ETH zürich

IGP
Institute of Geodesy and Photogrammetry

2D-Informed Point Cloud Registration: Leveraging RGB Image Priors

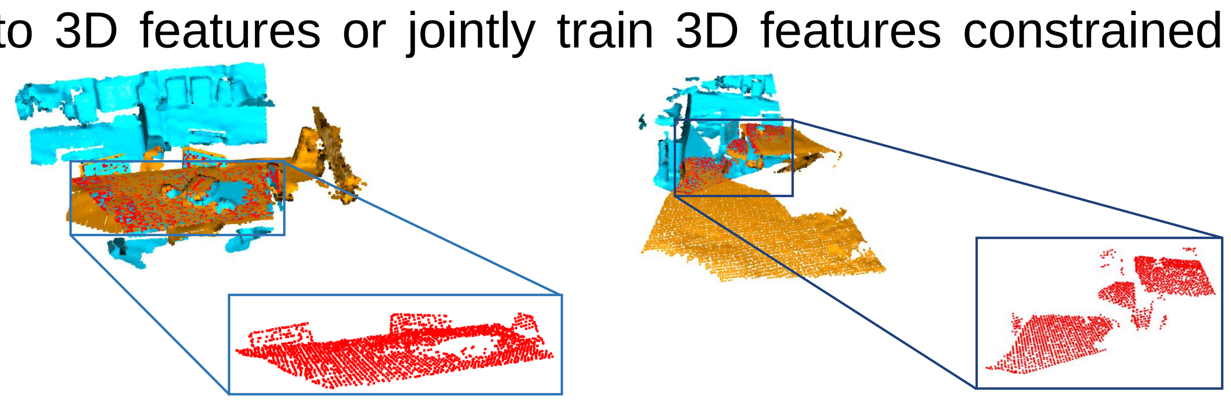
PhD Student: Zhaoyi Wang; Supervisor: Prof. Dr. Andreas Wieser

Geosensors and Engineering Geodesy, IGP, ETH Zürich

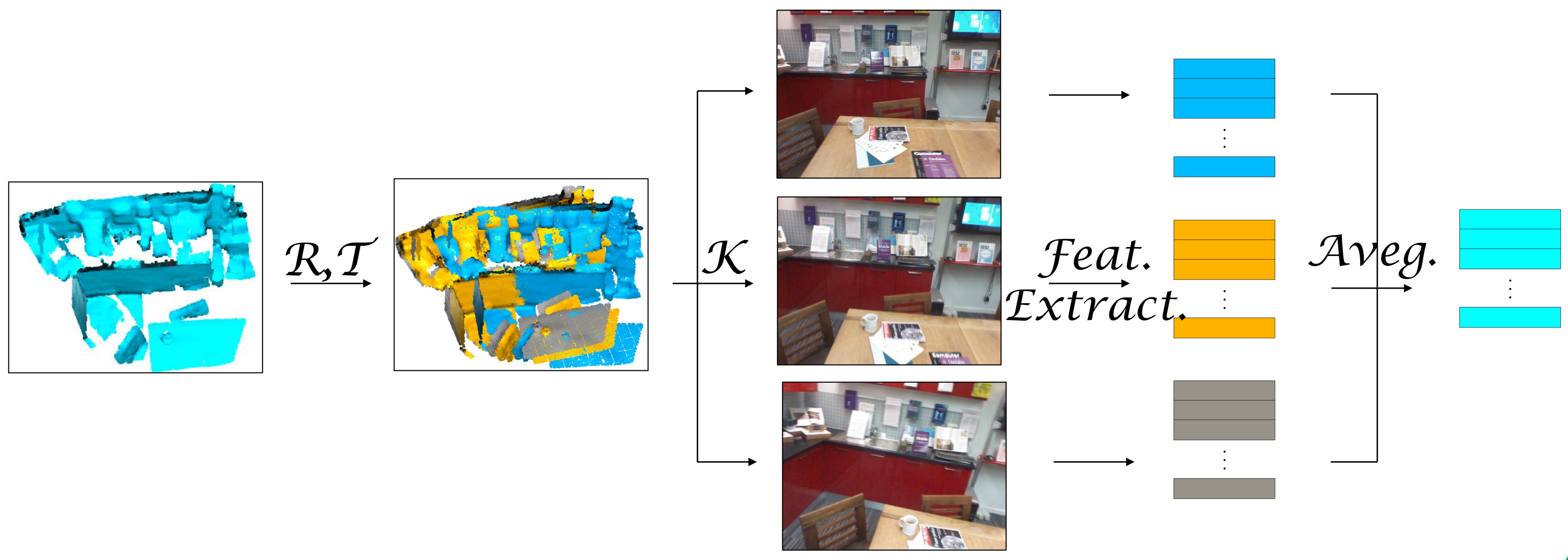
Motivation

Problem: Common geometry-based point cloud registration methods may fail to align two point clouds when the overlap is geometrically smooth.

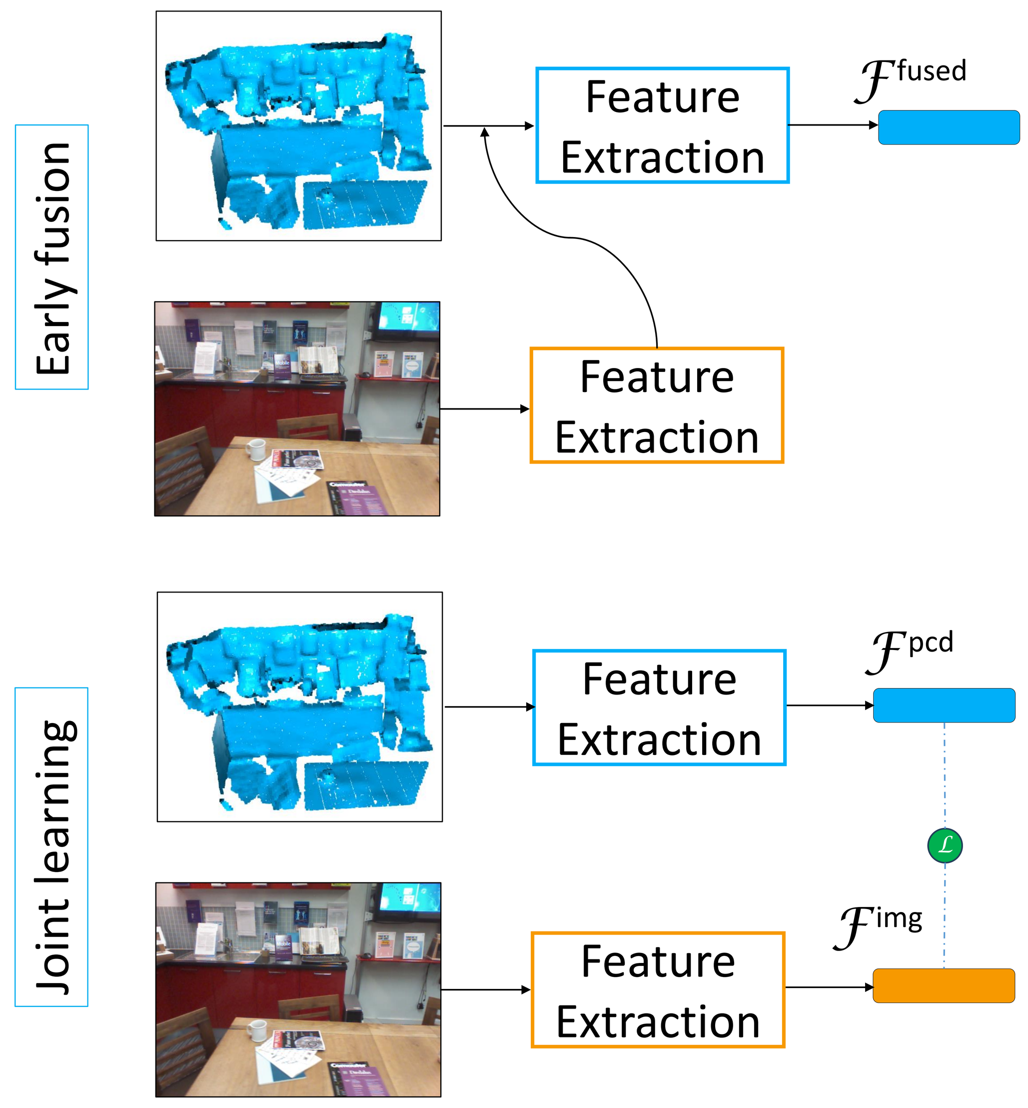
Solution: Use a 2D pretrained model (e.g., ResNet-50) to extract high-level image features from multi-view RGB images. Then, either unproject these features to 3D features or jointly train 3D features constrained by these features.

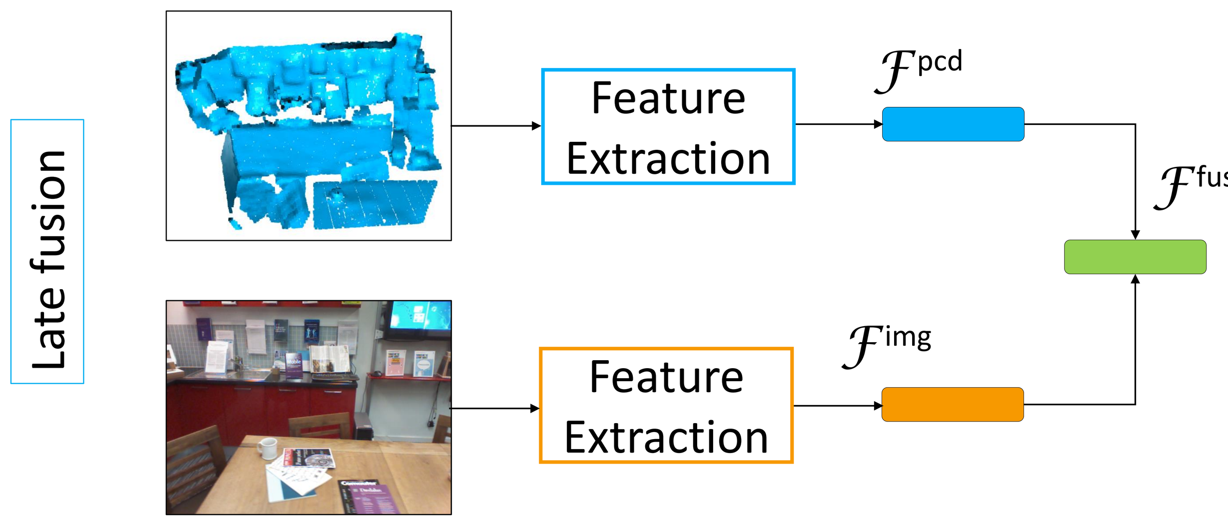


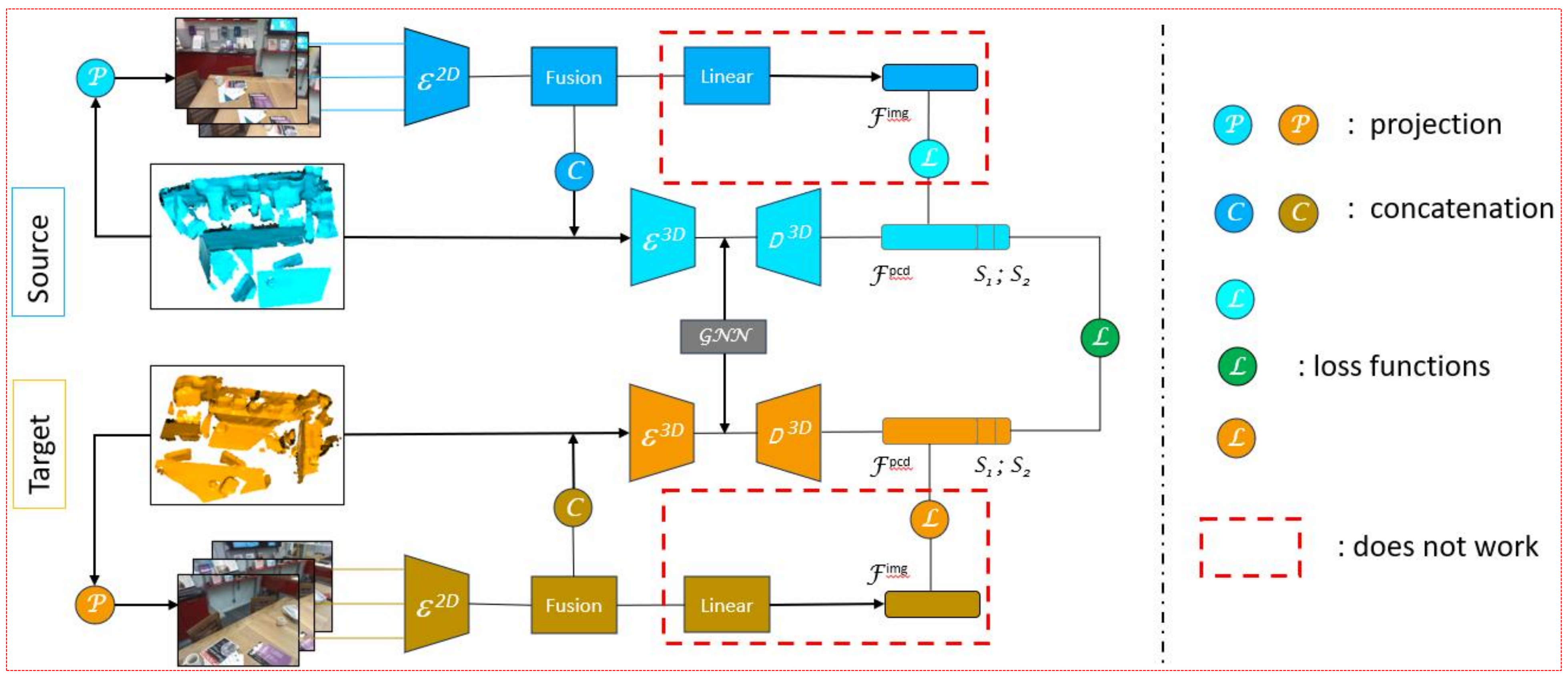
2D Feature Extraction



2D Image-3D Point Cloud Feature Fusion







Quantitative Results

Table 1. Results on 3DMatch and 3DLoMatch Dataset

# Samples	3DMatch 1000	500	250	3DLoMatch 1000	500	250
Methods	*Registration Recall(%)* ↑					
FCGF	83.3	81.6	71.4	38.2	35.4	26.8
D3Feat	83.4	82.4	77.9	46.9	43.8	39.1
SpinNet	84.5	79.0	69.2	49.8	41.0	26.7
Predator	90.6	88.5	86.6	62.4	60.8	58.1
PCR-CG(early fusion)	90.0	88.7	86.8	69.0	68.5	65.0
PCR-CG(early fusion, retrain)	90.0	89.5	87.8	65.6	64.0	60.7
Joint learning	88.3	88.4	86.1	59.0	57.9	55.2
Late fusion	92.7	91.1	89.0	66.3	65.5	61.6

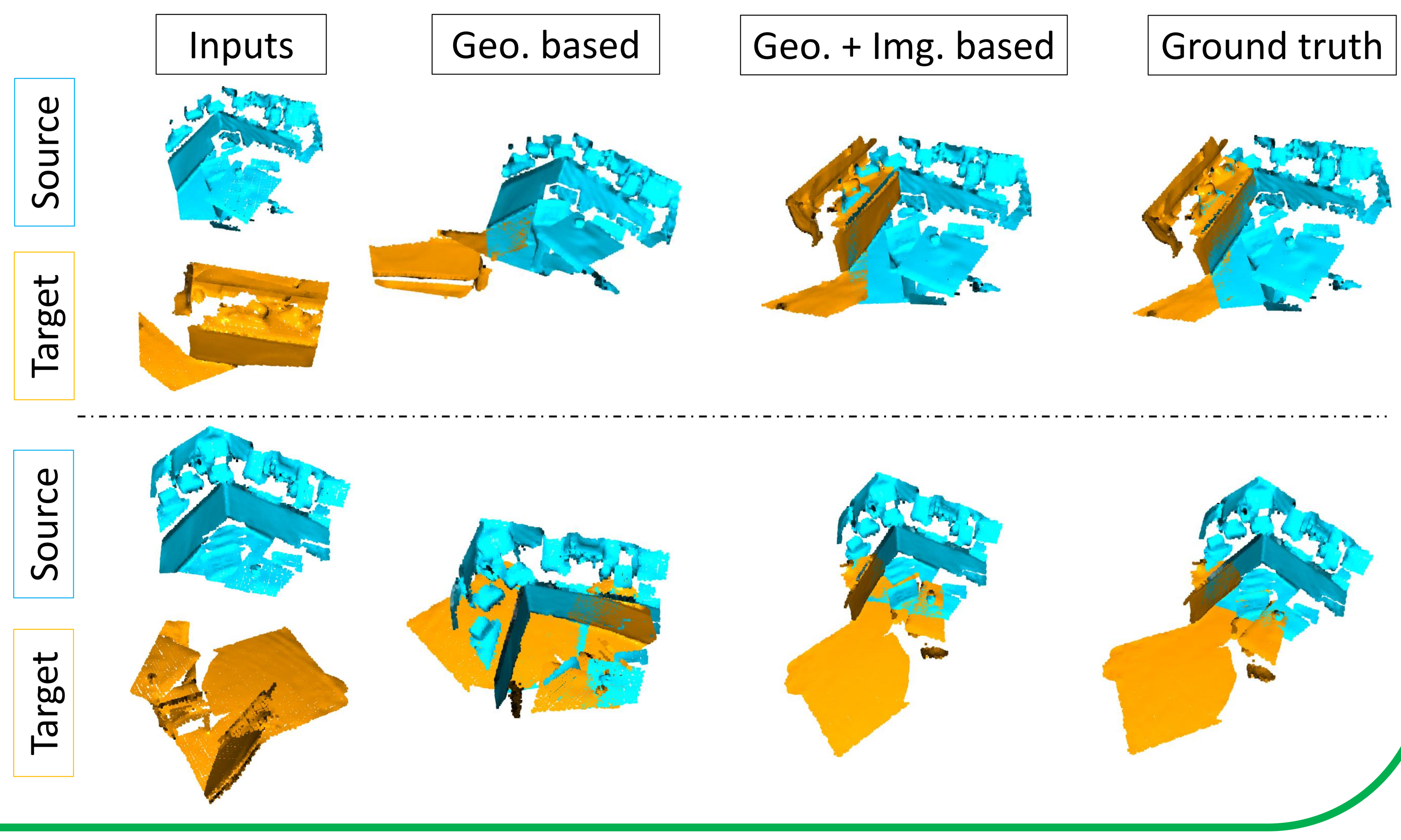
Table 2. Results on 3DMatch_Smooth and 3DLoMatch_Smooth Dataset

# Samples = 1k pts	3DMatch_Smooth			3DLoMatch_Smooth		
Methods	RRE(°)↓	RTE(m)↓	RR(%)↑	RRE(°)↓	RTE(m)↓	RR(%)↑
Predator	3.003	0.065	58.4	3.845	0.093	48.2
PCR-CG (early fusion)	2.682	0.069	65.2	3.791	0.101	53.6
Joint learning	3.338	0.086	59.0	4.803	0.120	34.5
Late fusion	2.849	0.074	62.6	3.607	0.094	51.0

Table 3. Generalizing to IndoorLRS_Smooth Dataset

	IndoorLRS_Smooth w. 1k pts			IndoorLRS_Smooth w. 250 pts		
Methods	RRE(°)↓	RTE(m)↓	RR(%)↑	RRE(°)↓	RTE(m)↓	RR(%)↑
Predator	2.159	0.100	78.7	2.875	0.130	76.5
LCD64 (only Img.)	2.933	0.139	69.2	5.100	0.226	64.8
Late fusion (Pred. + LCD64)	1.749	0.084	82.2	3.034	0.125	78.8
Late fusion (Pred. + Img16)	1.610	0.073	84.1	2.603	0.124	78.6

Visual Resuls on 3DMatch Dataset



Conclusion & Outlook

Conclusion:

- ❑ Instead of emphasizing the high or low levels of overlapping ratios, I subsetted new datasets that contained cases of geometric smoothness.
- ❑ I investigated different 2D image and 3D point cloud feature fusion strategies for point cloud registration task.
- ❑ Early fusion and late fusion perform better on these datasets w.r.t. selected pure geometry method, while joint learning method does not perform as effective as expected.

Outlook:

- ❑ Further investigate the joint learning method.
- ❑ Conduct experiments on end-to-end methods (i.e., plus matching and estimation).
- ❑ Extend the method to large-scale TLS datasets, which may contain different color format and LiDAR intensity.