IJITCE

ISSN 2347- 3657

International Journal of
Information Technology & Computer Engineering

Email : ijitce.editor@gmail.com or editor@ijitce.com

International Journal of Information Technology & Computer Engineering

ISSN 2347–3657

Volume 12 , Issue 1, Mar 2024

POTHOLE DETECTION USING DEEP LEARNING

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ABSTRACT

Industrialization of transportation system has derived serious accidents that resulted in thousands of deaths. To solve the problem, vision-based pothole detection for advanced driver assistance system has been researched. In this study, we provide experimentations of pothole detection and localization in on-road environment using deep learning. In India as poor quality of construction materials get used in road drainage system construction. Due to the above problems, roads get damaged early and potholes appear on the roads which cause accidents. According to a report submitted by the Ministry of Road Transport and Highways transport research wing New Delhi in 2022, approximately 1,55,622 accident deaths happen in India. This project proposed a deep learning-based model that can detect potholes early using images and videos which can reduce the chances of an accidents. Detailed real-time performance comparison of state-of-the-art deep learning models and object detection frameworks (YOLOv1, YOLOv2, YOLOv3, YOLOv4, Tiny-YOLOv4, YOLOv5, and SSD-mobilenetv2) for pothole detection is presented. The experimentation is performed on an image dataset with pothole in diverse road conditions and illumination variations as well as on real-time video captured through a moving vehicle. The Tiny-YOLOv4, YOLOv4, and YOLOv5 evince the highest mean average precision of 80.04%, 85.48%, and 95%, respectively, on the image set, thus proving the strength of the proposed approach for pothole detection and deployed on OAK-D for real-time detection. The study corroborated Tiny-YOLOv4 as the befitted model for real-time pothole detection with 90% detection accuracy and 31.76 FPS. For developing this project, we have used YoloV4-Tiny and OpenCV.

I.INTRODUCTION

Roads form a basis for people transportation and joining between different places. The size of roads varies based on their functionality. For instance, highways are large enough to contain many lanes designed for massive traffic. However, roads inside towns are constructed to be smaller and made up of one or two lanes. Roads are vital in people's daily life, so periodic maintenance shall be made to keep them functional and safe. The many roads that exist within a given country make it difficult to have a continuous assessment of roads; therefore, one can't predict the formation of potholes. Pavement distress is the main cause of defects of roads. Pavement distress can be classified into three classes. Pavement distortion (shoving, corrugation, and rutting), fracture (fatiguing, spalling, and cracking), and disintegration (raveling and stripping). This work focuses on potholes which are considered the worst pavement distress, and their creation is unpredictable. The main reason behind such distortions can be related to a combination of environmental conditions and traffic pavement stresses. Potholes are a worldwide problem as they cost governments and citizens billions of dollars yearly. 1.25 million people die each year because of road traffic accidents, 34% of which are related to road potholes. Pothole detection can be categorized into three approaches Vibration-technique approach, 3D reconstruction technique approach (with laser scanner method, stereo vision method, and Kinect sensor method, and Vision technique approach. Many different pothole detection approaches are based on technology used, response and sense time, processing, cost, pothole characterization, and accuracy of detection. One of the prevention techniques is sealing. Crack sealing and slurry sealing keep water from penetrating the surface by sealing small cracks.

II.LITERATURE REVIEW

Pothole detection project using deep learning would involve a comprehensive survey of existing research, methodologies, and techniques related to both pothole detection and deep learning-based computer vision.

1. Pothole Detection Techniques:

- Review studies that focus on traditional methods for pothole detection, including approaches based on image processing, computer vision, and sensor-based technologies.
- Analyze the limitations of these traditional techniques in terms of accuracy, speed, and scalability.

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3. Previous Works on Object Detection:

- Review research papers and projects that have employed deep learning techniques for real-time object detection, particularly those focusing on similar applications in transportation, infrastructure, or urban planning.
- Examine various state-of-the-art object detection models, such as YOLO (You Only Look Once), SSD (Single Shot Multibox Detector), and Faster R-CNN (Region-based Convolutional Neural Networks).

4. Pothole Detection Using Deep Learning:

- Investigate any existing studies or projects that have specifically targeted pothole detection using deep learning techniques, focusing on the methodologies, datasets used, and performance metrics.
- Analyze the strengths and weaknesses of these previous approaches, including challenges related to data collection, model training, and real-time deployment.

5. Data Augmentation and Preprocessing Techniques:

- Explore various data augmentation and preprocessing methods used in similar computer vision projects, including techniques for handling imbalanced datasets, data labeling, and data normalization.

6. Evaluation Metrics and Performance Benchmarks:

- Study the different evaluation metrics commonly used to assess the performance of object detection models, such as mean average precision (mAP), precision-recall curves, and F1-score.
- Examine the benchmarks set by previous studies in terms of detection accuracy, processing speed, and generalization capability.

7. Challenges and Future Directions:

- Identify the current challenges and limitations in the field of pothole detection using deep learning, and discuss potential areas for improvement or further research.
- Highlight any gaps in the existing literature and propose potential avenues for enhancing the accuracy, efficiency, and real-world applicability of pothole detection systems.

By conducting a thorough literature review, you can gain valuable insights into the state of the art in pothole detection and deep learning, which can guide the development of your own research methodology and help you address potential challenges more effectively.

III.METHODOLOGY

The pothole detection project utilizing Tiny YOLOv4 is geared towards developing an advanced computer vision system capable of accurately and efficiently identifying and localizing potholes in road images or video data. The primary objective is to address the critical issues surrounding road safety, infrastructure maintenance, and traffic management within urban environments. Potholes present a significant challenge, often leading to hazardous conditions for motorists, cyclists, and pedestrians, as well as causing detrimental effects on vehicles and traffic flow. The project acknowledges the limitations of conventional methods for pothole detection, which often lack the precision and speed necessary for real-time intervention. In response, the implementation of deep learning techniques, with a specific focus on the Tiny YOLOv4 architecture, offers a promising solution. However, this approach necessitates a meticulous examination of data scarcity, model robustness across diverse environmental conditions, and the optimization of the detection system for practical deployment in real-world scenarios. Therefore, the project's scope encompasses an extensive exploration of data preprocessing techniques, including image augmentation, data labeling, and standardization, to ensure the model's efficacy in diverse settings and lighting conditions. Additionally, the project involves the comprehensive evaluation of the Tiny YOLOv4 model's performance through rigorous testing and validation using appropriate metrics, such as mean average precision (mAP) and F1-score, to guarantee the system's reliability and accuracy in identifying potholes. Furthermore, the project aims to overcome the challenges associated with the scarcity of annotated data by employing transfer learning methods and exploring the utilization of synthetic data generation to augment the existing dataset. By leveraging these approaches, the project endeavors to create a robust and scalable pothole detection solution that can be seamlessly integrated into urban infrastructure management systems, empowering authorities to implement proactive maintenance strategies and optimize resource allocation for infrastructure upkeep. The ultimate goal is to contribute to the enhancement of road safety, reduction of maintenance costs, and the facilitation of more efficient traffic management within urban landscapes

IV.IMPLEMENTATION

Implementing pothole detection using deep learning involves several steps, from data collection and preparation to model training and evaluation. Here is a simplified guide to get you started. Keep in mind that the actual implementation may vary based on the specific requirements and dataset characteristics.

Data Collection:

Gather a dataset containing images with and without potholes. You can use publicly available datasets or create your own by capturing images using cameras or smartphones. Annotate the images to mark the location and boundaries of potholes.

Data Preprocessing:

Split the dataset into training and testing sets. Resize the images to a consistent size. Normalize pixel values to a common range (e.g., [0, 1]). Augment the dataset with transformations like rotation, flipping, and zooming to improve model generalization.

Model Selection:

Choose a deep learning architecture suitable for image classification or object detection. Common choices include Convolutional Neural Networks (CNNs) or more advanced architectures like Faster R-CNN, YOLO, or SSD. You may use pre-trained models and fine-tune them on your pothole dataset to leverage the knowledge learned from other similar tasks.

Model Training:

Initialize your chosen model with pre-trained weights if available. Define a loss function (e.g., binary cross-entropy for binary classification). Choose an optimizer (e.g., Adam, SGD). Train the model on the training dataset, adjusting the weights based on the loss. Monitor the model's performance on the validation set to avoid overfitting.

Evaluation:

Assess the model's performance on the test dataset using metrics like accuracy, precision, recall, and F1 score. Visualize the model predictions on test images to understand its strengths and weaknesses.

Deployment:

Once satisfied with the model's performance, deploy it for real-world pothole detection. Depending on your application, this could involve integrating the model into a mobile app, using it in a web service, or implementing it on edge devices.

Continuous Improvement:

Monitor the model's performance in the deployed environment. Periodically retrain the model with new data to adapt to changing conditions.

V RESULTS:

Fig-2

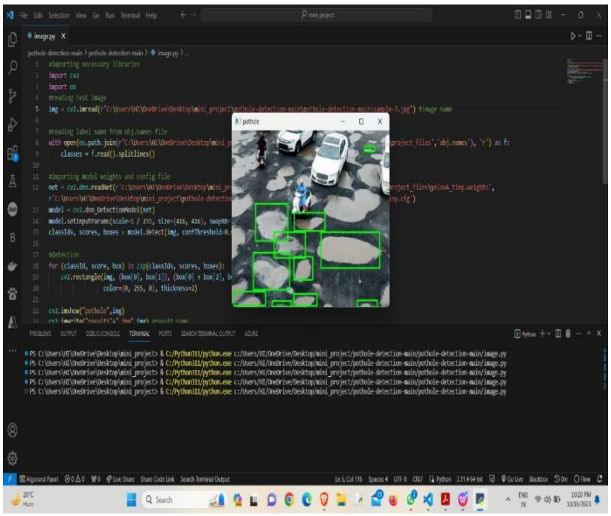

Fig-3

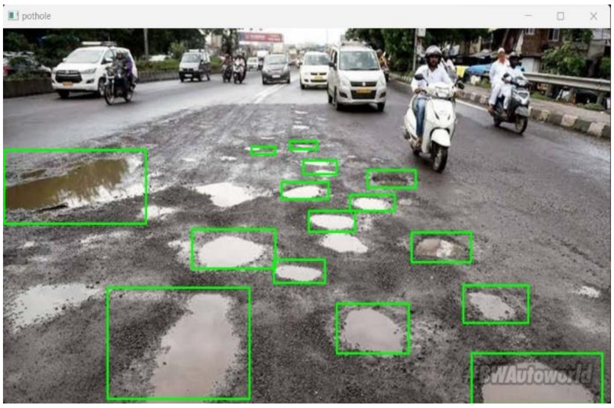

Fig -4

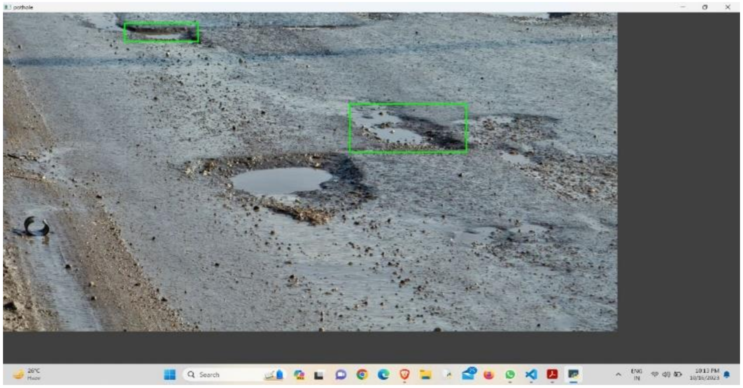

Fig-5

VI.CONCLUSION

Pothole detection using deep learning represents a significant advancement in road safety and maintenance. It offers a proactive solution to identify and locate road hazards swiftly, thereby minimizing potential accidents and vehicular damage. Deep learning models have shown promise in their ability to achieve high accuracy, even in challenging environmental conditions, making them invaluable for real-time pothole detection. As this technology matures, we can expect further improvements in accuracy, robustness, and adaptability to various scenarios. It will seamlessly integrate with other technologies, such as autonomous vehicles and predictive maintenance systems, creating safer and more efficient road networks. However, addressing privacy and ethical concerns, as well as fostering collaboration between stakeholders, will be pivotal to its widespread adoption and responsible use. Pothole detection using deep learning is not just a technological innovation; it's a key contributor to road safety and infrastructure maintenance, benefitting society as a whole.

I.

VII.REFERENCES

[1] O. o. I. R. a. Development, "Distress Identification Manual for the Long-Term Pavement Performance Project," U.S Department of Transportation Federal Highway Administration, 2014.

[2] I. G. V. P. Heggie, "Commercial Management and Financing of Roads," World Bank, Washington, 1998.

[3] A. M. Legreid, "Potholes and Strategies on the Road to Campus Internationalization," International Research and Review: Journal of Phi Beta Delta Honor Society for International Scholars, vol. 6, no. 1, 2016.

[4] A. F. Rita Justo-Silva, "Pavement maintenance considering traffic accident costs," International Journal of Pavement Research and Technology, 2019.

[5] S.-K. R. Taehyeong Kim, "A Guideline for Pothole Classification," International Journal of Engineering and Technology, vol. 4, 2014.

[6] B. X. Yu and X. Yu, "Vibration-Based System for Pavement Condition Evaluation," in Applications of Advanced Technology in Transportation, 2006.

[7] K. D. Zoysa, G. P. Seneviratne, W. W. A. T. Shihan and C. Keppitiyagama, "A Public Transport System Based Sensor Network for Road Surface Condition Monitoring," in SIGCOMM07: ACM SIGCOMM 2007 Conference, Kyoto, 2007.

[8] L. G. B. H. R. N. S. M. H. B. Jakob Eriksson, "The Pothole Patrol: Using a Mobile Sensor Network for Road Surface Monitoring," in Mobisys08: The 6th International Conference on Mobile Systems, Applications, and Services, Breckenridge, 2008.

[9] K. C. P. Wang, "Challenges and Feasibility for Comprehensive Automated Survey of Pavement Conditions," in Eighth International Conference on Applications of Advanced Technologies in Transportation Engineering (AATTE), Beijing, 2004.

[10] K. T. Chang, J. R. Chang and J. K. Liu, "Detection of Pavement Distresses Using 3D Laser Scanning Technology," in International Conference on Computing in Civil Engineering 2005, Cancun, 2005.

[11] Z. Hou, K. C. Wang and W. Gong, "Experimentation of 3d Pavement Imaging Through Stereovision," in International Conference on Transportation Engineering 2007, Chengdu, 2007.

[12] C. Koch and I. Brilakis, "Pothole detection in asphalt pavement images," Advanced Engineering Informatics, vol. 25, no. 3, pp. 507- 515, 2011.