# Rotation-Only Bundle Adjustment

Seong Hun Lee and Javier Civera (I3A, University of Zaragoza, Spain)

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## 1. Introduction

Global SfM pipeline:

(1) Feature extraction and matching.
(2) Relative pose estimation.
(3) Global rotation estimation by multiple rotation averaging (RA).
(4) Global translation estimation.
(5) Multiview triangulation.
(6) Bundle adjustment (BA).

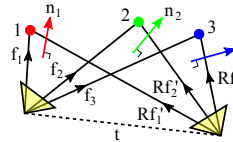
Steps (4), (5), (6) are influenced by the rotation accuracy of Step (3).

To improve the accuracy, we propose an intermediate step (3.5):

(3.5) Rotation-Only Bundle Adjustment

+ Simpler than BA, as rotations are decoupled from the rest.
+ Complete immunity to inaccurate translations and structure.
+ Accuracy improvement.

## 2. Two-View Rotation-Only [1]




Find $\mathrm{R}$ that makes the normals of the epipolar planes $\mathrm{n_i}$ coplanar.

→ Eigenvalue minimization problem:

$$\mathrm{R} = \mathrm{argmin}_{\mathrm{R}}\, \lambda_{\mathrm{M}}(\mathrm{R}) \qquad (1)$$

where $\lambda_{\mathrm{M}}$ is the smallest eigenvalue of matrix $\mathrm{M}$ defined as

$$\mathrm{M} = \sum_{\mathrm{i}} \left(\hat{\mathrm{f}}_{\mathrm{i}} \times \mathrm{R}\hat{\mathrm{f}}_{\mathrm{i}}'\right)\left(\hat{\mathrm{f}}_{\mathrm{i}} \times \mathrm{R}\hat{\mathrm{f}}_{\mathrm{i}}'\right)^{\mathsf{T}} \qquad (2)$$

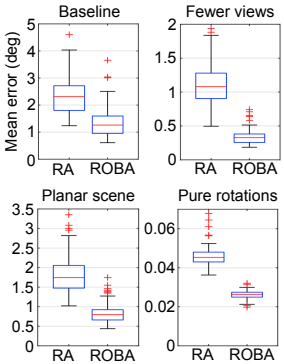
## 3. Multi-View Rotation-Only

Solve $$\underset{\mathrm{R}_1,\ldots,\mathrm{R}_{\mathrm{n}}}{\mathrm{argmin}} \sum_{(\mathrm{j},\mathrm{k})} \sqrt{\lambda_{\mathrm{M}}(\mathrm{R}_{\mathrm{jk}})} \qquad (3)$$

using the Adam optimizer [2].

## 4. Results in Simulation

- RA: SOTA rotation averaging [3]
- ROBA: RA [3] + Rotation-Only BA




1. In **1200 out of 1200** simulations under 12 different configurations, ROBA improved the results.
2. It works for planar scenes and pure rotations, and better for denser graphs.

## 5. Results on Real Data [4]

| | RA | | ROBA | |
|---|---|---|---|---|
| ALM | 4.08 | (16) | **2.35** | (267) |
| ELS | 2.10 | (1) | **1.06** | (48) |
| GDM | 6.05 | (3) | **2.43** | (87) |
| MDR | 6.20 | (2) | **4.42** | (61) |
| MND | 1.46 | (4) | **0.82** | (142) |
| NTD | 2.08 | (14) | **1.27** | (291) |
| NYC | 2.87 | (1) | **1.03** | (49) |
| PDP | 3.86 | (1) | **2.18** | (61) |
| PIC | 4.14 | (220) | **1.58** | (899) |
| ROF | 2.94 | (6) | **2.18** | (186) |
| TOL | 3.83 | (1) | **1.15** | (64) |
| TFG | 3.40 | (553) | **2.76** | (2194) |
| USQ | 5.59 | (1) | **3.26** | (62) |
| VNC | 6.12 | (15) | **4.96** | (289) |
| YKM | 3.67 | (1) | **1.66** | (74) |

L1 mean errors in deg (times in s)

## 6. Conclusions

- ROBA estimates the global rotations of multiple views, independently of the translations and the scene structure.
- We formulate the problem by extending the two-view method [1] and solve it using the Adam optimizer [2].
- Accuracy ↑ when used after RA [3].

[1] L. Kneip, S. Lynen. Direct optimization of frame-to-frame rotation, ICCV 2013.
[2] D. P. Kingma, J. L. Ba. ADAM: A method for stochastic optimization, ICLR 2015.
[3] A. Chatterjee, V. M. Govindu. Robust Relative Rotation Averaging, TPAMI, 2018.
[4] K. Wilson, N. Snavely. Robust global translations with 1DSfM, ECCV 2014.