

Reconstructing Objects in-the-wild for Realistic Sensor Simulation





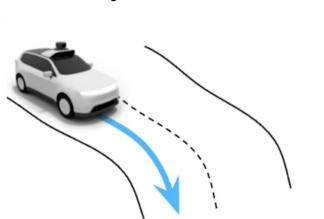
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Sensor simulation for robotics

- Testing long tail scenarios for developing safety robotics system
- Scalable and efficient data generator to boost autonomy system
- Run the full robotic system in closed loop



Test safety critical scenario



Closed-loop simulation

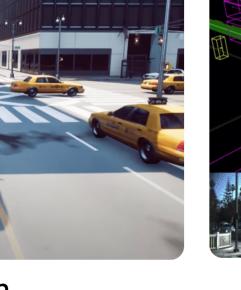
Sensor simulation as data generator

Motivation

Existing approaches lack scale, diversity, realism



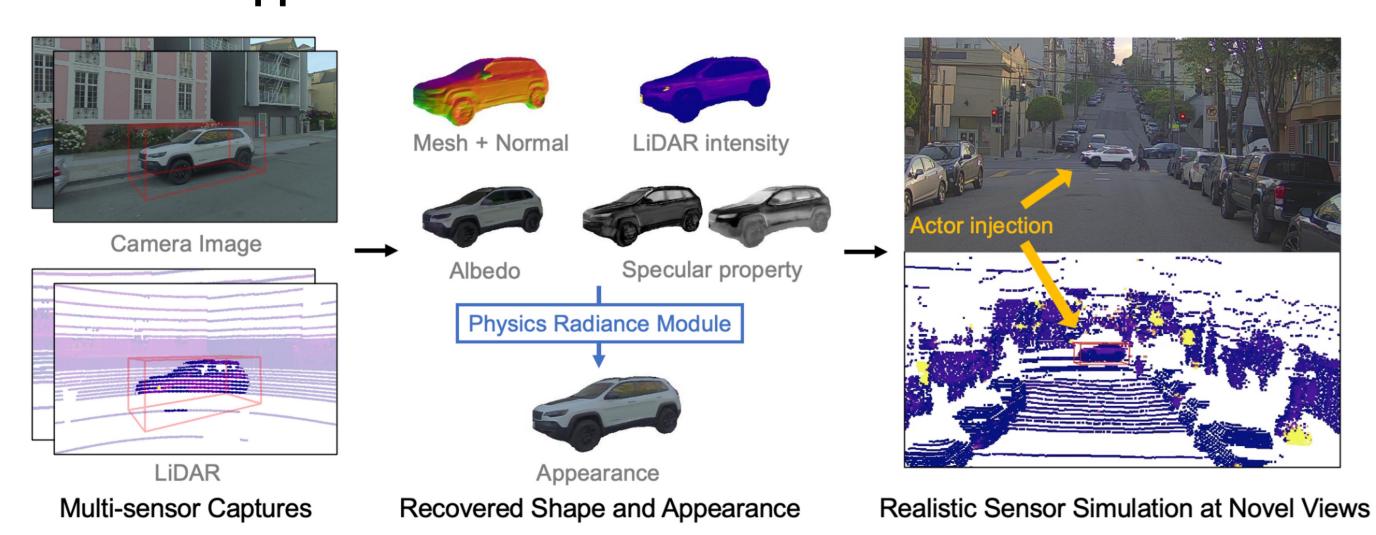
CARLA



AirSim

Real world replay

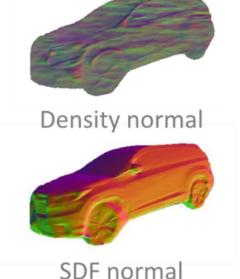
- Take in-the-wild lidar and camera data captures by a moving platform
- Automatically generate assets that have accurate geometry and realistic appearance



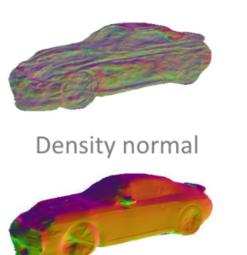
Method

- Surface is neural signed distance function (SDF)
- Reduces shape-radiance ambiguity
- Accurate surface normal for reflectance modelling

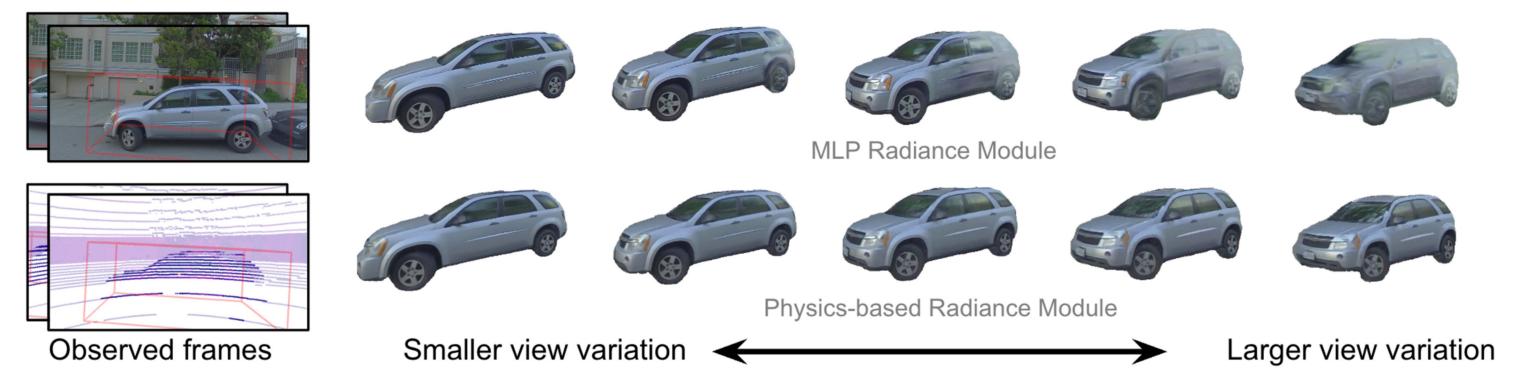




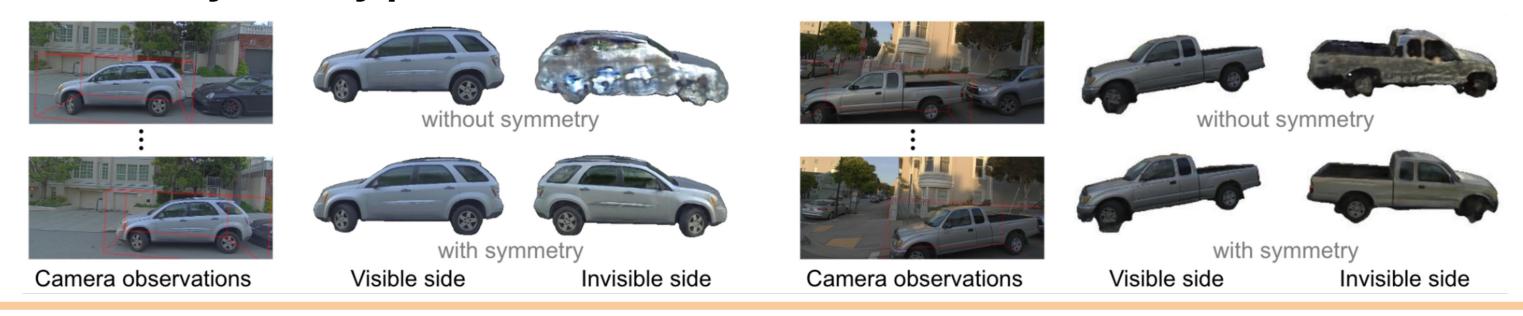




- Appearance is neural physics reflectance model:
- Robust and realistic novel view synthesis
- Controllable and composable
- Allows baking mesh for fast rendering

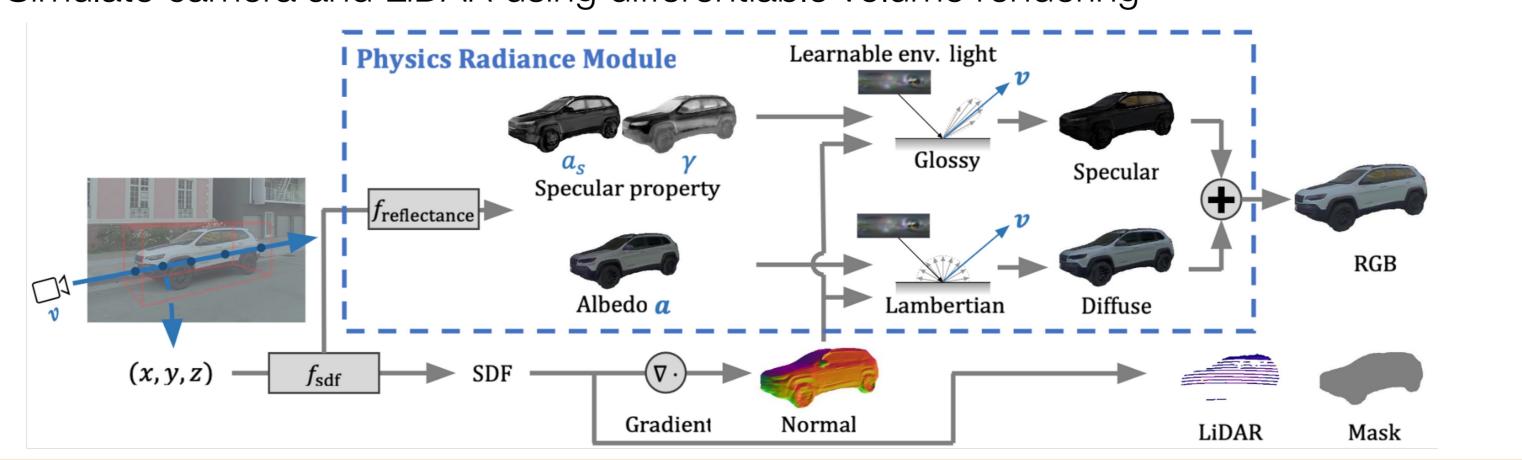


Structured symmetry priors for 360° full reconstruction



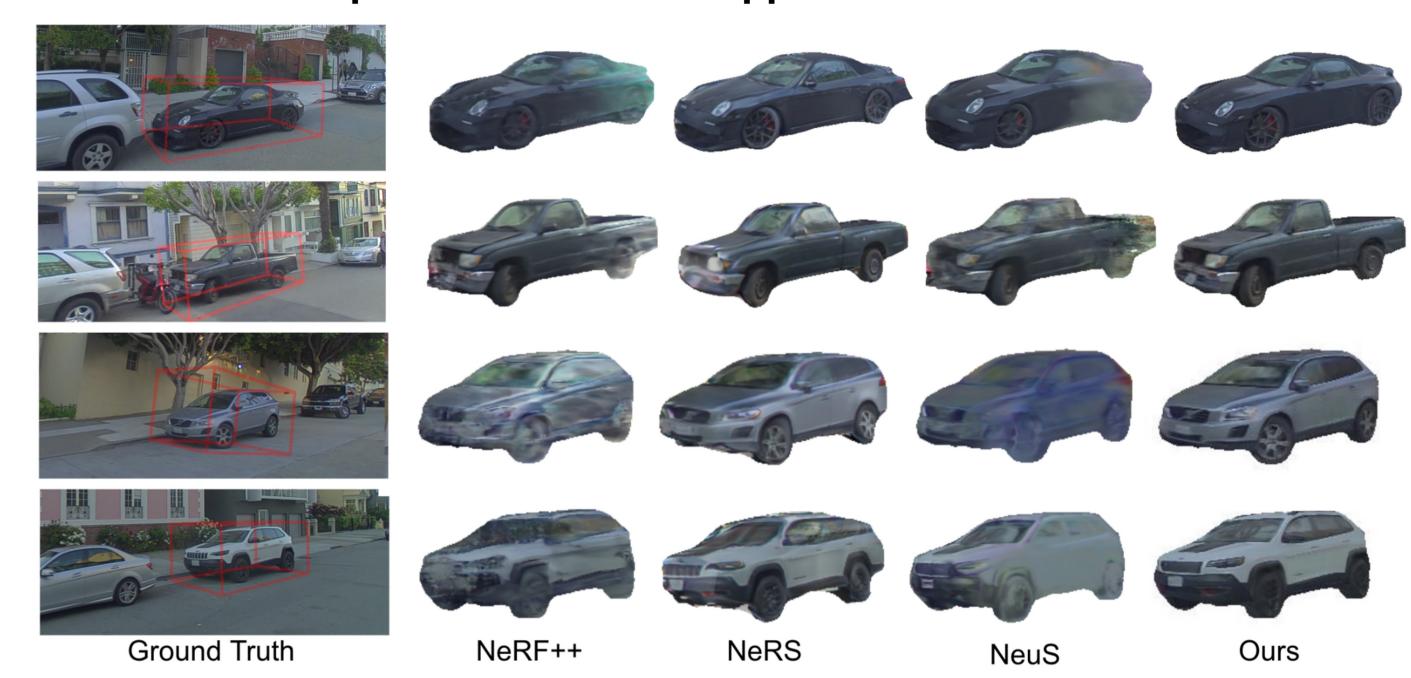
Network architecture

- NeuSim query (1) signed distance value to surface, and (2) albedo and specular property
- Derive surface normal from signed distance value, which is used to shade the diffuse and specular components to obtain RGB color via physics radiance module
- Simulate camera and LiDAR using differentiable volume rendering



Results

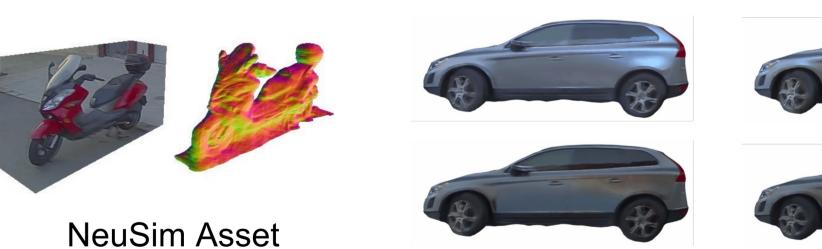
Qualitative comparison with SOTA approaches:



Quantitative comparison with SOTA approaches:

Methods	Photorealism Metric				Perception Agreement	
	MSE↓	PSNR↑	SSIM↑	LPIPS↓	Detection (IoU)↑	Inst. Segmentation (IoU)↑
SI-ViewWarp [57] SAMP [13]	0.0233 0.0144	17.51 19.52	0.514 0.628	0.371 0.283	90.39	89.58
NeRS [48] NVDiffRec [58]	0.0176 0.0114	18.49 20.46	0.562 0.593	0.265 0.396	- 85.26	- 85.88
NeRF++ [5] NeuS [6] Ours	0.0138 0.0115 0.0081	20.86 21.37 22.44	0.611 0.640 0.692	0.300 0.247 0.202	92.81 93.97 94.82	93.22 94.22 95.48

Results on Non-vehicle Objects



Control Lighting

Realistic Sensor Simulation

Real Image

