AdaLIO + PGO: Adaptive LiDAR Inertial Odometry and Pose Graph Optimization in HILTI SLAM Challenge'23

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***Abstract*— In this work, the method for achieving precise maps on the HILTI SLAM challenge 2023 dataset is presented. We propose a LiDAR-inertial odometry-based method that mainly consists of two steps: a) local odometry estimation by using an improved version of Faster-LIO, called *AdaLIO* and b) pose graph optimization (PGO) with precise loop closing. In particular, our AdaLIO adaptively adjusts the inner parameters by checking whether the surroundings are corridor-like environments. Then, if the surroundings are highly likely to be narrow and cramped scenes, the adaptive parameter setting strategy is applied to increase the number of correspondences. By doing so, we could avoid various divergence cases. Then, fine-tuned PGO is performed to increase the score. As shown in our score, PGO with fine-tuning substantially increases the performance in `site1` and `site3`.**

I. Our Approach: AdaLIO and Pose Graph Optimization

We utilize AdaLIO [1] as a front-end and pose graph optimization (PGO) as a back-end using GTSAM [2]. As we mentioned in HILTI SLAM challenge'22, Faster-LIO [3] occasionally diverges when sensor measurements are acquired in narrow or confined spaces such as corridors or geometrical stairs. This divergence is due to few valid correspondences. That is, Faster-LIO finds correspondences to estimate relative pose at time t after the voxelization of the point cloud. Then, the absolute number of the voxel-sampled cloud points in narrow spaces becomes much smaller than that in general cases. This phenomenon triggers a lack of measurements; thus, it ultimately leads to divergence of relative pose estimation.

To tackle this problem, we exploit AdaLIO [1], which is an adaptive LiDAR inertial odometry approach that forcibly preserves the number of measurements by adjusting the voxel size of surroundings. Then, as a post-processing step, PGO is exploited to refine the estimated poses by AdaLIO. Particularly, we additionally utilize `OrientedPlane3Factor` in GTSAM [2] in some places that contain distinct planar geometrical features, such as `site2_robot_1`. This is because `site2_robot_1` does not have a revisit but only moves in a spiral way, heading towards the lower floor. For this reason, `OrientedPlane3Factor` is exploited based on the Atlanta world assumption to minimize accumulated drift errors.

TABLE I: Reported scores of AdaLIO [3] in HILTI SLAM Challenge 2023.

Scene	Sequence	AdaLIO only	After PGO
site1	handheld_1	35.00	**100.00**
	handheld_2	46.25	70.00
	handheld_3	35.00	87.50
	handheld_4	53.33	**100.00**
	handheld_5	46.00	**100.00**
site2	robot_1	5.71	12.10
	robot_2	36.67	43.33
	robot_3	28.00	58.00
site3	handheld_1	125.0	**200.00**
	handheld_2	51.67	101.67
	handheld_3	41.25	105.00
	handheld_4	70.00	**200.00**

II. Experimental Results And Discussion

As shown in Table I, it was demonstrated that our PGO framework allows us to build precise mapping compared with AdaLIO-only approach. PGO with fine-tuning substantially increased the performance in `site1` and `site3`. However, in `site2`, the performance was increased only slightly compared with other scenes. We examined the outputs closely and observed that deskewed point cloud is still skewed when the robot rotates rapidly, indicating that the angular velocity from the inertial measurement unit (IMU) is somewhat inaccurate.

III. Conclusion

In this challenge, we exploited AdaLIO and PGO with fine-tuning and our proposed framework showed promising mapping accuracy. In future works, we will study how to increase the mapping performance in `site2_robot_1` where the direct revisit does not happen.

References

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