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Assignment 3
ME 8135: Robot Estimation

1 Kimera: an Open-Source Library for Real-Time Metric- Semantic Localization and Mapping

Kimera is an open-source C++ library for real-time metric-semantic visual-inertial Simultaneous Localization And Mapping (SLAM). The state of the robot is approximated by utilizing visual-inertial sensing and created a lightweight metric-semantic mesh model of the environment. It consists of VIO, pose graph optimization (PGO), mesh reconstruction, and 3D semantic segmentation. Kimera contains four main modules:

1. *Kimera-VIO:* A VIO module for fast and accurate IMU-rate state approximation. At its core, Kimera-VIO features a GTSAM-based VIO method, using IMU preintegration and structureless vision factors, and achieves top performance on the EuRoC dataset.

2. *Kimera-RPGO:* It is a robust pose graph optimization (RPGO) approach exploiting on modern methods for outlier rejection. Kimera-RPGO are able to prevent SLAM destructions according to perceptual aliasing by adding a robustness layer. In addition, it can alleviate the user from time-consuming parameter tuning.

3. *Kimera-Mesher:* It is a module evaluating a fast per-frame and multi-frame regularized 3D mesh so as to avoid obstacles.

4. *Kimera-Semantics:* It is a module constructing a slower but more precise global 3D mesh applying a volumetric algorithm. Additionally, 2D pixel wise semantic segmentation is exerted to semantically annotate the 3D mesh.

Kimera is modular, ROS-enabled, and runs on a CPU. Furthermore, each module in Kimera can be replaced with each other or perform individually. As an illustration, it can approximate a geometric mesh even if the semantic labels are not available.

As depicted in Fig 1, the inputs of Kimera are stereo frames and inertial measurements unit. The outputs of this structure are precise state approximate at IMU rate, a globally-consistent trajectory approximate, and multiple meshes of the environment such as a fast local mesh and a global semantically annotated mesh. As mentioned before, Kimera includes four threads. The first thread is Kimera-VIO front-end which takes stereo images and IMU data as inputs and outputs feature tracks and preintegrated IMU measurements. The second tread is Kimera-VIO back-end and Kimera-Mesher, which the optimized state approximate and multi frame 3D meshes are the outputs. The third thread is Kimera-RPGO which finds loop closure, rejects outliers, and estimates a globally consistent trajectory. The fourth thread is Kimera-Semantic utilizing dense stereo and 2D semantic labels to acquire a refined metric-semantic mesh, using Kimera-VIO's pose estimates [1].

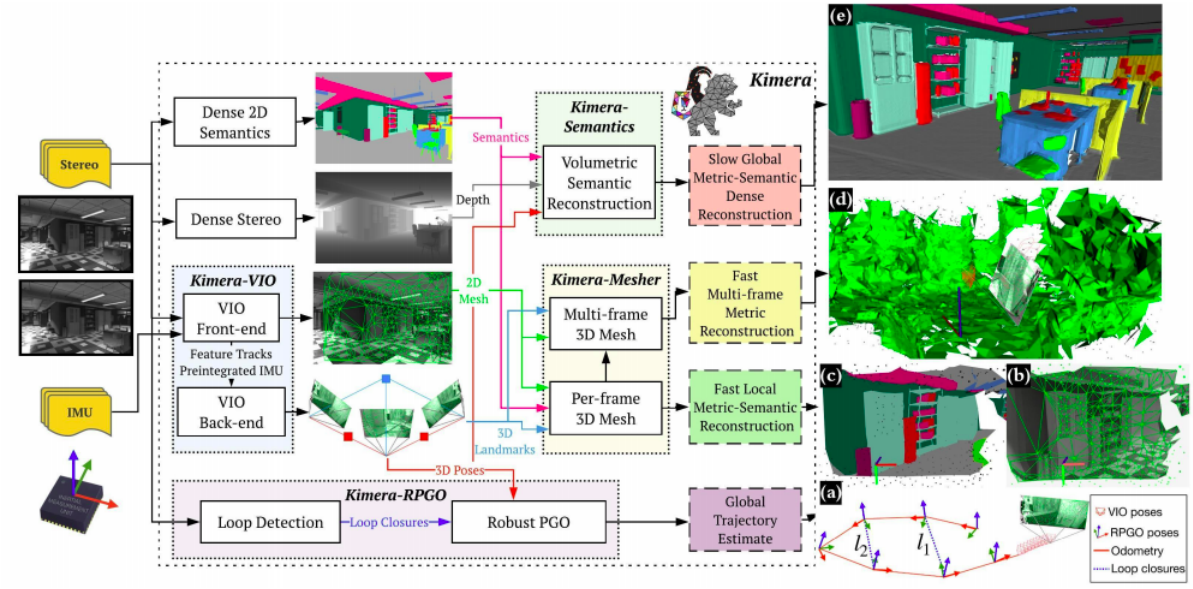

Figure 1: Kimera's Structure [1]

In this assignment, Kimera-Semantics is installed and run on the demo rosbag. Kimera-Semantics creates a 3D mesh from the VIO pose approximations. In this method, dense stereo and bundled raycasting are used. Kimera-Semantics with ground-truth (GT) poses and ground truth depth maps are exerted to evaluate the initial loss of performance due to bundled raycasting.

The instruction of installing and compiling Kimera-Semantics can be found at https://github.com/MIT-SPARK/Kimera-Semantics.

The result of running Kimera-Semantics is provided in https://github.com/Zeinab-E/ME8135-State-Estimation-for-Robotics-and-Computer-Vision .

References

[1] A. Rosinol, M. Abate, Y. Chang, and L. Carlone, "Kimera: an open-source library for real-time metric-semantic localization and mapping," in *2020 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE, 2020, pp. 1689–1696.