General Planar Motion from a Pair of 3D Correspondences - Supplementary

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1. Additional Results on Synthetic Data

Ground Plane Calibration Error. We present in Figure 1 the results when the motions in our synthetic dataset are rotated about the z axis. As mentioned in the original submission, the results are very similar as when rotating about the x axis. Our method is unaffected by ground plane calibration, and outperforms the calibrated planar solvers [6, 1, 3].

Non-planarity of motion. In Figure 2, we report the results for motion non-planarity considering the case when the rotation axis is rotated toward the translation vector, mentioned in the original submission. This particular case also contains ground plane calibration error, which is the reason our method performs better compared to the non-planarity experiment (rotating the translation towards the rotation axis) in the original submission.

2. RANSAC solvers time

Table 1 shows the median number of iterations and execution times in milliseconds for the RANSAC solvers for all sequences of the real datasets (KITTI and TUM). Our solver achieves a speed up of $\sim$2x w.r.t. the other methods on the KITTI dataset and is faster than the other methods (except the Ackermann solver) on the TUM dataset. The Ackermann solver requires fewer iterations (and thus less time) on the TUM dataset since it is better suited to this dataset than the KITTI dataset.

Table 1. Median number of iterations and execution times (in milliseconds) for the RANSAC solvers on the real datasets for all sequences. All solvers implemented in MATLAB R2020b.

	KITTI		TUM	
	Iters.	Time	Iters.	Time
2pt-5dof-3d3d (ours)	19	**1.14**	10	0.61
1pt-1*dof-2d2d [6]	53	2.25	7	**0.36**
2pt-3dof-2d3d [1]	16	2.93	8	1.67
3pt-6dof-3d3d [4]	52	2.50	18	0.85
3pt-6dof-2d3d [5]	7	2.13	7	2.36
3pt-2*dof-2d2d [3]	33	18.92	10	7.54

3. Additional Results on Real Data

KITTI Dataset. As mentioned in the original submission, we reported only the results for the first four sequences of the dataset considering a stride of 1 frame. In this supplementary material, we report the results for the remaining seven sequences in Table 2. We still observe that our method yields better orientation estimates compared to the other planar methods [6, 1, 3], and comparable translation estimates. As indicated in the original submission, we also report results considering different strides. In Table 3 we present the results for a stride of 2 and in Table 4 we report the results for a stride of 5. In both cases, we observe that our method still provides better orientation estimates compared to the planar solvers of [6, 1, 3] and also yields better translation estimates.

TUM Dataset. In the original submission, we reported results on the dataset considering a stride of 1 frame. Here, we report results considering a stride of 5 in Table 5 and a stride of 10 in Table 6. For stride of 5, we observe that the Ackermann solver of [6] still provides the best orientation and translation estimates of the evaluated planar methods, while our method has a higher success rate. However, for a stride of 10, we observe that our method provides the best orientation and translation estimates of the planar methods [6, 1, 3].

References

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Table 2. Median orientation error (in degrees), translation error (in meters), and success rate (in %) on the KITTI dataset [2] (stride of 1). Best in bold, best of planar methods underlined. The column ALL contains the median for all 11 sequences.

Sequence	00		01		02		03		04		05	
	deg	m	deg	m	deg	m	deg	m	deg	m	deg	m
2pt-5dof-3d3d (ours)	0.186	0.105	0.143	1.274	0.181	0.116	0.177	0.125	0.169	0.202	0.153	0.104
1pt-1*dof-2d2d [6]	0.319	0.631	0.194	1.931	0.274	0.918	0.256	0.498	0.147	1.073	0.206	0.654
2pt-3dof-2d3d [1]	0.237	0.109	0.112	0.378	0.198	0.094	0.182	0.094	0.119	0.118	0.163	0.081
3pt-6dof-3d3d [4]	0.255	0.129	0.359	2.025	0.270	0.147	0.242	0.152	0.318	0.363	0.227	0.121
3pt-6dof-2d3d [5]	**0.090**	**0.032**	**0.082**	**0.238**	**0.093**	**0.035**	**0.070**	**0.029**	**0.091**	**0.057**	**0.078**	**0.029**
3pt-2*dof-2d2d [3]	0.247	0.130	0.134	0.654	0.206	0.114	0.200	0.110	0.156	0.186	0.178	0.100

Sequence	06		07		08		09		10		ALL		
	deg	m	deg	m	deg	m	deg	m	deg	m	deg	m	%
2pt-5dof-3d3d (ours)	0.137	0.134	0.158	0.083	0.158	0.097	0.168	0.126	0.177	0.094	0.168	0.116	**100.0**
1pt-1*dof-2d2d [6]	0.213	0.796	0.196	0.486	0.239	0.680	0.244	0.899	0.268	0.694	0.239	0.694	99.4
2pt-3dof-2d3d [1]	0.128	0.097	0.158	0.069	0.179	0.086	0.175	0.096	0.206	0.093	0.175	0.094	**100.0**
3pt-6dof-3d3d [4]	0.239	0.184	0.243	0.108	0.226	0.115	0.271	0.163	0.245	0.115	0.245	0.147	**100.0**
3pt-6dof-2d3d [5]	**0.077**	**0.043**	**0.073**	**0.025**	**0.082**	**0.032**	**0.089**	**0.037**	**0.091**	**0.026**	**0.082**	**0.032**	**100.0**
3pt-2*dof-2d2d [3]	0.154	0.122	0.170	0.084	0.188	0.095	0.188	0.123	0.211	0.102	0.188	0.114	**100.0**

Table 3. Median orientation error (in degrees), translation error (in meters), and success rate (in %) on the KITTI dataset [2] (stride of 2). Best in bold, best of planar methods underlined. The column ALL contains the median for all 11 sequences.

Sequence	00		01		02		03		04		05	
	deg	m	deg	m	deg	m	deg	m	deg	m	deg	m
2pt-5dof-3d3d (ours)	0.261	0.152	0.200	2.145	0.247	0.178	0.229	0.190	0.209	0.328	0.194	0.149
1pt-1*dof-2d2d [6]	0.609	1.251	0.295	4.049	0.515	1.805	0.491	1.062	0.234	2.550	0.394	1.283
2pt-3dof-2d3d [1]	0.473	0.336	0.179	1.096	0.373	0.239	0.360	0.199	0.200	0.241	0.270	0.164
3pt-6dof-3d3d [4]	0.262	0.150	0.376	3.069	0.271	0.183	0.227	0.170	0.315	0.432	0.227	0.143
3pt-6dof-2d3d [5]	**0.120**	**0.048**	**0.100**	**0.485**	**0.117**	**0.057**	**0.089**	**0.042**	**0.099**	**0.085**	**0.097**	**0.043**
3pt-2*dof-2d2d [3]	0.440	0.309	0.199	1.453	0.350	0.230	0.349	0.204	0.212	0.256	0.271	0.182

Sequence	06		07		08		09		10		ALL		
	deg	m	deg	m	deg	m	deg	m	deg	m	deg	m	%
2pt-5dof-3d3d (ours)	0.172	0.198	0.207	0.118	0.209	0.147	0.232	0.193	0.244	0.149	0.209	0.178	**100.0**
1pt-1*dof-2d2d [6]	0.398	1.493	0.360	0.923	0.468	1.219	0.519	1.680	0.477	1.257	0.468	1.283	92.4
2pt-3dof-2d3d [1]	0.200	0.210	0.271	0.138	0.325	0.195	0.318	0.236	0.369	0.246	0.318	0.236	99.9
3pt-6dof-3d3d [4]	0.231	0.190	0.236	0.116	0.241	0.141	0.281	0.207	0.259	0.145	0.259	0.170	**100.0**
3pt-6dof-2d3d [5]	**0.094**	**0.070**	**0.098**	**0.037**	**0.102**	**0.049**	**0.114**	**0.057**	**0.110**	**0.041**	**0.100**	**0.049**	**100.0**
3pt-2*dof-2d2d [3]	0.211	0.210	0.271	0.145	0.315	0.185	0.321	0.245	0.368	0.227	0.315	0.227	**100.0**

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Table 4. Median orientation error (in degrees), translation error (in meters), and success rate (in %) on the KITTI dataset [2] (stride of 5). Best in bold, best of planar methods underlined. The column ALL contains the median for all 11 sequences.

Sequence	00		01		02		03		04		05	
	deg	m	deg	m	deg	m	deg	m	deg	m	deg	m
2pt-5dof-3d3d (ours)	0.444	0.306	0.353	5.568	0.426	0.395	0.389	0.342	0.365	0.752	0.293	0.273
1pt-1*dof-2d2d [6]	0.904	3.270	0.421	11.713	0.714	4.807	0.740	2.426	0.376	6.801	0.645	3.145
2pt-3dof-2d3d [1]	0.841	1.328	0.354	4.434	0.734	1.257	0.658	0.955	0.358	0.886	0.527	0.732
3pt-6dof-3d3d [4]	0.394	0.303	0.744	7.972	0.458	0.437	0.333	0.344	0.496	0.936	0.304	0.275
3pt-6dof-2d3d [5]	**0.188**	**0.110**	**0.181**	**1.753**	**0.200**	**0.151**	**0.128**	**0.095**	**0.163**	**0.179**	**0.141**	**0.088**
3pt-2*dof-2d2d [3]	0.795	1.193	0.371	5.592	0.677	1.177	0.647	0.933	0.360	0.860	0.488	0.708

Sequence	06		07		08		09		10		ALL		
	deg	m	deg	m	deg	m	deg	m	deg	m	deg	m	%
2pt-5dof-3d3d (ours)	0.244	0.465	0.291	0.198	0.343	0.298	0.428	0.424	0.392	0.290	0.365	0.342	**100.0**
1pt-1*dof-2d2d [6]	0.631	3.869	0.544	2.164	0.747	2.947	0.799	4.458	0.667	2.184	0.667	3.270	53.0
2pt-3dof-2d3d [1]	0.341	0.817	0.526	0.554	0.645	1.011	0.716	1.344	0.701	1.279	0.645	1.011	97.8
3pt-6dof-3d3d [4]	0.394	0.448	0.329	0.216	0.363	0.323	0.517	0.536	0.408	0.321	0.394	0.344	**100.0**
3pt-6dof-2d3d [5]	**0.148**	**0.154**	**0.150**	**0.079**	**0.166**	**0.113**	**0.204**	**0.153**	**0.174**	**0.099**	**0.166**	**0.113**	**100.0**
3pt-2*dof-2d2d [3]	0.338	0.821	0.494	0.513	0.586	0.962	0.684	1.333	0.670	1.168	0.586	0.962	98.8

Table 5. Median orientation error (in degrees), translation error (in meters), and success rate (in %) on the TUM dataset [7] (stride of 5). Best in bold, best of planar methods underlined. The column ALL contains the median for all 4 sequences.

Sequence	360		slam		slam2		slam3		ALL		
	deg	m	deg	m	deg	m	deg	m	deg	m	%
2pt-5dof-3d3d (ours)	1.003	0.088	0.773	0.044	0.749	0.045	0.496	0.032	0.761	0.045	98.2
1pt-1*dof-2d2d [6]	**0.821**	0.055	0.800	0.053	0.662	0.034	0.480	**0.021**	0.731	0.044	77.4
2pt-3dof-2d3d [1]	1.307	0.171	1.099	0.118	0.890	0.069	0.650	0.052	0.994	0.094	92.1
3pt-6dof-3d3d [4]	1.444	0.141	1.039	0.071	0.984	0.073	0.715	0.053	1.012	0.072	**98.5**
3pt-6dof-2d3d [5]	0.882	**0.054**	**0.703**	**0.029**	**0.624**	**0.026**	**0.421**	0.022	**0.663**	**0.028**	98.0
3pt-2*dof-2d2d [3]	0.900	0.101	0.826	0.077	0.699	0.042	0.521	0.033	0.763	0.059	93.2

Table 6. Median orientation error (in degrees), translation error (in meters), and success rate (in %) on the TUM dataset [7] (stride of 10). Best in bold, best of planar methods underlined. The column ALL contains the median for all 4 sequences.

Sequence	360		slam		slam2		slam3		ALL		
	deg	m	deg	m	deg	m	deg	m	deg	m	%
2pt-5dof-3d3d (ours)	1.260	0.107	1.016	0.061	0.870	0.055	0.608	0.042	0.943	0.058	97.1
1pt-1*dof-2d2d [6]	1.328	0.086	1.237	0.095	0.980	0.055	0.775	0.034	1.108	0.071	68.5
2pt-3dof-2d3d [1]	1.817	0.249	1.602	0.188	1.452	0.134	1.075	0.098	1.527	0.161	88.3
3pt-6dof-3d3d [4]	1.956	0.189	1.382	0.102	1.280	0.092	0.974	0.076	1.331	0.097	**97.4**
3pt-6dof-2d3d [5]	**1.082**	**0.081**	**0.894**	**0.048**	**0.748**	**0.039**	**0.557**	**0.033**	**0.821**	**0.044**	96.7
3pt-2*dof-2d2d [3]	1.457	0.175	1.315	0.115	1.115	0.074	0.861	0.059	1.215	0.094	90.4

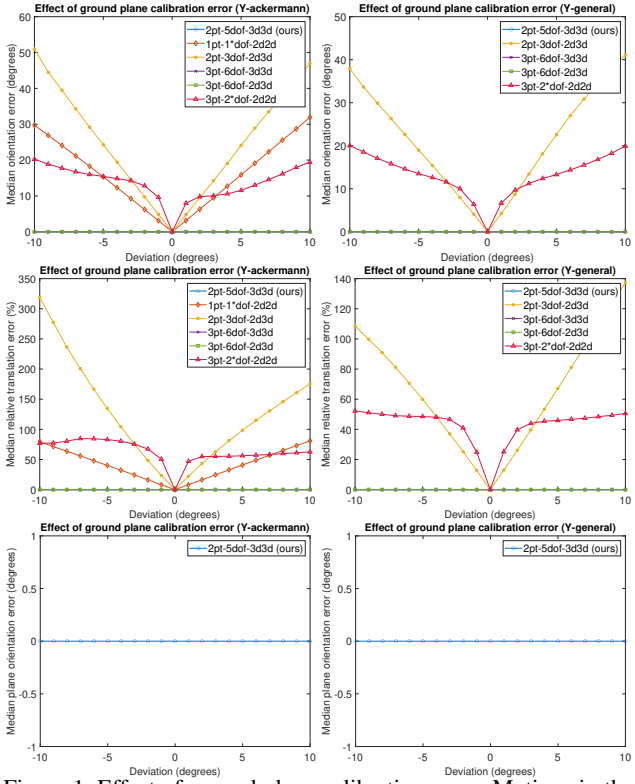

Figure 1. Effect of ground plane calibration error. Motions in the datasets were rotated about the z axis.

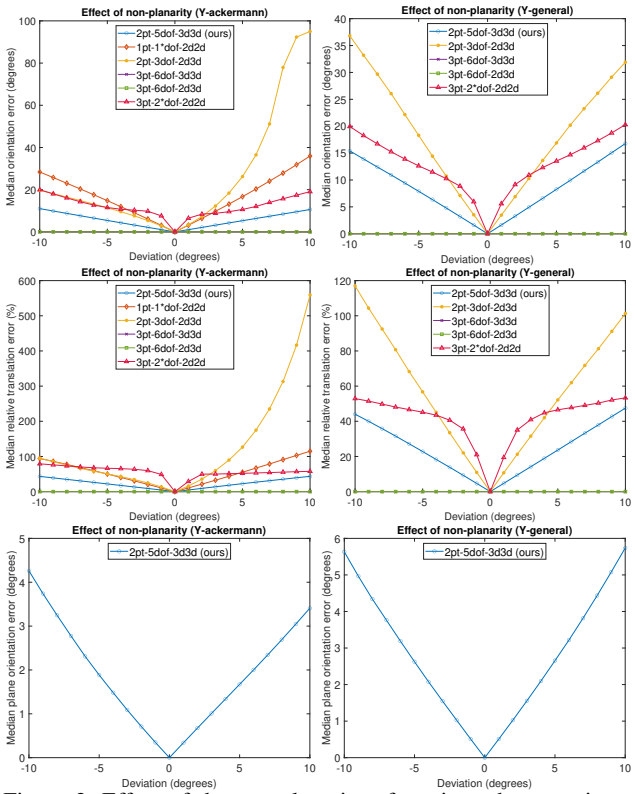

Figure 2. Effect of the non-planarity of motion when rotating t towards/away from the rotation axis.