Anomaly Detection for Semi-Supervised 3D Object Detection

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Background

Building a dataset for training and evaluating the performance of a neural network for object detection is a challenging task when considering the perspective of annotation cost, i.e., time and mouse clicks by hand required to draw 3d bounding boxes per LiDAR point cloud respectively. To address this issue [1] published CTRL at ICCV 2023 - the first open-sourced LiDAR-based auto-labelling system. While their model significantly outperformed previous online and offline 3D detection models on the Waymo Open Dataset (WOD) [2], from 1.03M vehicle objects 5.1k (0.48%) were missed by the detector. However, these results were achieved based on expensive training (with 8 GPUs for 20 hours per class) without any pseudo labels and a training-to-validation data ratio of 7:2.
Therefore, the goal of this thesis is to implement [1]'s approach for a pool of unlabeled raw sensor data from the Open Sensor Data for Rail 2023 (OSDaR23) dataset [3] and further improve their framework using significantly less manual-labeled data and compute for training. The final result should be a more efficient process to accelerate the generation of 3D annotations and save a huge amount of human manual workload.

Description

The main focus of this work is to implement and test various improvements of [1]'s LiDAR-based auto-labelling system by 3D anomaly detection, e.g., out-of-distribution detection. [1]'s approach is to reduce the amount of human manual workload by outputting as many high-quality annotations as possible. We observe a higher manual workload in annotating objects than in removing false annotations and suggest using low confidence thresholds in combination with a semi-supervised anomaly detector framework. This should result in a human-in-the-loop framework auditing reported anomalies of a certain degree and ultimately decrease the number of falsely detected vehicles.
We argue that autonomous driving will be technically feasible earlier in the railway domain than in the well-researched automotive domain due to fewer degrees of freedom and noise in traffic. Using OSDaR23 offers testing for a domain switch and acquiring valuable insights for autonomous driving.

Tasks

- Literature research on 3D anomaly detection and semi-supervised learning
- Implementation of anomaly detection framework on top of CTRL's base detector and CTRL
- Evaluate new framework on WOD and OSDaR23
- Optional: Evaluate on Siemens' railway dataset

References

[1] Lue Fan, Yuxue Yang, Yiming Mao, Feng Wang, Yuntao Chen, Naiyan Wang, and Zhaoxiang Zhang. Once detected, never lost: Surpassing human performance in offline lidar based 3d object detection, 2023.

[2] Pei Sun, Henrik Kretzschmar, Xerxes Dotiwalla, Aurelien Chouard, Vijaysai Patnaik, Paul Tsui, James Guo, Yin Zhou, Yuning Chai, Benjamin Caine, Vijay Vasudevan, Wei Han, Jiquan Ngiam, Hang Zhao, Aleksei Timofeev, Scott Ettinger, Maxim Krivokon, Amy Gao, Aditya Joshi, Yu Zhang, Jonathon Shlens, Zhifeng Chen, and Dragomir Anguelov. Scalability in perception for autonomous driving: Waymo open dataset. *CoRR*, abs/1912.04838, 2019.

[3] Rustam Tagiew, Pavel Klasek, Roman Tilly, Martin Köppel, Patrick Denzler, Philipp Neumaier, Tobias Klockau, Martin Boekhoff, and Karsten Schwalbe. Osdar23: Open sensor data

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Research project:
FAI

Type:
MT

Research area:
Formal verification, neural networks

Programming language:
Python

Required skills:
Knowledge in formal methods and machine learning, good mathematical background

Language:
English

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