Global Structure-from-Motion Revisited (GLOMAP)

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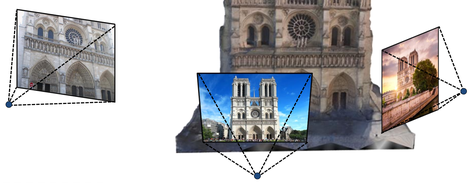
code project page

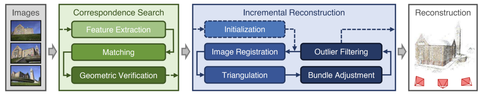
Introduction

Structure-from-Motion (SfM)



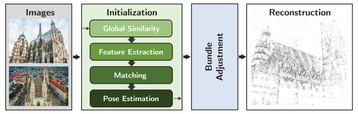
Incremental SfM

- Adding images incrementally
- Generally robust but inefficient



Global SfM

- Images processed in a single pass
- Generally efficient but less robust



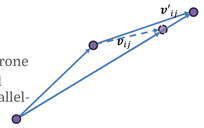
Overview

Goal: Efficiency + Robustness

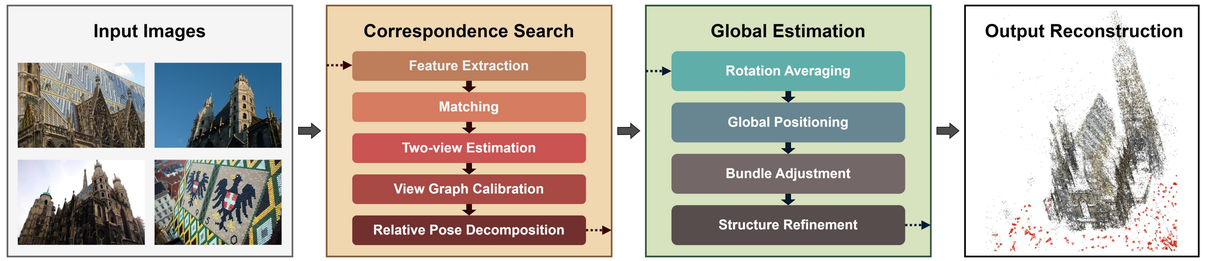
- Replacing translation averaging by global positioning
- Open-source software for Global SfM pipeline
- **Drop-in replacement** for COLMAP mapper
- **On par or superior performance** compared with COLMAP

Pitfalls of Previous Global SfM: Translation Averaging

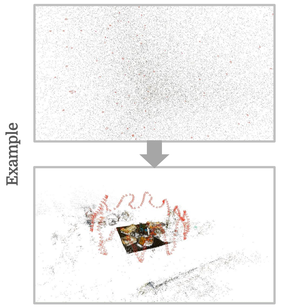
- **Challenges**: forward / sideway motion, uncalibrated cameras
- Error in relative pose estimation can be amplified by translation averaging
- Estimation of relative translation is error-prone
- The reconstruction can only be determined uniquely if the view-graph is subject to parallel-rigidity



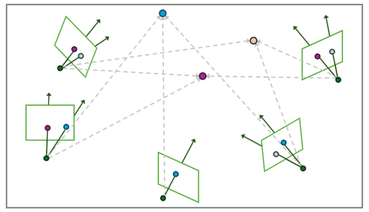
Pipeline



Global Positioning

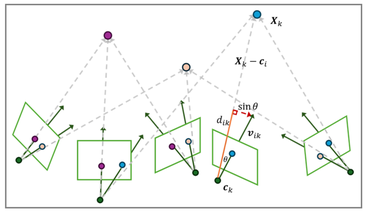


Random Initialization



Global Positioning

Valid Reconstruction



BATA Loss : $$\arg\min_{\boldsymbol{X},\boldsymbol{c},d} \sum_{i,k} \rho\left(\|\boldsymbol{v}_{ik} - d_{ik}(\boldsymbol{X}_k - \boldsymbol{c}_i)\|_2\right), \quad \text{subject to} \quad d_{ik} \geq 0,$$

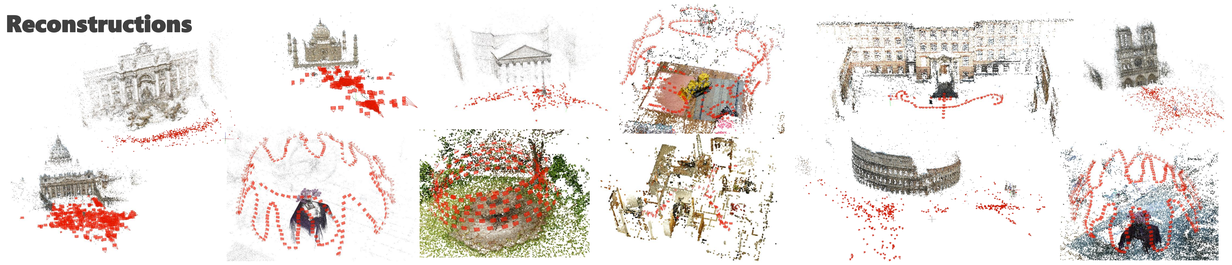
Properties

- **Bilinear form**: converges quickly from random initialization
- **Bounded error**: for optimal d_{ik}, each error term $\in[0, 1]$ is robust to outliers

Why more robust

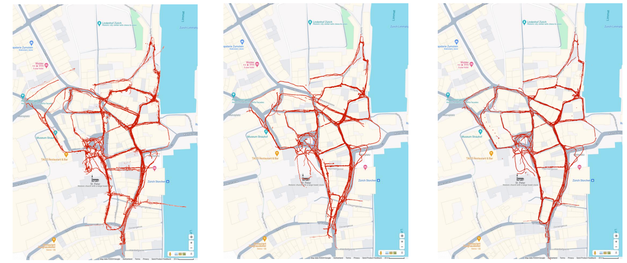
- More constraints lead to smaller variances
- Applicable when intrinsics are not accurate
- Constraints are not degenerate in case of colinear motion

Reconstructions



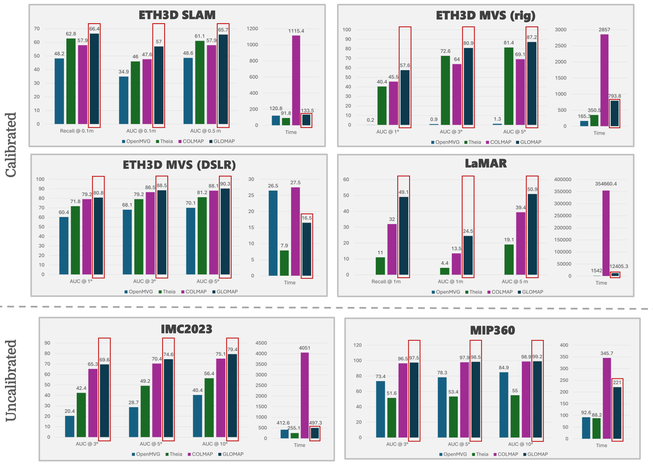
Experiments

LaMAR LIN



- LaMAR LIN: large scale, > 36k images, > 250 m
- ~90% recall at 1m, ~5.5h (GLOMAP) vs ~50% recall at 1m, > 7 days (COLMAP)

Experiment Summary



References

[1] Zhuang et al., "Baseline Desensitizing in Translation Averaging", CVPR 2018
[2] Moulon et al., "Global fusion of relative motions for robust, accurate and scalable structure from motion", ICCV 2013
[3] Sweeney, "Theia Multiview Geometry Library: Tutorial & Reference"
[4] Schönberger and Frahm, "Structure-from-Motion Revisited", CVPR 2016