Globally Optimal Relative Pose Estimation with Gravity Prior - Supplementary Material

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1. Introduction

This supplementary material provides the following information: Section 2 describes the numerical stability of the proposed PEP-based optimal solver (OPT) and its variant based on Sturm sequences (OPT(S)). Section 3 provides the results for forward motion. Section 4 provides the performance for the proposed OPT, OPT(S), LIN and LIN(S) solvers under increasing relative rotation. The default settings used in this material are: image noise of $\sigma = 1$ pixel, a baseline of $\mathbf{t} = 5\%$ of the average scene depth, the number of points is set to $N = 20$, the field of view of the camera is set to FOV = 90°, and the noise level in the gravity direction is set to $\tau = 0°$.

2. Numerical Stability

In Fig. 1 we show Gaussian kernel smoothed histograms of relative errors with noise-free data for general motion under the default settings. We can see that the OPT(S) solver is less stable than the OPT solver, but it is still stable enough to be used in practice. In our experiments, we observed that the numerical stability of the OPT(S) and LIN(S) solvers is affected by the baseline and the rotation angle. The stability of these solvers is decreasing with increasing rotation angle and with decreasing baseline (for more details see Section 4).

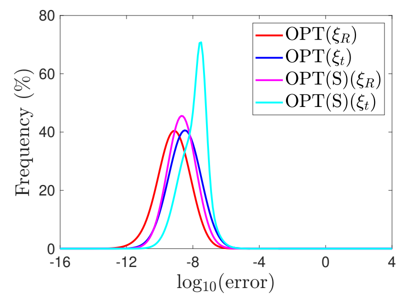
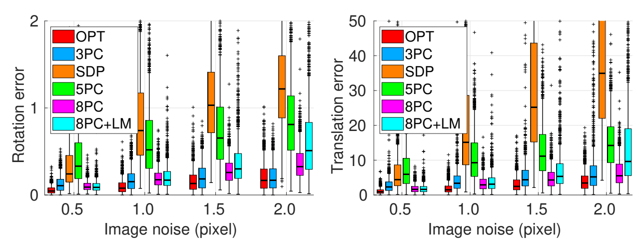


Figure 1: Gaussian kernel smoothed histograms of relative rotation and translation errors for 10,000 runs under general motion with default settings.

3. Forward Motion

In this section, we show results from synthetic experiments for cameras undergoing forward motion. Fig. 2 reports the rotation (Left) and translation (Right) errors in degree w.r.t. increased image noise when using the default settings. We see that the SDP-based solver [1, 2] performs much worse than the other solvers. While the rotation error for the SDP solver is still acceptable, the translation error is extremely large. In addition, 8PC+LM is returning worse results than 8PC. As illustrated in the main paper, there are more than 2,000 stationary points, and one explanation of this behavior is that 8PC+LM may get stuck in these local minima.

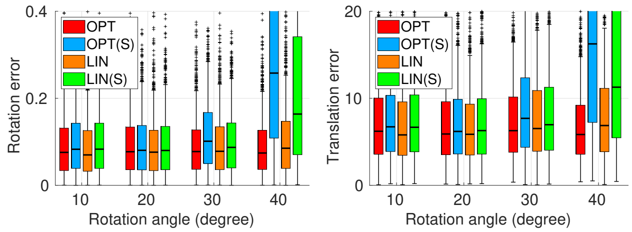


(a) (b)

Figure 2: Rotation and translation errors in degrees for forward motion under increasing image noise. Default settings are used.

4. Increased Relative Rotation

In this section, we provide two experiments to show that: (i) The propose LIN solvers might be better than the OPT solvers under critical conditions. (ii) The LIN solvers will fail with large rotation angles.



(a) (b)

Figure 3: Rotation and translation errors in degrees under forward motion. Default settings with 1% baseline and increasing rotation angle.

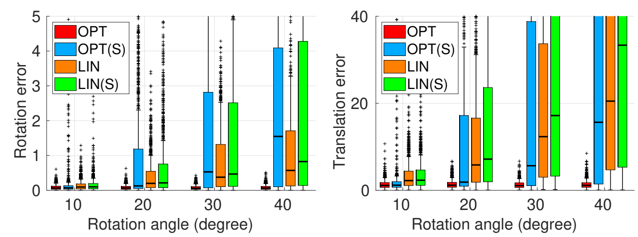
In Fig. 3, we show the performance of the proposed OPT, OPT(S), LIN and LIN(S) solvers w.r.t. an increasing rotation angle and forward motion. In this experiment we used the default settings, however with a 1% baseline. In this challenging scenario and for rotation angles smaller than 2 degrees, the LIN solver performs slightly better than the remaining three solvers. This is consistent with the results of the real experiments in the main paper. Even for a 5 degree rotation angle, the LIN solver is still comparable to the OPT solvers. On the other hand, the solvers based on Sturm sequences become unstable with larger rotation angles.

In Fig. 4, we show the performance for the proposed OPT, OPT(S), LIN and LIN(S) solvers w.r.t. increasing relative rotation angle for the default settings with general motion. It can be see that the OPT(S), LIN and LIN(S) solvers do not provide good estimates for large rotation angles. This behavior of the LIN and LIN(S) solvers can be expected, since large rotation angles do not meet the linearized rotation assumption. Moreover, we found that Sturm sequences are not stable for large rotation angles. The proposed OPT solver gives promising results for all the configurations. However, as shown in the main paper, since in visual odometry and SLAM applications, the relative rotation between consecutive frames is often small or negligible, the propose linearized solver and the solvers using Sturm sequences are also practical.

References

[1] Jesus Briales, Laurent Kneip, and Javier Gonzalez-Jimenez. A certifiably globally optimal solution to the non-minimal relative pose problem. In *Computer Vision and Pattern Recognition (CVPR)*, 2018. 1

[2] Ji Zhao. An efficient solution to non-minimal case essential matrix estimation. *Trans. Pattern Analysis and Machine Intelligence (PAMI)*, 2020. 1



(a) (b)

Figure 4: Rotation and translation errors in degrees under general motion. Default settings increased large rotation angle.