Supplementary Material for "Gyroscope-Guided Optimal Transport for SuperGlue: A Training-Free Epipolar-Arc Prior"

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Abstract

This document contains Supplementary Tables S1–S9 referred to in the article. Table, section and figure numbers without the prefix "S" refer to the article.

Supplementary Tables

Table S1 Calibration sanity check on the Hwangbo sequences (620 pairs): median residual (px) of RANSAC-homography-consistent SuperGlue matches under no prediction, the inverted rotation (R_{ab}) and the method's rotation ($R_{ab}^{\top}$), and the percentage of pairs for which $R_{ab}^{\top}$ is best.

Sequence	**pairs**	**identity [px]**	R_{ab} [px]	$R_{ab}^{\top}$ [px]	$R_{ab}^{\top}$ **best [%]**
`desk`	313	84.6	171.3	11.6	100.0
`aerial`	307	30.7	57.7	4.7	99.0

Table S2 Gyroscope integration accuracy per held-out sequence: mean integrated gyroscope rotation / mean angular error of the integrated rotation with respect to the ground-truth relative rotation (degrees), for each time baseline (full regime, 120 pairs per cell). "Bias": whether a standstill window was found and the gyroscope bias removed.

		Gyro rotation / error [°]			
Sequence	**Bias**	**200 ms**	**400 ms**	**600 ms**	**1000 ms**
`room2`	no	11.2 / 0.66	21.5 / 0.84	30.4 / 1.00	44.1 / 1.00
`room3`	no	11.3 / 0.55	22.0 / 0.74	30.6 / 0.84	44.8 / 0.82
`room4`	no	12.2 / 0.31	22.9 / 0.35	31.8 / 0.39	42.3 / 0.43
`room5`	no	16.8 / 0.26	30.6 / 0.34	41.7 / 0.36	54.2 / 0.39
`room6`	no	8.2 / 0.33	15.7 / 0.40	21.9 / 0.46	29.9 / 0.58
`MH01`	yes	2.0 / 0.02	3.6 / 0.04	4.6 / 0.05	6.3 / 0.09
`MH02`	yes	1.9 / 0.02	3.3 / 0.03	4.2 / 0.04	5.4 / 0.07
`MH04`	yes	2.2 / 0.03	3.9 / 0.07	5.2 / 0.10	7.6 / 0.17
`MH05`	yes	2.0 / 0.02	3.4 / 0.04	4.7 / 0.05	6.8 / 0.08
`V1_01`	yes	2.9 / 0.08	5.5 / 0.16	7.9 / 0.24	12.1 / 0.40
`V1_02`	yes	6.2 / 0.04	11.6 / 0.07	16.4 / 0.10	25.0 / 0.15
`V1_03`	yes	6.6 / 0.05	12.3 / 0.08	16.9 / 0.11	23.7 / 0.17
`V2_01`	yes	2.7 / 0.04	5.0 / 0.07	6.8 / 0.10	9.9 / 0.17
`V2_02`	yes	6.1 / 0.05	11.2 / 0.10	14.9 / 0.14	19.9 / 0.22
`V2_03`	yes	8.0 / 0.16	13.4 / 0.21	16.9 / 0.23	23.9 / 0.28

Table S3 Method families on the development sequence (TUM-VI `room1`, 9 settings): mean ΔAUC@10° over SuperGlue, the worst setting, and the mean relative change in the number of epipolar-consistent matches. Blue bold/red italic: best/worst per column.

Variant	**mean ΔAUC@10 [pp]**	**worst [pp]**	**Δ consist. [%]**
iso (pixel, penalty-only)	-1.38	-2.4	*-1.9*
maha (pixel, penalty-only)	-1.31	-2.3	-1.1
rotation prior, bearing, σ_R=3°, penalty-only	*-1.49*	*-2.9*	-1.8
rotation prior, bearing, σ_R=3°, reward-only	-0.48	-2.5	+0.1
rotation prior, bearing, σ_R=6°, reward-only	-0.27	-1.5	+0.4
post-hoc gate (arc, σ_E=1°)	-0.02	-0.6	-0.3
EAP, σ_E=1°, κ=4, penalty-only	+0.60	-1.1	+1.6
EAP, σ_E=1°, κ=4, reward-only	+1.48	-0.1	+3.6
EAP two-sided (sign-agnostic), σ_E=1°, κ=4	+1.55	+0.1	+3.7
EAP, selected: σ_E=0.5°, κ=8, reward-only	**+2.53**	-0.2	**+5.9**
PE compensation only	+1.05	+0.4	+2.0
PE comp. + EAP, selected: σ_E=1°, κ=8, reward-only	+2.49	**+0.8**	+5.0
PE comp. + maha	+0.10	-0.9	+1.0
image warp	+2.05	-1.3	+0.7

Table S4 Per held-out sequence (all regimes, 200–600 ms): mean gyroscope rotation (Rot., °), mean gyroscope error (Gyro, °), ΔAUC@10° over SuperGlue with bootstrap 95% CI, and, for the EAP, the relative change in the number of epipolar-consistent matches (Δcorr., %) and the change in their fraction (Δprec., points).

Seq.	Rot. [°]	Gyro [°]	EAP [pp]	PE+EAP [pp]	Δcorr. [%]	Δprec. [pp]
`room2`	21.0	0.83	+4.2 [+3.5, +5.0]	+2.9 [+2.3, +3.6]	+6.3	+1.4
`room3`	21.3	0.71	+5.3 [+4.5, +6.1]	+3.9 [+3.2, +4.7]	+10.2	+2.5
`room4`	22.3	0.35	+4.2 [+3.5, +5.0]	+2.5 [+1.8, +3.2]	+6.4	+1.6
`room5`	29.7	0.32	+6.0 [+5.1, +6.8]	+5.5 [+4.7, +6.4]	+8.9	+2.8
`room6`	15.2	0.40	+2.2 [+1.6, +2.8]	+1.2 [+0.6, +1.9]	+3.4	+0.4
`MH01`	3.4	0.04	+2.0 [+1.2, +2.7]	+1.4 [+0.6, +2.1]	+4.2	-2.9
`MH02`	3.1	0.03	+2.1 [+1.4, +2.9]	+0.0 [-0.7, +0.7]	+5.0	-2.8
`MH04`	3.8	0.07	+2.2 [+1.5, +3.0]	+0.6 [-0.1, +1.3]	+4.7	-1.8
`MH05`	3.4	0.04	+2.0 [+1.3, +2.7]	+0.9 [+0.2, +1.6]	+5.0	-2.0
`V1_01`	5.4	0.16	+1.4 [+0.7, +2.0]	+0.2 [-0.4, +0.9]	+2.6	-1.1
`V1_02`	11.4	0.07	+4.0 [+3.2, +4.8]	+1.7 [+1.0, +2.5]	+6.0	-0.9
`V1_03`	11.9	0.08	+3.9 [+3.1, +4.7]	+1.7 [+1.0, +2.5]	+5.0	-0.7
`V2_01`	4.8	0.07	+1.9 [+1.1, +2.6]	+0.8 [+0.1, +1.5]	+3.1	-1.3
`V2_02`	10.7	0.10	+2.7 [+1.9, +3.5]	+1.0 [+0.2, +1.7]	+7.7	-0.9
`V2_03`	12.8	0.20	+5.0 [+4.1, +6.0]	+2.3 [+1.5, +3.1]	+7.3	-0.1

Table S5 Held-out pairs (TUM-VI and EuRoC, 200–600 ms, all regimes) grouped by gyroscope rotation angle: number of pair evaluations, SuperGlue AUC@10° (SG), and ΔAUC@10° (bootstrap 95% CI).

Rotation [°]	n	SG [%]	EAP [pp]	PE+EAP [pp]
0–5	8944	33.6	+1.8 [+1.6, +2.1]	+0.6 [+0.3, +0.8]
5–15	6524	43.4	+2.8 [+2.5, +3.2]	+1.4 [+1.1, +1.8]
15–30	4112	47.2	+4.9 [+4.5, +5.4]	+2.8 [+2.4, +3.3]
30–∞	2020	47.0	+7.5 [+6.8, +8.3]	+6.1 [+5.4, +6.9]

Table S6 Secondary hypothesis tests on held-out data at the 1 s time baseline (`skip`= 20). Same quantities as Table 5; Holm adjustment over these 16 tests.

Hyp.	Data	Regime	n	Δ [pp]	95% CI [pp]	W/L	p	p_{Holm}
H1	TUM	full	600	+5.39	[+4.23, +6.57]	365/196	<0.001	<0.001
H2	TUM	full	600	+4.91	[+3.68, +6.19]	348/218	<0.001	<0.001
H1	TUM	Gauss	600	+6.35	[+5.12, +7.64]	367/190	<0.001	<0.001
H2	TUM	Gauss	600	+5.61	[+4.42, +6.84]	350/213	<0.001	<0.001
H1	TUM	128 kp	600	+8.79	[+7.38, +10.23]	372/153	<0.001	<0.001
H2	TUM	128 kp	600	+7.31	[+5.71, +8.91]	357/186	<0.001	<0.001
H1	TUM	motion	600	+19.09	[+17.29, +20.88]	439/80	<0.001	<0.001
H2	TUM	motion	600	+12.52	[+10.82, +14.22]	397/123	<0.001	<0.001
H1	EuRoC	full	1200	+4.18	[+3.38, +5.03]	700/396	<0.001	<0.001
H2	EuRoC	full	1200	+2.00	[+1.23, +2.74]	608/483	<0.001	<0.001
H1	EuRoC	Gauss	1200	+4.34	[+3.44, +5.27]	662/430	<0.001	<0.001
H2	EuRoC	Gauss	1200	+2.66	[+1.83, +3.51]	597/489	<0.001	<0.001
H1	EuRoC	128 kp	1200	+4.55	[+3.55, +5.58]	598/426	<0.001	<0.001
H2	EuRoC	128 kp	1200	+1.76	[+0.79, +2.73]	560/456	<0.001	<0.001
H1	EuRoC	motion	1200	+10.09	[+9.06, +11.21]	712/262	<0.001	<0.001
H2	EuRoC	motion	1200	+4.01	[+3.07, +4.95]	574/357	<0.001	<0.001

Table S7 Consistency on the Hwangbo sequences (no ground truth): mean number of matches, matches consistent with the RANSAC essential matrix (E-inl., 1 px/f_x), E-inlier ratio and RANSAC-homography inlier ratio (H, 3 px), averaged over 5 point-order permutations.

			SuperGlue				EAP			
Seq.	**skip**	n	match	E-inl.	E	H	match	E-inl.	E	H
`desk`	1	80	381	328	0.856	0.933	385	328	0.846	0.919
`desk`	3	78	343	279	0.800	0.872	349	280	0.789	0.855
`desk`	6	78	313	250	0.780	0.801	319	250	0.768	0.788
`desk`	10	77	319	252	0.777	0.733	325	254	0.771	0.722
`aerial`	1	78	140	129	0.926	0.980	149	134	0.902	0.943
`aerial`	3	77	127	113	0.886	0.957	137	117	0.852	0.913
`aerial`	6	76	112	95	0.852	0.893	121	99	0.816	0.840
`aerial`	10	76	92	75	0.820	0.820	100	79	0.782	0.770

Table S8 Full held-out results for TUM-VI `room2`–`room6`, pooled over 200/400/600 ms (AUC: mean over P=5 RANSAC point-order permutations, standard deviation across permutations in small font). Δ_{10}: AUC@10° difference to SuperGlue; Corr.: mean number of epipolar-consistent matches; Prec.: their fraction (%); best/worst per block in blue bold/red italic (baseline row not marked).

Method	**AUC@5°** [%]	**AUC@10°** [%]	**AUC@20°** [%]	Δ_{10} [pp]	**Corr.**	**Prec.** [%]
Full (512 kp), n = 1800 pairs						
SuperGlue	48.5±0.4	66.3±0.3	78.3±0.2	—	213	77.0
iso (pixel)	*47.3*±0.1	*65.4*±0.3	*77.8*±0.2	*-0.8*	210	77.7
maha (pixel)	47.9±0.7	65.9±0.5	78.1±0.3	-0.3	211	77.4
PE comp. + maha	48.9±0.4	67.0±0.2	79.0±0.2	+0.7	215	78.2
post-hoc gate	48.7±0.5	66.6±0.3	78.6±0.2	+0.3	213	78.2
image warp	49.5±0.5	67.6±0.3	79.6±0.2	+1.4	*197*	**79.3**
PE comp. only	49.6±0.3	67.5±0.3	79.3±0.3	+1.2	217	77.8
EAP (ours)	**50.8**±0.2	**68.2**±0.2	**79.7**±0.1	**+1.9**	**225**	78.5
PE comp. + EAP	50.5±0.3	68.0±0.2	79.5±0.1	+1.7	222	*76.9*
Gaussian blur, n = 1800 pairs						
SuperGlue	42.9±0.8	62.3±0.6	75.9±0.3	—	156	77.4
iso (pixel)	*41.7*±0.4	*61.4*±0.5	*75.3*±0.3	*-0.9*	*153*	78.2
maha (pixel)	42.3±0.2	61.8±0.1	75.7±0.2	-0.5	155	77.9
PE comp. + maha	43.1±0.3	62.7±0.3	76.4±0.2	+0.4	157	78.5
post-hoc gate	43.3±0.7	62.6±0.5	76.2±0.3	+0.4	156	78.6
image warp	44.0±0.5	63.5±0.3	77.1±0.2	+1.2	159	**79.0**
PE comp. only	44.2±0.5	63.5±0.4	76.9±0.2	+1.2	158	78.0
EAP (ours)	**45.7**±0.4	**64.8**±0.4	**77.8**±0.3	**+2.6**	**164**	78.7
PE comp. + EAP	45.4±0.2	64.5±0.2	77.5±0.2	+2.2	162	*77.2*
Low budget (128 kp), n = 1800 pairs						
SuperGlue	37.3±0.8	55.8±0.7	70.3±0.5	—	66	80.4
iso (pixel)	*36.3*±0.9	*54.9*±0.6	69.6±0.4	*-0.9*	*65*	81.3
maha (pixel)	*36.3*±0.8	*54.9*±0.5	*69.5*±0.4	*-0.9*	66	80.9
PE comp. + maha	37.4±0.5	56.3±0.3	70.7±0.2	+0.5	67	81.5
post-hoc gate	37.5±0.5	56.4±0.5	71.1±0.4	+0.6	66	**82.8**
image warp	**39.9**±0.3	**58.9**±0.3	**73.3**±0.3	**+3.1**	**70**	82.0
PE comp. only	38.3±0.7	56.8±0.5	71.1±0.3	+1.0	67	81.1
EAP (ours)	**39.9**±0.6	**58.9**±0.4	**73.3**±0.2	**+3.1**	69	81.8
PE comp. + EAP	**39.9**±0.4	58.8±0.2	73.1±0.1	+3.0	69	*80.1*
Motion blur, n = 1800 pairs						
SuperGlue	8.9±0.4	19.7±0.4	35.2±0.5	—	76	46.7
iso (pixel)	8.8±0.3	19.7±0.4	34.9±0.4	-0.0	*74*	48.3
maha (pixel)	9.1±0.2	19.8±0.2	34.7±0.5	+0.0	75	47.4
PE comp. + maha	*8.5*±0.3	*19.1*±0.4	*33.8*±0.4	*-0.6*	77	47.8
post-hoc gate	10.1±0.3	22.4±0.3	39.3±0.3	+2.7	*74*	**50.5**
image warp	9.2±0.2	20.3±0.2	35.1±0.2	+0.6	77	47.8
PE comp. only	9.6±0.4	20.9±0.4	35.6±0.3	+1.2	78	47.1
EAP (ours)	**14.1**±0.2	**29.6**±0.4	**48.4**±0.4	**+9.9**	**88**	49.6
PE comp. + EAP	12.2±0.2	25.6±0.5	42.6±0.6	+5.9	86	*46.8*

Table S9 Full held-out results for EuRoC (10 sequences), pooled over 200/400/600 ms (AUC: mean over P=5 RANSAC point-order permutations, standard deviation across permutations in small font). Δ_{10}: AUC@10° difference to SuperGlue; Corr.: mean number of epipolar-consistent matches; Prec.: their fraction (%); best/worst per block in blue bold/red italic (baseline row not marked).

Method	**AUC@5°** [%]	**AUC@10°** [%]	**AUC@20°** [%]	Δ_{10} [pp]	**Corr.**	**Prec.** [%]
Full (512 kp), $n = 3600$ pairs						
SuperGlue	23.7±0.3	43.8±0.3	62.3±0.3	—	290	87.7
iso (pixel)	*23.5*±0.5	*43.6*±0.5	*62.2*±0.4	*-0.2*	288	**88.2**
maha (pixel)	23.7±0.2	43.9±0.2	62.3±0.2	+0.0	289	87.9
PE comp. + maha	23.7±0.2	43.9±0.2	62.3±0.1	+0.1	290	88.1
post-hoc gate	23.6±0.3	43.8±0.2	62.3±0.2	-0.0	290	87.9
image warp	24.0±0.3	44.0±0.3	62.4±0.2	+0.2	*286*	88.1
PE comp. only	24.2±0.4	44.3±0.3	62.5±0.2	+0.5	290	87.9
EAP (ours)	**25.4**±0.4	**46.0**±0.5	**64.4**±0.4	**+2.2**	**300**	86.3
PE comp. + EAP	24.7±0.2	45.1±0.1	63.4±0.2	+1.2	297	*84.4*
Gaussian blur, $n = 3600$ pairs						
SuperGlue	23.6±0.5	43.8±0.2	62.2±0.1	—	287	88.1
iso (pixel)	*23.4*±0.4	43.6±0.5	61.9±0.3	-0.2	*285*	**88.6**
maha (pixel)	*23.4*±0.4	*43.4*±0.4	*61.8*±0.2	*-0.3*	286	88.3
PE comp. + maha	23.8±0.3	44.0±0.3	62.3±0.3	+0.2	287	**88.6**
post-hoc gate	23.7±0.5	43.8±0.2	62.3±0.1	+0.1	287	88.3
image warp	23.9±0.3	44.0±0.4	62.2±0.2	+0.2	289	88.2
PE comp. only	24.1±0.2	44.3±0.2	62.5±0.2	+0.5	287	88.3
EAP (ours)	**25.3**±0.3	**45.8**±0.4	**64.1**±0.3	**+2.0**	**296**	86.9
PE comp. + EAP	24.6±0.2	44.8±0.3	63.1±0.3	+1.0	293	*85.3*
Low budget (128 kp), $n = 3600$ pairs						
SuperGlue	18.9±0.1	36.8±0.1	54.9±0.2	—	65	84.8
iso (pixel)	*18.6*±0.5	*36.4*±0.4	*54.5*±0.2	*-0.4*	*65*	**85.6**
maha (pixel)	*18.6*±0.2	36.6±0.2	54.7±0.2	-0.2	*65*	85.2
PE comp. + maha	18.7±0.3	36.5±0.2	54.7±0.2	-0.3	*65*	85.3
post-hoc gate	18.9±0.3	37.0±0.1	55.1±0.2	+0.2	*65*	**85.6**
image warp	19.0±0.3	37.5±0.3	56.0±0.3	+0.7	66	85.1
PE comp. only	*18.6*±0.2	36.5±0.2	54.9±0.2	-0.2	*65*	84.8
EAP (ours)	**19.8**±0.1	**38.6**±0.1	**57.4**±0.2	**+1.8**	**68**	81.8
PE comp. + EAP	19.0±0.3	37.5±0.3	56.2±0.2	+0.7	67	*78.1*
Motion blur, $n = 3600$ pairs						
SuperGlue	6.8±0.2	16.0±0.2	29.4±0.3	—	142	57.2
iso (pixel)	*6.6*±0.1	15.7±0.1	29.1±0.1	-0.3	*141*	**57.8**
maha (pixel)	*6.6*±0.1	*15.6*±0.2	*29.0*±0.3	*-0.4*	142	57.5
PE comp. + maha	6.8±0.3	15.8±0.5	29.2±0.3	-0.2	142	57.7
post-hoc gate	6.9±0.2	16.1±0.2	29.5±0.2	+0.1	142	57.6
image warp	6.7±0.2	15.7±0.4	29.3±0.3	-0.3	142	57.3
PE comp. only	6.8±0.2	15.8±0.4	29.2±0.4	-0.1	143	57.3
EAP (ours)	**8.8**±0.3	**20.8**±0.3	**37.4**±0.2	**+4.8**	**158**	57.0
PE comp. + EAP	7.2±0.2	17.3±0.3	32.2±0.4	+1.3	151	*53.7*