Camera Based 2D Feature Tracking

MP.1 – MP.6 were the steps to implement the project code. I implemented the image ring buffer, detector, keypoint removal, descriptor extraction, and descriptor matching by reviewing the previous lectures and assignments as well as reading through the OpenCV documentation online.

MP.7 – MP.9 were performance evaluations of the different detector and descriptor algorithms.

MP.7

To complete MP.7 I used a rectangle filter to remove all keypoints not on the preceding vehicle. I shrunk the rectangle filter coordinates down as small as possible while keeping all the keypoints on the preceding vehicle through all ten images. Below is the chart of my results. I also looked for which algorithms found keypoints on key parts of the car (like the license plate and tires).

Detector \ Image	1	2	3	4	5	6	7	8	9	10	Average	License Plate	Tires
SHITOMASI	78	79	86	79	82	79	79	83	76	75	80	Always Lots	Always Some
HARRIS	29	31	33	36	34	38	34	39	40	36	35	Never	Never
FAST	87	84	83	94	84	88	96	98	88	94	90	Sometimes	Sometimes
BRISK	154	162	161	163	177	173	171	169	163	165	166	Always Some	Sometimes
ORB	545	521	523	556	530	556	549	550	537	532	540	Always	Always
AKAZE	103	93	99	95	104	107	111	109	110	101	103	Never	Always
SIFT	83	86	80	95	94	94	90	104	96	80	90	Always Some	Always

MP.8

To complete MP.8 I ran every combination of detector/descriptor algorithm that I have implemented. See the next page for a chart of my results.

Detector	Descriptor	Image 2	Image 3	Image 4	Image 5	Image 6	Image 7	Image 8	Image 9	Image 10	Average
AKAZE	AKAZE	1011	1025	1021	1027	1022	1039	1026	1043	999	1024
SHITOMASI	BRISK	752	731	708	697	703	685	715	753	715	718
SHITOMASI	BRIEF	1003	981	992	987	931	947	973	1003	971	976
SHITOMASI	ORB	898	876	915	900	891	879	870	909	878	891
SHITOMASI	FREAK	730	723	751	717	712	713	700	726	686	718
SHITOMASI	SIFT	1044	1050	1068	1045	1019	1032	1033	1078	1053	1047
HARRIS	BRISK	331	332	347	339	347	325	332	343	345	338
HARRIS	BRIEF	413	415	424	430	423	412	420	424	428	421
HARRIS	ORB	390	381	399	411	401	381	387	401	397	394
HARRIS	FREAK	310	313	331	333	327	314	317	332	317	322
HARRIS	SIFT	431	422	448	453	437	427	422	440	445	436
FAST	BRISK	999	988	989	953	1005	963	938	950	957	971
FAST	BRIEF	1284	1310	1293	1271	1219	1227	1223	1212	1222	1251
FAST	ORB	1197	1179	1200	1186	1174	1128	1126	1157	1144	1166
FAST	FREAK	934	939	938	922	934	909	889	897	912	919
FAST	SIFT	1409	1412	1391	1362	1357	1374	1379	1334	1341	1373
BRISK	BRISK	1494	1486	1477	1400	1451	1368	1400	1373	1385	1426
BRISK	BRIEF	1689	1739	1746	1674	1666	1622	1660	1646	1601	1671
BRISK	ORB	1435	1447	1411	1376	1425	1365	1350	1354	1362	1392
BRISK	FREAK	1333	1343	1358	1297	1369	1322	1296	1308	1285	1323
BRISK	SIFT	1677	1699	1648	1625	1688	1607	1645	1572	1580	1638
ORB	BRISK	4444	4421	4434	4453	4524	4438	4333	4342	4240	4403
ORB	BRIEF	3125	3069	3023	3062	3060	3105	2994	3165	3147	3083
ORB	ORB	4326	4340	4306	4369	4376	4367	4269	4303	4258	4324
ORB	FREAK	2112	2117	2108	2172	2137	2148	2105	2111	2195	2134
ORB	SIFT	4784	4756	4724	4780	4761	4741	4646	4663	4684	4727
SIFT	BRISK	566	559	566	534	544	542	552	530	560	550
SIFT	BRIEF	702	653	666	639	648	653	671	619	673	658
SIFT	ORB	Insufficient memory (ORB tried to allocate 65 GB)									
SIFT	FREAK	539	522	537	510	519	511	545	518	536	526
SIFT	SIFT	803	781	759	754	756	738	743	815	815	774

MP.9

I completed MP.9 at the same time as MP.8. See the next page for the chart of my results. I do not have results for the SIFT detector with the ORB descriptor because it tries to allocate more RAM than my machine has and crashes.

My first pick for top three pairs is the FAST detector with the ORB descriptor. It is the fasted pair (much faster than almost everything else) which is important in a real time application. Additionally, the FAST detector results in a good number of keypoints on the preceding vehicle, including some on interesting features like the license plate and tires.

My second pick is the FAST detector with the ORB descriptor. It is almost as fast as FAST/ORB and has the same benefits of the FAST keypoints.

My third pick is the SHITOMASI detector with the ORB descriptor. It is much slower than the previous two, but still probably suitable for most real time applications. Additionally, SHITOMASI creates a good number of keypoints on the preceding vehicle, including lots on the license plate and tires.

Detector	Descriptor	Detector (ms)	Descriptor (ms)	Sum (ms)
AKAZE	AKAZE	90.3	84.4	174.7
SHITOMASI	BRISK	21.6	13.6	35.2
SHITOMASI	BRIEF	21.4	5.3	26.7
SHITOMASI	ORB	17.6	3.1	20.7
SHITOMASI	FREAK	13.8	55.5	69.3
SHITOMASI	SIFT	15.9	34.4	50.3
HARRIS	BRISK	17.5	6.9	24.4
HARRIS	BRIEF	17.6	2.9	20.5
HARRIS	ORB	15.6	1.8	17.4
HARRIS	FREAK	11	44.5	55.5
HARRIS	SIFT	16.5	26.4	42.9
FAST	BRISK	1	17.8	18.8
FAST	BRIEF	0.9	6.3	7.2
FAST	ORB	1	3.8	4.8
FAST	FREAK	0.9	54.9	55.8
FAST	SIFT	1.1	92.3	93.4
BRISK	BRISK	42.5	27.6	70.1
BRISK	BRIEF	41.7	9.9	51.6
BRISK	ORB	43	9.1	52.1
BRISK	FREAK	40.7	65	105.7
BRISK	SIFT	42	255.8	297.8
ORB	BRISK	13.6	73.4	87
ORB	BRIEF	15.8	26.9	42.7
ORB	ORB	14.6	24.4	39
ORB	FREAK	13.7	73.9	87.6
ORB	SIFT	13.6	2208	2221.6
SIFT	BRISK	137.1	13.5	150.6
SIFT	BRIEF	136.9	4.9	141.8
SIFT	ORB			
SIFT	FREAK	143.6	54.6	198.2
SIFT	SIFT	108.9	116.5	225.4