KI WISSEN
Automotive AI Powered by Knowledge

1.15 Multi-Modal Sensor Fusion for Robust Obstacle Detection

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Detection

Motivation

Perception and multi-modal sensors are pivotal in the autonomous driving domain, enhancing the vehicle's ability to interpret its surroundings. By integrating visual, radar, and LiDAR sensors, autonomous vehicles can navigate diverse environments, detect obstacles, and make real-time decisions. This comprehensive sensory input ensures a robust and reliable perception system, crucial for the safety and efficiency of self-driving cars in complex and dynamic traffic scenarios.

Existing Problems

Reliance on a single modality sensor for obstacle detection in autonomous driving introduces significant limitations. For instance, a single sensor, such as a camera, may struggle in adverse weather conditions or fail to accurately perceive certain objects. Integrating multi-modal sensors, including LiDAR, mitigates these limitations, providing a more comprehensive and reliable perception system for effective obstacle detection in diverse driving environments. In addition, a significant limitation of object detection models is their inability to detect unknown classes, as they are trained on predefined categories and may struggle when encountering objects or entities not present in their training data.

Technical Solution

This work proposes a solution that uses multi-modal sensors data to identify potential obstacles in a traffic scene. This approach uses drivable road from 3D Lidar points as an external knowledge to identify the plane of the road. Using this plane height of each point is estimated followed by clustering of all mapped LiDAR points, where each cluster represents an object/obstacle. These detections are then used to validate camera-based detections[1].

Evaluation Metric

While mAP is frequently utilized in computer vision tasks, it may inadequately address the critical nature of false positives and false negatives in autonomous driving, where the consequences of misidentifying objects or failing to detect obstacles can be severe. Consequently, we propose $mAP_{critical}$, which adapts mAP to incorporate the context of object criticality by considering objects within the safety distance of the ego vehicle, as those outside this defined safety distance are physically unreachable, rendering them inherently uncritical.

	Baseline	Ours
$mAP_{critical}$	28.9	29.6 (↑0.7)
$mAP_{critical}$@50	73.2	74.7 (↑1.5)
$mAP_{critical}$@75	14.5	15.8 (↑1.3)

Table 1: Performance Comparison with Baseline (© DFKI GmbH)

Performance Evaluation

The evaluation of this approach was performed on nuScenes[2] dataset. Evaluation results show gain in performance using our approach as compared to the baseline approach.

Key Highlights

- Robust approach
- Identifies unknown objects
- Relatively less false positives & negatives
- Cross-modal verification of detected objects
- Object criticality-based metric

References:

[1] A. H. Khan, M. S. Nawaz, A. Dengel; Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2023
[2] nuScenes: A multimodal dataset for autonomous driving", H. Caesar, V. Bankiti, A. H. Lang, S. Vora, V. E. Liong, Q. Xu, A. Krishnan, Y. Pan, G. Baldan and O. Beijbom, In CVPR 2020

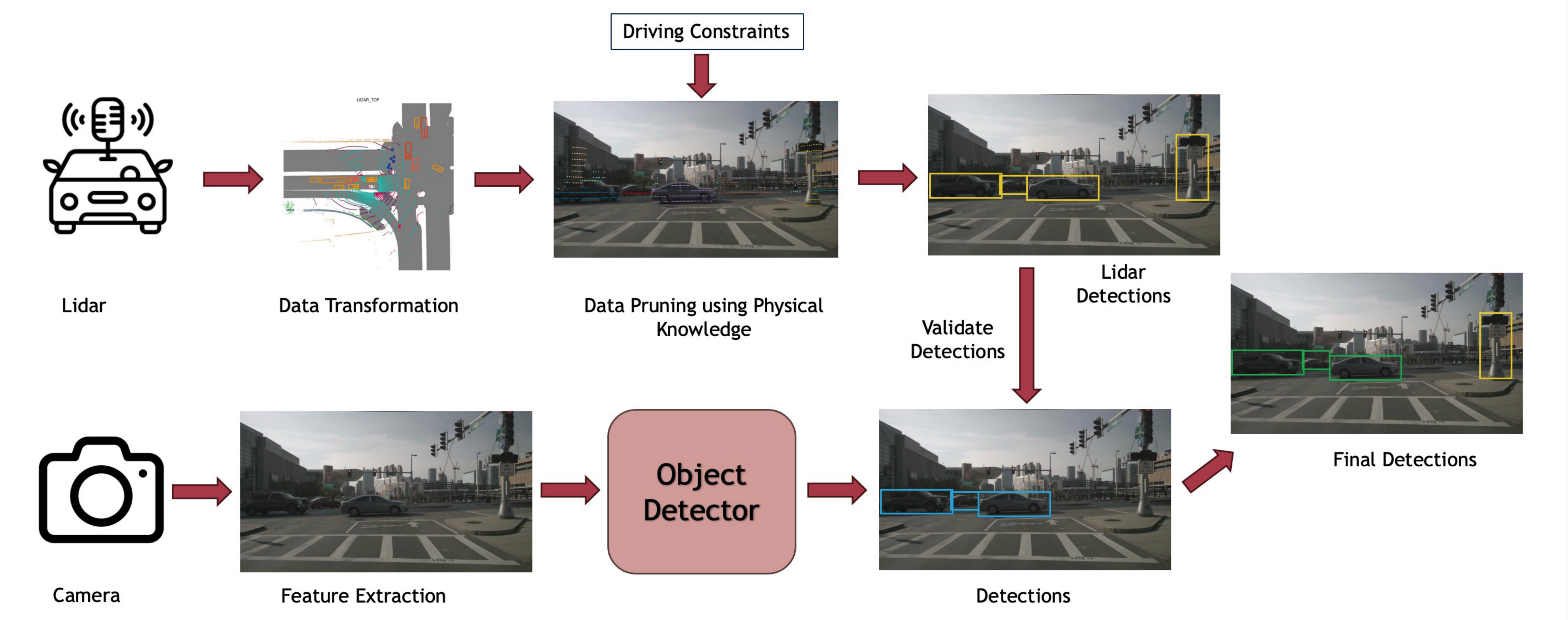

Figure 1: Multi-modal Sensor Fusion Pipeline for Obstacle Detection (© DFKI GmbH)

Partners

External partners

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