

FP1. Match 3D objects

-I Implemented the function in camFusion_student.cpp; Loop through all matches and find the pair of bounding boxes that contains matched keypoints. Keep track with a table to find the best matched BB at the end

FP2. Computer Lidar-based TTC

I Used the median of the point cloud cluster to as the representation of the target vehicle in 2 consecutive frames and applied the formular for constant velocity model.

FP3. Associate keypoint correspondences with bounding boxes

I calculated the mean of all Euclidian distance between matched keypoints and remove those have distance above the mean.

FP.4 Compute Camera-based TTC

I first implemented the function to find the matched keypoints within the ROI and then remove the outlier using the ration distance as introduced in the lesson

FP.5 Performance evaluation 1

- Erros observed in Lidar-based TCC: I notice that at frame 4 the TTC is 16 while the target car looks closer to our host vehicle and the at frame 6 the TTC go back to 12. This potential root cause might come from the way I used median (distance in X) to find the representation of the pointcloud, as the ROI changes, the points included changes and leads the change of point cloud distribution.



FP.6 Performance Evaluation 2

I summary all observation in the table below:

Detector	Descriptor	frame 1	frame 2	frame 3	frame 4	frame 5	frame 6	frame 7	frame 8	frame 9	frame 10	frame 11	frame 12	frame 13	frame 14	frame 15	frame 16	frame 17	frame 18
SHITOMASHI	BRISK	24.4928	14.528	18.3804	11.8507	14.1876	13.9102	22.3009	16.4756	11.3267	13.5138	11.5174	12.5502	12.5595	12.6567	10.5007	10.2477	9.31494	9.87553
HARRIS		n/a	10.586	n/a	12.4858	n/a	13.6217	16.7724	11.2543	0.134504	n/a	11.6702	5.33701	11.9102	7.72144	n/a	7.09479	11.7964	0.350321
FAST		12.5951	11.797	13.6008	12.8651	n/a	12.5645	15.6212	11.7252	13.0297	13.6593	24.3961	12.5689	12.8596	12.1132	11.8915	12.0872	7.88441	12.2182
BRISK		14.36	16.91	10.9949	16.9132	30.7918	18.1758	15.7748	19.7292	15.206	14.9163	12.4661	10.8666	12.5023	11.6022	12.2247	10.812	9.38048	10.4496
ORB		18.8847	18.6344	26.6842	19.9253	n/a	12.5033	16.4045	16.0542	12.0719	13.4335	9.78143	n/a	9.22601	9.51962	11.9076	11.8316	15.8889	25.7402
AKAZE		12.2751	14.7487	13.998	14.9035	13.8194	15.3823	16.4883	14.1263	13.7881	12.0597	12.6935	11.5922	10.2771	9.84639	9.48015	10.4517	9.26131	8.94209
SIFT		14.7371	15.6734	12.8992	20.6866	16.0607	10.4699	16.1066	15.4765	14.2222	10.5046	12.9654	11.3005	11.3185	11.5133	9.48497	8.72439	8.78325	8.76581
SHITOMASHI	BRIEF	14.0747	16.8411	9.93645	12.9215	13.2483	13.4042	15.2359	12.5114	11.7376	13.3275	11.4314	11.5364	11.9735	13.2126	12.0506	11.0235	10.7442	8.39865
HARRIS		10.9082	10.586	-11.4731	11.7693	13.6432	14.7045	15.8978	25.116	3.30058	n/a	11.7414	5.05076	13.456	5.6061	n/a	10.9006	12.5848	n/a
FAST		11.0695	11.981	13.8858	14.6808	15.7524	14.4533	11.7607	11.8219	12.699	17.1467	13.7704	11.1503	12.0299	11.0226	12.3176	11.2304	9.0786	10.4738
BRISK		12.9477	20.0678	13.3699	20.0963	17.3541	16.2282	17.2164	19.3832	14.819	12.0806	12.2549	12.4541	11.9443	10.7752	11.2997	11.4085	9.30693	11.4731
ORB		16.921	32.5893	19.9567	30.0516	33.1788	13.4145	188.74	13.8288	13.2276	13.0367	11.7678	14.641	10.7295	9.71308	15.4581	7.85888	28.5165	14.788
AKAZE		13.2783	16.8136	13.9164	15.1064	15.1909	13.5663	16.0175	13.9668	14.1769	12.567	13.0318	11.0693	10.5753	10.8589	9.37766	9.91621	9.54581	8.693
SIFT		11.8355	14.8188	15.3418	21.8725	14.7482	10.7532	15.8379	18.1733	13.2843	13.0845	12.0832	9.84375	10.4468	9.88427	8.8317	7.97504	8.61235	9.25026
SHITOMASHI	ORB	15.0726	12.1711	12.095	13.3448	12.7989	12.7954	14.6347	12.5114	10.9913	13	9.33785	12.0292	11.5554	11.8595	9.98359	13.1503	8.66612	8.14662
HARRIS		8.81335	52.7952	n/a	11.7693	35.3833	13.6217	14.2744	13.5704	3.97517	n/a	11.1552	11.1055	n/a	5.66097	n/a	7.21241	n/a	3.42677
FAST		12.0717	12.3776	12.7705	13.6805	43.2173	n/a	11.3027	10.7352	12.3241	13.8902	14.8673	13.301	12.0131	11.3079	10.9223	12.3436	9.49881	10.2184
BRISK		16.7888	15.6438	19.8978	20.1027	31.4115	17.7808	19.8573	19.9357	14.2959	13.894	12.4668	13.106	12.2247	13.5655	12.7251	14.3328	8.89827	11.1301
ORB		22.07	10.918	18.5308	29.9201	n/a	13.2729	15.3801	10.8951	30.4129	23.5366	9.35938	21.9028	10.2757	10.8872	13.6989	10.9958	40.195	14.5414
AKAZE		12.9182	15.0455	14.1216	14.3807	15.5579	13.7591	15.723	13.8922	13.691	12.1246	12.2719	11.6155	10.6776	11.6641	11.3596	10.5992	9.06497	8.9387
SIFT		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SHITOMASHI	FREAK	13.8926	14.6463	11.9751	12.2613	12.0556	15.3888	15.1847	13.7284	13.0174	14.1512	11.9428	13.2407	13.0002	17.8084	11.8818	12.6526	12.9845	8.02811
HARRIS		10.9082	n/a	1.53607	12.5101	n/a	15.2483	13.6036	10.7335	n/a	10.2931	11.8135	11.8228	13.456	6.06984	n/a	6.71705	12.5848	n/a
FAST		12.0961	27.8033	14.313	13.2689	23.4576	13.5266	16.5212	11.6952	12.0693	17.9109	12.9992	11.8227	12.0496	12.3436	11.4079	12.1987	7.86218	11.9008
BRISK		12.188	16.995	14.1325	15.2391	24.8776	13.3114	15.4119	16.9052	17.6251	12.5337	14.8692	12.0228	12.6791	11.1997	13.9176	8.76213	9.27288	11.0962
ORB		10.943	23.3622	12.6911	11.2087	59.0092	14.7623	156.243	9.38588	33.3573	n/a	6.46748	n/a	6.98176	21237.2	8.68208	8.25347	32.1974	24.1855
AKAZE		10.943	23.3622	12.6911	11.2087	59.0092	14.7623	156.243	9.38588	33.3573	n/a	6.46748	n/a	6.98176	21237.2	8.68208	8.25347	32.1974	24.1855
SIFT		14.7996	13.3585	13.3988	16.3518	16.8318	10.9177	16.5944	14.8423	14.0282	11.2396	10.6571	10.6904	11.2158	10.2517	9.66809	9.8641	8.46464	8.96286
AKAZE	AKAZE	12.5965	14.4355	13.0048	14.397	15.1878	13.2446	15.8094	14.1623	14.1482	11.6422	12.0663	10.8931	10.8519	10.533	10.7295	9.76202	9.20222	9.08333
SHITOMASHI	SIFT	14.0894	11.7773	11.1126	12.7502	11.9213	13.2703	13.2947	13.2285	12.332	13.5257	12.1981	11.5712	11.2894	11.8681	11.1123	7.48435	11.1681	8.26497
HARRIS		10.9082	n/a	n/a	11.0145	13.6432	27.8744	13.9875	25.116	n/a	n/a	11.0967	n/a	13.456	5.66097	n/a	8.86241	12.5848	3.98535
FAST		12.6702	10.7403	14.1559	14.1341	29.0545	13.0669	13.5023	14.1139	13.1594	14.6889	18.3879	11.7475	12.5276	11.6137	11.232	11.3076	7.78691	12.2465
BRISK		14.68	14.8942	17.9752	18.4394	36.8012	16.5901	16.3978	17.7167	15.5108	14.2078	11.994	13.1859	12.7527	10.6113	13.5836	10.2772	11.1837	13.2776
ORB		19.4124	11.0165	22.5752	n/a	70.6497	12.5581	44.1797	10.6807	11.924	12.6395	9.62025	n/a	9.65265	15.2678	16.9683	10.5643	18.7334	18.5157
AKAZE		12.649	14.6108	13.2831	14.1509	17.4249	13.8406	15.6829	14.063	14.2546	11.7404	12.8073	11.4842	11.027	10.4792	9.94151	10.1631	9.52286	8.86837
SIFT		12.0662	13.9837	12.7056	19.1004	15.275	12.5168	14.5659	18.4685	14.5452	10.7818	11.9401	11.7433	11.0237	12.9064	9.78012	9.39131	8.9451	9.24051

	frame 1	frame 2	frame 3	frame 4	frame 5	frame 6	frame 7	frame 8	frame 9	frame 10	frame 11	frame 12	frame 13	frame 14	frame 15	frame 16	frame 17	frame 18
Lidar	12.5156	12.6142	14.091	16.6894	15.9082	12.6787	11.9844	13.1241	13.0241	11.1746	12.8086	8.95978	9.96439	9.59863	8.57352	9.51617	9.54658	8.3988

The combination of **Shi Tomashi + SIFT** appear to have the most consistent performance (smallest standard deviation). Also, its results are closed to the results we got from Lidar based method.