SimBusters: Bridging Simulation Gaps in Intelligent Vehicles Perception

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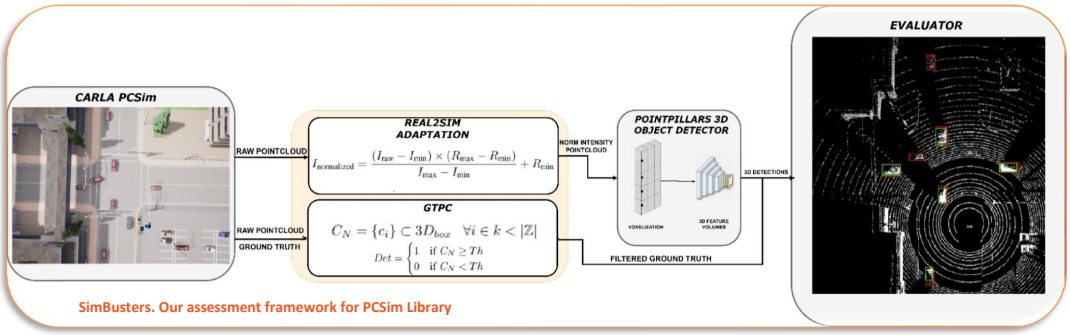
Context

Currently, LiDAR technology has become increasingly vital for perception in autonomous driving, due to its capability to accurately represent surroundings in three dimensions.
In this context, virtual environments are highly advantageous, as they offer limitless data collection and simplify labeling processes.

However, a significant challenge in 3D Object Detection is the transition from simulated data to real-world applications, due to differences in data characteristics between the two environments.

Objective

This paper presents an innovative approach to bridge the gap between LiDAR simulation and reality. For it, we develop, test, and validate within a realistic LiDAR library , PCSim, implemented in CARLA simulator.



SimBusters. Our assessment framework for PCSim Library

Contributions

- We present a novel assessment framework that evaluates how much PCSim mimics real LiDARs by state-of-the-art.
- We build a Real2Sim domain adaptation procedure, to transfer real-world 3D object detectors in enhanced CARLA.
- To make fair ground truth measurements for our validations, we have developed a Ground Truth Pointcloud Clustering (GTPC) method.

Evaluations

This section shows the results after conducting our experiment. We evaluated PointPillars model, pre-trained in real-world datasets, using 4 different sensor models with PCSIM + DA technique. We incorporated our Real2Sim domain adaptation, to see how detector's performance behaves after intensity normalization.

PointPillars detector trained in KITTI. Velodyne HDL-64

PointPillars detector trained in Pandaset. Hesai Pandar-64

Ground truth (red) vs vehicle detections (green) in PCSim

DATASET	PCSim LiDAR	DA	IoU	mAP @ 0.7
KITTI	HDL-64	-	4.29 %	12.34 %
	HDL-64	Real2Sim	1.42 %	10.26 %
NuScenes	HDL-32	-	8.33 %	13.23 %
	HDL-32	Real2Sim	8.33 %	13.23 %
	CARLA-32	-	9.52 %	20.58 %
	CARLA-32	Real2Sim	9.52 %	20.58 %
PandaSet	Pandar64	-	2.27 %	8.45 %
	Pandar64	Real2Sim	0.0 %	2.81 %

Comparison of different PointPillars-based detectors performance in PCSim

Conclusions and future works

Our results, based on SOTA metrics, highlight the importance of considering the intensity and pointcloud distribution in LiDAR-based 3D detectors.
To sum up, our assessment in PCSim shows that this library proves to be a promising solution for simulating realistic LiDARs in CARLA.
We aim to work on further validations in this field, comparing more 3D object detection models, real-world datasets, and sensors to this library.
Moreover, we think that PCSim has potential for transitioning models trained in simulated data to real-world situations.

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