DurLAR

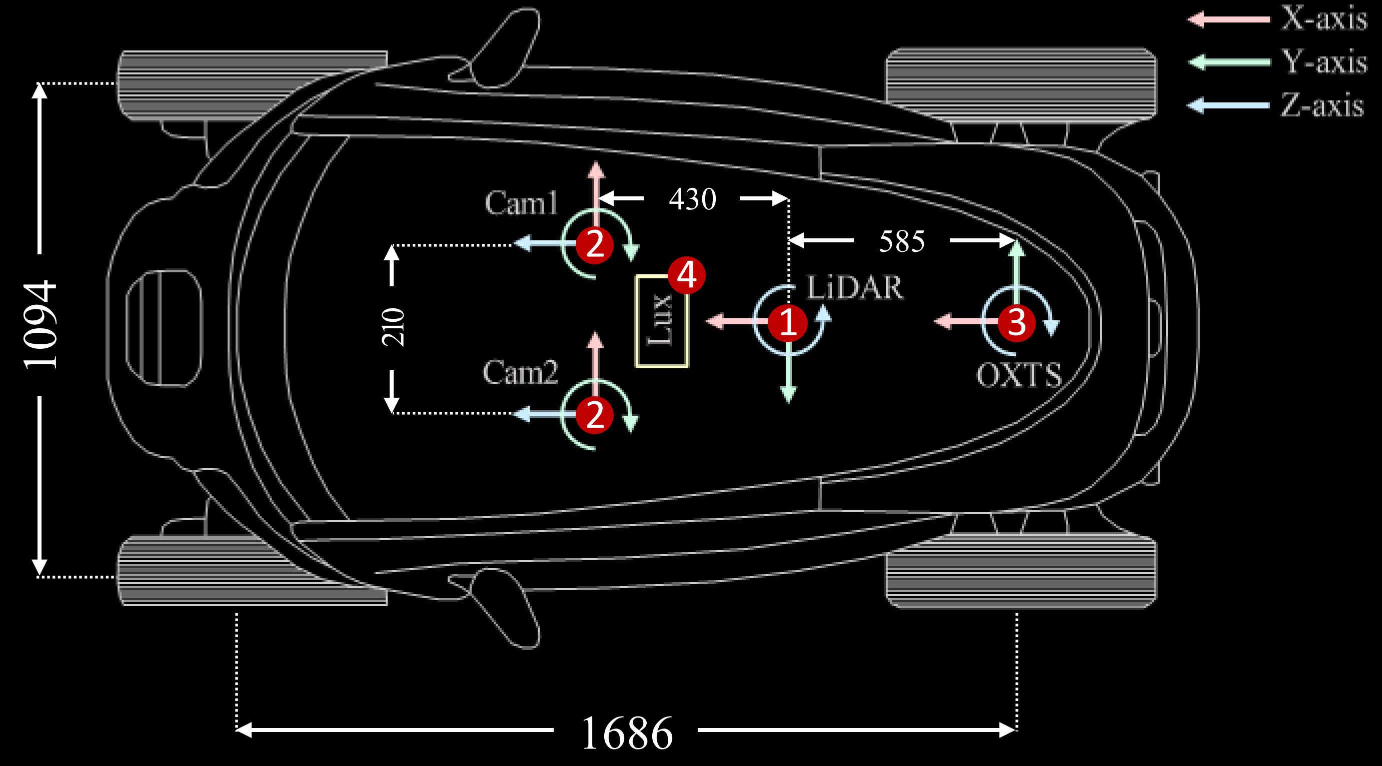
The World 1st High-fidelity 128-channel LiDAR Dataset

Li (Luis) LI

Department of Computer Science
Durham University
li.li4@durham.ac.uk

Supervisors: Prof Toby Breckon
Dr Hubert P. H. Shum

Twizy Vehicle
Sensor Placement



1 Ouster LiDAR
2 Stereo camera
3 GNSS/INS antenna
3 GNSS/INS (inside)
4 Lux meter

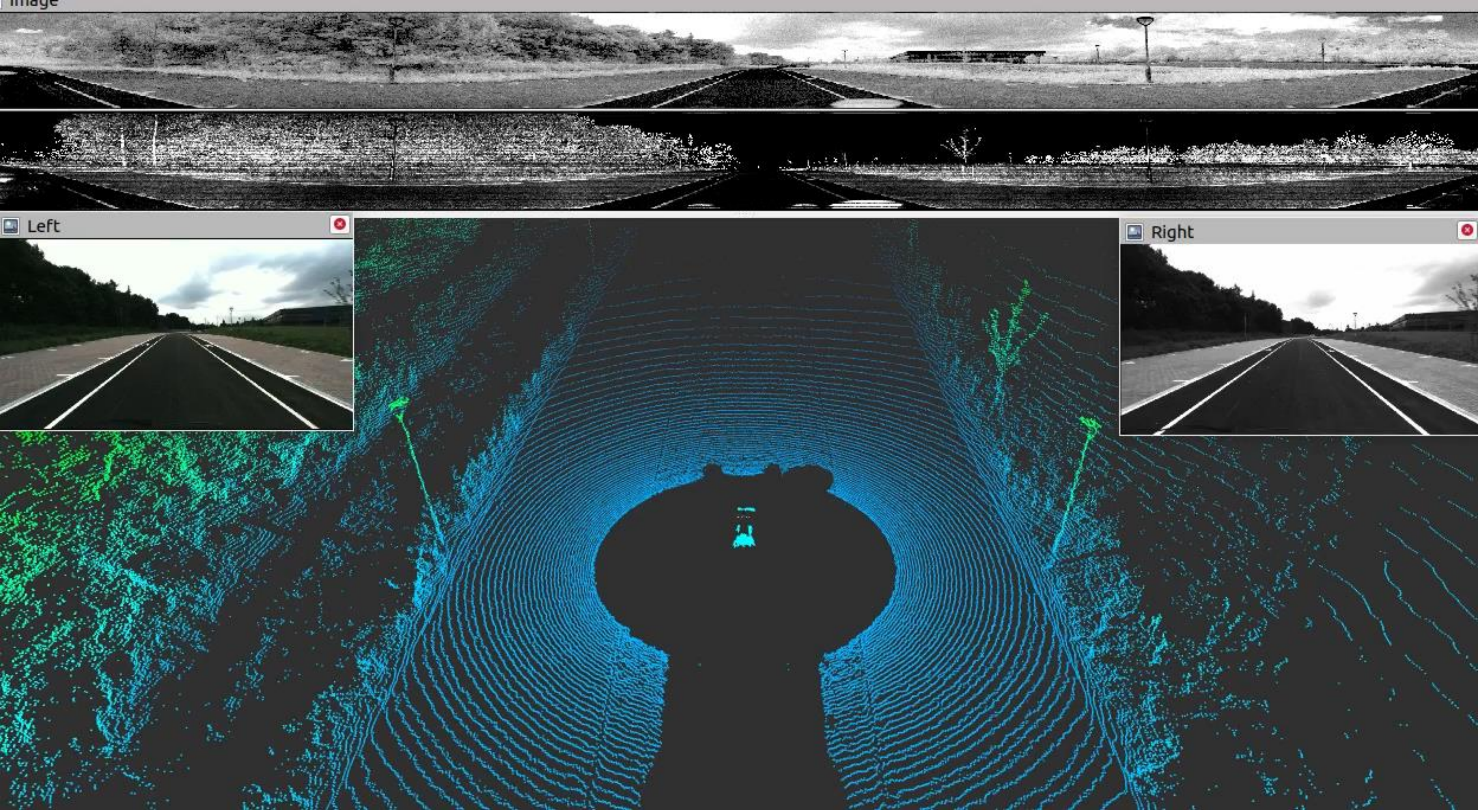
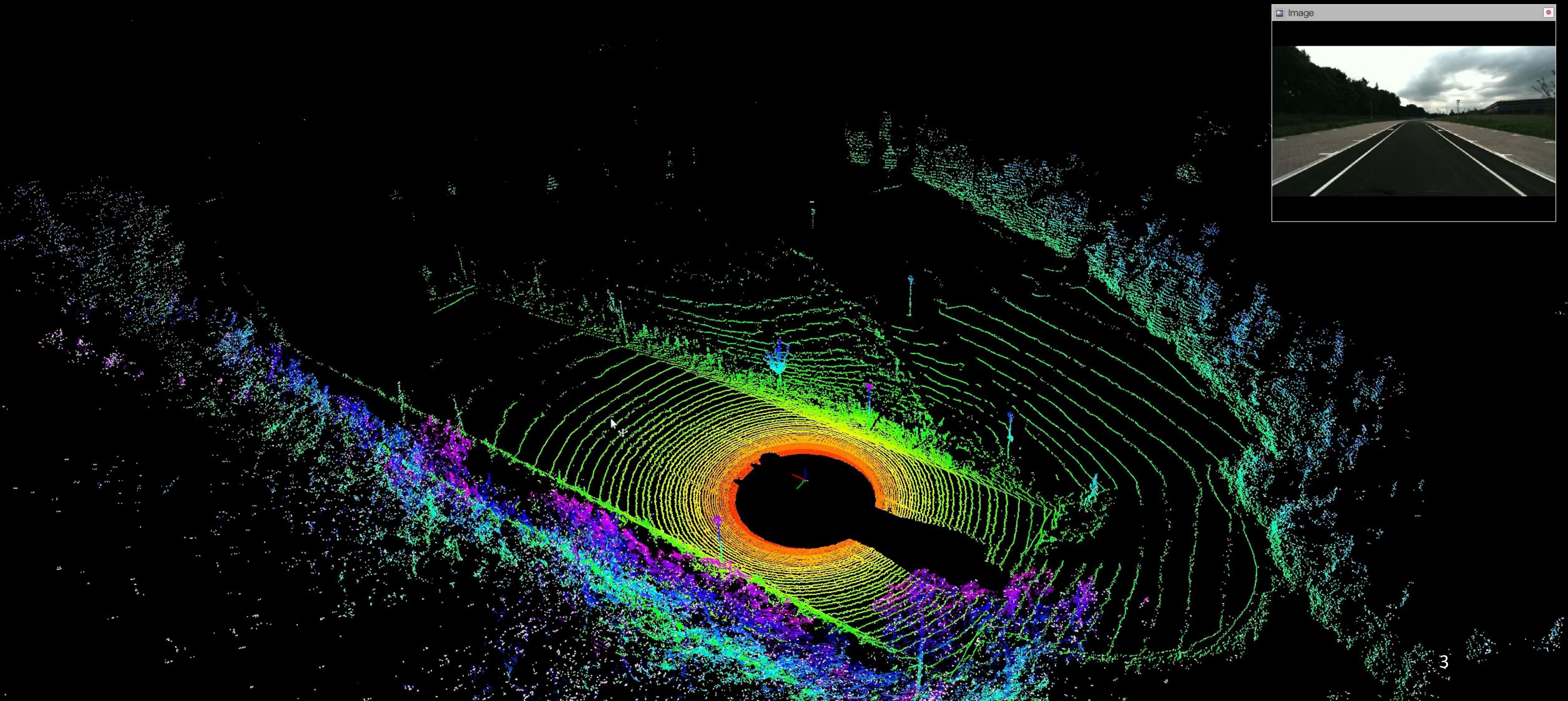
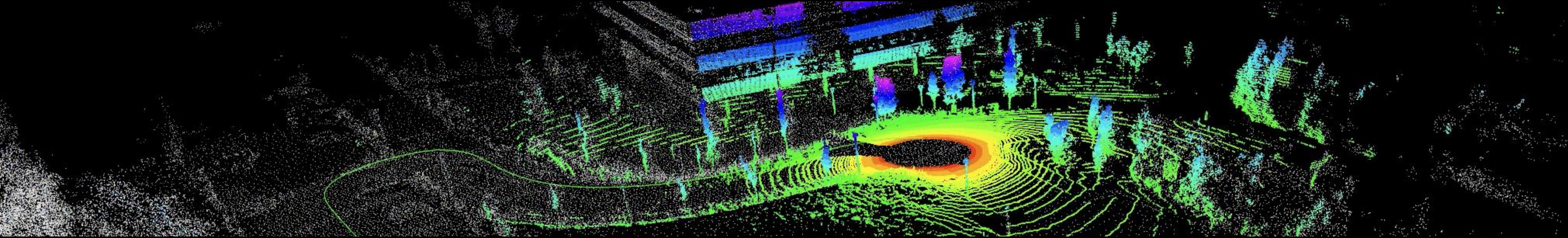


Image
Left
Right

High-Fidelity SLAM

Mathematical Sciences and Computer Science Building





DurLAR: A High-Fidelity 128-Channel LiDAR Dataset with Panoramic Ambient and Reflectivity Imagery for Multi-Modal Autonomous Driving Applications

Li (Luis) Li
Khalid N. Ismail
Hubert P. H. Shum
Toby P. Breckon

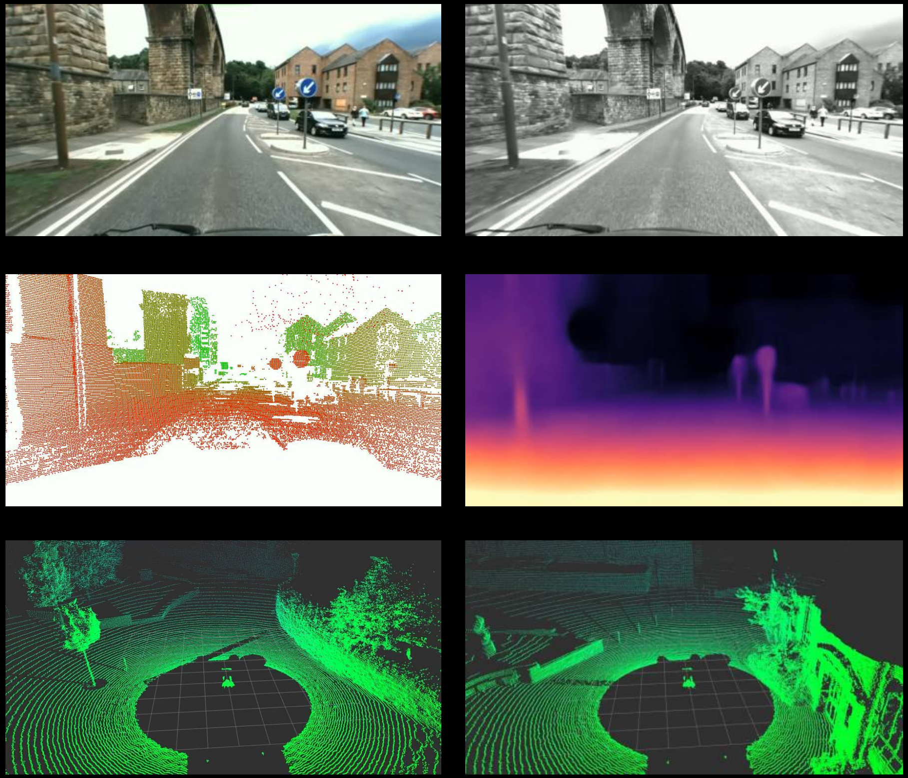
International Conference on 3D Vision

2021

Junior Seminar

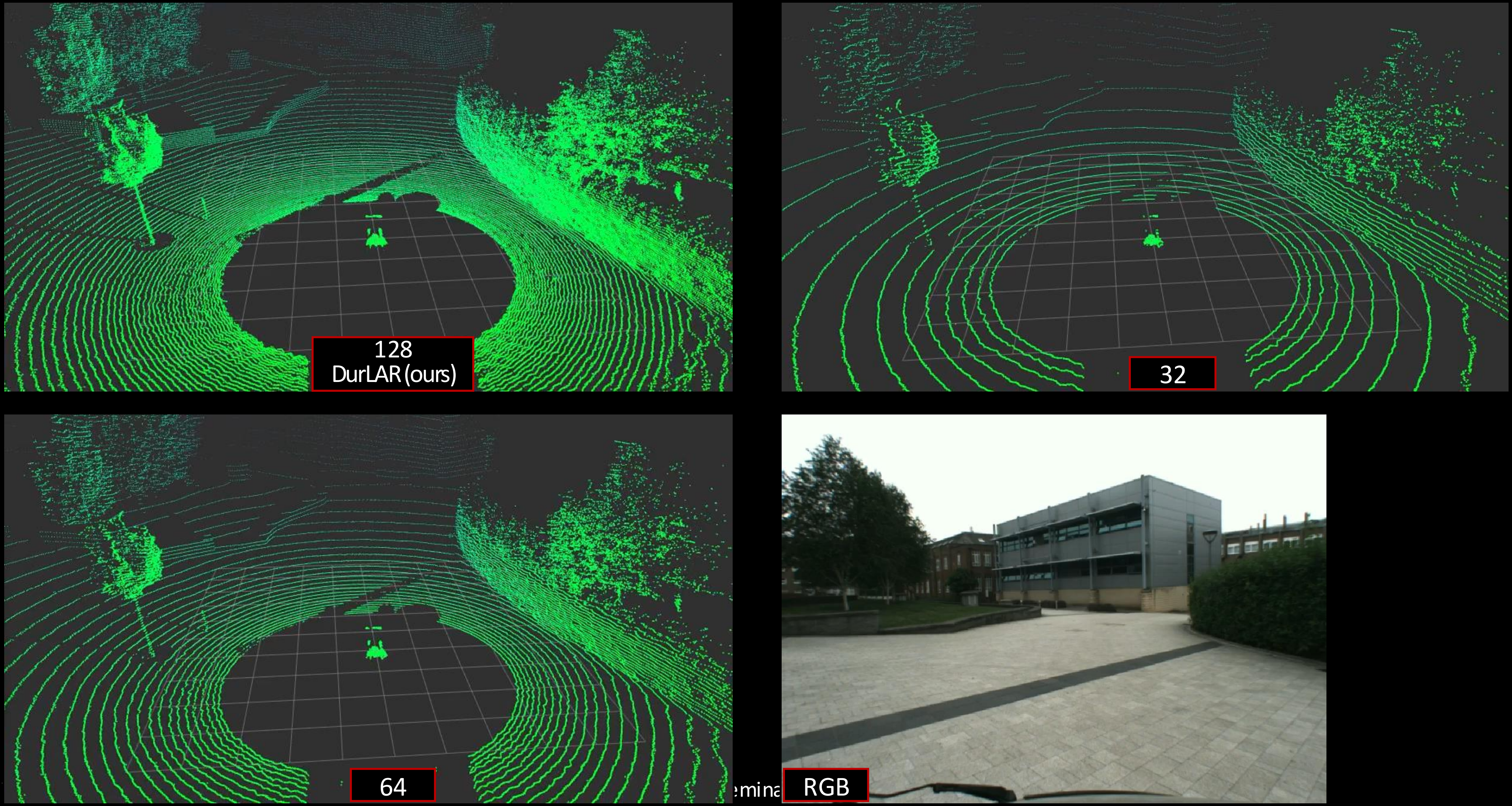
Durham University

DurLAR Dataset - Overview

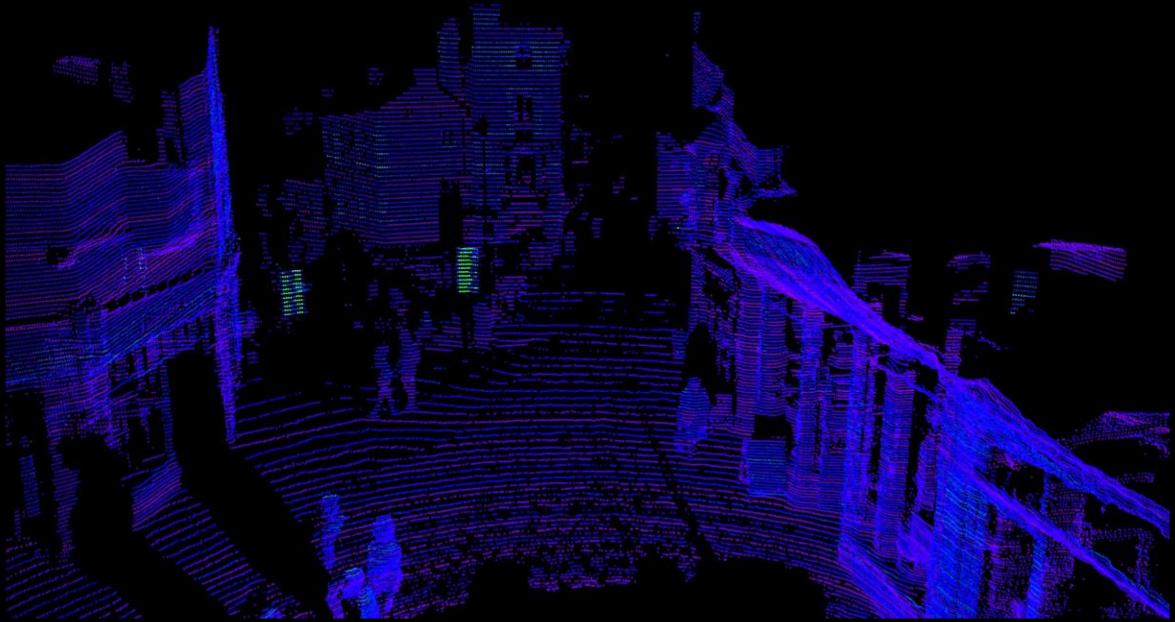


- A High-fidelity **128-channel LiDAR Dataset**
  - 100k+ frames
  - Synchronised at 10Hz
- First dataset with **LiDAR panoramic imagery**
  - Ambient imagery
  - Reflectivity imagery
- **Diversity**: time of day, repeated locations, weather
- **Monocular Depth Estimation - benchmark test**
  - Self-supervised ManyDepth
  - Supervised/Self-supervised ManyDepth

Higher Fidelity: 128 vs. 64/32 channel LiDAR

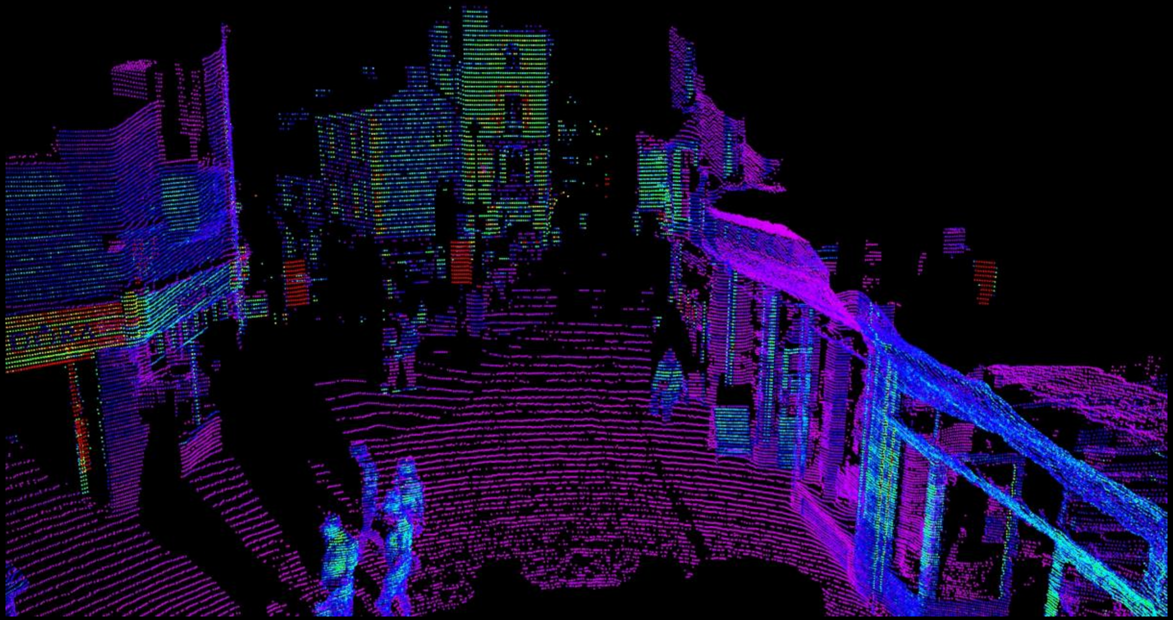


LiDAR Panoramic Imagery



Ambient

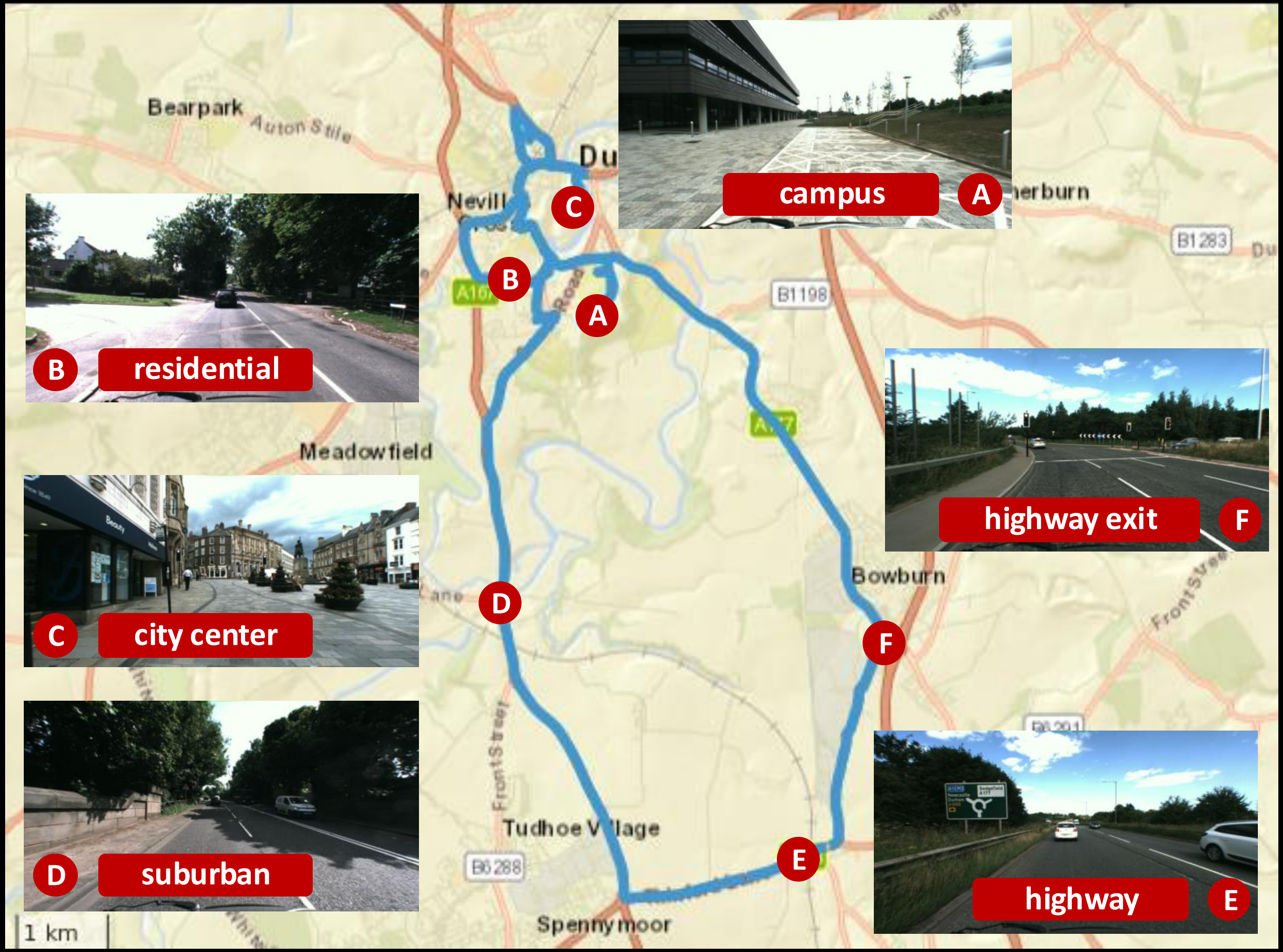
day/night scene visibility in the near-IR spectrum



Reflectivity

information indicative of the material properties of the object itself and offer good consistency across illumination conditions and range.

Diversity of Dataset Environments



Comparison with Existing Public LiDAR Datasets

Dataset	Resolution	Range/m	Diversity	Image	#Frames	Other sensors
DENSE	64	120	E/W/T	I	1M	D/M/F/T/B
H3D	64	120	E	I	28k	G/M
KITTI | SemanticKITTI	64	120	E	I	93k	N/S/G/M/B
KITTI-360	64	120	E	I	320k	N/S/G/M/B
LiVi-Set	32	100	E	I	10k	
Lyft Level 5	64	200	E/W/T	I	170k	D/B
nuScenes	32	100	E/W/T	I	1M	M/D/B
Oxford RobotCar	4	50	E/W/T	I	3M	N/S/G/M/B
Stanford Track	64	120	E	I	14k	M
Sydney Urban Objects	64	120	E	I	0.6k	
DurLAR (ours)	**128**	**120**	**E/W/T/L**	**I/A/R**	**100k**	**U/N/S/G/M/B**

Image	Refer to	Diversity	Refer to	Sensors	Refer to	Sensors	Refer to
I	intensity	E	environments	D	radar	M	IMU
A	ambient	W	weather condition	U	lux meter	F	FIR camera
R	reflectivity	T	times of day	N	GNSS	T	Near IR camera
		L	repeated location	S	INS	B	stereo camera
				G	GPS		

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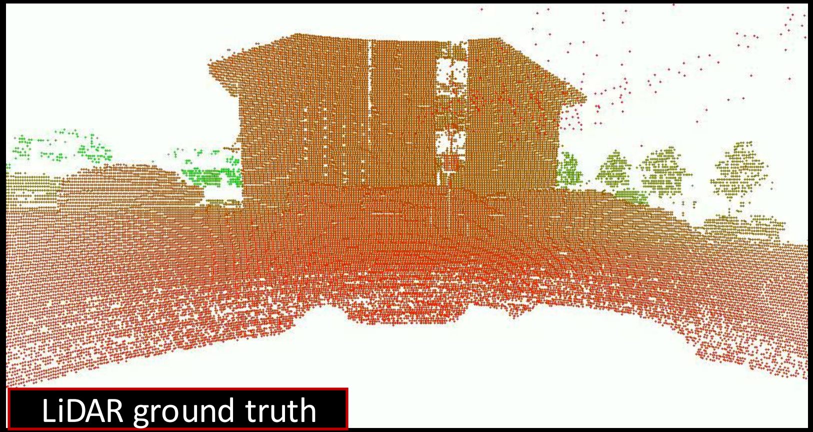
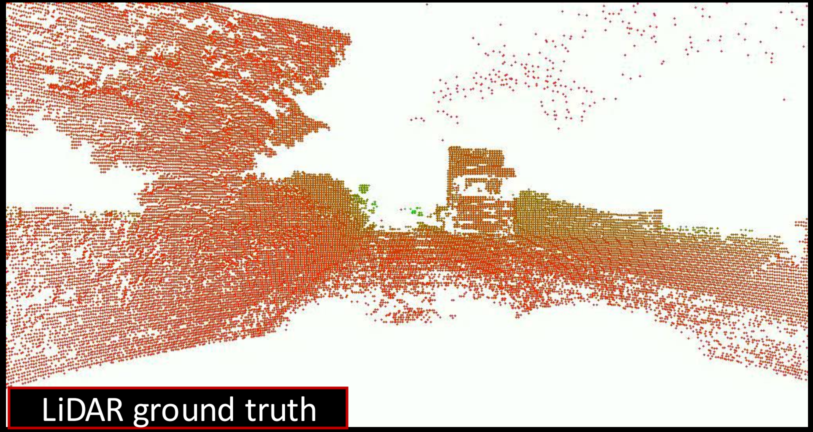
DurLAR Exemplar Environment
- City -

DurLAR Exemplar Environment

- Campus -

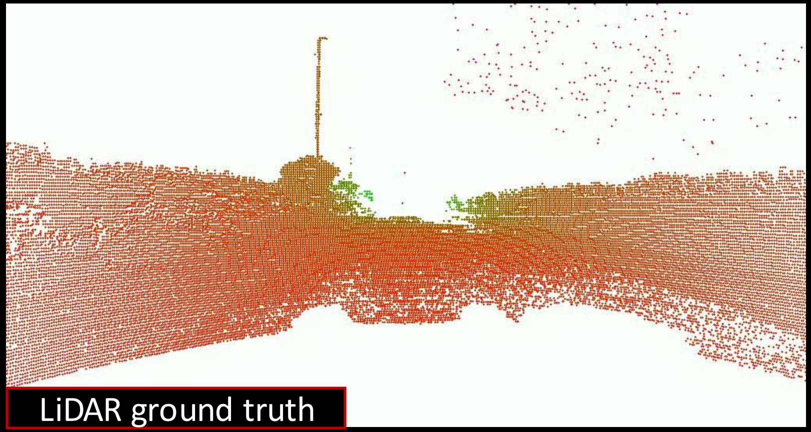


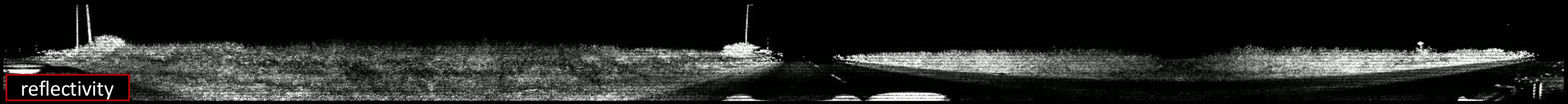
DurLAR Exemplar Environment
- Highway -



DurLAR Exemplar Environment

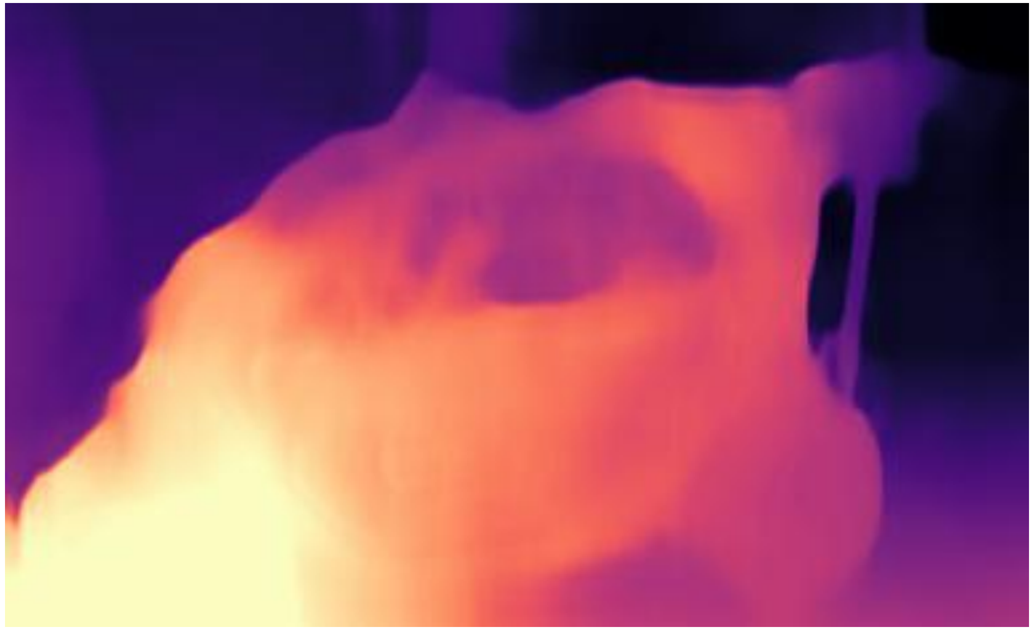
- Suburban -





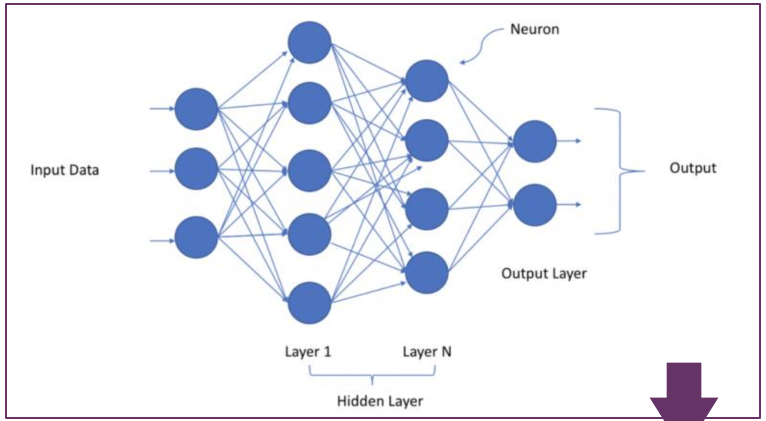
Depth Estimation Using LiDAR Dataset

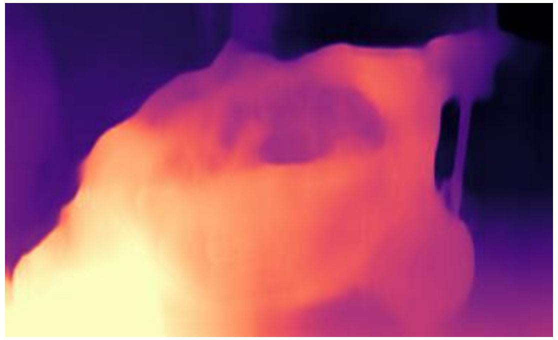
Input: RGB

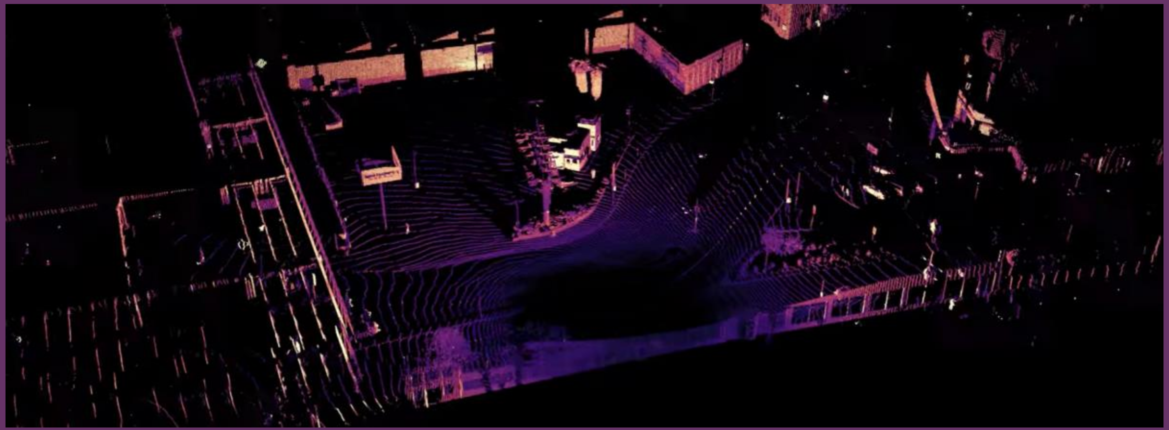


Output:
Depth prediction

Depth Estimation Using LiDAR Ground Truth



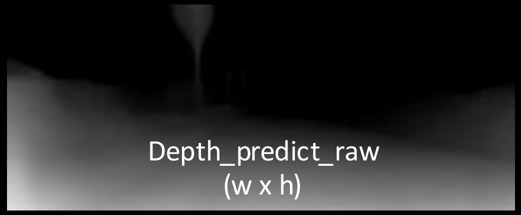




Stereo dataset
RGB-D dataset
...
★ **LiDAR dataset (Ours)** → LiDAR ground truth

Benchmark Task: Monocular Depth Estimation

Supervised/self-supervised ManyDepth



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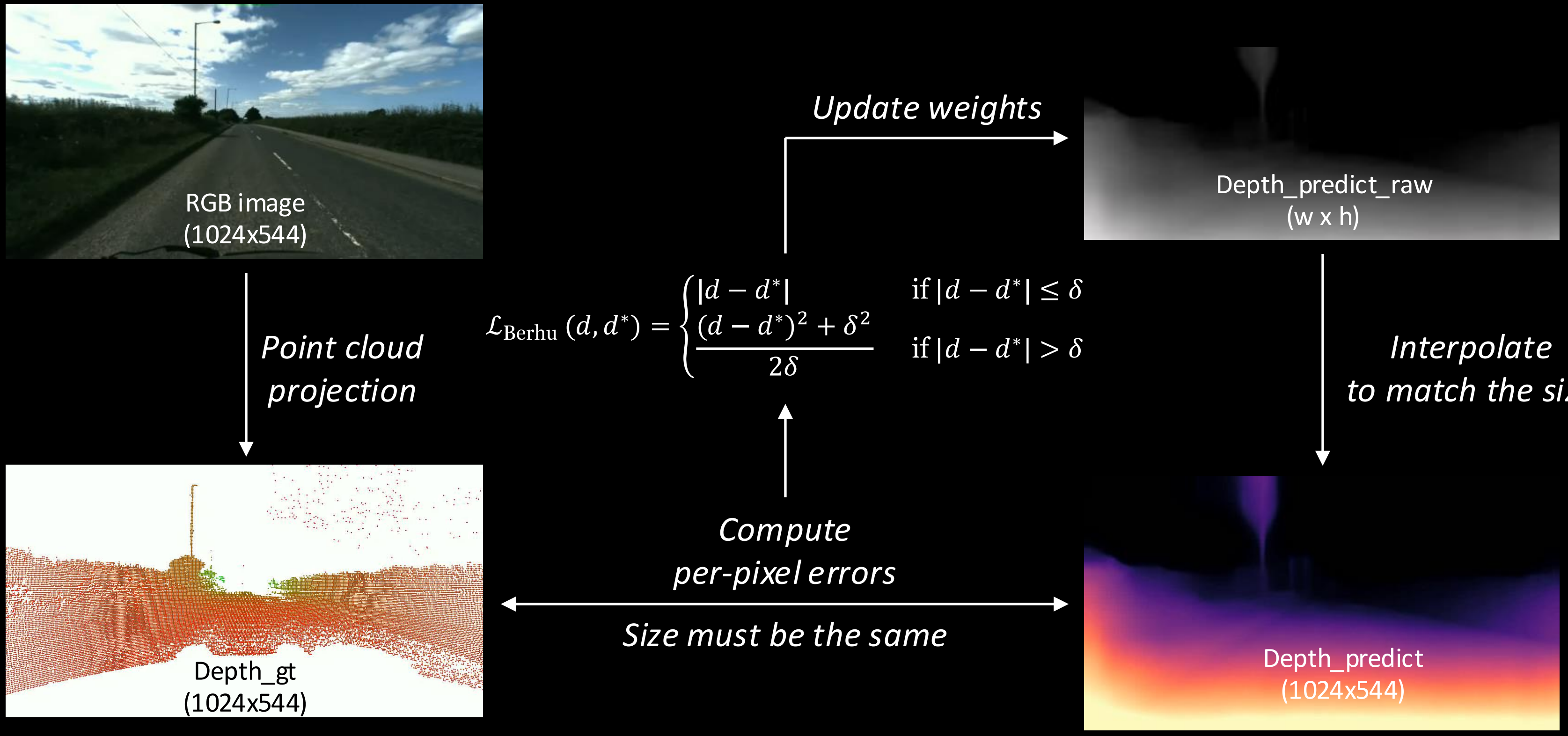
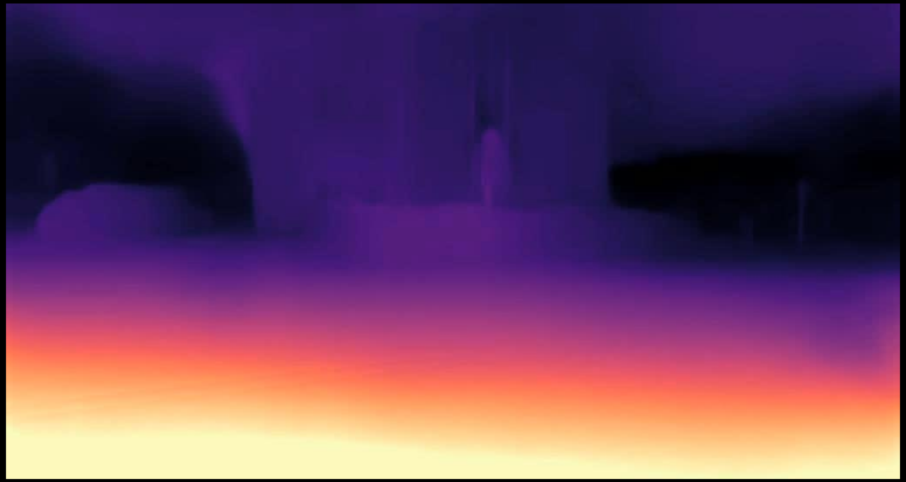
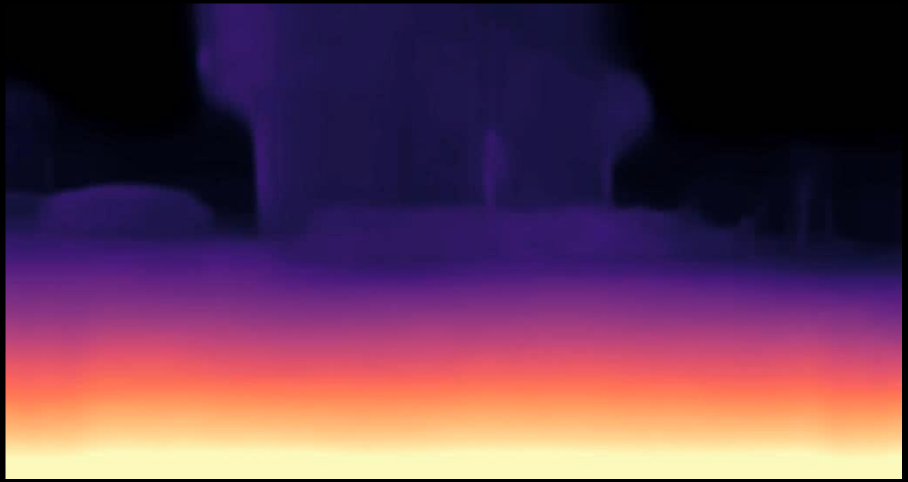


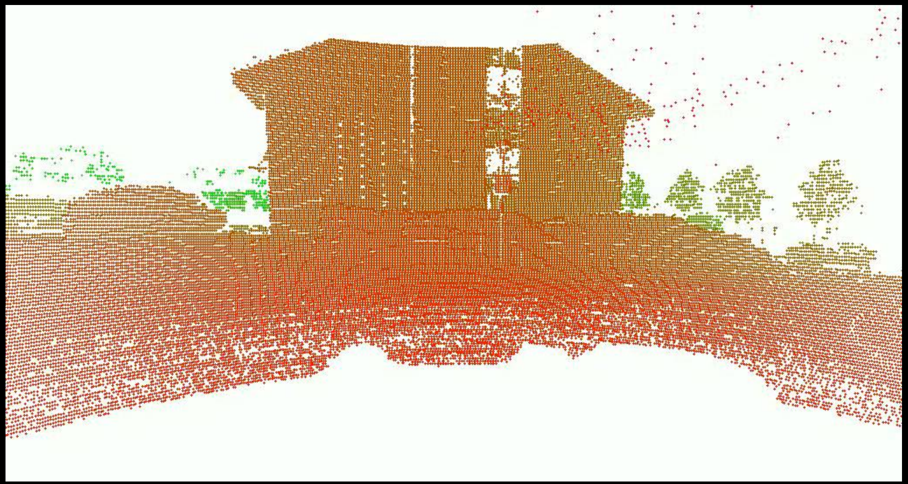
$$\mathcal{L}_{\mathrm{Berhu}}(d, d^*) = \begin{cases} |d - d^*| & \text{if } |d - d^*| \leq \delta \\ \dfrac{(d - d^*)^2 + \delta^2}{2\delta} & \text{if } |d - d^*| > \delta \end{cases}$$

Qualitative Evaluation

Monocular Depth Estimation







Qualitative Evaluation

Monocular Depth Estimation

	Abs Rel	Sq Rel	RMSE	RMSE log	$\delta < 1.25$	$\delta < 1.25^2$	$\delta < 1.25^3$
ManyDepth	0.109	1.111	3.875	0.177	0.901	0.966	0.984
Ours	**0.104**	**0.936**	**3.639**	**0.171**	**0.906**	**0.969**	**0.986**

ManyDepth
[Watson *et al.*, 2021]

Ours

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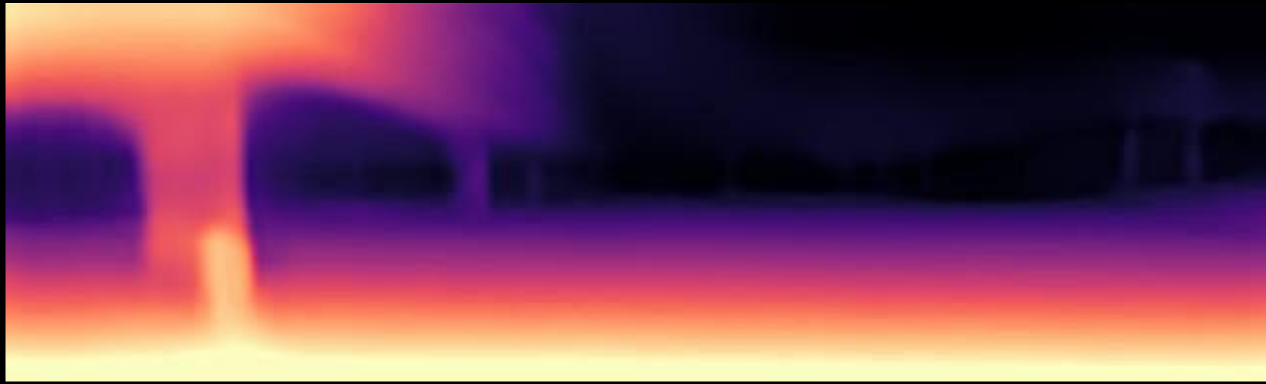

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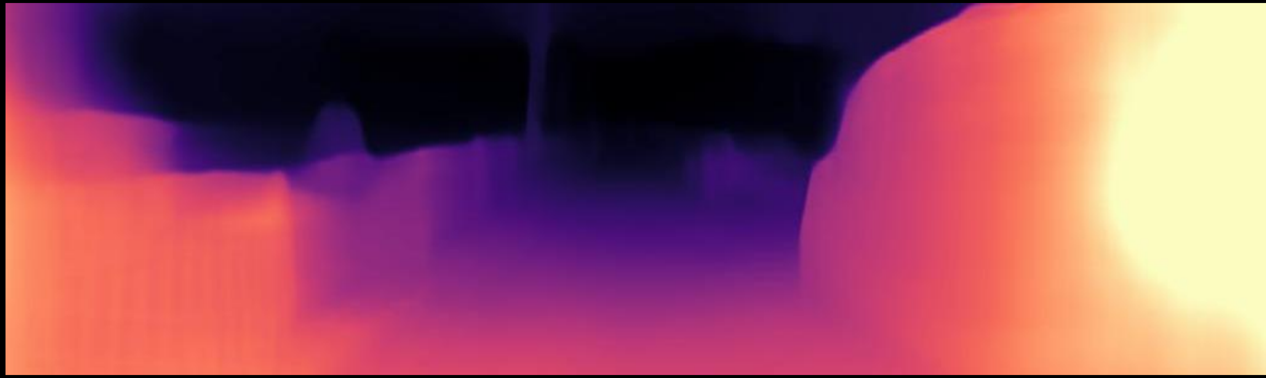

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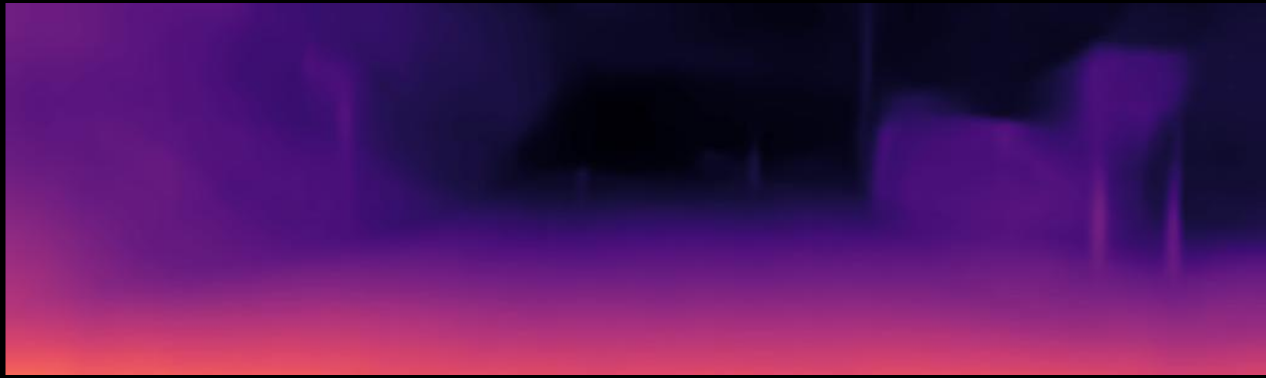

Ours

Quantitative Evaluation

Monocular Depth Estimation

Dataset	Method	+S	WxH	Abs Rel	Sq Rel	RMSE	RMSE log	$\delta < 1.25$	$\delta < 1.25^2$	$\delta < 1.25^3$
KITTI	ManyDepth (MR)	x	640x192	0.098	0.770	4.459	0.176	0.900	0.965	0.983
	ManyDepth (MR)	x	1024x320	0.093	0.715	4.245	0.172	0.909	0.966	0.983
Cityscapes	ManyDepth	x	416x128	0.114	1.193	6.223	0.170	0.875	0.967	0.989
DurLAR	Depth-hints	x	640x192	0.122	1.070	4.148	0.211	0.870	0.946	0.972
	Depth-hints	√	640x192	0.121	1.109	4.121	0.210	0.874	0.946	0.972
	MonoDepth2	x	640x192	0.111	1.114	4.002	0.187	0.895	0.960	0.981
	MonoDepth2	√	640x192	0.108	1.010	3.804	0.185	0.898	0.963	0.982
	ManyDepth (MR)	x	640x192	0.115	1.227	4.116	0.186	0.892	0.962	0.982
	ManyDepth (MR)	√	640x192	0.109	0.936	3.711	0.176	0.895	0.964	0.984
	ManyDepth (HR)	x	1024x320	0.109	1.111	3.875	0.177	0.901	0.966	0.984
	ManyDepth (HR)	√	1024x320	0.104	0.936	3.639	0.171	0.906	0.969	0.986

+S=√ **Supervised/self-supervised ManyDepth**

+S=x self-supervised ManyDepth

Quantitative Evaluation

Monocular Depth Estimation

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+S=√ Supervised/self-supervised ManyDepth

+S=x self-supervised ManyDepth

Ablation Results

Monocular Depth Estimation

vRes	Abs Rel	Sq Rel	RMSE	RMSE log	$\delta < 1.25$	$\delta < 1.25^2$	$\delta < 1.25^3$
32/+S	0.115	0.908	3.677	0.179	0.888	0.966	0.985
64/+S	0.107	0.918	3.735	0.175	0.895	0.967	0.986
128/-S	0.109	1.111	3.875	0.177	0.901	0.966	0.984
128/+S	0.104	0.936	3.639	0.171	0.906	0.969	0.986

+S **Supervised/self-supervised ManyDepth**

-S self-supervised ManyDepth

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Monocular Depth Estimation

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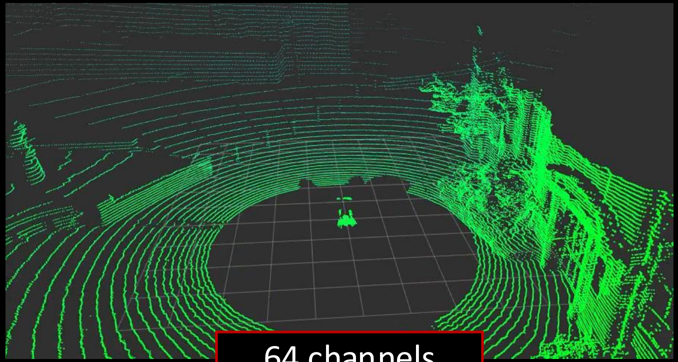
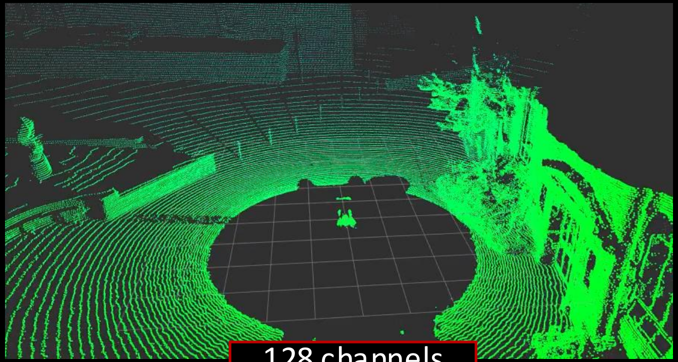
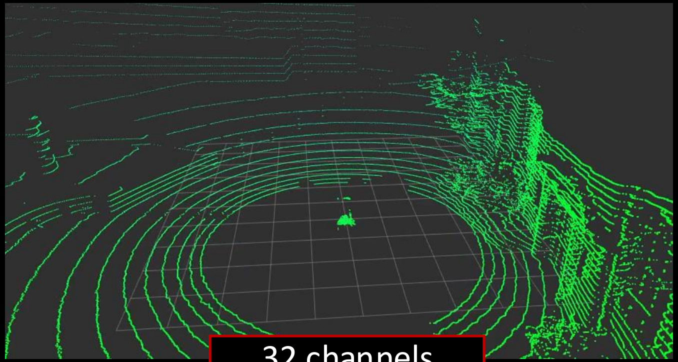
+S	**Supervised/self-supervised ManyDepth**
-S	self-supervised ManyDepth



64 channels
50%



128 channels
DurLAR (ours)



32 channels
75%