SFND_2D_Feature_Tracking writeup

MP.1 Data Buffer Optimization

- A vector for dataBuffer objects whose size does not exceed a limit of 2 was implemented using a ring buffer which remove the first element in the vector if the size exceeds 2.

MP.2 Keypoint Detection

- Implemented 6 detector functions and their prototypes (HARRIS, FAST, BRISK, ORB, AKAZE, and SIFT) and make them selectable by setting a string accordingly.
- Returned the elapsed time of each detector.

MP.3 Keypoint Removal

- Then I Removed all keypoints outside of the rectangle (535, 180, 180, 150) which is a rectangle of the preceding vehicle .
- I used the function (cv::Rect::contains) for this purpose.

MP.4 Keypoint Descriptors

- Implemented 5 descriptors BRIEF, ORB, FREAK, AKAZE and SIFT and made them selectable by setting a string accordingly.
- Returned the elapsed time of each descriptor.

MP.5 Descriptor Matching

- Implemented FLANN matching that use KD-tree to search for matching pairs and avoids the exhaustive search of the MAT_BF approach

MP.6 Descriptor Distance Ratio

- Implemented K-Nearest-Neighbor matching which takes the best 2 matches and looks at the ratio of best vs. second-best match to decide whether to keep an associated pair of keypoints.

MP.7 Performance Evaluation 1

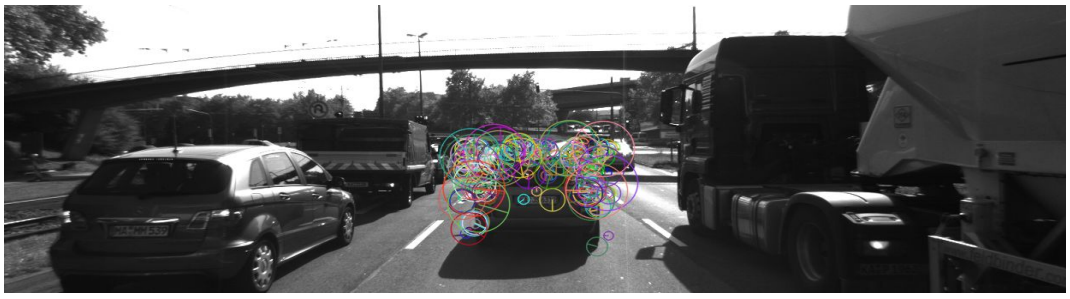
No. of keypoints on the preceding vehicle for all 10 images and the distribution of their neighborhood size:

No of kpts for 10 images in SHI TOMASI:
125 , 118 , 123 , 120 , 120 , 113 , 114 , 123 , 111 , 112
Notes:

- All keypoints neighborhood sizes are extremely small .

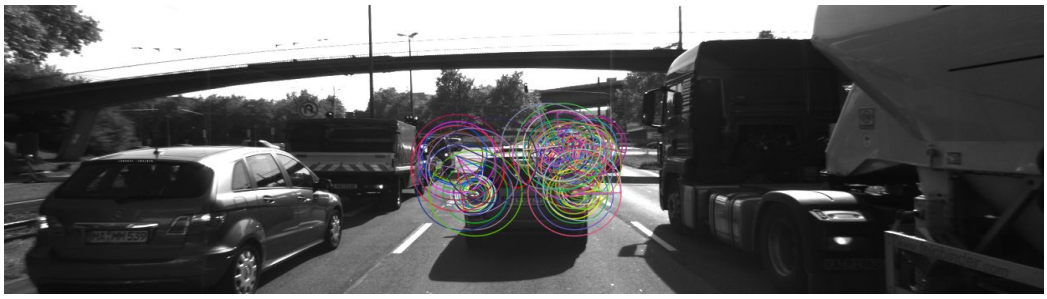
No of kpts for 10 images in BRISK:
264 , 282 , 282 , 277 , 297 , 279 , 289 , 272 , 266 , 254
Notes:

- There is a wide variety of neighborhood sizes in BRISK of large , medium and small.



No of kpts for 10 images in ORB
92 , 102 , 106 , 113 , 109 , 125 , 130 , 129 , 127 , 128
Notes:

- All keypoints neighborhood sizes are very large.

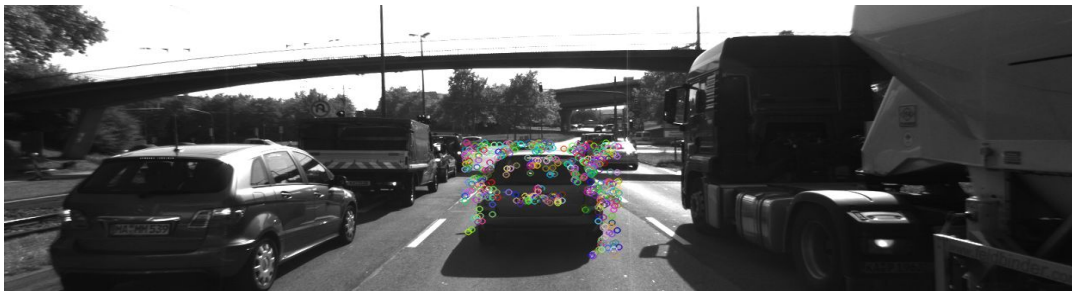


No of kpts for 10 images in HARRIS
17 , 14 , 18 , 21 , 26 , 43 , 18 , 31 , 26 , 34
Notes:

- All keypoints neighborhood sizes are small.
- The no. of keypoints is significantly low compared to other algorithms.

No of kpts for 10 images in FAST
419 , 427 , 404 , 423 , 386 , 414 , 418 , 406 , 396 , 401
Notes:

- All keypoints neighborhood sizes are larger than **SHI TOMASI** & **HARRIS** but also small .
- The no. of keypoints is high compared to other algorithms.

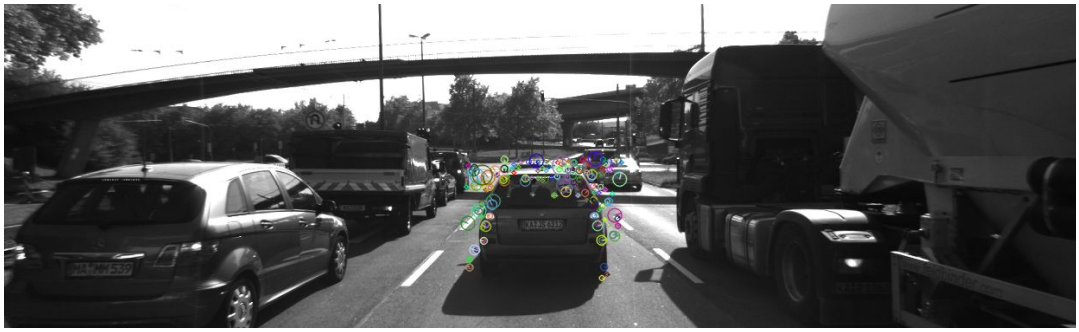


No of kpts for 10 images in AKAZE

166 , 157 , 161 , 155 , 163 , 164 , 173 , 175 , 177 , 179

Notes:

- All keypoints neighborhood sizes are small or medium size .



No of kpts for 10 images in SIFT

138 , 132 , 124 , 137 , 134 , 140 , 137 , 148 , 159 , 137

Notes:

- There is a variety of keypoints neighborhood sizes in BRISK of large , medium and small sizes.
- The density of keypoints in this algorithm is relatively low.

MP.8 Performance Evaluation 2

Count the number of matched keypoints for all 10 images using all possible combinations of detectors and descriptors.

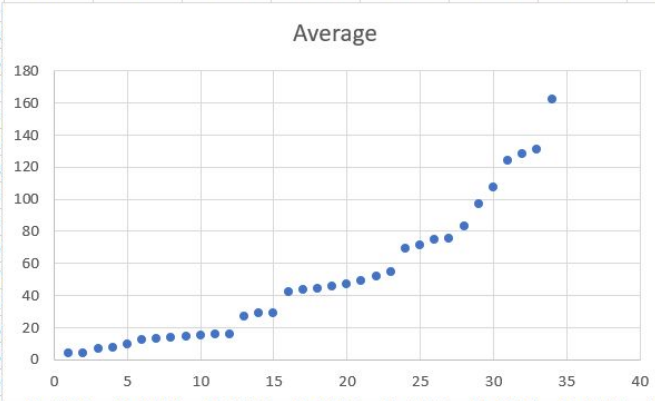
- In the matching step, the BF approach is used with the descriptor distance ratio set to 0.8.
- The numbers of matches of all combinations are attached in "**PerformanceTask2_matches**" spreadsheet in SFND_2D_Feature_Matching\documentation directory.

Detector	Descriptor	No of matches pair 1	pair 2	pair 3	pair 4	pair 5	pair 6	pair 7	pair 8	pair 9	Average
SHITOMASI	BRIEF	96	93	92	89	92	93	85	91	85	91
SHITOMASI	FREAK	66	66	64	63	62	64	61	65	63	64
SHITOMASI	BRISK	84	80	73	77	74	70	79	81	72	77
SHITOMASI	ORB	86	84	87	91	87	76	81	88	88	85
SHITOMASI	SIFT	112	109	104	103	99	101	96	106	97	103
HARRIS	BRIEF	12	12	14	17	17	16	12	20	21	16
HARRIS	FREAK	11	9	13	14	13	18	10	17	18	14
HARRIS	BRISK	11	9	10	11	16	14	12	21	17	13
HARRIS	ORB	11	11	14	17	19	19	13	21	20	16
HARRIS	SIFT	14	11	16	19	22	22	13	24	22	18
FAST	BRIEF	229	253	233	247	224	243	251	260	238	242
FAST	FREAK	178	181	156	182	159	179	196	164	171	174
FAST	BRISK	213	216	187	205	185	200	215	203	208	204
FAST	ORB	226	220	218	226	220	235	251	226	239	229
FAST	SIFT	316	325	297	311	291	326	315	300	301	309
BRISK	BRIEF	138	166	129	141	148	155	158	161	148	149
BRISK	FREAK	114	121	113	118	103	129	135	129	131	121
BRISK	BRISK	138	144	133	144	139	155	137	150	158	144
BRISK	ORB	94	107	88	97	85	114	112	114	122	104
BRISK	SIFT	182	193	169	183	171	195	194	176	183	183
ORB	BRIEF	37	38	37	53	42	64	58	62	59	50
ORB	FREAK	39	33	37	40	33	40	41	39	44	38
ORB	BRISK	60	65	65	76	72	83	83	73	72	72
ORB	ORB	40	57	49	54	57	68	71	62	72	59
ORB	SIFT	67	79	78	79	82	95	95	94	94	85
SIFT	BRIEF	63	72	64	66	52	57	72	67	84	66
SIFT	FREAK	59	63	54	64	51	50	47	53	65	56
SIFT	BRISK	57	63	58	61	55	52	54	63	73	60
AKAZE	BRIEF	108	116	110	109	116	129	133	135	131	121
AKAZE	FREAK	103	105	93	99	97	115	126	118	117	108
AKAZE	BRISK	126	112	121	117	114	119	134	140	127	123
AKAZE	ORB	102	96	96	84	90	116	103	113	118	102
AKAZE	SIFT	134	134	130	136	137	147	147	154	151	141
AKAZE	AKAZE	128	128	125	117	121	132	137	140	144	130

MP.9 Performance Evaluation 3

Log the time it takes for keypoint detection and descriptor extraction.
The time of both descriptor and detector in all 10 images and the sum of was recorded in the "PerformanceTask3_time" spreadsheet and The best 3 combination analysis is in **"PerformanceTask3_timeAvg"** spreadsheet .

detector	descriptor	Index	Average	Image 1	Image 2	Image 3	Image 4	Image 5	Image 6	Image 7	Image 8	Image 9	Image 10
FAST	BRIEF	1	3.702106	4.43913	3.91984	3.45944	3.48037	3.38095	4.19665	3.55476	3.57722	3.53655	3.47615
FAST	ORB	2	3.783383	3.94015	3.8546	3.75371	3.57264	3.59946	3.64896	3.70388	4.08153	3.84943	3.82947
FAST	BRISK	3	6.734788	6.9849	6.91782	6.52545	6.73125	6.70081	6.64603	6.77115	6.60957	6.69904	6.76186
ORB	BRIEF	4	7.486431	7.66473	7.93645	7.22022	7.32227	7.28972	7.2943	7.75435	7.29871	7.62554	7.45802
ORB	BRISK	5	9.33832	10.1758	9.25498	8.94379	8.86719	9.09717	9.45561	9.31634	9.33136	9.62415	9.31681
ORB	ORB	6	12.4345	12.5553	12.3115	12.5298	12.4071	12.3481	12.3645	12.2921	12.0965	12.5868	12.8533
SHITOMAS	ORB	7	12.91833	12.6712	12.9656	12.0634	13.3531	14.8775	13.5299	12.36	12.3539	12.7024	12.3063
SHITOMAS	BRISK	8	13.80507	13.7907	14.1417	13.9328	14.5558	13.8974	13.9085	13.3421	13.1768	13.2635	14.0414
HARRIS	BRIEF	9	14.78863								5712	13.1331	17.9406
HARRIS	ORB	10	15.18648								6536	13.3292	18.399
HARRIS	BRISK	11	15.90866								1328	15.2048	19.0201
SHITOMAS	BRIEF	12	16.03263								6096	15.1174	15.746
FAST	SIFT	13	27.18295								4226	25.5959	31.2772
HARRIS	SIFT	14	28.99482								8084	27.0163	33.0812
SHITOMAS	SIFT	15	29.32398								3923	28.1219	32.3562
BRISK	BRIEF	16	42.36235								7669	41.9355	42.3536
BRISK	BRISK	17	43.72565								1083	42.1433	43.6628
FAST	FREAK	18	44.05409								6193	42.605	42.994
BRISK	ORB	19	45.4867								8552	45.0235	45.4059
ORB	FREAK	20	47.29262								3811	48.7209	48.1289
ORB	SIFT	21	49.34296								3032	53.6206	50.9415
SHITOMAS	FREAK	22	51.79186								2096	51.7975	51.2009
HARRIS	FREAK	23	54.38799								7715	58.0396	58.3036
AKAZE	BRIEF	24	69.07179	69.6093	78.3305	65.7116	69.2506	61.6356	64.2548	68.3277	74.1839	74.1095	65.3044
AKAZE	BRISK	25	71.22818	65.2185	75.1426	72.8672	72.0831	68.5403	70.9185	70.5775	69.8389	74.1766	72.9186
AKAZE	ORB	26	74.6024	71.3376	79.3092	77.8638	72.531	73.9763	75.2406	76.6419	71.0498	74.7155	73.3583
BRISK	SIFT	27	75.218	79.2656	79.3326	77.0266	77.1148	77.8258	72.9639	75.6917	71.3444	71.0514	70.5632
BRISK	FREAK	28	83.368	82.4261	84.7418	83.5511	82.469	84.4052	83.5283	82.9205	82.0092	84.3177	83.3111
AKAZE	SIFT	29	96.97757	105.952	91.9101	93.057	91.3063	100.698	102.657	96.9342	96.3932	90.2849	100.583
AKAZE	FREAK	30	107.0848	100.809	106.294	102.493	105.92	104.606	110.094	109.643	111.646	110.532	108.811
SIFT	BRISK	31	124.2372	125.866	117.973	122.513	121.525	121.638	133.68	125.224	125.903	120.6	127.45
SIFT	BRIEF	32	128.0174	126.696	131.434	133.033	138.586	136.484	125.108	123.061	123.533	120.625	121.614
AKAZE	AKAZE	33	131.0376	143.328	129.872	122.893	122.544	128.376	133.762	126.269	132.433	139.094	131.805
SIFT	FREAK	34	162.4968	159.599	158.142	159.258	160.335	161.733	163.85	166.069	164.12	166.273	165.589



The best 3 combinations are:

- FAST detector - BRIEF descriptor
- FAST detector - ORB descriptor
- FAST detector - BRISK descriptor