Enhancing Autonomous Vehicle Safety with AI-Powered Pothole Detection

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Introduction

While autonomous vehicles (AVs) are becoming a viable method of transportation, they still face challenges in perception, environment detection, and real-time decision-making. One significant issue is the detection of potholes, which poses safety and reliability concerns. Current AV sensors provide rudimentary solutions but lack dependability, especially for potholes filled with rainwater or under varying lighting conditions. *We aim to address these limitations and enhance the safety of AVs and their passengers by leveraging deep learning techniques for real-time pothole detection.*

Objectives

This research seeks to improve pothole and road hazard detection for autonomous vehicles using AI and object detection. By implementing an AI-detection model for real-time image processing, we aim to:

1. Enhance the accuracy of pothole detection in various environmental conditions.
2. Enable real-time decision-making to mitigate the risks associated with road hazards.
3. Promote the widespread adoption of autonomous vehicles by improving passenger safety.

Methodology

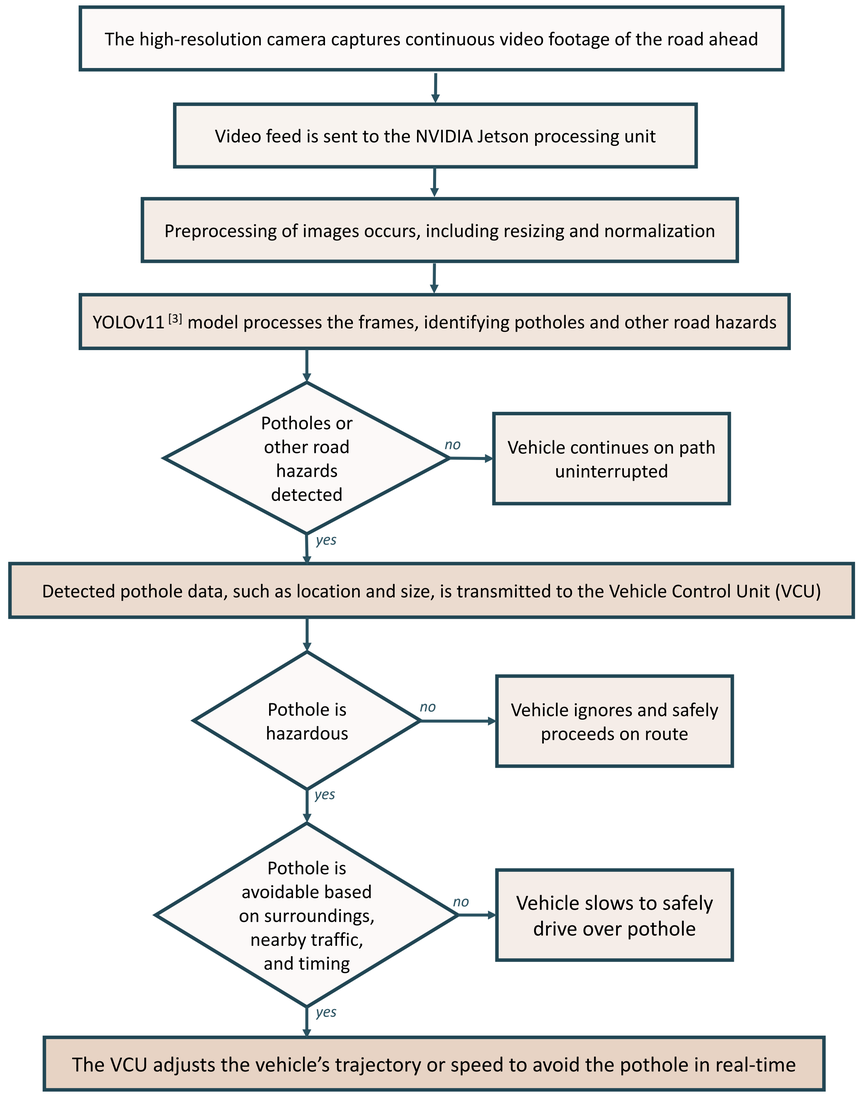
Collecting Data
- Over 4,000 images collected
- Use of Google Streetview API[1] and a high-resolution camera

Labeling
- Images annotated using Roboflow [2]
- Identified and labeled potholes

Training
- 70% train, 20% validate, 10% test
- Image preprocessing
- Use of YOLOv11 [3]

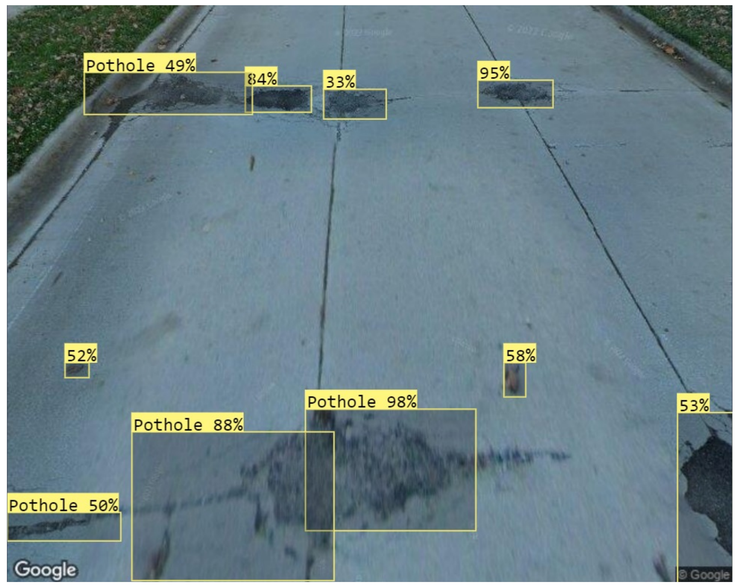
Implementing
- Hardware requirements
- Real-time image processing
- Detection algorithm
- VCU navigation and decision-making

System Design

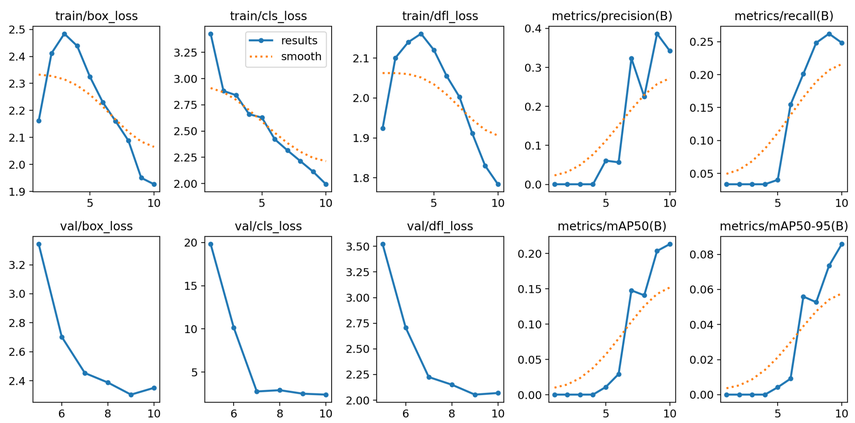


Data & Results

Model Detection and Confidence Scores [3]



Training/Validation Loss and Performance Metrics for YOLOv11 Object Detection Model [3]



Conclusions

This research has significant potential to improve the safety and trustworthiness of AVs, accelerating their mainstream adoption as a reliable mode of transportation. By integrating real-time detection with automated vehicle control, the system enhances the vehicle's ability to avoid hazards, ultimately improving safety and reliability. Future work will focus on refining the detection accuracy, optimizing the system for diverse road conditions, and incorporating it into existing AV technologies to overcome current limitations.

References & Acknowledgements

[1] Google, "Google Street View API," Google Developers. [Online]. Available: https://developers.google.com/maps/documentation/streetview/.

[2] Roboflow, "Roboflow: Computer vision dataset management and model training," Roboflow. [Online]. Available: https://roboflow.com/.

[3] G. Jocher, et al., "YOLOv11," GitHub repository, https://github.com/ultralytics/ultralytics, 2024.

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