Project Proposal

"Bundle Adjustment"

1 Abstract

Bundle Adjustment [4] is a vital part of 3D reconstruction algorithms. It aims to minimize an energy function to find the poses of cameras and position of 3D points. In our project, we are going to reconstruct sparse 3D coordinates of landmarks extracted from images in the TUM RGB-D dataset [3] and implement bundle adjustment to refine the 3D reconstruction as well as to estimate the camera poses. To achieve this, first, we extract features and descriptors from RGB-D images [1]. Then, we match the features across frames. Using these correspondences and a RANSAC approach [2] we can intialize the relative poses between frames. Finally, we refine these poses as well as the landmarks' positions through an optimization approach, and hence acquire our resulting sparse 3D reconstruction. An overview of the processing pipeline can be seen in Fig. 1.

2 Requirements

- Libraries: C++ Standard Library, OpenCV (image manipulations, feature descriptors, feature matching), FreeImage, Eigen, Ceres Solver, FLANN, Sophus (Lie groups), OpenGV (Ransac and relative pose initialization)
- Dataset: TUM RGB-D

3 Team

Group 24:

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4 Milestones

List your weekly milestones for this project proposal.

- Setup (Week 1)
  - Set up collaboration tools, git repository.
  - Download and familiarize ourselves with the dataset.

  - Create the CMAKE file and add dependencies.

- Feature Detection (Week 2)
  - Choose feature detector (e.g. Fast, SIFT, blob, Harris, BRISK).
  - Implement, visualize, test.

- Feature Descriptors and Matching (Week 3)
  - Choose an appropriate feature descriptor (e.g. Fast, SIFT, BRISK, ORB).
  - Choose an appropriate distance metric (e.g. L^2, Hamming, or something more robust...).
  - Implement, visualize, test.

- Pruning correspondences, optimization initialization (Week 4)
  - Use 3D-3D correspondences (or another method) and RANSAC to initialize the relative poses between two frames.

- Optimization (Week 5)
  - Choose parameterizations (rotations etc.).
  - Write energies.
  - Assess properties of the data (sparsity, ...) and choose an appropriate optimization algorithm.

- Results and Evaluation (Week 6)
  - Compute quantitative and qualitative results and compare them with other works.
  - Write the final report and record the presentation video.

References

[1] Ali Ismail Awad and Mahmoud Hassaballah. *Image Feature Detectors and Descriptors; Foundations and Applications*, volume 630. 02 2016.

[2] Martin A. Fischler and Robert C. Bolles. Random sample consensus: A paradigm for model fitting with applications to image analysis and automated cartography. *Commun. ACM*, 24(6):381–395, jun 1981.

[3] Jürgen Sturm, Nikolas Engelhard, Felix Endres, Wolfram Burgard, and Daniel Cremers. A benchmark for the evaluation of rgb-d slam systems. In *2012 IEEE/RSJ international conference on intelligent robots and systems*, pages 573–580. IEEE, 2012.

[4] Bill Triggs, Philip F. McLauchlan, Richard I. Hartley, and Andrew W. Fitzgibbon. Bundle adjustment — a modern synthesis. In Bill Triggs, Andrew Zisserman, and Richard Szeliski, editors, *Vision Algorithms: Theory and Practice*, pages 298–372, Berlin, Heidelberg, 2000. Springer Berlin Heidelberg.

Figure 1: Overview of our proposed processing pipeline