Maplab + OKVIS

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Our approach for the HILTI SLAM challenge [1] was a full global optimization incorporating multiple sensors. As an odometry source, we used OKVIS [2] in stereo mode with the two frontal cameras and the ADIS IMU. The odometry together with the IMU biases calculated by OKVIS were used to initialize a pose graph using Maplab [3], which is a multimodal VIO optimization framework for maps. We included the following sensor modalities into Maplab:

- The 5 cameras were used to compute BRISK features for visual global loop closures.
- The LiDAR was used to generate sequential constraints and local loop closures using an ICP alignment algorithm.
- The ADIS IMU was used to constrain the relative motion between nodes in the pose graph and the measurements and biases were included in the optimization process.

The entire pose graph was optimized using a full bundle adjustment (meaning it is not causal) implemented using a Ceres [4] backend. A different set of optimization commands and procedures were used on each map depending on the environment and some visual inspection. Additionally, for a few of the cases (e.g. Basement3&4, Campus1&2 and ConstructionSite1&2), the maps were merged together using global loop closures to benefit from additional information in the optimization process. We used two machines, each equipped with an Intel(R) Core(TM) i7-8700 CPU and 32GB of RAM. The approximate processing times for each sequence are listed in the table below.

Map	Lab	Campus1 Campus2	Basement1	Basement3 Basement4	ConstructionSite1 ConstructionSite2
Time	25min	3h 44min	19min	2h 57min	3h 22min

Map	UZH Arena	IC Office	Office Mitte	Parking
Time	16min	42min	2h 30min	1h 4min

[1] M. Helmberger, K. Morin, N. Kumar, D. Wang, Y. Yue, G. Cioffi, and D. Scaramuzza. *"The Hilti SLAM Challenge Dataset". arXiv preprint arXiv:2109.11316*, 2021.
[2] S. Leutenegger, S. Lynen, M. Bosse, R. Siegwart, and P. T. Furgale. "*Keyframe-based visual–inertial odometry using nonlinear optimization*". In *International Journal of Robotics Research*, 2015.
[3] T. Schneider, M. T. Dymczyk, M. Fehr, K. Egger, S. Lynen, I. Gilitschenski, and R. Siegwart. "*maplab: An open framework for research in visual-inertial mapping and localization*". In *IEEE Robotics and Automation Letters* 2018.
[4] S. Agarwal, K. Mierle, *et al. "Ceres Solver".* http://ceres-solver.org.