Incremental Rotation Averaging, IJCV2021

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Introduction

- **Rotation averaging**[1] estimates the absolute camera orientations given the relative rotation measurements.
- It is non-trivial because some of the relative rotations in the Epipolar-geometry Graph (EG) are **outliers**.
- Existing methods either seek to design **robust loss functions** to make the optimization process more robust[2-3] or try to develop **effective filtering strategies** to clean the outlier-contaminated EG[4-5].
- In order to achieve a more **accurate** and **robust** absolute rotation estimation, we present a novel rotation averaging pipeline, which is inspired by the well-developed **incremental SfM** techniques.
- Instead of estimating all the absolute rotations **simultaneously** like traditional rotation averaging methods, they are estimated in an **incremental** way.

Preliminary

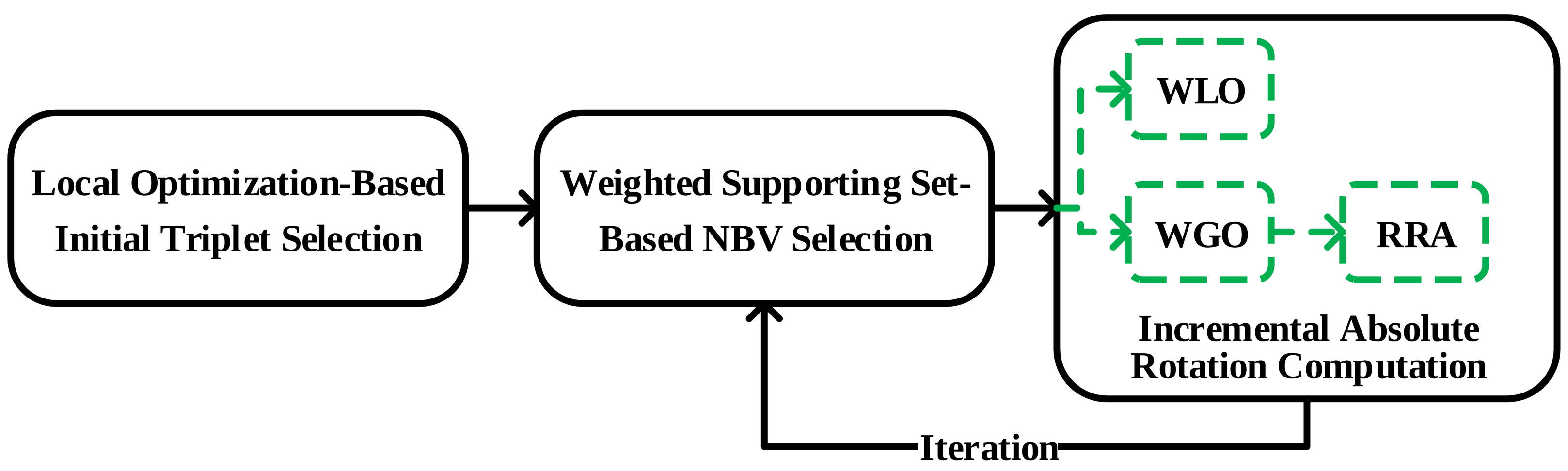
- Given an EG, $\mathcal{G} = (\mathcal{V}, \mathcal{E})$, where each vertex $v_i \in \mathcal{V}$ corresponds to a camera with an absolute rotation $\boldsymbol{R}_i$ to estimate, and each edge $e_{ij} \in \mathcal{E}$ links a matched image pair with a relative rotation measurement $\boldsymbol{R}_{ij}$. The rotation averaging problem here is defined as:

$$\{\boldsymbol{R}_i^*\} = \arg\min \sum_{\substack{v_i, v_j \in \mathcal{V} \\ e_{ij} \in \mathcal{E}}} d_\theta^2\left(\boldsymbol{R}_{ij}, \boldsymbol{R}_j \boldsymbol{R}_i^{\mathrm{T}}\right).$$

- The $\boldsymbol{R}_{ij}$ inlier/outlier criterion is defined as:

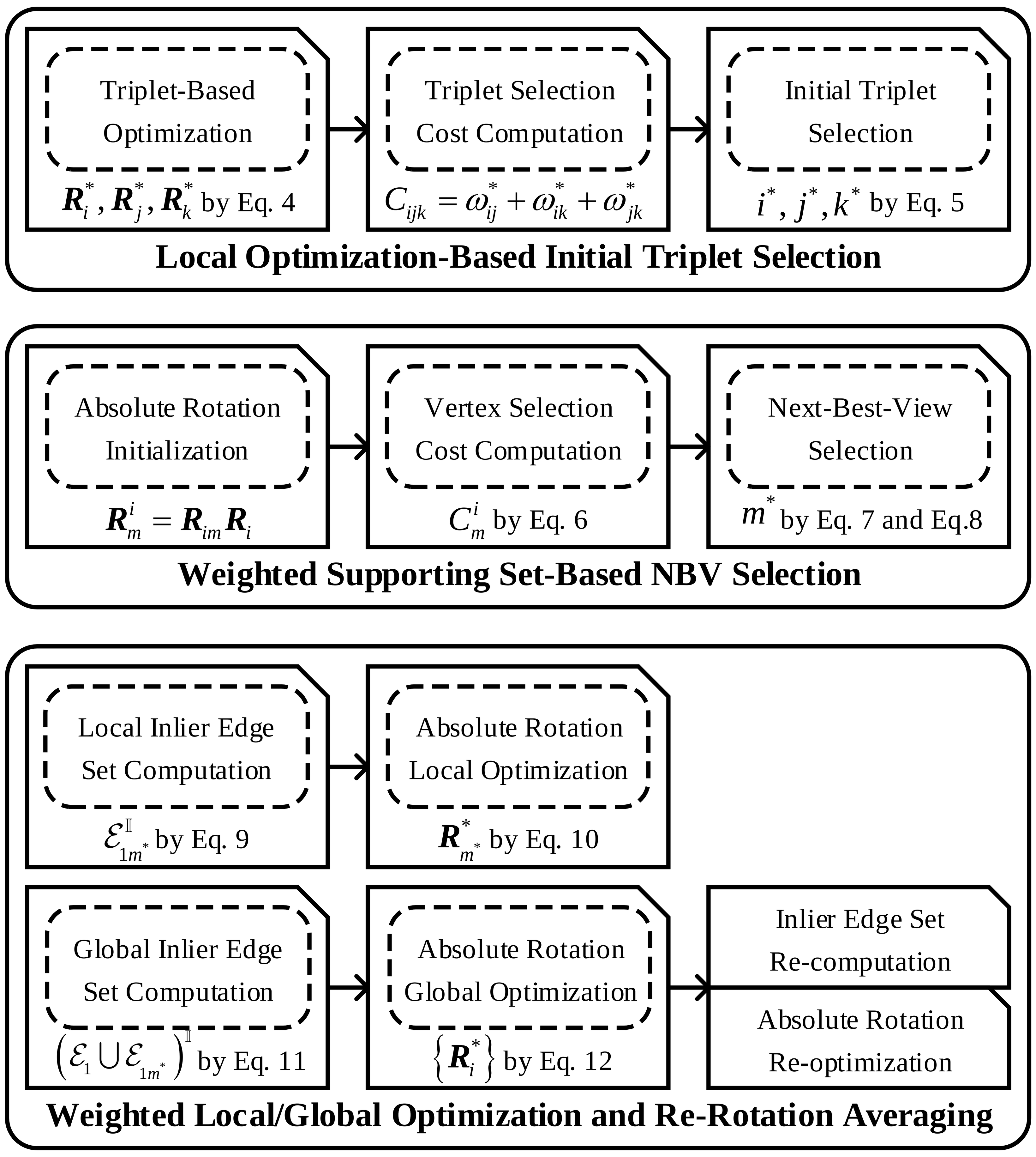
$$\boldsymbol{R}_{ij} = \begin{cases} \boldsymbol{R}_{ij}^{\mathbb{I}} & \text{if} \quad d_\theta\left(\boldsymbol{R}_{ij}, \boldsymbol{R}_j^* \boldsymbol{R}_i^{*\mathrm{T}}\right) \le \theta_{th} \\ \boldsymbol{R}_{ij}^{\mathbb{O}} & \text{if} \quad d_\theta\left(\boldsymbol{R}_{ij}, \boldsymbol{R}_j^* \boldsymbol{R}_i^{*\mathrm{T}}\right) > \theta_{th} \end{cases}.$$

Overview



- Input: relative rotation measurements and the feature match number on each EG edge, $\{\boldsymbol{R}_{ij}, n_{ij} | e_{ij} \in \mathcal{E}\}$.
- Output: optimized absolute rotations, $\{\boldsymbol{R}_i^* | v_i \in \mathcal{V}\}$.

Method



Result

Comparison experimental results of the final rotation averaging accuracy in degrees

Data	ℓ_1-IRLS[2]	ℓ_1-IRLS($\ell_{0.5}$)[3]	WRST-RA[4]	OMSTs-RA[5]	IRA	ℓ_1-IRLS($\ell_{0.5}$) w/ IRA
ALM	2.12	2.14	2.11	1.26	0.83	1.23
ELS	1.02	1.15	1.32	0.75	0.51	0.52
MDR	2.75	3.08	35.38	1.12	0.85	1.02
MND	0.77	0.71	1.03	0.68	0.51	0.55
NYC	1.43	1.40	4.51	1.30	1.00	1.11
PDP	2.19	2.62	1.48	1.73	0.90	1.30
PIC	2.38	3.12	14.40	1.41	1.67	1.63
ROF	1.59	1.70	10.55	1.85	1.51	1.48
TOL	2.55	2.45	4.08	2.10	2.45	2.45
TFG	1.85	2.03	13.25	2.63	3.30	3.22
USQ	4.34	4.97	15.39	3.83	4.40	4.22
VNC	4.47	4.64	3.63	3.30	1.02	1.06
YKM	1.71	1.62	2.90	1.55	1.57	1.44
CPS	2.06	2.05	1.24	2.35	1.24	1.75
SNF	3.05	3.56	15.07	3.26	2.06	2.36

Conclusion

- A simple yet effective rotation averaging pipeline, IRA, is presented, which shares similar workflow with the **incremental SfM**, thus it is **accurate** in parameter estimation and **robust** to measurement outliers as well.
- Several key techniques are proposed to push the results further for the particular rotation averaging assignment.

Reference

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