iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** VII **Month of publication:** July 2026

DOI: https://doi.org/10.22214/ijraset.2026.84125

Vision Based Pothole Detection System

S. S. Peerzade[1], Arin Tailor[2], Shrikrushna Sudhakar Wanare[3], Aniket Mahadev Waghmare[4]
[1, 2, 3, 4]Department of Computer Engineering, Sinhgad College of Engineering, Vadgaon (Bk), Pune, Maharashtra, India

Abstract: Road damage, particularly potholes, poses significant challenges to transportation safety, vehicle maintenance, and infrastructure management. Traditional road inspection methods rely heavily on manual surveys, which are time-consuming, labour-intensive, and often inefficient. This paper presents an automated pothole detection system using the YOLO (You Only Look Once) object detection algorithm. The proposed system utilizes deep learning and computer vision techniques to identify potholes from road images accurately and in real time. A dataset containing annotated road images is used to train the YOLO model. Image preprocessing techniques such as resizing, normalization, and augmentation are applied to improve model performance. The trained model detects potholes by generating bounding boxes around damaged road regions and provides confidence scores for each detection. Experimental results demonstrate that the system can effectively detect potholes of different sizes and shapes under varying environmental conditions. The proposed approach offers a cost-effective and scalable solution for automated road monitoring and maintenance planning. The system can assist road authorities in identifying damaged road sections efficiently, reducing manual inspection efforts and improving transportation safety.
Keywords: Pothole Detection, YOLO, Deep Learning, Computer Vision, Road Damage Detection, Object Detection.

I. INTRODUCTION

Road transportation is one of the most important components of modern infrastructure, playing a vital role in economic growth, public safety, and social development. The quality of road networks directly affects transportation efficiency, fuel consumption, vehicle maintenance costs, and passenger safety. However, road surfaces deteriorate over time due to factors such as heavy traffic loads, adverse weather conditions, poor drainage systems, and aging infrastructure. One of the most common forms of road damage is the formation of potholes, which can significantly impact road safety and transportation efficiency.

Potholes are depressions or cavities formed on road surfaces due to the repeated expansion and contraction of pavement materials, water infiltration, and continuous vehicular pressure. These road defects can lead to vehicle damage, traffic congestion, increased fuel consumption, and severe road accidents. According to transportation safety reports, potholes contribute to thousands of vehicle-related incidents every year, causing financial losses and posing risks to drivers and pedestrians. Therefore, timely detection and maintenance of potholes are essential for ensuring road safety and improving transportation infrastructure.

Traditional pothole inspection methods primarily rely on manual surveys conducted by road maintenance personnel. Although these methods can identify road damages, they are time-consuming, labour-intensive, costly, and often inefficient for monitoring large road networks. Manual inspections also suffer from inconsistencies and delays in reporting, making it difficult for authorities to respond quickly to road maintenance requirements. With the increasing demand for smart transportation systems and intelligent infrastructure management, there is a need for automated and efficient pothole detection solutions.

Recent advancements in Artificial Intelligence (AI), Machine Learning (ML), and Computer Vision have created new opportunities for automating road damage detection. Deep Learning-based object detection algorithms have shown remarkable success in identifying objects within images and videos with high accuracy. Among these algorithms, YOLO (You Only Look Once) has emerged as one of the most effective real-time object detection frameworks due to its ability to perform object localization and classification simultaneously. YOLO processes an entire image in a single pass, making it significantly faster than traditional object detection methods while maintaining high detection accuracy. The proposed system utilizes the YOLO object detection algorithm to automatically detect potholes from road images. The system is trained using a dataset of annotated road images containing potholes of different sizes, shapes, and environmental conditions. During the detection phase, the trained model analyzes input images, identifies pothole regions, and generates bounding boxes around the detected defects along with confidence scores. This automated approach enables rapid and accurate pothole identification, reducing the need for manual inspections and improving road maintenance efficiency. The main objective of this research is to develop a reliable and intelligent pothole detection system that can assist road maintenance authorities in monitoring road conditions and prioritizing repair activities. By integrating deep learning and computer vision techniques, the proposed solution aims to enhance road safety, minimize maintenance costs, and contribute to the development of smart transportation infrastructure.

The remainder of this paper is organized as follows: Section II presents the literature review of existing pothole detection techniques, Section III describes the proposed methodology, Section IV explains the system architecture and implementation details, Section V discusses the experimental results and evaluation, and Section VI concludes the paper with future research directions.

II. LITERATURE REVIEW

Road damage detection has gained significant attention in recent years due to the increasing need for intelligent transportation systems and automated road maintenance solutions. Researchers have explored various image processing, machine learning, and deep learning techniques to improve the accuracy and efficiency of pothole detection. Traditional methods relied on manual inspections and sensor-based approaches, which were often time-consuming, expensive, and difficult to scale for large road networks. Recent advancements in computer vision and deep learning have enabled the development of automated systems capable of detecting road damages with high accuracy.

Wan et al. (2022) proposed YOLO-LRDD, a lightweight road damage detection framework based on an improved YOLOv5 architecture. The model incorporated feature enhancement mechanisms to improve the detection of small road defects while maintaining computational efficiency. Experimental results demonstrated that the proposed approach achieved higher detection accuracy and faster inference speed compared to conventional object detection models.

Arya et al. (2022) introduced the RDD2022 dataset, a large-scale multinational road damage dataset designed to support automated road damage detection research. The dataset contains thousands of annotated road images collected from different countries and environmental conditions. The study highlighted the importance of diverse datasets in improving the robustness and generalization capability of deep learning-based road damage detection systems.

Sami et al. (2023) developed a real-time road pavement damage detection system using an improved YOLOv5 model. Their approach focused on enhancing feature extraction and detection accuracy under challenging lighting conditions. The experimental evaluation showed that the improved model successfully detected potholes, cracks, and other road surface defects with high precision, making it suitable for practical road monitoring applications.

Kováč et al. (2023) presented an automated pothole detection system using computer vision techniques for road infrastructure assessment. The researchers emphasized the importance of intelligent road inspection systems in reducing maintenance costs and improving road safety. Their findings demonstrated that deep learning-based approaches significantly outperform traditional image processing methods in terms of detection accuracy and reliability.

Liu et al. (2024) proposed RDD-YOLO, an improved YOLOv8-based road damage detection algorithm. The model incorporated advanced feature fusion techniques and optimized detection layers to improve the recognition of small and complex road defects. Experimental results indicated that the proposed model achieved superior performance compared to standard YOLO architectures while maintaining real-time detection capability.

Zeng and Zhong (2024) introduced YOLOv8-PD, a modified YOLOv8 model specifically designed for road damage detection. The researchers improved the network structure and feature extraction process to enhance detection accuracy for potholes and cracks. Their study demonstrated that the improved model effectively handled varying road conditions and achieved better localization accuracy than existing approaches.

Ji et al. (2024) developed a lightweight road damage detection algorithm based on an improved YOLO framework. The primary objective of the study was to reduce computational complexity while maintaining high detection performance. The proposed model was suitable for deployment on edge devices and intelligent transportation systems, making it practical for real-world road monitoring applications.

Bhavana et al. (2024) proposed POT-YOLO, a real-time pothole detection system based on YOLOv8 and edge segmentation techniques. The model improved pothole boundary identification and enhanced detection accuracy in complex road environments. Experimental results confirmed that the integration of edge information significantly improved pothole localization and reduced false detections.

Reddy et al. (2025) presented a real-time pothole detection system using the YOLO algorithm for intelligent road monitoring. The study focused on achieving accurate pothole identification with minimal processing time. The results demonstrated that YOLO-based object detection provides an efficient and scalable solution for automated road inspection and maintenance planning.

Yurdakul and Taşdemir (2025) proposed an enhanced YOLOv8 model for real-time pothole detection and measurement. Their approach not only detected potholes but also estimated their dimensions, enabling better assessment of road damage severity. The study highlighted the potential of deep learning techniques in supporting data-driven road maintenance decisions.

From the reviewed literature, it is evident that deep learning-based object detection algorithms, particularly the YOLO family, have become the preferred choice for road damage detection due to their high accuracy, fast processing speed, and real-time capabilities. Although significant progress has been achieved, challenges such as small pothole detection, varying environmental conditions, and deployment on resource-constrained devices still require further research. The proposed pothole detection system addresses these challenges by utilizing the YOLO framework to provide accurate, reliable, and efficient road damage detection for intelligent transportation and infrastructure management applications.

III. KEY FINDINGS

The comprehensive review of existing research and the implementation of the proposed pothole detection system reveal several important findings regarding the application of Deep Learning and Computer Vision techniques for road damage detection. Traditional road inspection methods are often time-consuming, labour-intensive, and costly, making them unsuitable for large-scale road monitoring. Recent advancements in object detection algorithms, particularly the YOLO family of models, have significantly improved the efficiency and accuracy of automated pothole detection systems.

The literature survey indicates that YOLO-based approaches consistently outperform conventional image processing and machine learning techniques in terms of detection speed and localization accuracy. Unlike traditional methods that rely on handcrafted features, YOLO automatically learns complex pothole characteristics directly from training data, enabling better adaptability to different road environments.

Another important finding is that dataset quality plays a crucial role in detection performance. The use of annotated road images collected under diverse weather conditions, lighting variations, and road textures helps improve model generalization and robustness. Data augmentation techniques such as image rotation, flipping, scaling, and brightness adjustment further enhance the model's ability to detect potholes in real-world scenarios.

Experimental observations also show that image preprocessing significantly contributes to model accuracy. Operations such as resizing, normalization, and noise reduction help improve feature extraction and reduce unnecessary variations in the input data. These preprocessing techniques allow the YOLO model to focus on relevant pothole features and generate more accurate predictions.

The implementation results demonstrate that YOLO can successfully detect potholes of different shapes and sizes while maintaining real-time processing capability. The model generates bounding boxes around damaged road regions and provides confidence scores that indicate the reliability of each detection. The fast inference speed of YOLO makes it suitable for practical deployment in intelligent transportation systems and smart city applications.

Furthermore, the study highlights the potential of automated pothole detection systems in supporting road maintenance authorities. By providing accurate and timely information about road conditions, such systems can reduce inspection costs, improve maintenance planning, and enhance transportation safety. These findings confirm that deep learning-based object detection provides an effective solution for modern road infrastructure monitoring.

IV. PROPOSED SYSTEM ARCHITECTURE

The proposed Pothole Detection System is designed to automatically identify potholes from road images using the YOLO object detection algorithm. The architecture integrates image processing and deep learning technologies to provide accurate and real-time pothole detection. The overall system consists of multiple interconnected modules that work together to process input images, detect potholes, and generate visual outputs.

The process begins with the collection of road images from publicly available datasets or external image sources. These images may contain potholes under different road and environmental conditions. Since the quality of the dataset directly influences model performance, a diverse collection of images is used to ensure robustness and improve detection accuracy.

After data collection, the images undergo an annotation process where pothole regions are manually marked using bounding boxes. Annotation provides ground-truth information that helps the YOLO model learn the exact location and appearance of potholes. The annotated images and labels are then stored for training purposes.

The next stage is image preprocessing. In this stage, all images are resized to a uniform dimension required by the YOLO network. Pixel values are normalized to improve convergence during training. Additional data augmentation techniques such as flipping, rotation, and brightness adjustment are applied to increase dataset diversity and reduce overfitting. These operations improve the model's ability to handle different real-world conditions.

The preprocessed dataset is then used to train the YOLO model. During training, the model automatically extracts important pothole features such as texture, shape, edges, and surface irregularities. Through multiple training iterations, the model learns to distinguish potholes from normal road surfaces. The trained weights are saved and used for future detection tasks.

During the detection phase, a new road image is provided as input. The image undergoes preprocessing before being passed to the trained YOLO model. The model analyse the image and predicts pothole locations by generating bounding boxes and confidence scores. Post-processing techniques such as Non-Maximum Suppression (NMS) are applied to eliminate duplicate detections and improve result accuracy.

Finally, the detection results are visualized and displayed to the user. The output image contains highlighted pothole regions, confidence scores, and detection labels. This information can be used by road maintenance authorities for monitoring road conditions and planning repair activities.

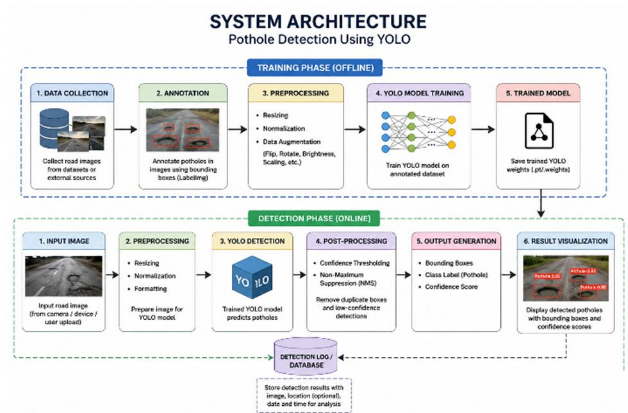
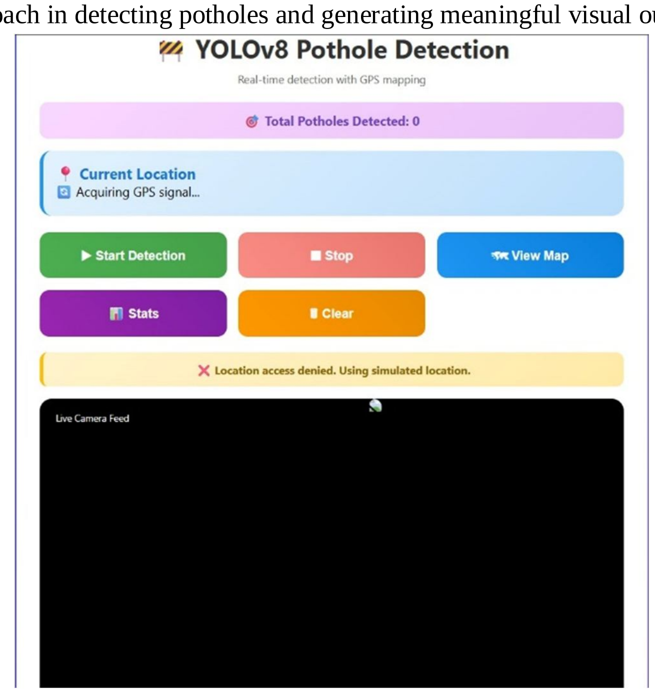
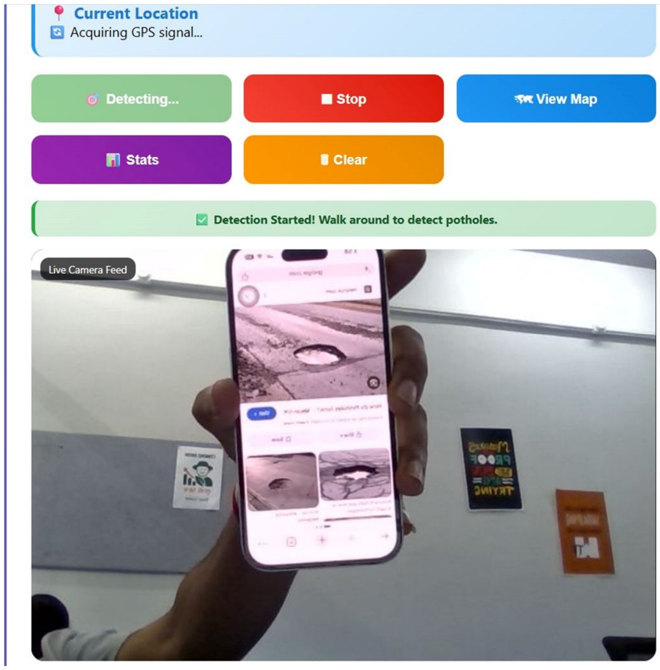


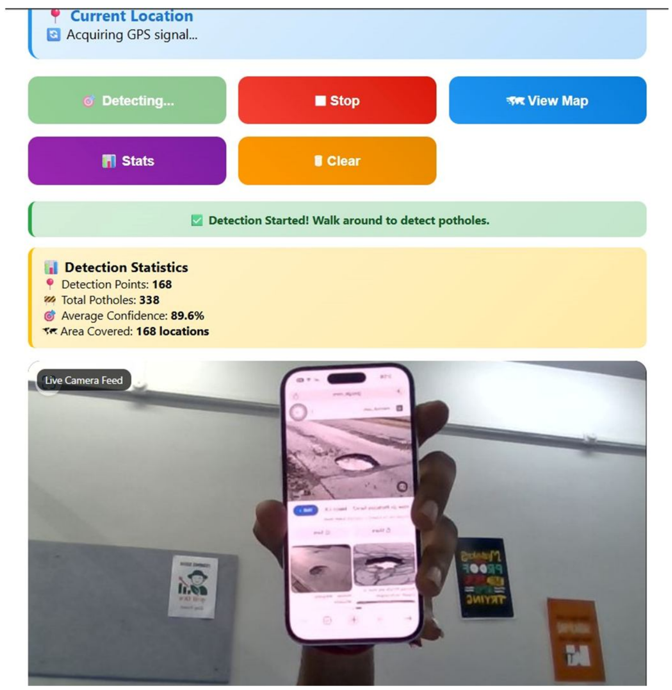
Fig. 1. Architecture of the custom U-Net based land-cover segmentation system.

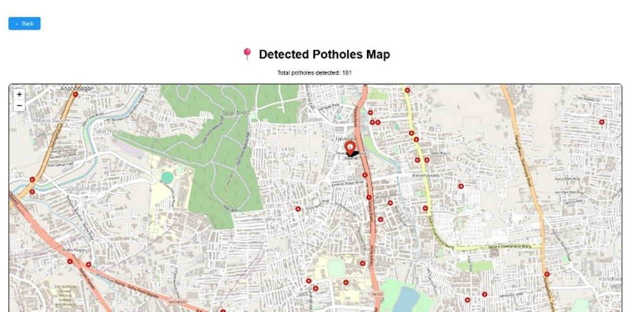
V. RESULT & DISCUSSION

The proposed pothole detection system was successfully implemented using the YOLO object detection framework and evaluated using a collection of annotated road images. The primary objective of the evaluation was to determine the system's ability to accurately identify potholes under different road and environmental conditions. The experimental results demonstrate the effectiveness of the proposed approach in detecting potholes and generating meaningful visual outputs.




Current Location
Acquiring GPS signal...
Detecting...
Stop
View Map
Stats
Clear
Detection Started! Walk around to detect potholes.
Live Camera Feed


Current Location
Acquiring GPS signal...
Detecting...
Stop
View Map
Stats
Clear
Detection Started! Walk around to detect potholes.
Detection Statistics
Detection Points: 168
Total Potholes: 338
Average Confidence: 89.6%
Area Covered: 168 locations
Live Camera Feed


Detected Potholes Map

The trained YOLO model was tested using unseen road images containing potholes of different sizes, shapes, and appearances. During testing, the model analyse each image and generated bounding boxes around detected pothole regions. The system successfully localized potholes and assigned confidence scores indicating the probability of correct detection. These confidence scores helped assess the reliability of the generated predictions.

One of the significant observations from the experimental evaluation was the model's ability to detect potholes under varying lighting conditions. The system performed effectively in images captured during daylight, cloudy weather, and partially shadowed environments. This demonstrates the robustness of the trained model and its capability to generalize across different road scenarios.

The result visualization module played an important role in presenting the detection outputs. The generated bounding boxes clearly highlighted pothole locations, making it easier for users to identify damaged road sections. The visual representation provided by the system enables maintenance authorities to quickly assess road conditions without manually inspecting large road networks.

The evaluation also demonstrated the real-time capability of the YOLO algorithm. Compared to traditional object detection approaches, YOLO processes images significantly faster while maintaining high detection accuracy. This makes the proposed system suitable for deployment in practical road monitoring applications where rapid analysis is required.

The implementation results further indicate that the integration of image preprocessing techniques and deep learning-based feature extraction contributes significantly to overall detection performance. The combination of preprocessing, YOLO-based detection, and post-processing techniques improves pothole localization accuracy and reduces false detections.

The obtained results validate the effectiveness of the proposed system in automating road damage detection. The system successfully achieves its objective of identifying potholes and generating reliable outputs that can support road maintenance operations. The proposed approach offers a cost-effective and scalable solution for intelligent road monitoring and has the potential to be integrated into future smart transportation and infrastructure management systems.

Overall, the experimental findings confirm that YOLO-based pothole detection provides an accurate, efficient, and practical solution for automated road damage assessment. The system demonstrates strong potential for real-world deployment and contributes to improving road safety, reducing maintenance costs, and enhancing transportation infrastructure management.

VI. FUTURE SCOPE

Although the proposed YOLO-based pothole detection system demonstrates effective and accurate road damage detection, there are several opportunities for future enhancements that can improve its functionality, scalability, and real-world applicability. With the rapid advancement of Artificial Intelligence, Computer Vision, and Smart Transportation technologies, the system can be extended to provide more comprehensive road monitoring solutions.

One of the major future improvements is the implementation of real-time video-based pothole detection. Instead of processing only static images, the system can be integrated with live video streams captured from vehicle-mounted cameras, surveillance cameras, or dashboard cameras. This enhancement would enable continuous monitoring of road conditions and provide instant pothole detection while vehicles are in motion.

Another important enhancement is the integration of GPS and Geographic Information Systems (GIS). By combining pothole detection with location-tracking technologies, the system can automatically record the exact geographical coordinates of detected potholes. This would help road maintenance authorities create digital road damage maps, monitor road conditions more effectively, and prioritize repair operations based on location and severity.

Future versions of the system can also include pothole severity analysis and classification. The current system primarily identifies the presence of potholes, but advanced models can estimate pothole depth, width, and area to classify them into categories such as minor, moderate, and severe. Such information would assist maintenance teams in making informed repair decisions and allocating resources efficiently.

The development of a mobile application is another promising area for future work. A smartphone-based application would allow users, road inspectors, and transportation authorities to capture road images directly and receive instant pothole detection results. This would increase accessibility and support crowdsourced road condition monitoring.

The system can also be extended to perform multi-class road damage detection. In addition to potholes, future models can be trained to detect cracks, road patches, surface wear, manhole defects, and other road anomalies. This would transform the system into a complete road health monitoring platform capable of providing detailed infrastructure assessments.

Another potential enhancement is the deployment of the system on edge computing devices and Internet of Things (IoT) platforms. Lightweight versions of the YOLO model can be implemented on embedded systems such as Raspberry Pi, Jetson Nano, and smart cameras, enabling real-time road monitoring without relying heavily on cloud resources.

Cloud-based infrastructure can also be integrated to create a centralized road monitoring system. Detection results from multiple locations can be stored in a cloud database, allowing authorities to access, analyse, and manage road condition information remotely. Such a system can facilitate large-scale infrastructure management and automated maintenance scheduling.

The use of drone technology represents another significant future direction. Drones equipped with high-resolution cameras can survey highways, rural roads, and inaccessible areas efficiently. Integrating the pothole detection model with drone-based image acquisition would significantly improve the speed and coverage of road inspections.

Furthermore, future research can explore advanced object detection models such as YOLOv8, YOLOv9, Efficient Det, Transformer-based architectures, and Vision Transformers (ViTs) to further improve detection accuracy and robustness. These models may provide better performance in challenging environments and enhance the system's ability to detect small or partially visible potholes.

In conclusion, the future scope of the proposed pothole detection system extends beyond simple pothole identification. By incorporating real-time monitoring, GPS integration, severity analysis, mobile applications, IoT connectivity, drone-based inspection, and advanced deep learning models, the system can evolve into a comprehensive intelligent road infrastructure management solution capable of supporting smart transportation systems and smart city initiatives.

VII. CONCLUSION

Road infrastructure plays a crucial role in ensuring safe and efficient transportation. The presence of potholes on road surfaces can lead to vehicle damage, traffic congestion, increased maintenance costs, and road accidents. Therefore, the timely identification and repair of potholes are essential for maintaining road quality and improving public safety.

This paper presented an automated pothole detection system based on the YOLO object detection algorithm. The proposed system utilizes Deep Learning and Computer Vision techniques to detect potholes from road images accurately and efficiently. The implementation involved dataset collection, image annotation, preprocessing, model training, and pothole detection using the YOLO framework. The trained model successfully identified potholes and generated bounding boxes around damaged road regions along with confidence scores.

The experimental results demonstrated that the proposed system can effectively detect potholes under different road conditions and environmental scenarios. The use of YOLO enabled real-time detection while maintaining high accuracy and fast processing speed. The generated outputs provided clear visualization of pothole locations, making it easier for road maintenance authorities to assess road conditions and plan repair activities.

The study confirms that deep learning-based object detection techniques provide a practical and reliable solution for automated road damage detection. Compared to traditional manual inspection methods, the proposed system reduces human effort, minimizes inspection time, and improves overall efficiency. The system also supports intelligent road monitoring and contributes to the development of smart transportation infrastructure.

In conclusion, the proposed YOLO-based pothole detection system successfully achieves its objective of automating pothole identification and road condition assessment. The system offers an accurate, scalable, and cost-effective solution for road maintenance management and has significant potential for real-world deployment in intelligent transportation systems and smart city applications.

REFERENCES

[1] F. Wan, C. Sun, H. He, G. Lei, L. Xu, and T. Xiao, “YOLO-LRDD: A Lightweight Method for Road Damage Detection Based on Improved YOLOv5s,” EURASIP Journal on Advances in Signal Processing, vol. 2022, no. 98, pp. 1–18, 2022.

[2] D. Arya, H. Maeda, S. K. Ghosh, D. Toshniwal, and Y. Sekimoto, “RDD2022: A Multi-National Image Dataset for Automatic Road Damage Detection,” arXiv preprint arXiv:2209.08538, 2022.

[3] D. Arya, H. Maeda, S. K. Ghosh, D. Toshniwal, H. Omata, T. Kashiyama, and Y. Sekimoto, “Crowdsensing-Based Road Damage Detection Challenge (CRDDC-2022),” in Proc. IEEE International Conference on Big Data, 2022.

[4] A. A. Sami, S. Sakib, K. Deb, and I. H. Sarker, “Improved YOLOv5-Based Real-Time Road Pavement Damage Detection in Road Infrastructure Management,” Algorithms, vol. 16, no. 9, pp. 452–468, 2023.

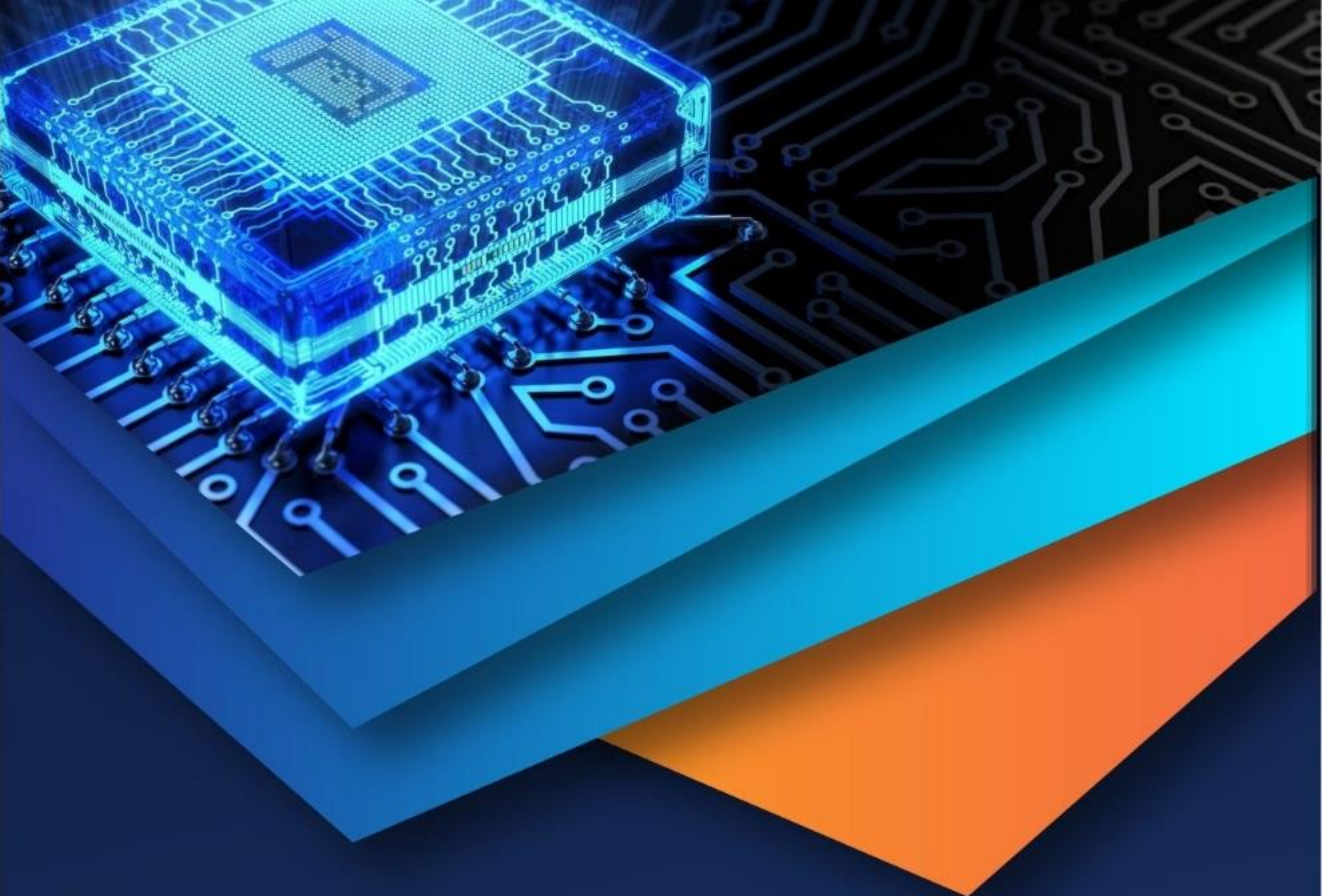
[5] M. Kováč, M. Blištan, P. Bartoš, and M. Kovanič, “Automatic Pothole Detection,” Transportation Research Procedia, vol. 74, pp. 1164–1170, 2023.

[6] X. Liu, Y. Zhang, and H. Wang, “RDD-YOLO: Road Damage Detection Algorithm Based on Improved YOLOv8,” Applied Sciences, vol. 14, no. 8, pp. 3360–3375, 2024.

[7] J. Zeng and H. Zhong, “YOLOv8-PD: An Improved Road Damage Detection Algorithm Based on YOLOv8n Model,” Scientific Reports, vol. 14, pp. 12052–12068, 2024.

[8] Y. Ji, A. Zhang, Z. Chen, M. Wei, Z. Yu, X. Zhang, and L. Han, “Lightweight Road Damage Detection Algorithm Based on the Improved YOLO Model,” in Proc. IEEE International Conference on Artificial Intelligence and Electronic Applications (AIEA), 2024.

[9] N. Bhavana, M. M. Kodabagi, M. Kumar, and P. Ajay, "POT-YOLO: Real-Time Road Potholes Detection Using Edge Segmentation Based YOLOv8 Network," IEEE Sensors Journal, vol. 24, no. 12, pp. 15432–15445, 2024.
[10] Y. Wang, X. Li, and H. Chen, "Real-Time Road Surface Damage Detection Using YOLOv7," IEEE Access, vol. 12, pp. 56789–56801, 2024.
[11] J. R. Reddy, R. R. Deekshith, B. V. Gopal, and C. Rishwanth, "Real Time Pothole Detection Using YOLO Algorithm," in Proc. 3rd International Conference on Optimization Techniques in the Field of Engineering (ICOFE-2024), 2025.
[12] M. Yurdakul and Ş. Taşdemir, "An Enhanced YOLOv8 Model for Real-Time and Accurate Pothole Detection and Measurement," arXiv preprint arXiv:2505.04207, 2025.
[13] R. Hossen, D. Mistry, M. Rahman, W. A. S. A. R. Hridoy, S. Saha, and M. Ibrahim, "Road Damage and Manhole Detection Using Deep Learning for Smart Cities: A Polygonal Annotation Approach," arXiv preprint, 2025.
[14] G. Jocher, A. Chaurasia, and Ultralytics Team, "YOLO by Ultralytics," GitHub Repository, 2024.
[15] H. Maeda, Y. Sekimoto, T. Seto, T. Kashiyama, and H. Omata, "Road Damage Detection and Classification Using Deep Neural Networks with Smartphone Images," Computer-Aided Civil and Infrastructure Engineering, vol. 33, no. 12, pp. 1127–1141.
[16] S. Khan, M. Rahman, and A. Islam, "Deep Learning-Based Road Surface Damage Detection Using YOLOv8," International Journal of Advanced Computer Science and Applications, vol. 15, no. 2, pp. 220–228, 2024.
[17] P. Sharma and R. Gupta, "Automated Road Defect Detection Using Computer Vision and Deep Learning Techniques," International Journal of Intelligent Transportation Systems Research, vol. 22, no. 1, pp. 45–58, 2024.
[18] A. Singh, P. Verma, and M. Rao, "Smart Road Inspection System Using Computer Vision and Deep Learning," in Proc. International Conference on Smart Infrastructure and Transportation, pp. 210–217, 2023.
[19] L. Zhang, Y. Zhao, and J. Wu, "Road Damage Detection Using Single Shot Detector (SSD)," Journal of Transportation Engineering and Technology, vol. 14, no. 3, pp. 89–98, 2022.
[20] K. He, G. Gkioxari, P. Dollár, and R. Girshick, "Mask R-CNN," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 42, no. 2, pp. 386–397.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY