Sumário

1.INTRODUÇÃO

After implementation of keypoint-detection, descriptor extraction and keypoint-matching in consecutive images, the results obtained are presented in the following sections. Here are some notes on the results:

* AKAZE detector works only with AKAZE descriptor

* For matching with SIFT descriptor we need to use FLANN. SIFT does not work with BF

* SIFT detector and ORB descriptor do not work together

* for SHITOMASI blockSize of 4 has been used

* for HARRIS blockSize of 2 has been used

2.KEYPOINT-DETECTED

Total number of keypoints detected by each method for every image are listed in the table bellow:

IMAGEM	SHITOMASI	HARRIS	FAST	BRISK	ORB	AKAZE	SIFT
Imagem 0	1370	339	1824	2757	500	1351	1438
Imagem 1	1301	286	1832	2777	500	1327	1371
Imagem 2	1361	349	1810	2741	500	1311	1380
Imagem 3	1358	356	1817	2735	500	1351	1335
Imagem 4	1333	521	1793	2757	500	1360	1305
Imagem 5	1284	2611	1796	2695	500	1347	1370
Imagem 6	1366	200	1788	2715	500	1363	1396
Imagem 7	1366	806	1695	2628	500	1331	1382
Imagem 8	1389	572	1749	2639	500	1357	1463
Imagem 9	1339	1471	1770	2672	500	1331	1422

Corresponding time taken in detection is shown in the plot here along with a sample output for `AKAZE` descriptor:

Mean keypoint detection time (ms)
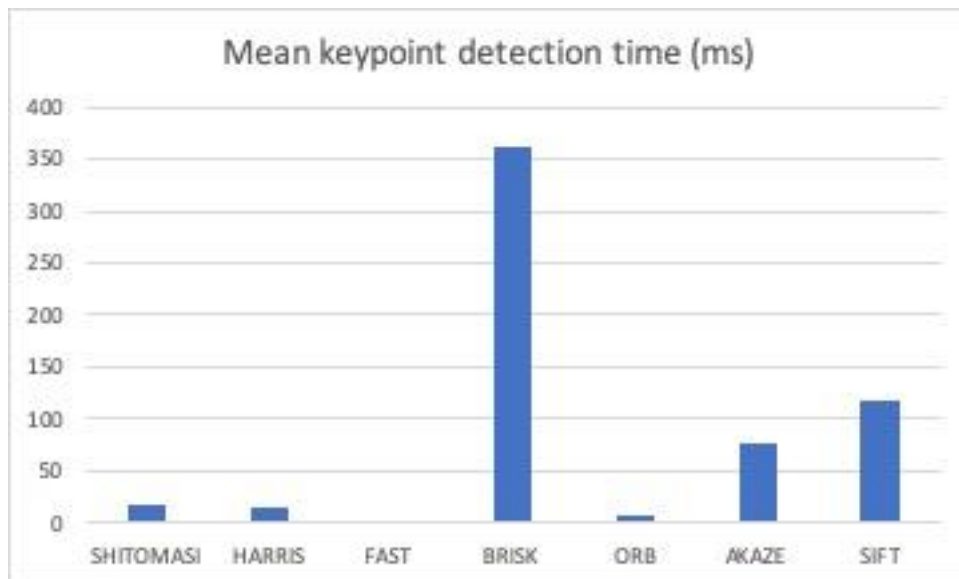
Associated number of keypoints detected on preceding vehicle in the images are:

IMAGEM	SHITOMASI	HARRIS	FAST	BRISK	ORB	AKAZE	SIFT
img-0	715	190	970	1472	280	727	771
img-1	680	162	974	1494	277	710	731
img-2	716	201	967	1480	280	705	734
img-3	705	202	970	1467	282	724	714
img-4	699	299	954	954	284	733	702
img-5	672	1454	961	1450	288	724	741
img-6	690	115	957	1463	288	736	749
img-7	711	461	908	1412	289	720	745
img-8	722	328	928	1417	287	736	791
img-9	698	823	940	1429	292	725	757

Keypoints on the preceding vehicle
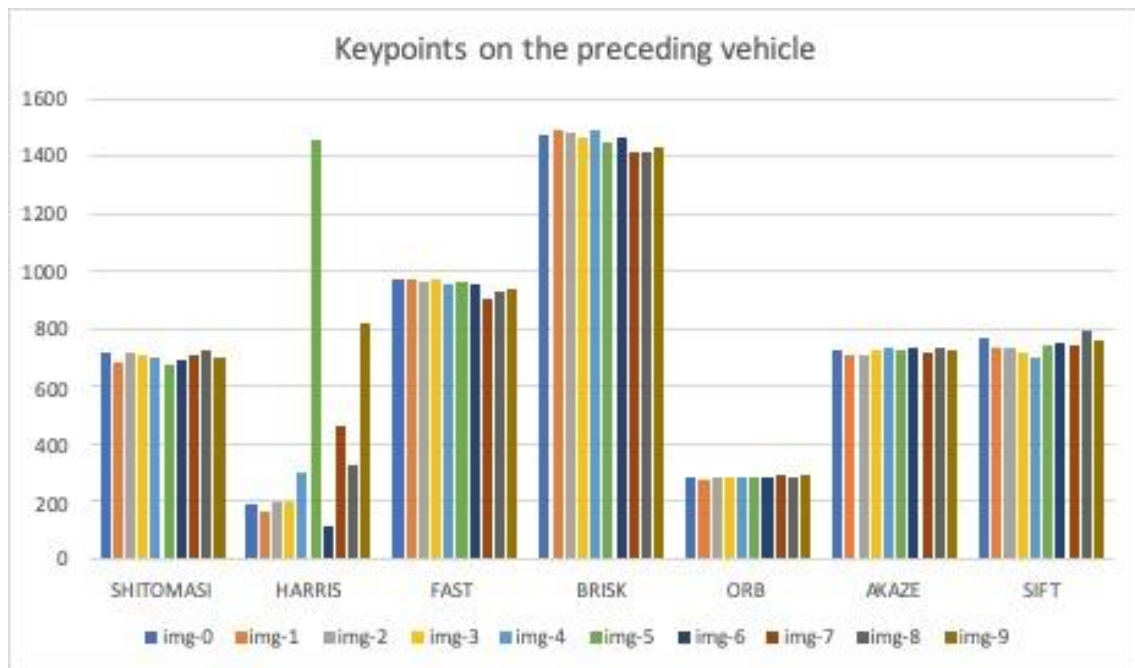
3.NEIGHBORHOOD SIZE

As far as distribution of neighborhood size of keypoints detected on preceding vehicle is concerned, some of the detector methods have fixed neighborhood sizes, namely:

* SHITOMASI -- 4

* HARRIS -- 6

* FAST -- 7

while others have a distribution, among which ORB seems to have large spread. The distribution is shown in following four figures and standard deviation is tabulated here:

DETECTOR	BRISK	ORB	AKAZE	SIFT
standard-deviation	14.40	25.83	3.43	6.30

BRISK neighborhood-size distribution

ORB neighborhood-size distribution

SIFT - neighborhood-size distribution

AKAZE- neighborhood-size distribution
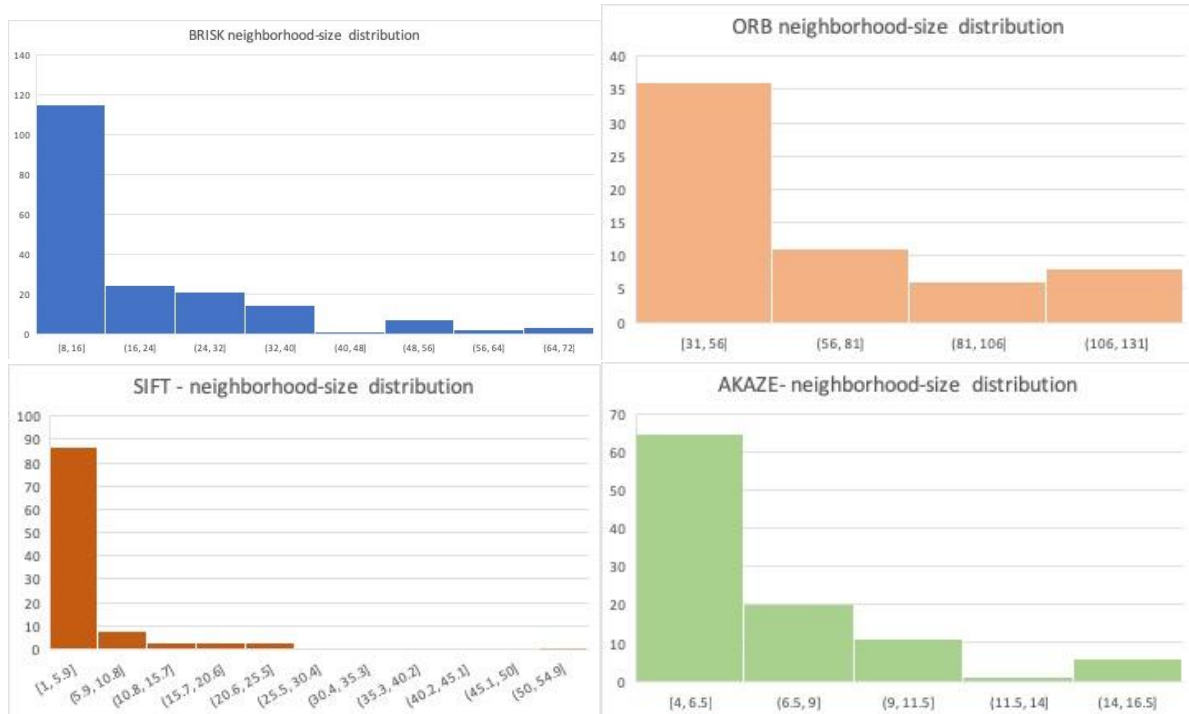
4.MATCHED KEYPOINTS

A mean of the number of matched keypoints for all 10 images using all possible combinations of detectors and descriptors is shown here.

	BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
SHITOMASI	251	359	317	255	N/A	365
HARRIS	144	177	172	150	N/A	157
FAST	352	545	473	352	N/A	646
BRISK	564	830	566	556	N/A	803
ORB	153	156	163	70	N/A	178
AKAZE	359	449	371	359	385	409
SIFT	275	356	N/A	273	N/A	291

The details for every single combination of detectors and descriptors with corresponding matched points are also provided in the following table for reference

Total number of matched keypoints for each combination:

HARRIS							
images		BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
img-0	img-1	88	107	103	86	N/A	99
img-1	img-2	83	93	98	94	N/A	86
img-2	img-3	107	144	124	101	N/A	110
img-3	img-4	113	129	118	106	N/A	99
img-4	img-5	152	141	165	153	N/A	127
img-5	img-6	245	427	387	325	N/A	403
img-6	img-7	66	57	62	64	N/A	53
img-7	img-8	231	284	283	235	N/A	254
img-8	img-9	210	212	208	189	N/A	182

SHITOMASI							
images		BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
img-0	img-1	268	348	308	256	N/A	353
img-1	img-2	239	357	302	260	N/A	363
img-2	img-3	252	369	342	284	N/A	366
img-3	img-4	242	336	306	242	N/A	354
img-4	img-5	248	364	327	250	N/A	373
img-5	img-6	242	356	301	247	N/A	356
img-6	img-7	256	364	323	252	N/A	371
img-7	img-8	256	376	331	256	N/A	381
img-8	img-9	252	364	316	252	N/A	364

FAST							
		BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
img-0	img-1	367	539	484	365	N/A	636
img-1	img-2	367	592	507	381	N/A	676
img-2	img-3	358	538	480	343	N/A	640
img-3	img-4	347	543	473	324	N/A	648
img-4	img-5	344	543	458	335	N/A	636
img-5	img-6	355	548	481	368	N/A	672
img-6	img-7	343	526	453	349	N/A	653
img-7	img-8	341	541	475	345	N/A	639
img-8	img-9	348	534	443	354	N/A	614

BRISK							
		BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
img-0	img-1	589	845	579	567	N/A	810
img-1	img-2	578	864	592	558	N/A	837
img-2	img-3	554	815	533	531	N/A	798
img-3	img-4	567	823	571	567	N/A	817
img-4	img-5	569	803	590	559	N/A	812
img-5	img-6	557	853	578	573	N/A	820
img-6	img-7	563	829	561	555	N/A	815
img-7	img-8	540	805	532	532	N/A	758
img-8	img-9	556	837	559	566	N/A	758

ORB		BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
img-0	img-1	146	159	158	68	N/A	174
img-1	img-2	156	153	155	58	N/A	176
img-2	img-3	154	137	155	65	N/A	180
img-3	img-4	145	148	155	75	N/A	164
img-4	img-5	152	146	166	65	N/A	175
img-5	img-6	155	172	175	72	N/A	181
img-6	img-7	148	156	165	76	N/A	186
img-7	img-8	162	177	171	66	N/A	193
img-8	img-9	160	155	166	82	N/A	176

AKAZE		BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
img-0	img-1	376	449	387	350	390	394
img-1	img-2	359	446	367	344	380	406
img-2	img-3	353	444	363	348	384	411
img-3	img-4	331	437	346	328	378	402
img-4	img-5	347	455	369	347	380	414
img-5	img-6	368	456	379	365	407	422
img-6	img-7	363	453	370	377	378	397
img-7	img-8	371	432	371	405	391	430
img-8	img-9	367	469	388	364	375	407

SIFT		BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
img-0	img-1	280	362	N/A	290	N/A	292
img-1	img-2	286	364	N/A	286	N/A	288
img-2	img-3	256	344	N/A	267	N/A	292
img-3	img-4	265	343	N/A	264	N/A	276
img-4	img-5	274	363	N/A	265	N/A	290
img-5	img-6	255	347	N/A	251	N/A	272
img-6	img-7	272	344	N/A	267	N/A	287
img-7	img-8	282	354	N/A	270	N/A	297
img-8	img-9	303	386	N/A	293	N/A	323

A sample matched-pair with ORB-FREAK combination is shown here:

5.TIME-TAKEN

The mean of time taken for keypoint detection and descriptor extraction for all combinations is listed below.

mean of detection + extraction time (ms)						
detector/descriptor	BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
SHITOMASI	347.66	19.74	18.87	56.84	N/A	38.18
HARRIS	341.79	17.44	17.46	54.08	N/A	46.13
FAST	331.96	4.85	3.50	47.20	N/A	52.42
BRISK	697.93	366.22	368.88	411.60	N/A	501.93
ORB	331.11	8.99	12.27	47.45	N/A	93.72
AKAZE	404.95	84.25	84.28	116.27	142.18	117.31
SIFT	435.23	125.50	N/A	165.51	N/A	191.12

6.RECOMMENDATION

In a dynamic scenario like autonomous driving, the speed and accuracy of detection are of utmost importance. Hence, to arrive at recommendation, I computed the ratio of mean-matched-keypoints to mean-detection-extraction-time, defining a score parameter as:

score = 1000 * (mean-matched-keypoints / mean-detection-extraction-time)

The corresponding scores are shown in image below, with highest three highlighted in different shades of green.

detector/descriptor	BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
SHITOMASI	721	18,199	16,815	4,494	N/A	9,547
HARRIS	421	10,158	9,849	2,780	N/A	3,404
FAST	1,061	112,389	134,902	7,449	N/A	12,324
BRISK	808	2,268	1,535	1,352	N/A	1,599
ORB	462	17,339	13,275	1,468	N/A	1,903
AKAZE	888	5,329	4,403	3,085	2,706	3,488
SIFT	631	2,839	N/A	1,647	N/A	1,521

Based on these scores my recommendations are:

RANK	DETECTOR	DESCRIPTOR
1	FAST	ORB
2	FAST	BRIEF
3	SHITOMASI	BRIEF