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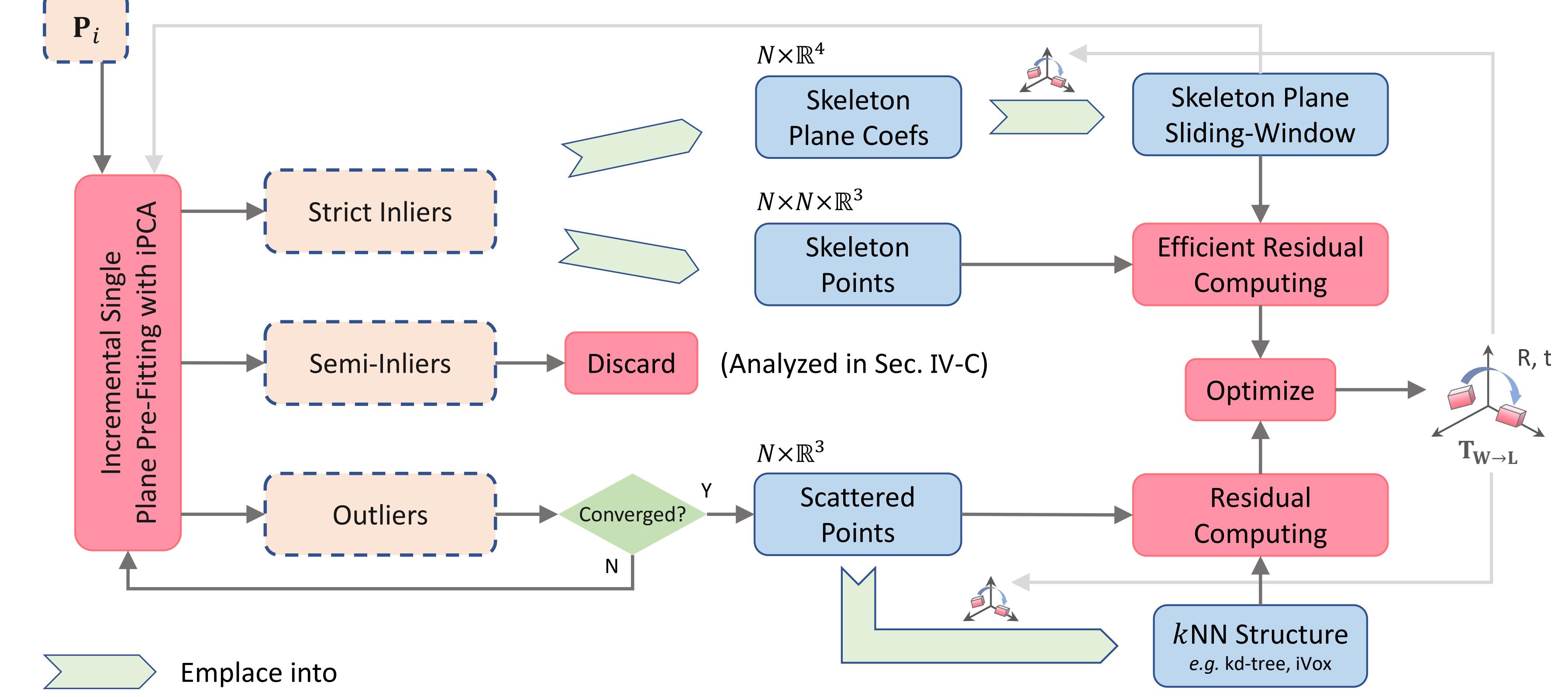
IEEE/RSJ International Conference on Intelligent Robots and Systems

LiO-PPF: Fast LiDAR-Inertial Odometry via Incremental Plane Pre-Fitting and Skeleton Tracking

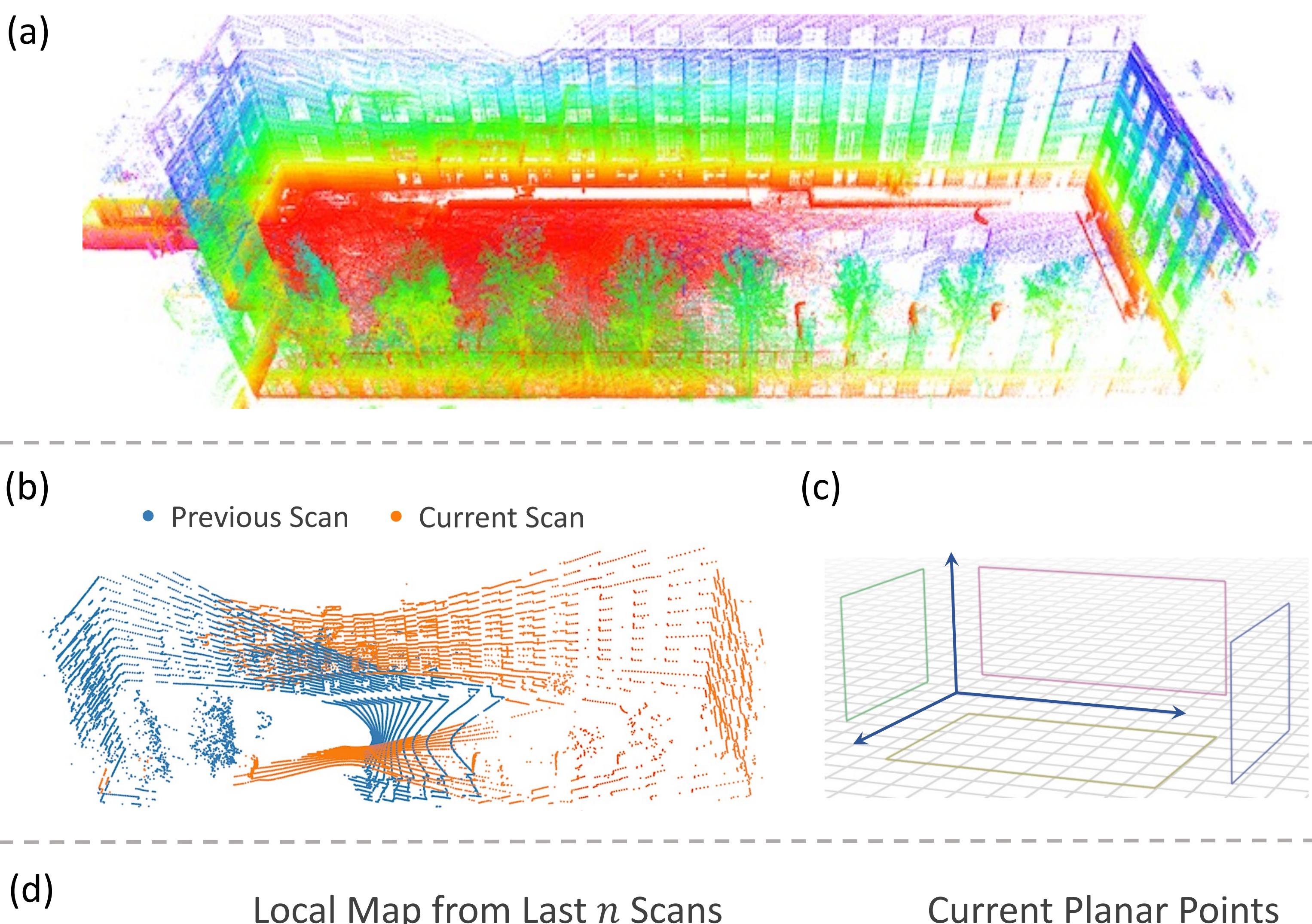
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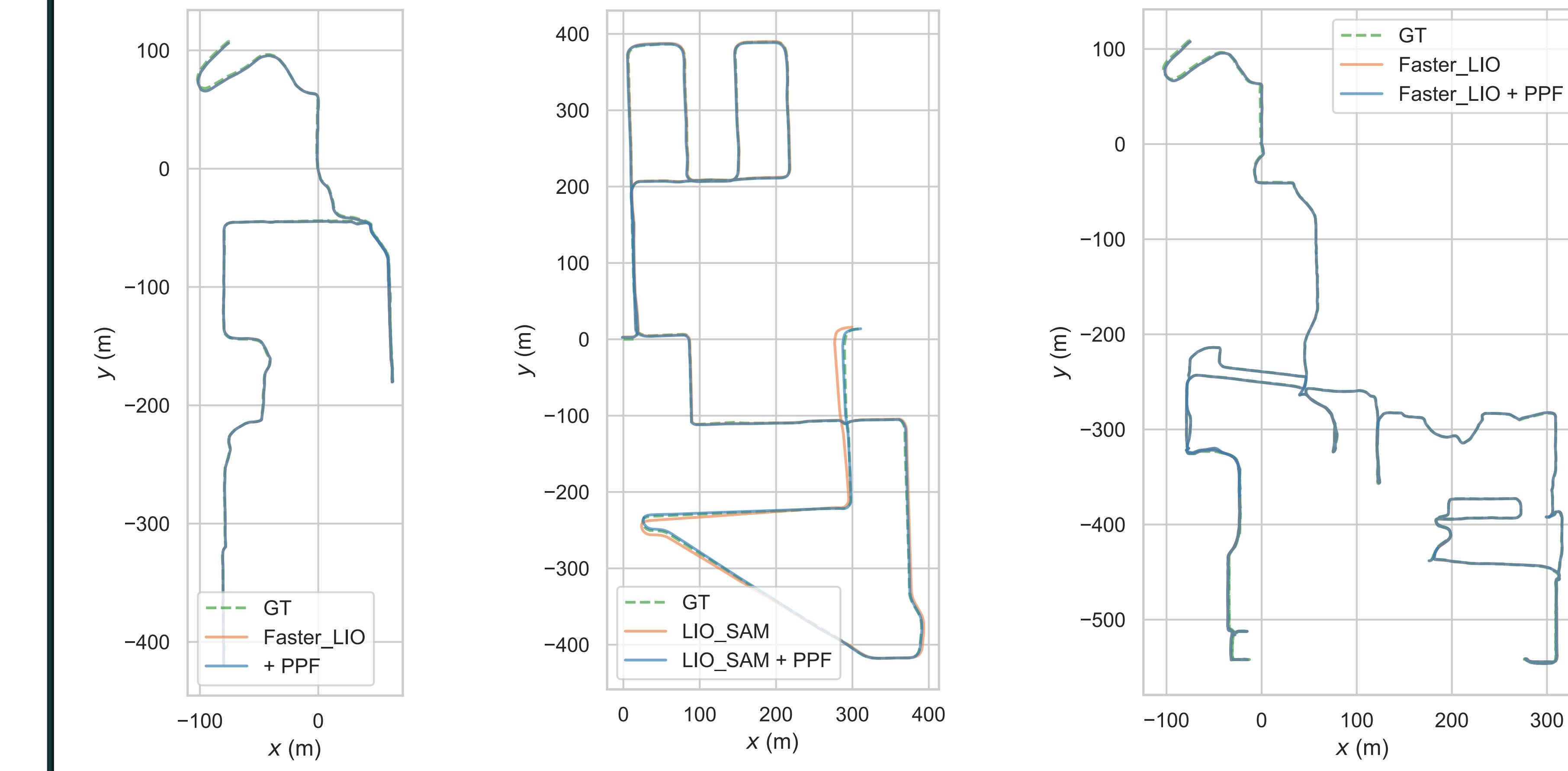
Pipeline



Motivation

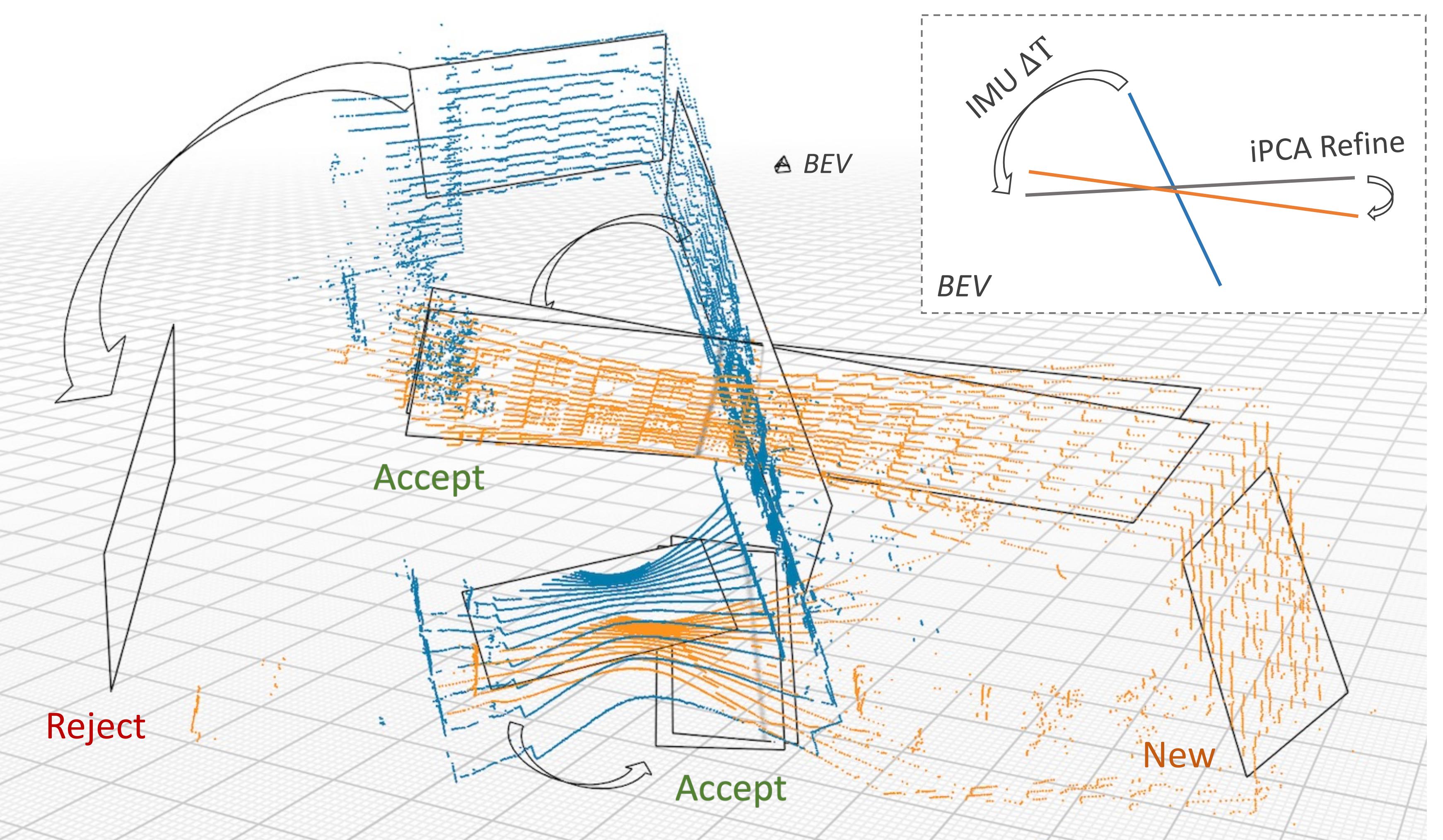


Estimated Trajectories



Incremental Plane Fitting

- Planes are not fitted individually for each scan, let alone for each point, but are updated *incrementally* as the scene ‘flows’.
 - Planes of last scan (after the IMU ΔT transformation) are treated as *initial plane guess*.
 - The accepted guesses need only to be refined.
 - Only a few planes are *newly* fitted from scratch.



(d)

The diagram illustrates the search process for different feature types across three levels: Point Level, Plane Level, and Global Map.

- kNN:**
 - Local Map from Last n Scans:** Shows a point cloud with $n = 1$. A green arrow labeled "Search at the Point Level" points to the right.
 - Current Planar Points:** Shows a point cloud with $n = 1$. A green arrow labeled "Search at the Point Level" points to the right. The text "No Correspondence" is displayed in red.
- PPF:**
 - Local Map from Last n Scans:** Shows a point cloud with $n = 1$. A green arrow labeled "Search at the Plane Level" points to the right.
 - Current Planar Points:** Shows a point cloud with $n = 1$. A green arrow labeled "Search at the Plane Level" points to the right. The text "All Matched" is displayed in green.
- Current Planar Points:**
 - Local Map from Last n Scans:** Shows a point cloud with $n = 10$. A green arrow labeled "Search at the Point Level" points to the right.
 - Current Planar Points:** Shows a point cloud with $n = 10$. A green arrow labeled "Search at the Point Level" points to the right. The text "All Matched" is displayed in green.

- Large planes across the scans form the ***basic skeleton*** of the scene and reveal its overall geometry structure.
 - A large local map is needed by kNN otherwise most points can't find neighbors to fit planes.
 - While we use the ***basic skeleton*** (Fig. c) to represent the scene for point matching. The search field is enlarged to plane level with no kNN search required any longer.

Time & Memory Cost

TIME (ms) AND MEMORY CONSUMING OF EACH STEP IN LIO-SAM [5] USING kNN OR PPF														
PPF		Build Local Map		Build kd-tree		Scan Match		Calc. Residual		Total time ¹		Local Map Size ²		
kNN	PPF	kNN	PPF	kNN	PPF	kNN	PPF	kNN	PPF	kNN	PPF	kNN	PPF	
0	2.64	21.28	10.48	8.43	5.51	19.97	13.84	1.50	0.69	45.12	30.80	66.9k	44.1k	
0	3.16	28.12	13.65	9.56	6.25	21.99	15.96	1.66	0.76	54.36	36.98	75.8k	49.9k	
0	3.07	18.20	9.97	8.55	6.05	22.03	17.51	2.01	0.97	44.37	34.69	67.9k	48.3k	
0	3.61	17.69	10.33	8.88	6.36	23.36	18.55	2.11	1.14	44.95	36.39	70.4k	50.5k	
0	1.30 [†]	55.08	21.56	8.20	3.72	42.93	19.47	3.95	0.83	112.66	58.73	67.6k	29.4k	
0	1.96 [†]	36.76	13.95	5.19	2.61	35.63	16.99	3.80	0.99	91.25	51.77	41.6k	15.7k	
0	1.50 [†]	44.55	24.30	4.30	2.75	28.96	17.48	2.49	0.78	93.05	62.82	37.0k	19.5k	
0	1.25 [†]	45.86	21.92	4.37	2.32	28.47	15.23	2.95	0.73	93.96	58.02	37.3k	17.0k	
0	1.48 [†]	43.29	17.32	5.48	2.34	30.96	15.15	4.12	0.90	93.23	52.93	44.3k	15.9k	
0	1.22 [†]	55.24	23.11	7.31	3.44	43.17	21.10	3.52	0.73	114.89	64.43	60.8k	26.6k	
0	1.29 [†]	45.04	22.79	4.70	2.69	32.25	17.98	3.07	0.80	97.18	61.96	40.3k	19.8k	

¹ The total time includes some common steps e.g. de-skewing (not listed) whose timings are unchanged - we only tabulate steps which are sped up.

² The local map denotes the one used in the scan-matching algorithm, not the reconstructed map. We only decrease the memory usage of LIO algorithms but do not

[†]The ignore_outliers setting is enabled for KITTI dataset to show the benefits for handling the large number of points obtained by Velodyne HDL-64E Laser scanner.

Reconstructed Maps

