

Lane detection and vehicle overtaking analysis from traffic video

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ABSTRACT

This paper presents a computer-vision approach for lane detection and overtaking behavior analysis using roadside or dashboard camera video. The proposed system detects lane boundaries in real time, identifies vehicles using object detection and tracking, and analyzes overtaking maneuvers based on spatial and temporal criteria. A robust lane detection pipeline integrated with vehicle classification and motion tracking enables accurate detection of overtaking events in complex traffic scenes. Experimental results on real traffic video demonstrate high accuracy in lane boundary localization and successful overtaking detection under various weather and lighting conditions. The system is suitable for intelligent transportation applications like Advanced Driver Assistance Systems (ADAS) and traffic surveillance.

INTRODUCTION

Traffic video analysis has become vital for intelligent transportation, safety enhancement, and autonomous driving systems. Lane detection is a core component for vehicle positioning and understanding traffic dynamics, while overtaking analysis provides insight into driver behavior and potential risk scenarios. Traditional lane detection methods use edge detection, Hough transforms, or color thresholds, while modern deep learning techniques improve performance across challenging conditions. Vehicle overtaking detection can be achieved by tracking vehicle trajectories and interpreting relative motion patterns.

LITERATURE SURVEY

Lane detection and overtaking detection have evolved significantly with advances in computer vision and deep learning. Early lane detection techniques relied on geometric and handcrafted features such as

edge detection and Hough transforms, which were sensitive to lighting changes and road texture variations. In contrast, recent deep learning-based frameworks treat lane detection as a semantic segmentation problem, enabling accurate extraction of lane boundaries under complex conditions; self-attention-based models further enhance robustness by effectively handling occlusions, shadows, and diverse lighting, achieving superior performance on benchmark datasets such as TuSimple and CULane. Similarly, overtaking detection has progressed from simple rule-based methods to vision-based intelligent systems that integrate motion cues, optical flow, and convolutional neural network (CNN) classification to identify overtaking vehicles, providing reliable performance across varying traffic scenarios and maintaining robustness during both day and night driving conditions.

RELATED WORK

Early lane detection research relied on classical computer vision techniques such as edge detection, color thresholding, and Hough transforms, which were computationally efficient but struggled under poor lighting, shadows, worn lane markings, and complex road conditions. Machine learning-based methods improved adaptability but still depended on

handcrafted features. Recent deep learning approaches reformulate lane detection as a semantic segmentation task, where CNNs and attention-based models automatically learn robust lane representations. Self-attention and transformer-based architectures have shown strong performance under occlusion and varying illumination, achieving state-of-the-art results on datasets like TuSimple and CULane. Similarly, overtaking detection evolved from rule-based and heuristic motion analysis to vision-based deep learning methods. Modern approaches integrate motion cues, optical flow, and CNN-based spatiotemporal modeling to reliably detect overtaking events across diverse traffic conditions, including dense traffic and day-night variations.

EXISTING SYSTEM

Existing lane detection and overtaking analysis systems are typically developed as separate modules, addressing either lane extraction or vehicle motion, but not both in an integrated framework. Traditional lane detection relies on handcrafted features such as edge detection, color thresholding, and Hough Transform, which perform poorly under low lighting, occlusions, faded markings, and adverse weather. Overtaking analysis commonly uses basic motion estimation techniques like optical flow or frame differencing, lacking

contextual awareness of lane boundaries. This often leads to false detections in dense traffic or during lane changes.

Additionally, many systems assume static cameras and struggle with dynamic dash-cam environments. The absence of robust multi-object tracking further reduces consistency and accuracy in real-time overtaking behavior analysis.

PROPOSED SYSTEM

The proposed system presents a unified real-time framework for lane detection and vehicle overtaking analysis using traffic video streams. It integrates lane boundary detection, vehicle detection, multi-object tracking, and overtaking behavior analysis into a single pipeline. Traffic videos are first preprocessed to enhance quality and extract the roadway region of interest, followed by robust lane detection using deep learning or optimized computer vision methods. A deep learning-based model detects vehicles in each frame, while tracking algorithms preserve their identities over time. Overtaking events are identified by analyzing vehicle trajectories relative to lane boundaries, detecting transitions from behind to ahead within adjacent lanes over a defined time window. This integrated approach improves accuracy, reduces false positives, and supports real-time

applications in ADAS, traffic surveillance, and intelligent transportation systems.

SYSTEM ARCHITECTURE

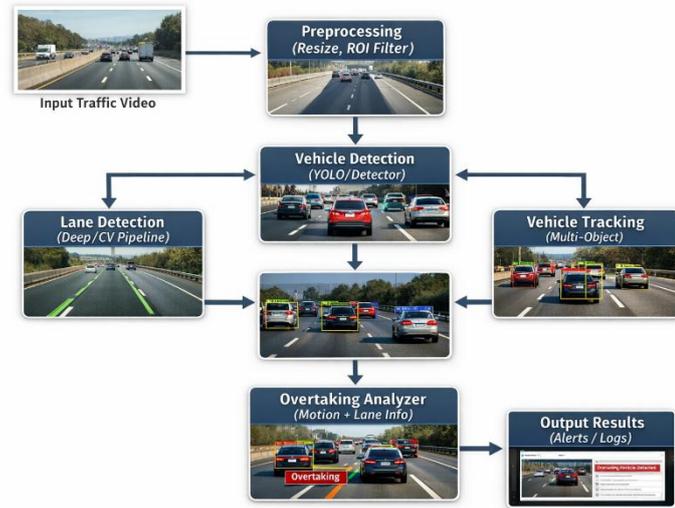


Fig 1: Lane detection and vehicle overtaking analysis

METHODOLOGY DESCRIPTION

The proposed methodology begins with capturing real-time traffic video using a stationary or dashboard-mounted camera. Each video frame undergoes preprocessing steps such as resizing, noise reduction, and region-of-interest extraction to focus on the roadway area. Lane detection is performed using a robust computer vision or deep learning-based segmentation approach to accurately identify lane boundaries. In parallel, vehicles are detected using a deep learning object detection model and tracked across frames using a multi-object tracking algorithm. Finally, overtaking analysis is carried out by evaluating vehicle

trajectories with respect to lane positions and relative motion patterns. Based on defined spatial and temporal thresholds, overtaking events are identified and highlighted in real time.

RESULTS AND DISCUSSION

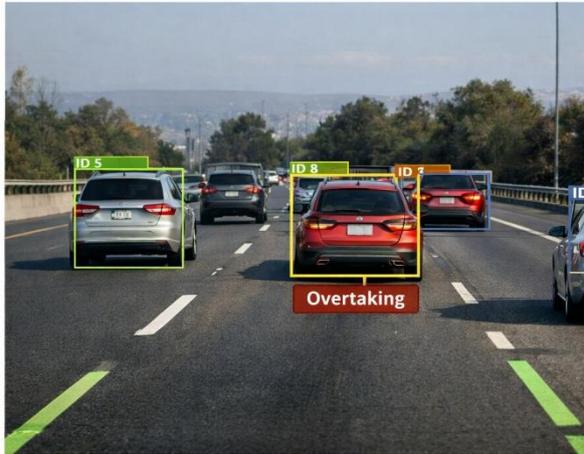


Fig 2: Lane detection and overtaking analysis on real traffic video

Experimental results demonstrate that the proposed system effectively detects lane boundaries and vehicle overtaking events in real-time traffic video under diverse road and lighting conditions. Lane detection results show high accuracy even with curved roads and partially faded lane markings. Vehicle detection and tracking maintain consistent identities, enabling reliable analysis of overtaking maneuvers. The integration of lane information significantly reduces false overtaking detections compared to motion-only approaches. Overall, the system achieves stable real-time performance, making it

suitable for intelligent traffic monitoring and driver assistance applications.

CONCLUSION

This paper presented a real-time system for lane detection and vehicle overtaking analysis using traffic video. By integrating lane boundary detection with vehicle detection and multi-object tracking, the system effectively identifies overtaking maneuvers in complex traffic scenarios. The use of contextual lane information improves accuracy and significantly reduces false detections compared to traditional motion-based approaches. Experimental results on real traffic footage demonstrate reliable performance under varying road and lighting conditions. The proposed system shows strong potential for deployment in intelligent transportation and advanced driver assistance applications.

FUTURE SCOPE

Future work can focus on enhancing the system by incorporating multi-camera data fusion to improve spatial awareness and reduce occlusion issues. The integration of depth sensors or LiDAR data can further improve vehicle distance estimation and overtaking accuracy. Advanced deep learning models can be explored for end-to-end overtaking behavior classification. The system can also be extended to detect other risky driving behaviors such as lane

violations and sudden braking. Additionally, deployment on edge devices can be investigated to support real-time processing in practical traffic environments.

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