Simulator HC: Regression-based Online Simulation of Starting Problem-Solution Pairs for Homotopy Continuation in Geometric Vision

Supplementary Material

This supplementary presents the results not shown in the main paper for the lack of space.

10. GRPS Numerical Stability Full Results

In addition to rotation errors, we also present the translation and scale error distributions in the following. We can observe consistent performance on both translation and scale errors similar to the rotation errors.

11. GRPS Noise Resilience Full Results

We further present the translation and scale errors for our HC simulator in the noise resilience experiments. Similar performances can be observed on rotation, translation, and scale when varying the noise level. And the rotation errors appear to be less sensitive to image noise than translation and scale errors.

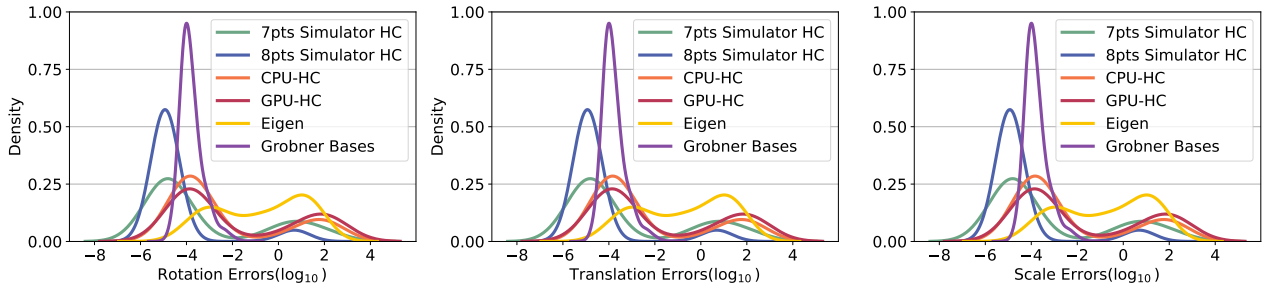
12. Evaluation within RANSAC

We further compare the proposed 8pts simulator HC and Gröbner Bases solver inside RANSAC using synthetic data. The following table presents translation error and scale error in percentage.

13. More Discussion

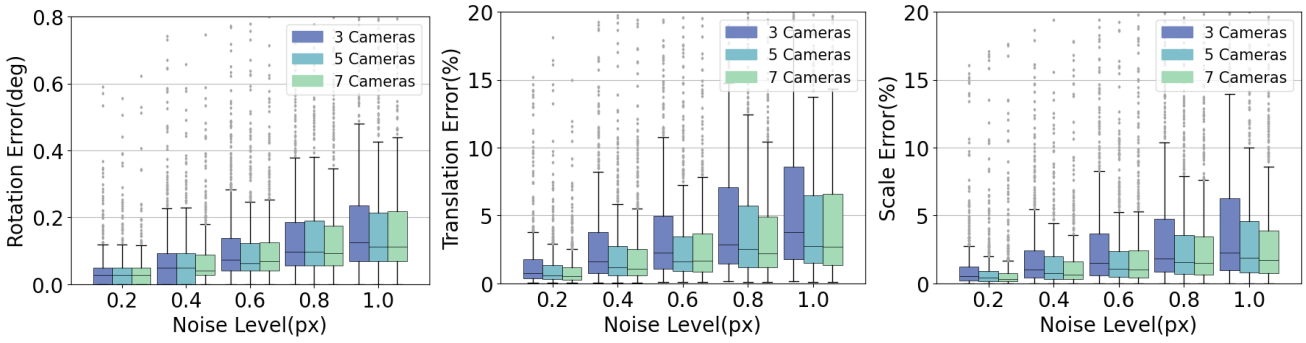
We propose a general method to solve nonlinear equations, particularly polynomial systems that challenge traditional approaches such as Gröbner Bases (GB) and Levenberg-Marquardt (LM). Given the limitations of classical methods, researchers have actively explored modern alternatives, such as homotopy continuation (HC) and learning-based approaches. However, these methods either induce high computational cost (HC exhaustively tracks all roots) or suffer from poor performance. Simulator HC significantly enhances the performance of simple learning-based methods while avoiding the computational expenses of tracking all solution paths, as in standard HC.

The proposed Simulator HC could be applied to many applications. Examples of important problems for which no alternative exists and where our approach could be applied are given by: *Rolling Shutter Camera Relative Pose Problem (no minimal solver available)*, *Inverse Kinematics Problem (high degrees of freedom)*. Applying simulator HC to these unsolved problems is a very interesting direction for future research.



(a) Rotation Error (deg) (b) Translation Error (%) (c) Scale Error (%)

Figure 6. Error distribution over 1000 trials on noise-free data. The camera number is set to be 3. Considering the rotation error, except for Gröbner Bases, the other minimal solvers all present a similar error distribution with around 70% success rate, and the eigen solver presents only around 60% success rate. The proposed 8pts simulator HC presents 96.3% success rate where the Gröbner Bases has 100% success rate.



(a) Rotation Error (b) Translation Error (c) Scale Error

Figure 7. Error statistics of simulator HC with respect to different noise levels ranging from 0.2 pixel to 1.0 pixel.

Table 4. RANSAC experiments for the GRPS problem using Gröbner Bases | simulator HC. Image points are randomly perturbed by 2-pixel uniform noise. We use vanilla RANSAC with at most 200 iterations. As can be observed, outlier ratios of up to 40% are easily handled within 200 iterations. And regressor-based simulator HC is consistently faster than Gröbner Bases.

Ratio	Succ. (%)	$\mathcal{E}_{\mathbf{R}}(deg)$	$\mathcal{E}_{\mathbf{t}}(\%)$	$\mathcal{E}_{\mathbf{s}}(\%)$	# Iters	Time(s)
10%	99.5 | 100	0.10 | 0.09	2.19 | 2.03	2.13 | 1.98	93 | 125	2.33 | 0.85
20%	99.4 | 100	0.11 | 0.10	2.31 | 2.11	2.40 | 2.23	171 | 193	4.37 | 1.31
30%	99.4 | 100	0.13 | 0.14	2.75 | 3.40	2.61 | 3.17	200 | 200	5.10 | 1.35
40%	98.9 | 91	0.21 | 0.29	5.26 | 7.57	5.07 | 7.81	200 | 200	4.59 | 1.35