Efficient generic calibration method for general cameras with single centre of projection

Selected Experimental Results Datasets

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1 Introduction

This document contains the data underlying the results plots in Figs. 4 and 11 of the paper 'Efficient generic calibration method for general cameras with single centre of projection'.

2 Simulated experiments

Fig. 1 shows the relative performances of the standard generic method, the standard generic method with subsequent bundle adjustment, and the proposed generic method for a simulated camera for increasing additive Gaussian noise. Each trial was repeated 50 times with random noise. The data underlying the plots is presented in Table 1.

3 Experimental results

Fig. 2(a) shows the results for a translation estimation task for a hyperboloidal catadioptric camera calibrated using both the standard and proposed generic methods. The accompanying data is presented in Tables 2. Fig. 2(b) shows the results for a rotation estimation experiment for the same camera calibrated using both the standard and proposed generic methods. Table 3 contains the corresponding data. Note that for visualisation purposes the differences between the average translation vector and the estimated translation vectors in Fig. 2(a) are scaled $\times 10$ for each method.

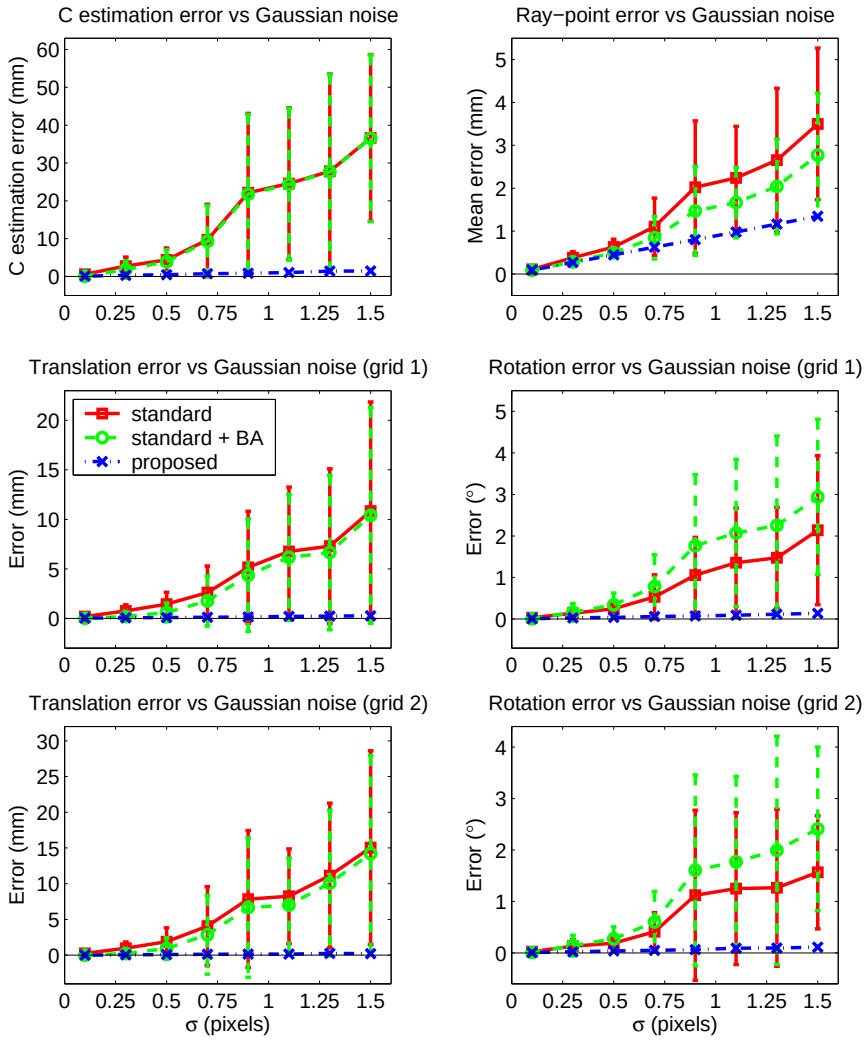
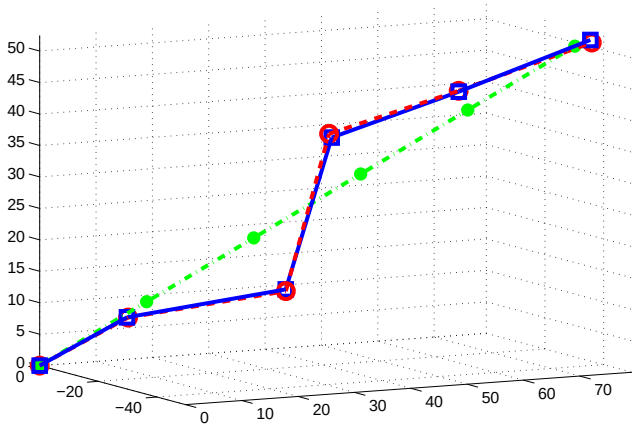


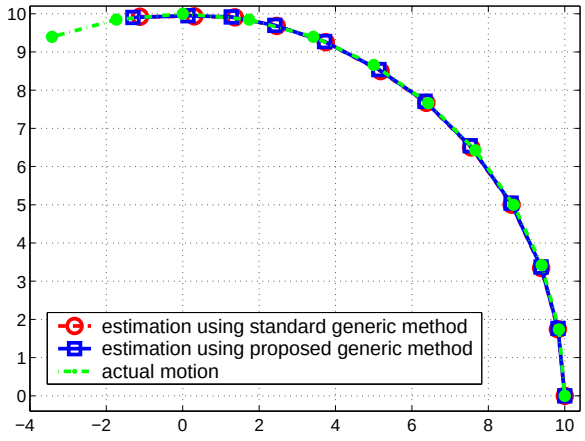
Figure 1: Centre and transformation estimation performance plots versus Gaussian noise for standard generic method, standard generic method with bundle adjustment, and proposed generic method (BA = bundle adjustment). The rotation error is defined as the sum of the out-of-plane and in-plane rotation errors. Note that the SDs for the proposed generic method in these results are non-zero, but are significantly smaller in magnitude than the SDs of the standard generic method.

Table 1: Data underlying Fig. 1.

	Method	Error type	Gaussian noise standard deviation (pixels)							
			0.1	0.3	0.5	0.7	0.9	1.1	1.3	1.5
C estimation error (mm)	Standard	Mean	0.5769	2.7643	4.4157	9.6959	22.1382	24.5759	27.8104	36.6232
		SD	0.3629	2.3431	3.1170	9.3825	20.9556	20.0411	25.7186	22.0392
	Standard + BA	Mean	0.0933	1.8409	3.8982	9.3167	21.7579	24.3738	27.7091	36.5224
		SD	0.0482	2.2734	3.1874	9.4640	21.0891	20.0904	25.7042	22.0325
	Proposed	Mean	0.1054	0.3019	0.4792	0.7416	0.8649	1.0403	1.4200	1.4756
		SD	0.0622	0.1441	0.2295	0.3718	0.3969	0.4937	0.7519	0.6527
Ray-point error (mm)	Standard	Mean	0.1067	0.3783	0.6288	1.1047	2.0232	2.2420	2.6535	3.5008
		SD	0.0182	0.1416	0.1803	0.6667	1.5461	1.2003	1.6760	1.7675
	Standard + BA	Mean	0.0894	0.2829	0.4969	0.8453	1.4719	1.6641	2.0407	2.7726
		SD	0.0021	0.0481	0.0890	0.4959	1.0385	0.8198	1.1051	1.4409
	Proposed	Mean	0.0894	0.2687	0.4480	0.6249	0.8011	0.9804	1.1631	1.3448
		SD	0.0021	0.0060	0.0097	0.0138	0.0192	0.0234	0.0243	0.0289
Translation error grid 1 (mm)	Standard	Mean	0.1852	0.7537	1.4383	2.6021	5.1502	6.7572	7.2935	10.8411
		SD	0.1393	0.6121	1.1933	2.6865	5.6602	6.5074	7.8203	11.0117
	Standard + BA	Mean	0.0153	0.1826	0.5974	1.7560	4.3587	6.1544	6.6521	10.4023
		SD	0.0088	0.1921	0.9507	2.5267	5.6776	6.3673	7.8067	10.9021
	Proposed	Mean	0.0185	0.0523	0.0857	0.1158	0.1346	0.1923	0.2333	0.2594
		SD	0.0094	0.0300	0.0569	0.0670	0.0853	0.1062	0.1060	0.1296
Rotation error grid 1 (^{o})	Standard	Mean	0.0311	0.1397	0.2462	0.5312	1.0562	1.3573	1.4731	2.1392
		SD	0.0172	0.1012	0.1568	0.5320	0.9103	1.3144	1.2164	1.7937
	Standard + BA	Mean	0.0073	0.1625	0.3400	0.7818	1.7647	2.0714	2.2530	2.9404
		SD	0.0042	0.2107	0.2858	0.7647	1.7122	1.7742	2.1554	1.8687
	Proposed	Mean	0.0080	0.0268	0.0379	0.0587	0.0717	0.0908	0.1133	0.1365
		SD	0.0044	0.0121	0.0190	0.0310	0.0322	0.0425	0.0505	0.0592
Translation error grid 2 (mm)	Standard	Mean	0.2438	0.9846	1.8903	4.0697	7.8513	8.2439	11.1387	15.0503
		SD	0.1972	0.8678	1.9245	5.5066	9.5829	6.6144	10.1301	13.5420
	Standard + BA	Mean	0.0141	0.2233	0.9294	2.8447	6.6524	7.0085	10.0703	14.2287
		SD	0.0067	0.4387	1.5154	5.4960	9.7573	6.5490	10.1884	13.6921
	Proposed	Mean	0.0150	0.0463	0.0861	0.1220	0.1553	0.1551	0.2500	0.2162
		SD	0.0079	0.0229	0.0599	0.0702	0.0822	0.1036	0.1543	0.1274
Rotation error grid 2 (^{o})	Standard	Mean	0.0233	0.1297	0.1901	0.4111	1.1195	1.2502	1.2656	1.5664
		SD	0.0170	0.1293	0.1343	0.3709	1.6533	1.4746	1.5267	1.0990
	Standard + BA	Mean	0.0067	0.1426	0.2722	0.6027	1.6052	1.7721	1.9935	2.4098
		SD	0.0036	0.2016	0.2346	0.5897	1.8535	1.6572	2.2167	1.5896
	Proposed	Mean	0.0072	0.0212	0.0371	0.0503	0.0640	0.0911	0.0949	0.1120
		SD	0.0036	0.0101	0.0151	0.0237	0.0267	0.0402	0.0423	0.0475



(a)



(b)

Figure 2: a) Translation and b) rotation reconstruction using calibration data from standard generic method and proposed generic method.

Table 2: Data underlying Fig. 2(a).

Point	Coordinate	Motion		
		Actual	Estimated using standard method	Estimated using proposed method
1	x	0.0000	0.0000	0.0000
	y	0.0000	0.0000	0.0000
	z	0.0000	0.0000	0.0000
2	x	13.8171	12.8227	12.7840
	y	-9.9434	-11.2215	-11.2562
	z	10.4984	10.4717	10.4818
3	x	27.6342	28.1003	28.1267
	y	-19.8867	-20.0892	-20.0327
	z	20.9969	20.1449	20.1649
4	x	41.4513	40.8569	40.8970
	y	-29.8301	-29.8918	-29.9058
	z	31.4953	32.1799	32.1197
5	x	55.2684	55.2442	55.2352
	y	-39.7735	-39.5100	-39.5332
	z	41.9937	42.2683	42.2589
6	x	69.0855	70.1025	70.0839
	y	-49.7169	-48.3445	-48.3293
	z	52.4921	52.3129	52.3523

Table 3: Data underlying Fig. 2(b).

Point	Coordinate	Motion		
		Actual	Estimated using standard method	Estimated using proposed method
1	x	10.0000	10.0000	10.0000
	y	0.0000	0.0000	0.0000
2	x	9.8481	9.8225	9.8229
	y	1.7365	1.7407	1.7644
3	x	9.3969	9.3825	9.3805
	y	3.4202	3.3445	3.3723
4	x	8.6603	8.6104	8.5975
	y	5.0000	5.0011	5.0417
5	x	7.6604	7.5521	7.5247
	y	6.4279	6.5000	6.5470
6	x	6.4279	6.3792	6.3438
	y	7.6604	7.6678	7.7087
7	x	5.0000	5.1814	5.1340
	y	8.6603	8.4989	8.5386
8	x	3.4202	3.7462	3.7148
	y	9.3969	9.2549	9.2715
9	x	1.7365	2.4641	2.4114
	y	9.8481	9.6812	9.6970
10	x	0.0000	1.3639	1.2716
	y	10.0000	9.9064	9.9173
11	x	-1.7365	0.3048	0.1365
	y	9.8481	9.9322	9.9493
12	x	-3.4202	-1.1205	-1.3015
	y	9.3969	9.9214	9.9035