SGLC: Semantic Graph-Guided Coarse-Fine-Refine Full Loop Closing for LiDAR SLAM
(Supplementary)

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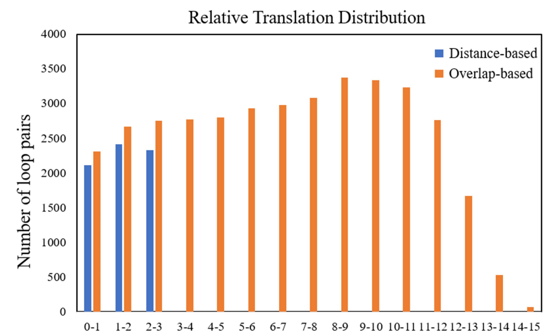
A. Experimental Setup

We evaluate our method in KITTI [1], KITTI-360 [2], Ford Campus [3] and Apollo datasets [4]. For loop pair selection, many existing methods with different settings, mainly divided into distance-based and overlap-based. For a comprehensive evaluation, we select loop pairs using both distance-based and overlap-based criteria.

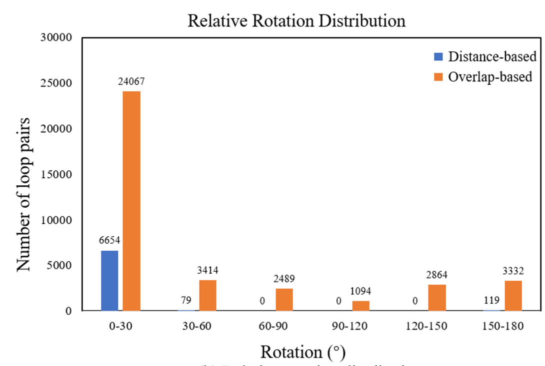
(1) Distance-based: following SSC [5], we regard LiDAR scan pairs as positive samples of loop closure when their Euclidean distance is less than 3 m and as negative samples if the distance exceeds 20 m.

(2) Overlap-based: following OverlapTransformer [6], we regard LiDAR scan pairs as positive samples of loop closure when their overlap ratio exceeds 0.3; otherwise, it is regarded as negative.

Taking the sequence 00 as a case, we present the distribution of rotations and translations of loop pairs across different criteria. As shown in Fig. 1, the number of loop pairs based on overlap criteria is significantly higher than those based on distance, and they exhibit larger viewpoint changes in rotation and translation.



(a) Relative translation distribution



(b) Relative rotation distribution

Fig. 1: The distribution of rotations and translations of loop pairs across different criteria on KITTI sequence 00.

B. Overlap-based Evaluation on KITTI Sequence 08

For overlap-based experimental setups, sequence 08 typically is split as a training set for Deep Neural Networks (DNN)-based approaches. However, the sequence 08 contains many reverse loop closures, allowing for a more comprehensive evaluation of loop detection performance. Consequently, we further test the performance of our approach using overlap-based loop pairs and compare the performance with the handcrafted-based method. including: Scan Context (SC) [7], GosMatch [8], SSC [5], BoW3D [9], Contour Context (CC) [10]. The results are presented in Tab. I. Under this challenging setup, most methods exhibit significant degradation. However, our approach consistently demonstrates the best performance, highlighting its superiority.

TABLE I: The performance evaluation of loop closure detection on the KITTI 08 sequence using overlap-based loop pairs.

Methods	AUC	F1max	Recall @1	Recall @1%
SC	0.531	0.483	0.785	0.917
GOSMatch⋆	0.605	0.561	0.875	0.990
SSC⋆	<u>0.924</u>	<u>0.917</u>	**0.958**	<u>0.991</u>
BoW3D	-	0.562	0.391	-
CC	0.651	0.636	0.780	0.780
Ours⋆	**0.934**	**0.929**	<u>0.942</u>	**0.993**

⋆ denotes semantic-assisted method.

C. Generalization Evaluation

We provide visual results of semantic segmentation on the Ford Campus and Apollo dataset for readers to assess the labels quality. As shown in Fig. 2 and Fig. 3

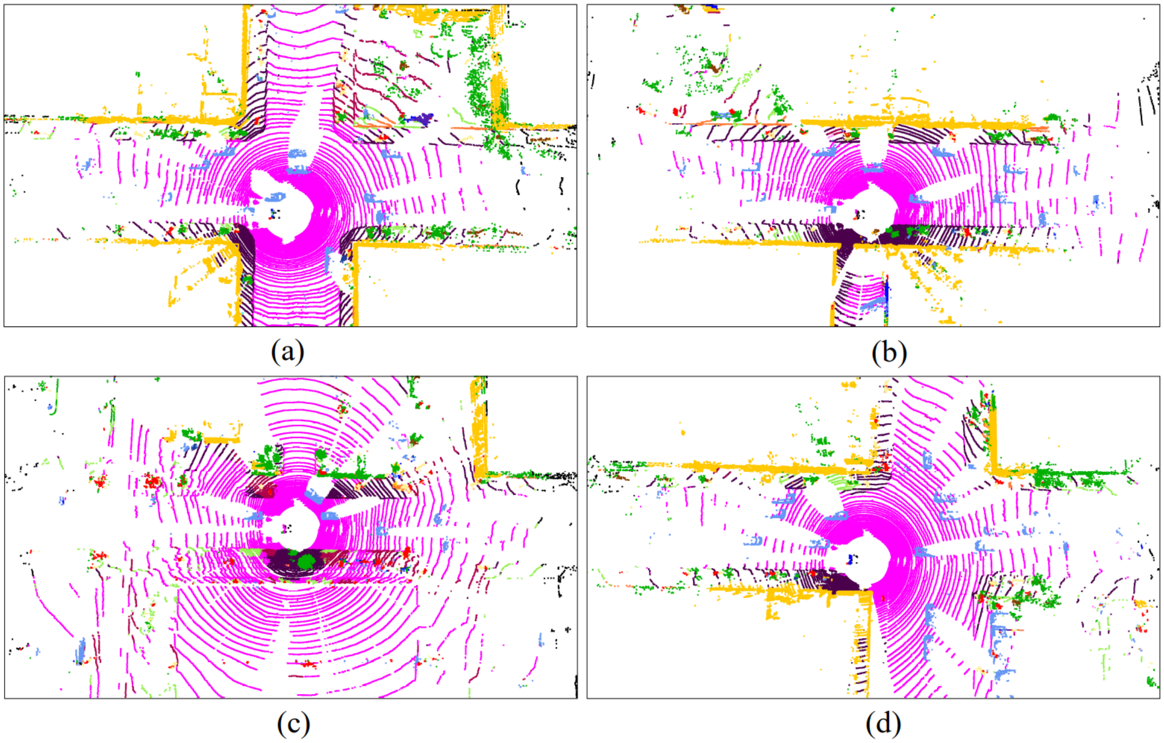


Fig. 2: Semantic labels from SegNet4D on the Ford dataset. Many moving vehicles on the road.

D. Loop Pose Estimation

Further visualization results of alignment are presented as Fig. 4:

E. Runtime

We provide a full runtime comparison with 6-DoF pose estimation baselines, helping readers understand the real-time performance of our system. From the results, our method achieves the fastest running speed even when the time of semantic segmentation is included.

TABLE II: The runtime comparison.

Method	Descriptors Generation	Retrival	Pairwise Registration	Total
BoW3D	17.4	60.6	40.0	<u>118.0</u>
LCDNet(fast)	142.0	5.7	81.7	229.4
LCDNet	142.0	5.7	429.1	576.8
Ours	67.1*+4.5	5.7	20.8	**98.1**

* denotes the semantic segmentation time, i.e., SegNet4D.

References

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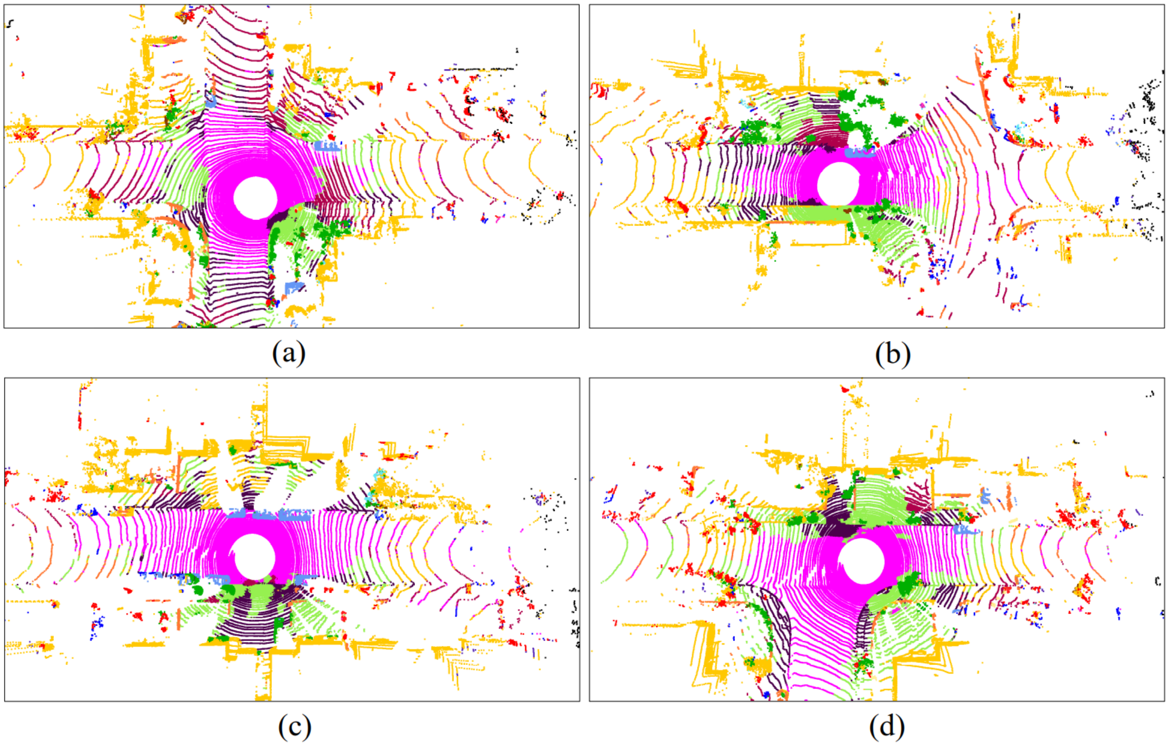

Fig. 3: Semantic labels from SegNet4D on the Apollo dataset. The quality of semantic segmentation has significantly declined.

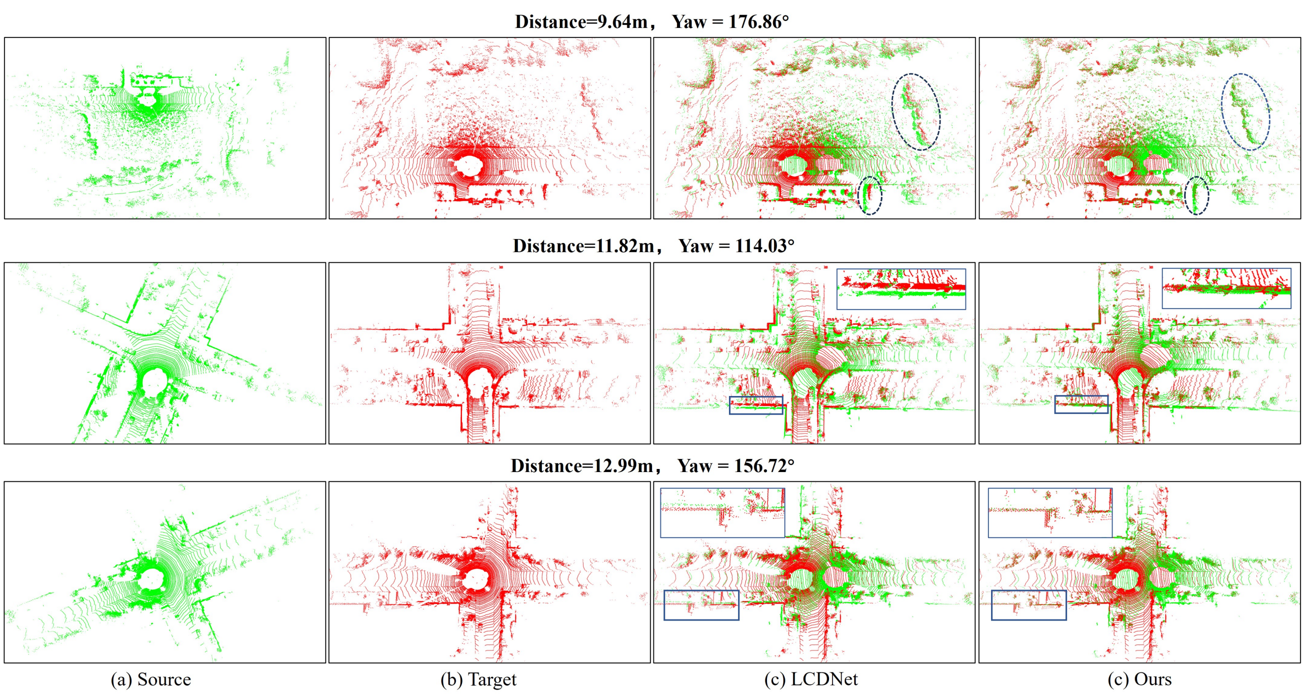

Fig. 4: The qualitative comparison of loop pose estimation on the KITTI dataset using overlap-based loop pairs. Dashed ellipses are directly annotated on the registration results, while solid boxes indicate local magnification. The top displays the ground truth distance and yaw angle difference of the loop pair.