.

LITERATURE SURVEY

Road damage detection has become an active research area because of increasing transportation demands and the need for efficient road maintenance. Traditional image processing methods such as edge detection, thresholding, texture analysis, and morphological operations have been widely used for crack detection. Although these techniques provide acceptable results under controlled environments, they fail under varying lighting conditions and complex road textures. Deep learning approaches, particularly Convolutional Neural Networks (CNNs), have significantly improved detection performance. Object detection models including Faster R-CNN, SSD, RetinaNet, and YOLO have demonstrated superior accuracy.

EXISTING METHOD

The existing method for pothole and road crack detection mainly rely on manual road inspection and traditional image processing techniques. In manual inspection, engineers or maintenance personnel periodically survey roads to identify damaged areas. This approach is time-consuming, labor-intensive, expensive, and prone to human errors, making it unsuitable for monitoring large road networks. Traditional computer vision methods can identify simple cracks under controlled conditions, their performance decreases significantly in the presence of shadows, uneven lighting, rain, dust, water accumulation, and complex road textures. Furthermore, these approaches require manual feature extraction and parameter tuning, limiting their adaptability to different road environments.

PROPOSED METHOD

The proposed method introduces a Deep Learning- Based Automated Pothole and Road Crack Detection System that uses the YOLOv3-Tiny object detection algorithm to accurately identify road surface defects from digital images. The system is developed

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using Python, Flask, and OpenCV, providing a simple web-based interface where users can upload road images for analysis. Initially, the uploaded image is preprocessed using OpenCV by resizing and normalizing it to improve detection performance. The preprocessed image is then passed to the trained YOLOv3-Tiny model, which extracts features and detects potholes and road cracks by generating bounding boxes with confidence scores.

SYSTEM ARCHITECTURE

The Proposed Deep Learning-Based Automated Pothole and Road Crack Detection System is designed to automatically identify road surface defects using deep learning techniques. The system consists of Several interconnection modules that work together to process road images and detect potholes and cracks accurately. Initially, the user uploads a road image through the Flask-based web application. The uploaded image is received by the flask server, which forwards it to the image preprocessing module. In this stage, OpenCV performs operations such as image loading, resizing, normalization, and format conversion to prepare the image for the deep learning model.

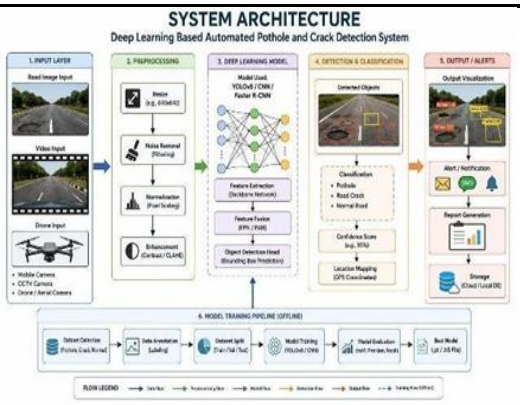


Fig 1: System Architecture

METHODOLOGY DESCRIPTION

The proposed Deep Learning-Based Automated Pothole and Road Crack Detection System employs a structured methodology to automatically identify road surface damages using deep learning and computer vision techniques. Initially, users upload a road image through a web interface developed using the Flask framework. The uploaded image is then preprocessed using OpenCV, where it is resized, normalized, and converted into a suitable format for analysis. This preprocessing step enhances image quality and improves the detection performance of the deep learning model.

RESULTS AND DISCUSSION

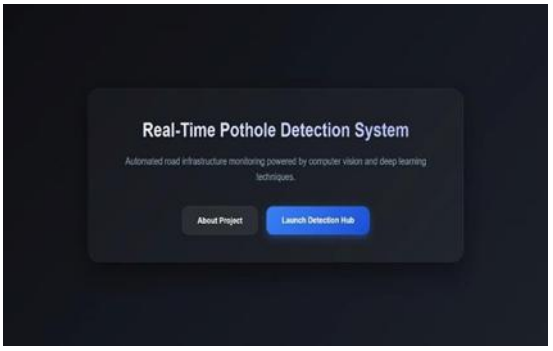


Fig 1: Home Page

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The Home Page is the main entry point of the Deep Learning-Based Automated Pothole and Road Crack Detection System. It provides users with information about the system and enables them to upload road images for automated damage detection. The page offers easy access to the platform's features, including pothole detection, crack analysis, and result.

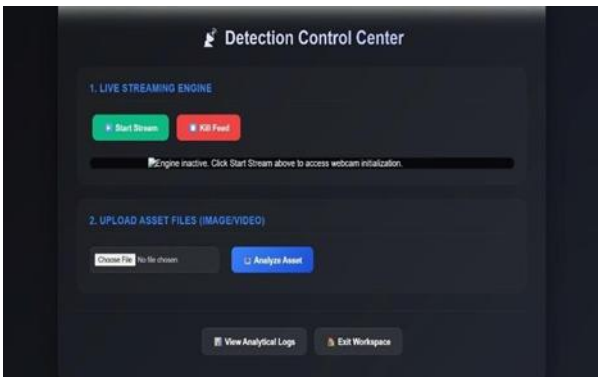


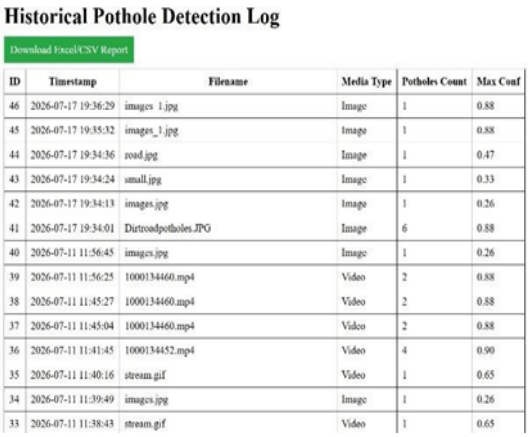
Fig 2: Dashboard

The Dashboard serves as the central interface of the Deep Learning-Based Automated Pothole and Road Crack Detection System. It provides users with access to key features such as road image upload, damage detection, result visualization, and report generation.



Fig 3: Upload and Analyze

The Upload and Analyze module allows users to upload road images for automated pothole and crack detection. Using deep learning algorithms, the system analyzes the uploaded image and identifies damaged road areas with high accuracy. The detected potholes and cracks are highlighted and displayed along with the analysis results for further evaluation.



Historical Pothole Detection Log

Download Excel/CSV Report

ID	Timestamp	Filename	Media Type	Potholes Count	Max Conf
46	2026-07-17 19:36:29	images_1.jpg	Image	1	0.88
45	2026-07-17 19:35:32	images_1.jpg	Image	1	0.88
44	2026-07-17 19:34:36	road.jpg	Image	1	0.47
43	2026-07-17 19:34:24	small.jpg	Image	1	0.33
42	2026-07-17 19:34:13	images.jpg	Image	1	0.26
41	2026-07-17 19:34:01	Dirtroadpotholes.JPG	Image	6	0.88
40	2026-07-11 11:56:45	images.jpg	Image	1	0.26
39	2026-07-11 11:56:25	1000134460.mp4	Video	2	0.88
38	2026-07-11 11:45:27	1000134460.mp4	Video	2	0.88
37	2026-07-11 11:45:04	1000134460.mp4	Video	2	0.88
36	2026-07-11 11:41:45	1000134452.mp4	Video	4	0.90
35	2026-07-11 11:40:16	stream.gif	Video	1	0.65
34	2026-07-11 11:39:49	images.jpg	Image	1	0.26
33	2026-07-11 11:38:43	stream.gif	Video	1	0.65

Fig 4: Report Generation

The Report Generation module creates a detailed report of the pothole and road crack detection results. It includes information such as the uploaded image, detected damages, analysis outcomes, and detection statistics. Users can download the generated report for documentation, monitoring, and maintenance planning purposes.

CONCLUSION

The Deep Learning-Based Automated Pothole and Road Crack Detection System provides an intelligent solution for automatic road damage detection. By integrating YOLOv3-Tiny, OpenCV, and

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Flask, the system accurately detects potholes and road cracks from uploaded images in real time. The proposed solution minimizes manual inspection, reduces maintenance costs, improves detection accuracy, and enchances road safety. Its lightweight architecture makes it suitable for deployment on low-cost hardware and web-based platforms.

FUTURE SCOPE

The proposed system can be enhanced in several ways. Future improvements include integrating GPS for automatic road damage-location tracking, supporting live video detection using vehicle-mounted cameras or drones, developing Andeoid and iOS mobile applications, implementing cloud-based road monitoring, classifying road damage severity, generating automatic maintenance reports, and upgrading to advanced object detection models such as YOLOv8.Integration with smart city infrastructure and loT technologies will further improve large-scale road mmonitoring and maintenance efficiency.

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