MP.7 Performance Evaluation 1 & MP.8 Performance Evaluation 2

Count the number of key points on the preceding vehicle for all 10 images and take note of the distribution of their neighborhood size. Do this for all the detectors you have implemented.

Count the number of matched key points 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.

Below is a table with the sum of all the key points detected for 10 images using different detector / descriptor cases.

Detector	Descriptor						
		BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
	Shi-Tomasi	690	816	768	574	0	927
	AKAZE	1215	1266	1182	1187	8813	0
	Harris	53595	113128	88593	61994	0	100272
	FAST	1832	2178	2061	1566	0	2782
	BRISK	1570	1703	1514	1524	0	0
	ORB	751	545	763	420	0	0
	SIFT	536	597	0	506	0	800

Table 1. Sum of matched key points for 10 images

It immediately appears that the Harris detector is the most capable detector in the mix. However, an examination of the average number of key points for the 10 images divided by the time taken for total detections paints a very different picture.

Detector	Descriptor						
		BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
	Shi-Tomasi	17.39491	20.57137	29.61132	16.79685	#DIV/0!	32.0844
	AKAZE	26.2999	27.40384	30.21598	25.51981	27.05961	#DIV/0!
	Harris	0.031464	0.066413	0.099443	0.036481	#DIV/0!	0.070484
	FAST	4.348163	5.169377	8.696511	3.686807	#DIV/0!	9.972748
	BRISK	16.4631	17.85774	18.69603	21.98048	#DIV/0!	#DIV/0!
	ORB	24.5168	17.79182	25.74307	20.10619	#DIV/0!	#DIV/0!
	SIFT	8.039655	8.954616	#DIV/0!	8.059094	#DIV/0!	17.58791

Table 2. Avg / Time of matched key points

This table notes that although the Harris detector finds a huge number of features, it takes much longer to do so, making it a very inefficient detector. Visual examination of the distribution of features also shows that the Harris detector, when compared to other detectors like FAST is much too dense to do a descriptor & match task quickly.

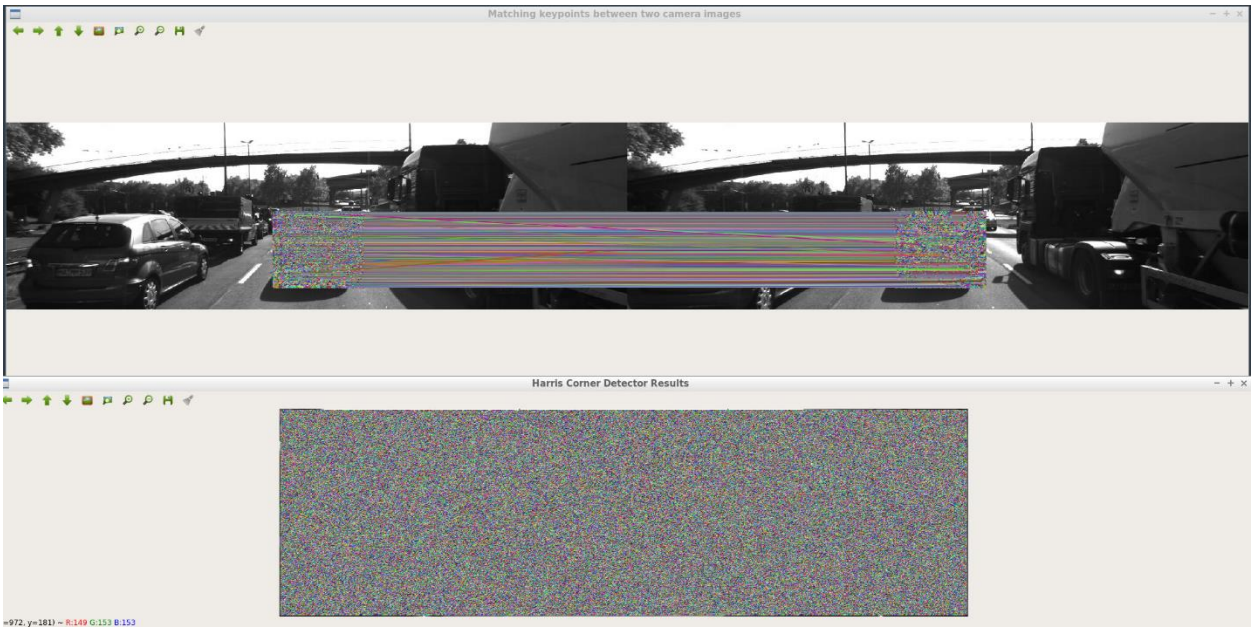

Fig 1. Features detected using Harris detector & matched with ORB

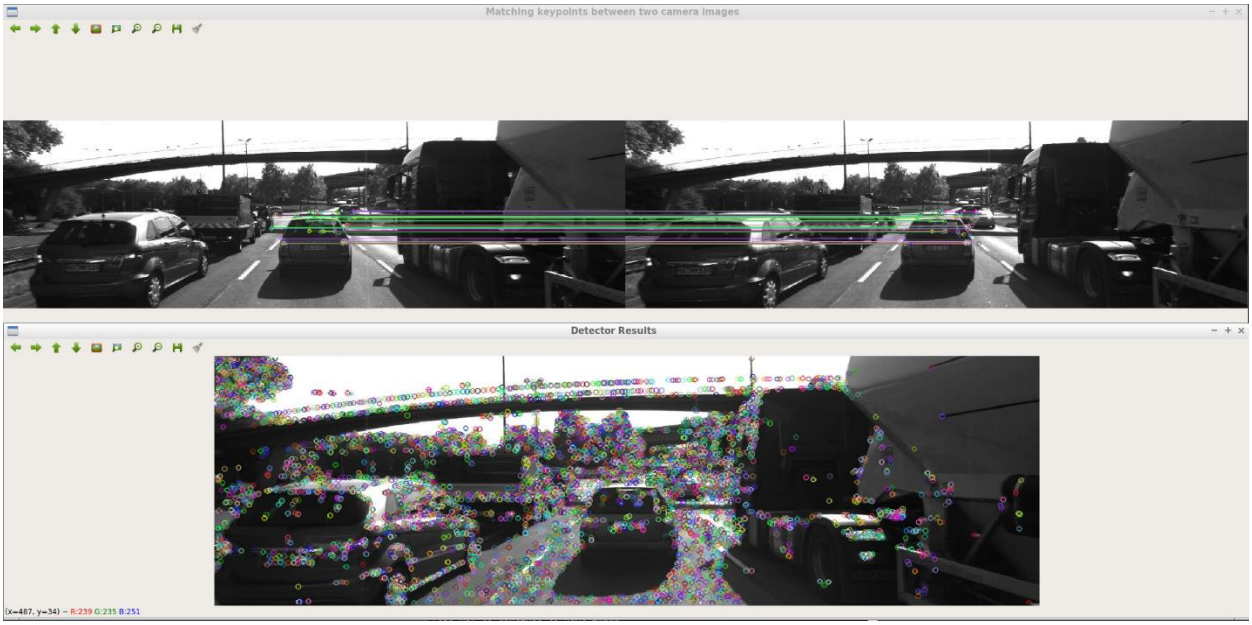

Fig 2. Features detected using FAST detector & matched with ORB

The results of the other detectors are attached in the annex and are similar to the FAST result, with a good distribution around the tail lights, license plate, the VW logo and the headrests inside the car visible through the rear windshield.

MP.9 Performance Evaluation 3

Log the time it takes for keypoint detection and descriptor extraction. The results must be entered into a spreadsheet and based on this data, the TOP3 detector / descriptor combinations must be recommended as the best choice for our purpose of detecting keypoints on vehicles.

Detector \ Descriptor	BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
Shi-Tomasi	19.06752	16.10711	16.17773	52.10169	#DIV/0!	28.31305
AKAZE	85.42287	83.14221	83.76026	126.3464	134.4256	105.8982
Harris	346.9489	181.1518	137.8706	322.8635	#DIV/0!	464.5478
FAST	6.784623	3.891855	3.707404	47.55001	#DIV/0!	37.79191
BRISK	48.08114	45.79295	45.5322	82.03829	#DIV/0!	86.5384
ORB	9.996196	9.724589	14.19086	51.99633	#DIV/0!	57.60834
SIFT	134.1965	143.7751	#DIV/0!	182.2846	#DIV/0!	203.2965

Table 3. Avg. of the detection + descriptor time for 10 images

Based on this data it is evident that the best 3 detectors in descending order are

1. FAST
2. ORB
3. Shi-Tomasi

The best 3 descriptors in descending order are

1. ORB
2. BRIEF
3. BRISK

Therefore, the top 3 detector & descriptor combinations are

1. FAST detector & ORB descriptor
2. FAST detector & BRIEF descriptor
3. FAST detector & BRISK descriptor

Finally, combining the average number of keypoints with the average time taken for detector + descriptor, it becomes evident that choices are still valid if we discount the skewing because of Harris detector's feature detections.

Detector \ Descriptor	BRISK	BRIEF	ORB	FREAK	AKAZE	SIFT
Shi-Tomasi	4.0207997	5.62898414	5.27474053	1.2241019	#DIV/0!	3.63789842
AKAZE	1.58037303	1.69188033	1.56796715	1.04386774	7.28449358	0
Harris	17.1639109	69.3881074	71.3978663	21.3347821	#DIV/0!	23.9831812
FAST	30.0024859	62.181145	61.7682885	3.65930507	#DIV/0!	8.17929425
BRISK	3.62812659	4.13212581	3.69457675	2.06407683	#DIV/0!	0
ORB	8.34761988	6.22705526	5.97411093	0.89749929	#DIV/0!	0
SIFT	0.44379379	0.46136866	#DIV/0!	0.30843094	#DIV/0!	0.43723765

Table 4: Avg matched keypoints / Avg Time for detector + descriptor

The spreadsheet used is attached with the project in the extra files folder.

Annex 1: Results of all detectors with ORB descriptors & kNN matching

Fig3. AKAZE

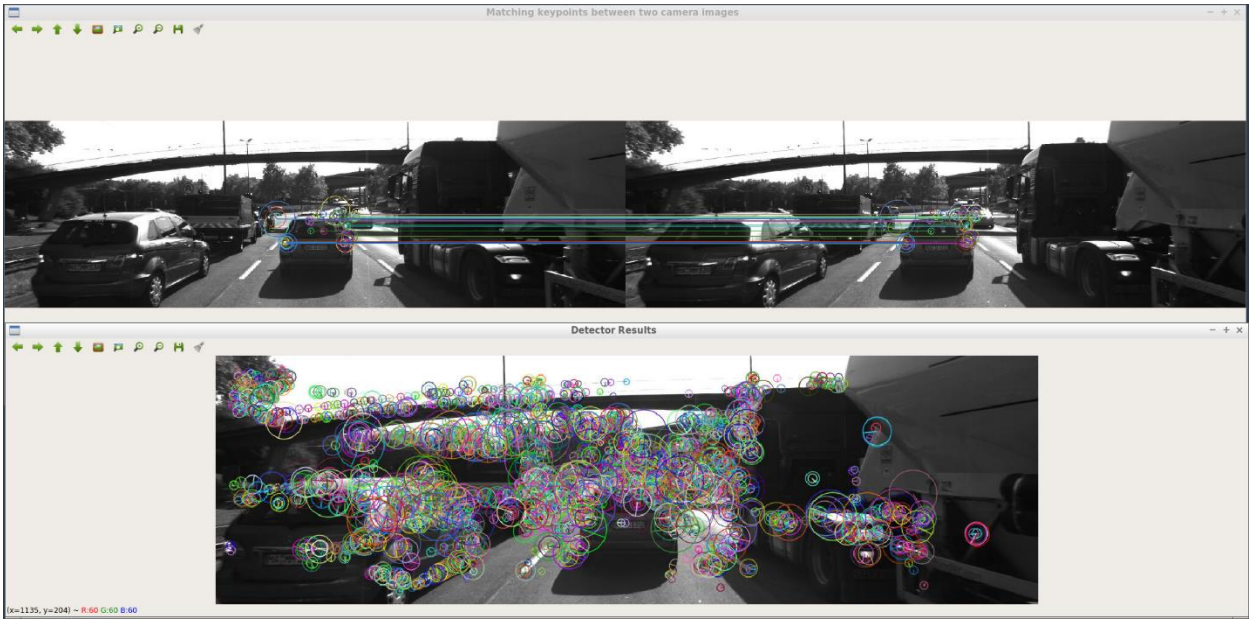

Fig4. BRISK

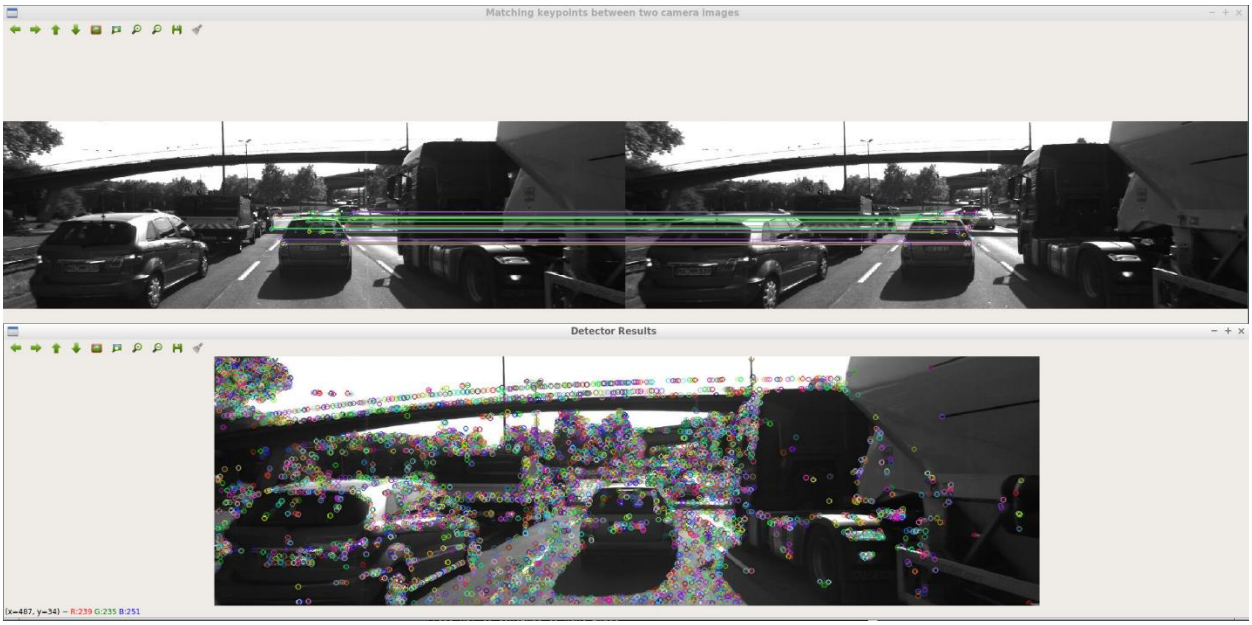

Fig5. FAST

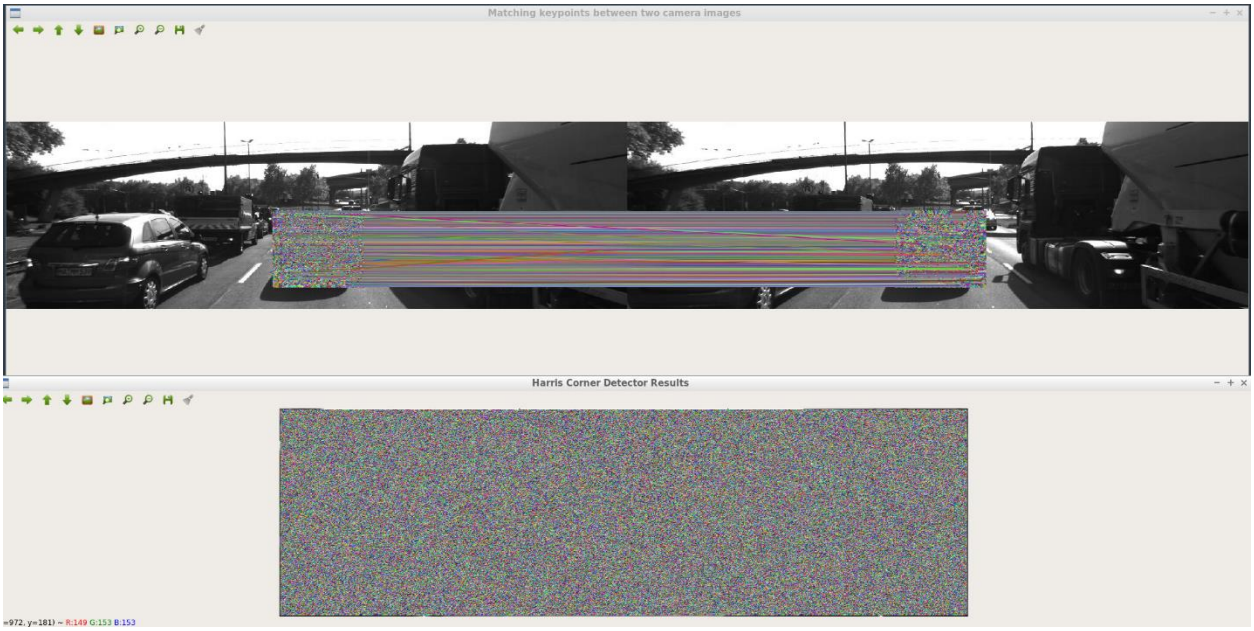

Fig6. HARRIS

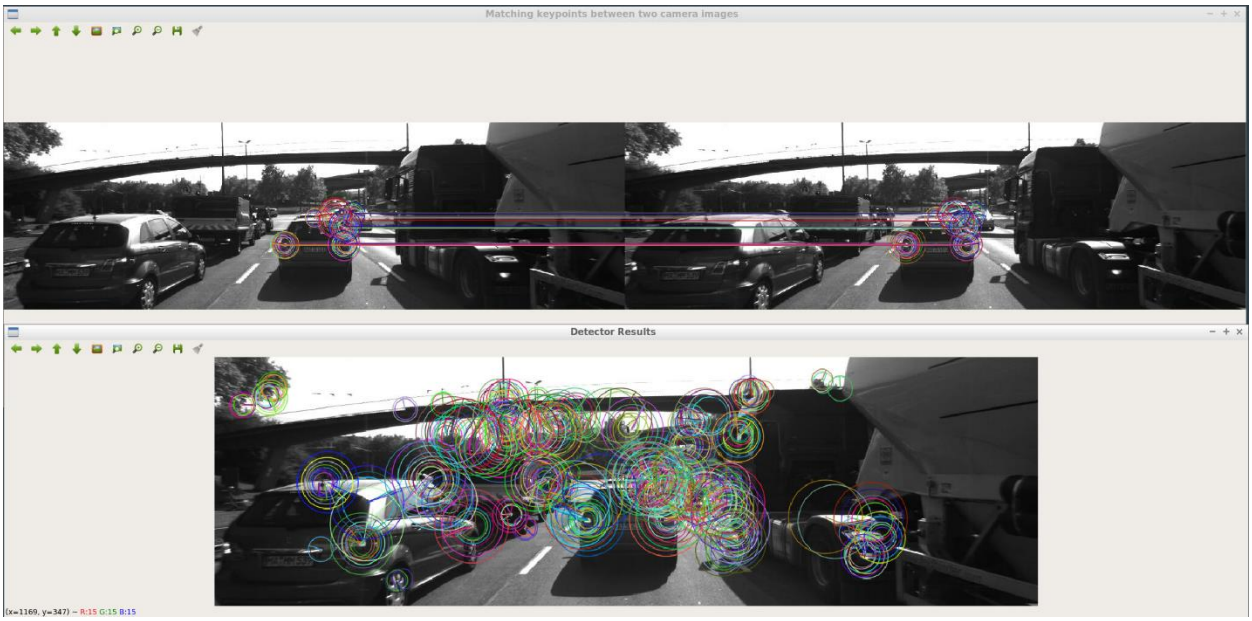

Fig7. ORB

Fig8. SHI-TOMASI


Matching keypoints between two camera images
(x=623, y=276) ~ R:34 G:34 B:34
Detector Results
(x=851, y=212) ~ R:22 G:22 B:22

Fig9. SIFT