KI DELTA LEARNING
Scalable AI for Automated Driving

HALS: A Height-Aware Lidar Super-Resolution Approach for Autonomous Driving

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Introduction

High-resolution sensors provide more details about the surroundings because they contain more vertical beams, but they come at a much higher cost, limiting their inclusion in autonomous vehicles. Upsampling lidar pointclouds is a promising approach to gain the benefits of high resolution while maintaining an affordable cost.

Motivation:

Lidar Pointlouds exhibit a hight-aware range distribution.

Contributions:

- In this work, we present a strong empirical evaluation of previous works on the Kitti Raw dataset with unified metrics, which reveals the superiority of grid-based methods relative to point-based methods.
- We present a novel framework for lidar Upsampling.
- Evaluations on three standard datasets, Kitti Raw, Kitti Object detection and Nuscenes, show the effectiveness and superior performance of HALS compared to the baselines.

Method:

- We propose a novel grid-based generator architecture that upsamples the pointcloud at different receptive fields, so that it can adapt to the range distribution of the upper and lower parts of the range image. Each upsampling branch outputs a confidence map of its own prediction.
- This can be considered as a Bayesian network with different upsampling layers, where each one layer has a different receptive field.
- Shallow upsampling layer focuses on the upper part of the range image, deeper upsampling layer upsamples the lower part.
- We propose to use polar coordinates in the input and output range image. Moeover, we show the importance of adopting a surface normal loss besides the conventional L1-loss to preserve structural details.

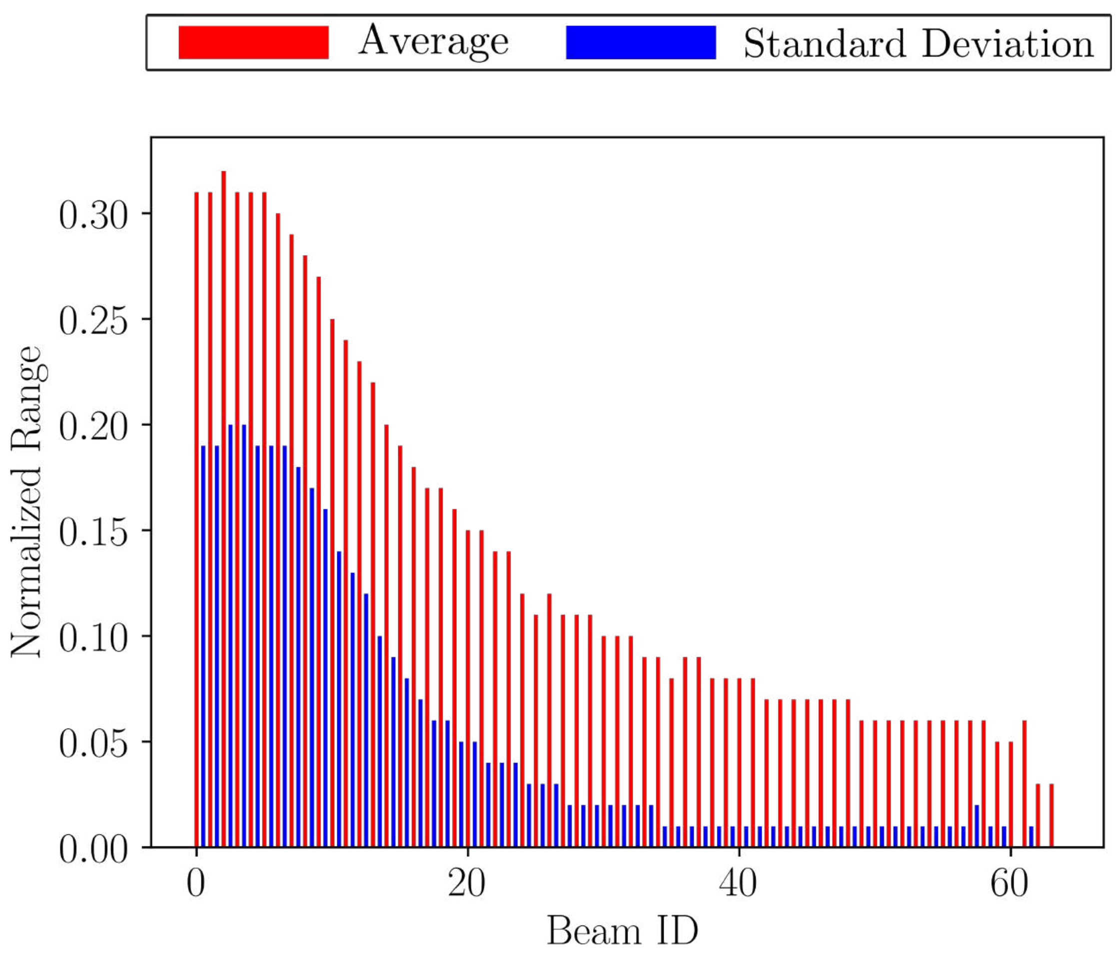

Figure 1: We record the average range and standard deviation per beam (a beam corresponds to a row in the range image.) Beam 0 represents the highest one from the ground. We note that the range distribution exhibits a height-dependent behaviour: faraway objects are mostly represented in the upper part of the range image.

Results

We outperform previous approaches in 2D and 3D metrics.

Model	EMD ↓	CD ↓	MAE ↓	RMSE ↓	IOU ↑	Precision ↑	Recall ↑	F1-score ↑
KITTI Raw Dataset 4x Output Resolution: 40×256								
Bilinear	173	0.110	0.62	1.30	0.097	0.177	0.174	0.176
LIDAR-CNN [20]	101	0.052	0.19	0.86	0.393	0.564	0.564	0.564
LIDAR-SR [11]	130	0.162	0.39	2.03	0.342	0.515	0.506	0.51
SWIN-IR [27]	101	0.051	0.19	**0.85**	0.451	0.621	0.621	0.621
ILN [16]	104	0.061	0.23	0.93	0.392	0.588	0.54	0.563
Ours	**82**	**0.015**	**0.17**	0.89	**0.510**	**0.672**	**0.671**	**0.671**
KITTI Object Dataset 4x Output Resolution: 64×700								
Bilinear	834	0.270	1.30	3.94	0.110	0.181	0.203	0.191
LIDAR-CNN [20]	390	0.105	0.48	2.98	0.256	0.400	0.410	0.411
LIDAR-SR [11]	757	0.110	1.113	5.59	0.277	0.447	0.419	0.432
SWIN-IR [27]	391	0.105	**0.44**	**2.81**	0.376	0.537	0.554	0.545
ILN [16]	629	0.101	0.49	2.97	0.336	0.501	0.504	0.502
Ours	**369**	**0.09**	0.45	3.01	**0.402**	**0.567**	**0.573**	**0.57**
Nuscenes Dataset 2x Output Resolution: 32×1024								
Bilinear	595	0.89	1.53	5.31	0.106	0.181	0.201	0.19
LIDAR-CNN [20]	388	0.231	0.82	4.97	0.317	0.467	0.493	0.48
LIDAR-SR [11]	514	0.209	1.39	6.77	0.200	0.340	0.325	0.332
SWIN-IR [27]	373	0.210	0.75	4.90	0.332	0.489	0.506	0.498
ILN [16]	383	0.198	0.73	4.82	0.501	0.656	**0.678**	0.667
Ours	**338**	**0.171**	**0.69**	**4.72**	**0.505**	**0.664**	0.676	**0.670**

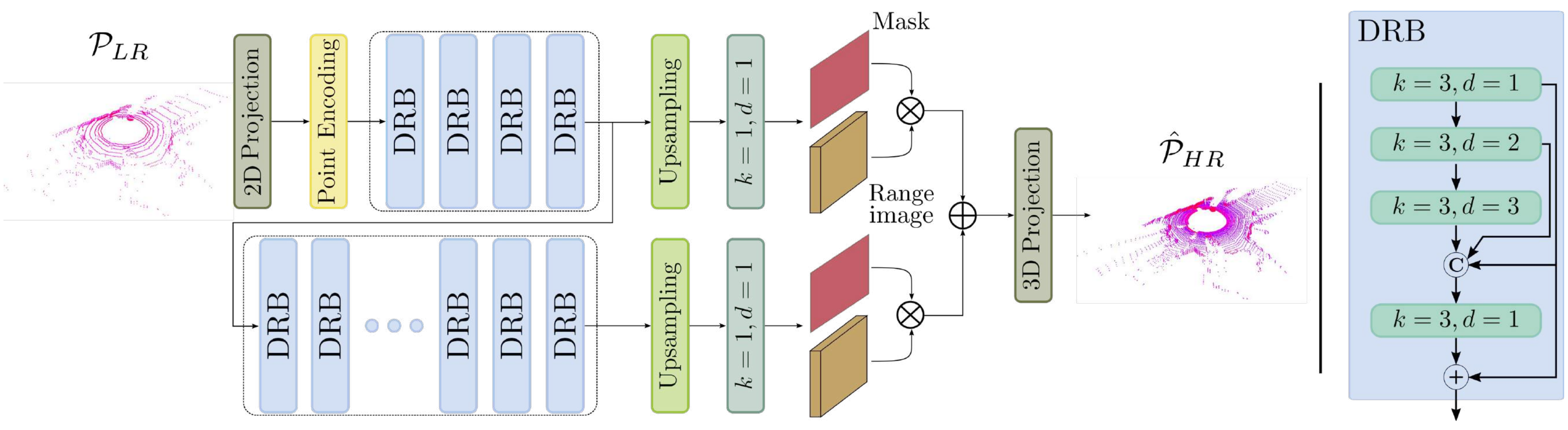

Figure 1: Left: The proposed generators architecture. We upsample the pointcloud at two locations in the backbone, intentionally chosen to have a local and a global receptive field. Both outputs are fused using confidence maps from each branch. Right: The architecture of the DRB used in the backbone to provide flexible receptive fields.

Sensors

Partners

External partners

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