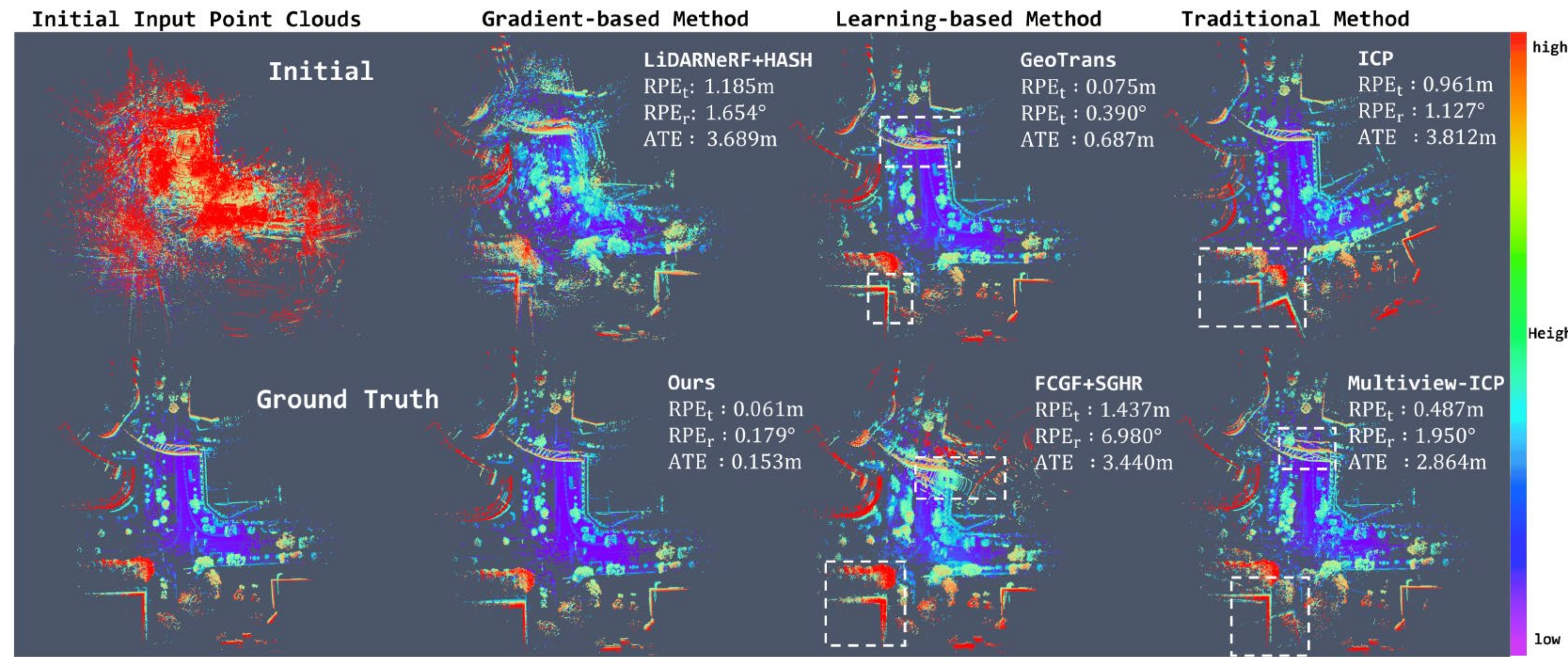


## Motivation

Previous LiDAR Point Registration Method Do Not Always Provide Accurate Pose Estimation

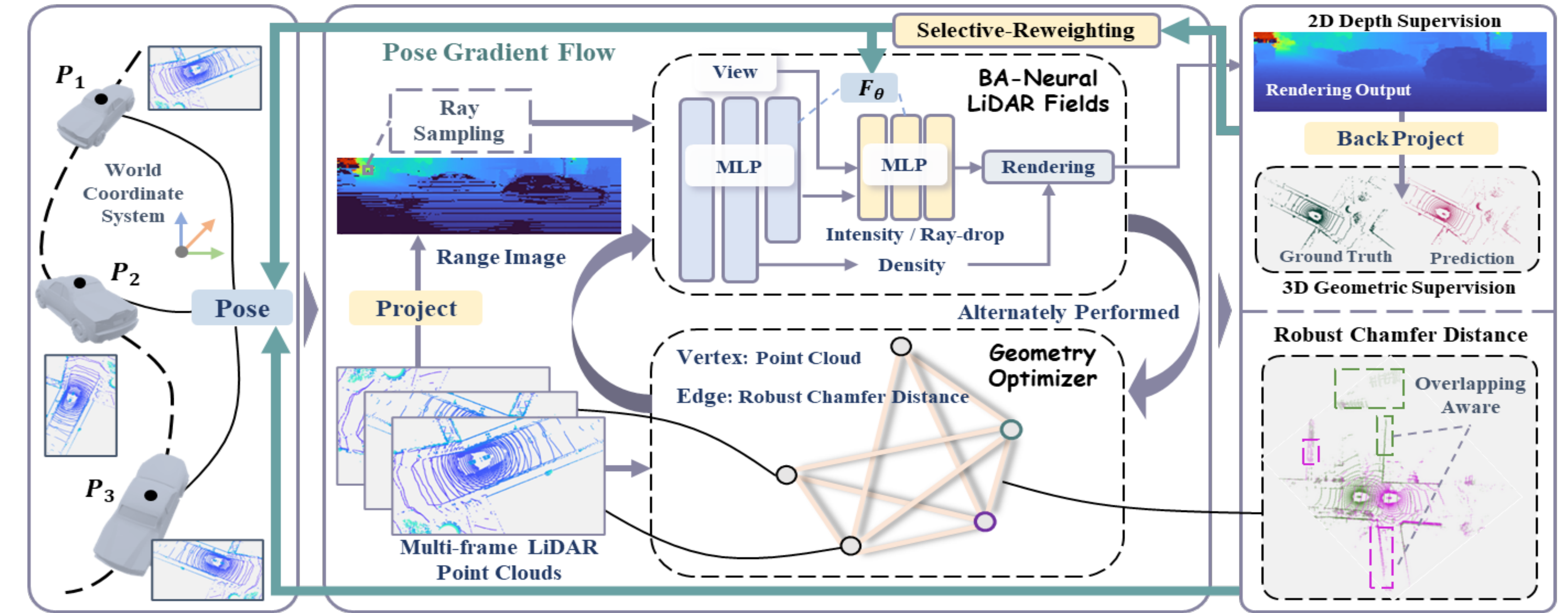


## Challenges

- **Large-scale reconstruction**
  - Hundreds of meters
  - Sparsity of point clouds
- **Ill-conditioned optimization**
  - No accurate pose
  - Prone to getting trapped in local optima
  - Unstable optimization
- **Generation realism**
  - Intensity reconstruction
  - Ray-drop characteristic

How can we generate/simulate novel point clouds without accurate pose?

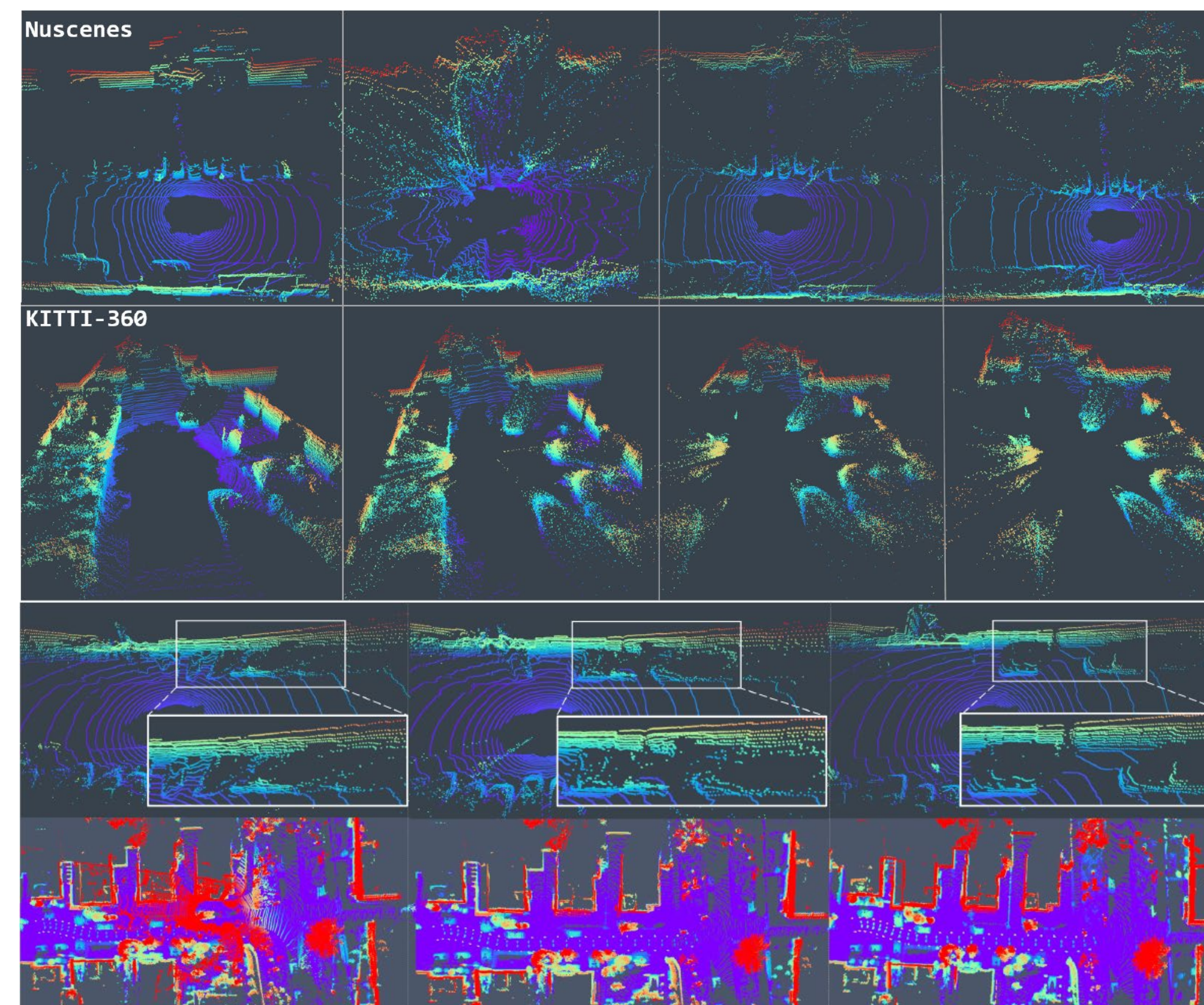
## GeoNLF Overview



## Quantitative & Qualitative Results

Method	Dataset	Point Cloud				Depth				Intensity			
		CD↓	F-score↑	RMSE↓	MedAE↓	LPIPS↓	SSIM↑	PSNR↑	RMSE↓	MedAE↓	LPIPS↓	SSIM↑	PSNR↑
BARF-LN [32, 52]	Nuscenes	1.2695	0.7589	8.2414	0.1123	0.1432	0.6856	20.89	0.392	0.0144	0.1023	0.6119	26.2330
HASH-LN [22, 52]		0.9691	0.8011	7.8353	0.0441	0.1190	0.6543	20.6244	0.0459	0.0135	0.0954	0.6279	26.8870
GeoTrans [45, 52]		4.1587	0.2993	10.7899	2.1529	0.1445	0.3671	17.5885	0.0679	0.0256	0.1149	0.3476	23.6211
<b>GeoNLF (Ours)</b>		<b>0.2408</b>	<b>0.8647</b>	<b>5.8208</b>	<b>0.0281</b>	<b>0.0727</b>	<b>0.7746</b>	<b>22.9472</b>	<b>0.0378</b>	<b>0.0100</b>	<b>0.0774</b>	<b>0.7368</b>	<b>28.6078</b>
BARF-LN [32, 52]	KITTI-360	3.1001	0.6156	7.5767	2.0583	0.5779	0.2834	22.5759	0.2121	0.1575	0.7121	0.1468	11.9778
HASH-LN [22, 52]		2.6913	0.6082	6.3005	2.1686	0.5176	0.3752	22.6196	0.2404	<b>0.1502</b>	0.6508	0.1602	12.9286
GeoTrans [45, 52]		0.5753	0.8116	4.4291	0.2023	<b>0.3896</b>	0.5330	<b>25.6137</b>	0.2709	0.1589	0.5578	0.2578	12.9707
<b>GeoNLF (Ours)</b>		<b>0.2363</b>	<b>0.9178</b>	<b>4.0293</b>	<b>0.1009</b>	0.3900	<b>0.6272</b>	25.2758	<b>0.1495</b>	0.1525	<b>0.5379</b>	<b>0.3165</b>	<b>16.5813</b>

Method	NuScenes			KITTI-360			Method	Point Cloud CD↓	Depth PSNR↑	Intensity PSNR↑	Pose		
	RPE <sub>t</sub> (cm)↓	RPE <sub>r</sub> (deg)↓	ATE(m)↓	RPE <sub>t</sub> (cm)↓	RPE <sub>r</sub> (deg)↓	ATE(m)↓					RPE <sub>t</sub> (cm)↓	RPE <sub>r</sub> (deg)↓	ATE(m)↓
ICP [5]	15.410	0.647	1.131	30.383	1.019	1.894							
MICP [52]	38.84	1.101	2.519	35.584	1.419	1.483							
HRegNet [35]	120.913	2.173	7.815	290.16	9.083	7.423	w/o G-optim	0.6180	21.3211	25.8551	54.72	0.283	1.328
SGHR [55]	100.98	0.699	9.557	95.576	0.906	2.539	w/o RCD	0.2711	21.1323	26.7232	8.476	0.163	0.332
GeoTrans [45]	16.097	<b>0.363</b>	<b>0.892</b>	<b>6.081</b>	<b>0.213</b>	<b>0.246</b>	w/o SR	0.2654	21.1096	26.5269	8.124	0.156	0.264
BARF-LN [52, 32]	210.331	0.819	5.244	199.74	2.203	2.763	w/o L <sub>3d</sub>	0.2877	21.7128	28.5210	7.273	0.124	0.234
HASH-LN [52, 22]	180.282	0.832	4.151	196.791	2.171	2.666	<b>GeoNLF</b>	<b>0.2363</b>	<b>22.9472</b>	<b>28.6078</b>	<b>7.058</b>	<b>0.103</b>	<b>0.228</b>



## Applications

### Shift poses

- Sensor Height
- Translate / Rotate

### Configuration

- Field of View
- Angular Resolution
- LiDAR Beams

### Simulation

- Scene Re-play
- Novel Trajectory

