AI CAR WITH REAL-TIME DETECTION OF DAMAGED ROAD AND LANE DETECTION

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Abstract: The objective of this project is to improve roadway management for autonomous vehicles by implementing AI-powered damage detection and lane detection systems. The primary focus is to develop algorithms that can accurately identify road damage and detect lane markings in real-time. By leveraging machine learning and computer vision techniques, this system aims to enhance safety and efficiency on roadways. The damage detection component will help self-driving cars navigate around obstacles and hazards effectively, while the lane detection feature ensures precise vehicle positioning within designated lanes. Overall, this integrated approach aims to improve the capabilities of autonomous vehicles, contributing to safer and more reliable transportation systems.

***Index Terms* -** YOLOv8, Canny edge detection, roadway management, AI-powered damage detection, lane detection, self-drivingcars, machine learning, computer vision, real-time detection, transportation safety.

I. INTRODUCTION

The integration of artificial intelligence (AI) and autonomous systems has brought transformative changes in various domains, including transportation. Self-driving cars are a pinnacle of such innovations, and they hold the promise of revolutionizing the way we commute by providing mobility solutions that are safer, more efficient, and more convenient, we aim to improve transportation for everyone. It is crucial for the successful deployment of autonomous vehicles to have precise and reliable perception and navigation abilities in complex road environments. In this context, efficient roadway management emerges as a critical component that ensures the safety and smooth operation of self-driving fleets. We understand the importance of these tasks in ensuring safe navigation, and as such, our focus is on developing robust algorithms that can accurately identify road damage and detect lane markings in real-time. To achieve this, we will be utilizing advanced techniques such as YOLOv8 for damage detection and Canny edge detection for lane detection. Our commitment to leveraging cutting-edge methodologies reflects our determination to deliver optimal performance.

Through the utilization of machine learning and computer vision, our objective is to equip autonomous vehicles with the ability to perceive and react to their environment with heightened awareness and accuracy. By incorporating these algorithms into the vehicle's onboard systems, we enhance its capacity to navigate around obstacles and hazards and also guarantee precise positioning within designated lanes.

Deep Learning

Deep learning models are a subset of machine learning algorithms that are designed to mimic the structure and function of the human brain's neural networks. These models are characterized by their ability to automatically learn hierarchical representations of data from raw inputs. The building blocks of deep learning models are interconnected neurons arranged in layers. Each neuron receives input signals,processesthem through an activation function, and produces an output signal.

YOLOv8

In YOLOv8, a convolutional neural network (CNN) is used to process input images by passing them through series of layers. These layers apply filters to detect patterns and features across different scales, enabling the network to extract meaningful information from the images. CNNs are effective for image tasks since they can learn features in a spatial hierarchy. This process enables YOLOv8 to detect objects accurately by learning and analyzing visual patterns in the input images.

Image Processing

Image Processing Techniques encompass a broad array of methods for manipulating and analyzing digital images. These techniques include operations such as filtering, enhancement, and transformation, aimed at improving image quality and extracting useful information. Canny edge detection is a popular image processing technique that utilizes a multi-stage algorithm to accurately detect edges.

Canny Edge Detection

Canny edge detection is a popular computer vision algorithm used to detect edges in images. It works by detecting abrupt changes in intensity, which often correspond to edges of objects or features in the scene. The Canny edge detector employs a multi-stage process involving Gaussian smoothing, gradient calculation, non-maximum suppression, and edge tracking by hysteresis to accurately identify edges while minimizing noise and false detections. By incorporating Canny edge detection for lane detection, we can reliably identify lane markings on road surfaces, providing crucial information for autonomous vehicles to maintain proper lane positioning and navigation.

Figure 1: Lane detection with deep learning

II. RELATED WORK

Authored by Vung Pham, this paper discusses the utilization of Google Street View for collecting and labeling road damage data, emphasizing its potential as a valuable resource for training road damage detection models. Additionally, it explores various state-of-the-art object detection methods and assesses their suitability for road damage detection and classification tasks. The review highlights the contributions of existing research in this area, identifying gaps and opportunities for further investigation.

Authored by Keval Doshi, this paper introduces an ensemble model for road damage detection. The model leverages the state-of-the-art YOLOv4 object detector as its base, trained on images depicting various typesof road damages sourced from Czech, Japan, and India. Through deep ensemble learning techniques, the proposed approach aims to enhance the accuracy and robustness of road damage detection systems, contributing to improved roadway maintenance and safety.

Authored by Yaxin FENG, Yuan LAN, Luchan ZHANG, and Yang XIANG, this paper presents ElasticLaneNet, a novel and efficient geometry-flexible approach for lane detection. The framework introduces a new concept of lane implicit representation, allowing it to effectively handle highly complex lane shapes such as crosses, large curves, and Y-shaped lanes. Situated within the College of Mathematics and Statistics at Shenzhen University, China, this research offers a promising solution for robust and accurate lane detection in diverse road environments.

Authored by Sapir Kontente, Roy Orfaig, and Ben-Zion Bobrovsky, this research presents CLRMatchNet, a novel approach for enhancing curved lane detection through deep matching processes. The proposed MatchNet sub-module replaces traditional label assignment methods within state-of-the-art lane detection networks, such as the Cross Layer Refinement Network for Lane Detection (CLRNet). Situated within the School of Electrical Engineering at Tel-Aviv University, this research introduces an innovative technique to improve the accuracy and robustness of lane detection systems.

The edge-detection version emphasizes the outlines of cars, road markings, and other elements, revealingthe underlying structure of thescene.

III. IMPLEMENTATION

Loading YOLO Model:

Load the YOLO model for road damage detection using Ultralytics YOLO library.

Retrieve the class names for road damages.YOLO Detection Function:

Implement a function (yolo_detection) to perform road damage detection using the YOLOmodel:

Convert the image to the required format and size.Predict road damages using YOLO.

Draw bounding boxes and labels for detected damages on the image.

Road Lane detection:

Create a pipeline funct

The image processing functions in the Combined Detection Application work together to prepare input images for road lane detection.These functions include:

- **Region of Interest**
- **Grayscale Conversion:** Converts the RGB image to grayscale, retaining essential intensity information.
- **Canny Edge Detection:** Identifies edges in the grayscale image, highlighting potential lane markings.
- **Gaussian Blurring:** Smoothens the image to reduce noise and enhance edge detection accuracy.

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IV.METHODOLOGY

The proposed system is a Combined Detection Application designed for road lane and road damage detection. It utilizes both computer vision techniques and deep learning models to accurately analyze road conditions. The system offers both image and video processing capabilities, allowing users to upload files and select the desired detection type. For road lane detection, the application utilizes techniquessuch as grayscale conversion, edge detection, and Hough transform to identify lane markings. Additionally, for road damage detection, thesystem employs YOLO object detection to detect various types of damage on the road surface. The Stream lit interface provides a user- friendly experience, enabling users to interact with the application seamlessly. The ultimate goal of the system is to improve road safety byproviding a versatile tool to analyze road conditions. The Combined Detection Application integrates two functionalities: Road Lane Detection and Road Damage Detection using YOLO (You Only Look Once).

V. RESULTS

Figure 2: Patch Holes detected

The description emphasizes the dual-color representation of the detected lanes, with green indicating one set of detected lanes and red highlighting another set. This color scheme enhances the visualization of lane detection accuracy for users. Additionally, the presence of the "Select Detection Type" option on the left side of the interface, with "Road Lane Detection" chosen, indicates the software's specific focus on lane detection. Furthermore, the availability of the "Run Lane Detection on Image" button suggests that users can conveniently initiate lane detection processing on their uploaded images with a single click. Overall, this description offers a clear understanding of thelane detection results and the functionality of the software interface.

VI. CONCLUSION

The conclusion highlights the successful integration of traditional computer vision techniques and state-of-the-art deep learning models forroad lane and road damage detection, emphasizing the practical utility of the application in various real-world scenarios.

Additionally, the conclusion reflects on the effectiveness of the application in enhancing road safety, facilitating proactive maintenancemeasures, and contributing to the optimization of transportation infrastructure management. It underscores the importance of accurate and efficient detection of lane markings and road damages inmitigating risks and improvingoverall road conditions.
Moreover, the conclusion discusses potential areas for future research and development, such as enhancing detection accuracy, optimizingcomputational efficiency, and expanding the application's capabilities to address evolving road infrastructure challenges. It also acknowledges any limitations encountered during the project and proposes strategies for overcoming them in future iterations.

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