IJERST

International Journal of Engineering Research and Science & Technology

www.ijerst.org

ISSN : 2319-5991

Vol. 22 No. 2(1) (2026)

ijerst.editor@gmail.com

editor@ijerst.com

ISSN 2319-5991 www.ijerst.com

Peer Reviewed, Referred & Indexed Journal

Research Paper

AI BASED ROAD CONDITION MONITORING POTHOLE DETECTION USING YOLOV11 AND DEEP LEARNING WITH PYTHON

VIJAY VARDHAN[1],G. DHARMALINGAM[1],D. AKASH[1],K. SIVAMMA[1] ,M. SANDYA RANI[1],

B. AVINASH[2]

B-Tech Student, Dept.of CSE,**UNIVESAL COLLEGE OF ENGINEERING AND TECHNOLOGY**,Andhra pradhesh, India [1]
Assist Professor, Dept.of CSE,**UNIVERSAL COLLEGE OF ENGINEERING AND TECHNOLOGY**,Andhra pradhesh, India[2]
vijayvardhankorivi@gmail.com , avinashbanda4u@gmail.com

ABSTRACT

The Smart Road Monitoring System for AI-based pothole detection was developed to provide an automated and efficient solution for identifying road surface damages and assisting road maintenance authorities. Traditional road inspection methods require manual observation, which is time-consuming, labor-intensive, and often inaccurate. The maintenance of road infrastructure is a critical aspect of urban and highway management, directly impacting safety, vehicle longevity, and overall transportation efficiency. Traditional methods of road inspection, which rely heavily on manual surveys, are time-consuming, labor-intensive, and prone to human error. The proposed system addresses these limitations by using modern computer vision and deep learning techniques to automatically detect potholes from road inspection videos. To address these limitations, this project proposes an AI-based automated pothole detection and reporting system that leverages deep learning, computer vision, and automated reporting techniques to modernize road condition monitoring.The system utilizes a YOLOV11-based object detection model to analyze video footage captured from dashcams or road inspection cameras. Each frame is processed to identify potholes in real-time, with bounding boxes drawn around detected potholes and confidence scores calculated. A de-duplication logic ensures that each pothole is counted only once across video frames, enabling accurate identification of unique potholes. For every detected pothole, the system estimates its length, width, and depth, calculates volume, and determines material requirements including sand, cement, aggregates, and coal tar, as well as labor costs.The project also incorporates automated generation of professional PDF reports using the Report Lab library. These reports include a detailed pothole analysis table, aggregated material and cost summary, and a formal letter addressed to relevant road authorities. Furthermore, the system can automatically send the PDF report via Gmail, ensuring timely communication and decision-making. By integrating artificial intelligence with geospatial insights, material estimation, and automated reporting, the proposed system significantly reduces the time, effort, and cost associated with manual road inspection. It provides municipalities and infrastructure agencies with actionable, data-driven insights for efficient road maintenance and repair planning, thereby enhancing road safety, optimizing resource allocation, and promoting the development of smart transportation infrastructure.

KEYWORDS:Monitoring,Pothole,Dashcams,Geospatial,Infrastructure,Automated,Transportation.

1. INTRODUCTION:

Road infrastructure plays a crucial role in the economic development, social connectivity, and transportation safety of a nation. Roads serve as the primary medium for the movement of people, goods, and services, supporting industrial growth and daily commuting. However, with rapid urbanization and the continuous increase in vehicle density, road networks are exposed to heavy mechanical stress and various environmental conditions that gradually deteriorate road surfaces. Factors such as heavy traffic loads, poor drainage systems, temperature fluctuations, rainfall, and substandard construction materials often lead to road defects such as cracks, surface deformations, and potholes. Traditionally, road condition monitoring has been carried out through periodic inspections conducted by highway authorities or public works departments. These inspections are usually scheduled at fixed intervals or initiated after receiving complaints from the public. While these approaches provide a basic understanding of road conditions, they are often inefficient and difficult to implement across large transportation networks. Manual inspection methods rely heavily on human observation, which may introduce subjectivity and inconsistencies in the evaluation process. Different inspectors may interpret road conditions differently depending on their experience, fatigue levels, or environmental conditions. As a result, road damage may be inaccurately reported or overlooked, leading to delays in maintenance activities.Another major limitation of manual road inspection is the significant amount of time, manpower, and resources required to monitor extensive road networks. Inspections are generally conducted periodically rather than continuously, meaning that road defects developing between inspection cycles may remain undetected for long periods. During this time, minor cracks and surface damage can gradually expand into larger potholes, increasing the risk of accidents, vehicle damage, and traffic congestion. Furthermore, manual inspection often exposes personnel to safety risks, as they must work close to moving traffic under challenging environmental conditions. These limitations highlight the need for more efficient and automated road monitoring solutions.With the advancement of Artificial Intelligence (AI) and computer vision technologies, automated monitoring systems have emerged as effective alternatives to traditional inspection methods. AI-based systems can analyze images and video data captured through cameras mounted on vehicles, drones, or roadside infrastructure to automatically detect road defects such as potholes and cracks. Deep learning models, particularly object detection algorithms such as YOLO (You Only Look Once), have demonstrated high efficiency and accuracy in detecting objects within images and video streams. These models can process large volumes of visual data in real time, enabling continuous monitoring of road conditions without constant human supervision. Automated pothole detection systems provide several advantages over manual inspection methods. They can identify road damage early, allowing authorities to take preventive action before the damage becomes severe. These systems can also estimate pothole size and severity, providing useful information for planning repair activities and allocating maintenance resources efficiently. In addition, automated detection can be integrated with digital reporting systems to generate structured reports and communicate road damage information quickly to maintenance authorities.

2. LITARATURE REVIEW

Road condition monitoring and pothole detection have become important research areas in intelligent transportation systems, smart city infrastructure, and autonomous driving applications. Traditional road inspection methods mainly depend on manual surveys and physical inspections, which are time-consuming, costly, and prone to human error.

Several researchers have proposed deep learning-based pothole detection systems using YOLO architectures. Earlier studies employed YOLOv3, YOLOv4, and YOLOv5 models for real-time detection of potholes from road images and video streams. These models significantly improved detection speed and accuracy compared to traditional image processing methods. A study on in-vehicle technologies using YOLOv5 reported 96.3% mAP, demonstrating the effectiveness of deep learning for automated road monitoring.

Recent works have shifted toward advanced versions such as YOLOv8 and improved segmentation-based models for accurate pothole localization and dimension estimation. These approaches also integrate GPS tagging, area estimation, and cloud-based reporting systems to support smart road maintenance.

Research in low-light and adverse weather conditions has shown that model performance is highly dependent on dataset diversity, augmentation, and shadow handling techniques. Studies conducted under low-light scenarios emphasized the importance of robust preprocessing and real-world training data for minimizing false detections.

More recent systems focus on real-time video analytics, where dashcam footage is continuously processed to detect potholes and road defects. These systems are widely used in smart vehicles, autonomous cars, and municipal road surveillance platforms.

The proposed system extends these studies by employing YOLOv11 with deep learning in Python, aiming to achieve higher detection accuracy, faster inference speed, and better robustness under real-world road conditions.

3. EXISITING METHOD:

The existing system for road condition monitoring and pothole detection mainly relies on manual inspection and traditional surveying techniques. In most cities and highways, road maintenance authorities depend on field workers who physically inspect roads to identify damages such as potholes, cracks, and surface deterioration. These inspections are usually performed through visual observation or by driving slowly across roads to detect irregularities.Although this approach allows authorities to identify damaged areas, it has several limitations. Manual inspection is time-consuming, labor-intensive, and prone to human error. It is also difficult to monitor large road networks regularly, which often leads to delayed detection of road damage. As a result, potholes may remain unnoticed for long periods, increasing the risk of vehicle damage and road accidents.Some modern systems use sensors, accelerometers, or GPS-based detection methods to identify road surface irregularities. While these technologies provide better accuracy compared to manual inspection, they require specialized equipment, expensive infrastructure, and technical expertise to operate. In addition, these systems often lack intelligent analysis and automated reporting capabilities.Due to these limitations, existing road monitoring systems fail to provide a scalable, efficient, and automated solution for real-time road condition monitoring. Therefore, there is a need for a smart system that can automatically detect potholes, estimate repair requirements, and generate professional reports for road maintenance authorities.

3.1 DIS-ADVANTAGES:

1. Existing road monitoring systems fail to provide a scalable, efficient, and automated solution for real-time road condition monitoring.
2. Therefore, there is a need for a smart system that can automatically detect potholes, estimate repair requirements, and generate professional reports for road maintenance authorities.

4.PROPOSED METHOD

The proposed system introduces an AI-based road condition monitoring and automated pothole detection system that uses advanced technologies such as Computer Vision, Deep Learning, Image Processing, and Data Analysis to improve the efficiency of road maintenance. The system captures road images or video frames using cameras mounted on vehicles or mobile devices. These images are processed using deep learning algorithms to automatically detect potholes and other road surface damages. The system analyzes the detected potholes and estimates important parameters such as size, depth, and required repair material.In addition to detection, the system also generates professional reports containing pothole location, severity level, and estimated repair resources. These reports help road maintenance authorities prioritize repair work and allocate resources effectively.The proposed system also provides visualization features such as dashboards, charts, and location mapping for easier monitoring and analysis of road conditions. By automating pothole detection and reporting, the system improves road safety, reduces manual workload, and enables faster decision-making for infrastructure maintenance.

4.1 ADVANTAGES:

1. These reports help road maintenance authorities prioritize

repair work and allocate resources effectively.

2. The proposed system also provides visualization features such as dashboards, charts, and location mapping for easier monitoring and analysis of road conditions

3. By automating pothole detection and reporting, the system improves road safety, reduces manual workload, and enables faster decision-making for infrastructure maintenance.

5.SYSTEM ARCHITECTURE

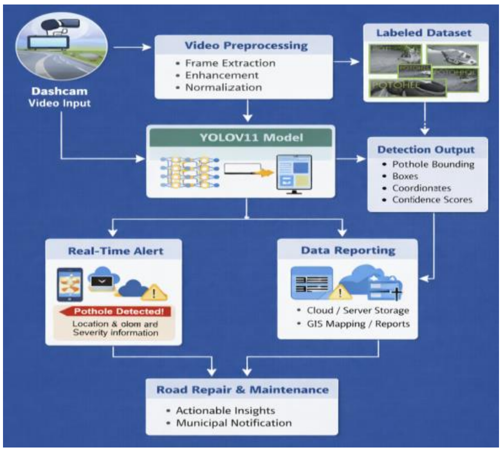

FIG 2.0:SYSTEM ARCHITECTURE

6. RELATED WORK:

Road condition monitoring and pothole detection have been extensively studied in the domains of computer vision, deep learning, and intelligent transportation systems. Early approaches mainly relied on traditional image processing techniques, such as edge detection, thresholding, and morphological operations, to identify potholes from road images. Although these methods were computationally simple, they often failed under varying lighting conditions, shadows, and different road textures.

With the advancement of deep learning, researchers started using Convolutional Neural Networks (CNNs) and object detection models for real-time pothole detection. Models such as Faster R-CNN, SSD, YOLOv3, and YOLOv4 significantly improved detection accuracy and localization performance. A real-time deep learning study reported that YOLOv4 achieved around 85% mean Average Precision (mAP) and processed road videos at nearly 20 frames per second, making it suitable for intelligent vehicle systems.

Later, YOLOv5, YOLOv8, and YOLOv9 based approaches further enhanced performance by improving speed, precision, and robustness. These systems were successfully applied in dashcam-based road monitoring, smart city infrastructure maintenance, and autonomous vehicle navigation. Recent reviews highlight that deep learning-based methods can achieve up to 97% accuracy under controlled datasets.

Recent studies specifically focus on YOLOv11-based pothole detection, which offers better feature extraction, faster inference, and improved detection in complex road environments such as rain, low light, shadows, and damaged surfaces. A recent 2025 study on intelligent pothole detection using YOLOv11 demonstrated its effectiveness in road safety applications and automated maintenance systems.

The proposed system builds upon these existing works by implementing YOLOv11 with Python and deep learning frameworks for accurate, real-time pothole detection and road condition monitoring.

7. RESULTS:

FIG 2.1: The Above screen is about Detection video window.

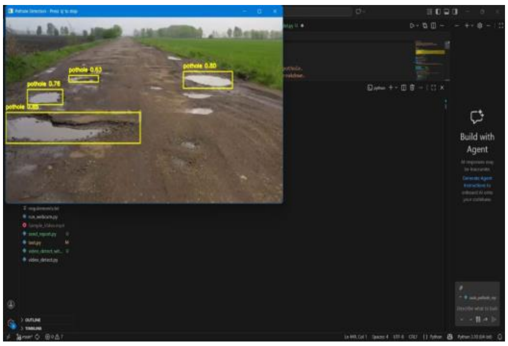

FIG2.2 : The above screen is about Potholes detection.

8. CONCLUSION:

By utilizing the **YOLOv11** for real-time object detection and integrating image processing through **OpenCV**, the system is able to identify potholes accurately and efficiently. Once the potholes are detected, the system performs additional analysis to estimate the materials required for repair and calculates the approximate budget needed for road maintenance. The system further enhances practicality by automatically generating a detailed inspection report using **ReportLab**, which summarizes pothole locations, estimated repair materials, and total cost. This report is then automatically delivered to the concerned authority through email using the **SMTP**, enabling faster communication and quicker response for road repairs. The implementation of this system demonstrates how artificial intelligence and automation can significantly improve road monitoring and infrastructure maintenance processes. Overall, the developed project successfully achieves its objective of detecting potholes, estimating repair resources, and generating automated reports, thereby providing a reliable and scalable approach for smarter road management systems.

9. REFFRENCES

[1] M. Lakshmi Chetana, P. Hemanth Sai Vikas, and S. Balakrishna, "Towards Safer Roads: Intelligent Pothole Detection with YOLOv11," Proceedings of the 4th International Conference on Information Technology, Civil Innovation, Science, and Management (ICITSM 2025), EAI, 2025. DOI: 10.4108/eai.28-4-2025.2357949.

[2] Y. Matouq, D. Manasreh, and M. D. Nazzal, "AI-Driven Approach for Automated Real-Time Pothole Detection, Localization, and Area Estimation," Transportation Research Record, vol. 2678, no. 11, 2024.

[3] S. Sivanraj, N. Uduwage, R. K. Shiwakoti, and M. Tripathi, "YOLOv11-s-Based Pothole Detection Model with Integrated Traffic Data for Maintenance Decision Support," Journal of Advanced College of Engineering and Management, vol. 11, pp. 77–92, 2025.

[4] J. Liu, "Research on Road Pothole Detection System Based on Improved YOLOV11," Theory and Practice of Science and Technology, vol. 6, no. 6, pp. 30–34, 2025.

[5] Y. Zanevych, V. Yovbak, O. Basystiuk, N. Shakhovska, S. Fedushko, and S. Argyroudis, "Evaluation of Pothole Detection Performance Using Deep Learning Models Under Low-Light Conditions," Sustainability, vol. 16, no. 24, 2024.

[6] J. Ravichandra Reddy, R. R. Deekshith, B. V. Gopal, and C. Rishwanth, "Real Time Pothole Detection Using YOLO Algorithm," Proceedings of ICOFE 2024, SSRN, 2025.

[7] N. Ma, J. Fan, W. Wang, J. Wu, Y. Jiang, L. Xie, and R. Fan, "Computer Vision for Road Imaging and Pothole Detection: A State-of-the-Art Review of Systems and Algorithms," arXiv preprint arXiv:2204.13590, 2022.

[8] M. Yurdakul and Ş. Tasdemir, "An Enhanced YOLOv8 Model for Real-Time and Accurate Pothole Detection and Measurement," arXiv preprint arXiv:2505.04207, 2025.

FIRST AUTHORS:

K. **VIJAY VARDHAN** pursuing his B.Tech in Computer Science And Engineering in Universal College Of Engineering And Technology.

G DHARMALINGAM pursuing his B.Tech in Computer Science And

Engineering in Universal College Of Engineering And Technology.

D. **AKASH** pursuing his B.Tech in Computer Science And Engineering in Universal College Of Engineering And Technology.

K. **SIVAMMA** pursuing her B.Tech in Computer Science And Engineering in Universal College Of Engineering And Technology.

M. SANDYA RANI pursuing her B.Tech in Computer Science And Engineering in Universal College Of Engineering And Technology.

Second Author:

B. AVINASH M.Tech received his M.Tech degree and B.Tech degree in computer science and engineering. He is currently working as an Assist Professor in , Universal College Of Engineering And Technology.