

Project 2 - SFND 2DFeature Tracking Report

Criteria

1. MP.1 Data Buffer Optimization
 - a. The vector was replaced for deque, and pop_front() is called when size is exceeding the data buffer size. I probably should write a new class, but it will take some time. Also, it was not necessary to use deque, but in this case, it doesn't matter
2. MP.2 Keypoint Detection.
 - a. I've implemented HARRIS, FAST, BREAK, BRISK, ORB, AKAZE, and SIFT and made them selectable by setting a string accordingly.
3. MP.3 Keypoint removal
 - a. I've implemented filtering using a predefined rectangle. All next performance evaluation was done using filtered keypoints list.
4. MP.4 Keypoint Descriptors
 - a. I've implemented BRIEF, ORB, FREAK, AKAZE, and SIFT descriptors.
 - b. I've discovered that the AKAZE descriptor works only with the AKAZE detector.
 - c. I've discovered that the ORB descriptor refuses to work with the SIFT detector.
5. MP.5 Descriptor Matching
 - a. I've implemented FLANN matching with KNN selection where N=2.
6. MP.6 Descriptor Distance Ratio
 - a. I've implemented filtering
7. MP.7-9 Performance Evaluation
 - a. Please see the corresponding part of the report.
 - b. All measurements were done on a virtual machine.
 - c. I've implemented loop over detectors and descriptors, logged time measurements and processed them to present here.
 - d. I've measured the performance using KNN matching with N=2.

Performance Evaluation

1. Part 1 - Detector performance
 - a. The fastest detector is FAST, whether AKAZE and SIFT are the slowest.
 - b. FAST also provides an enormous number of key points (~400), which can lead to bigger procession time later. HARRIS provides the least number of keypoint (~25).
 - c. ORB is tricky because it always finds predefined number of keypoints.
2. Part 2 - Descriptor performance
 - a. BRISK, BRIEF and ORB are very fast (~2ms)
 - b. FREAK is pretty slow (~40ms)
 - c. AKAZE is pretty slow (~60ms)
 - d. SIFT varies from ~20 to ~100ms.
3. Matching performance
 - a. Matched ratio
 - i. 0.87 - SHITOMASI + SIFT (35ms)

- ii. 0.85 - AKAZE + SIFT (103ms)
- iii. 0.78 - AKAZE + AKAZE (130ms)
- iv. 0.77 - SHITOMASI + BRIEF (20ms)
- b. Time
 - i. FAST + BRISK|BRIEF|ORB - from 10ms to 12 ms.
 - ii. Any combination of SHITOMASI|HARRIS|ORB + BRISK|BRIEF|ORB is within 20 ms.
 - iii. AKAZE detector and SIFT detector are slow.
 - iv. FREAK descriptor is slow.
- 4. TOP 3 combinations
 - a. BEST - SHITOMASI + SIFT
 - b. Slow but accurate - AKAZE + AKAZE
 - c. FAST - SHITOMASI + BRIEF.

Appendix 1 - Table 1 - Number of keypoints on the full image

Image	SHITOMASI	HARRIS	FAST	BRISK	ORB	AKAZE	SIFT
0	1 370,00	124,00	5 063,00	2 757,00	1500,00	1 351,00	1 438,00
1	1 301,00	102,00	4 952,00	2 777,00	1500,00	1 327,00	1 371,00
2	1 361,00	123,00	4 863,00	2 741,00	1500,00	1 311,00	1 380,00
3	1 358,00	125,00	4 840,00	2 735,00	1500,00	1 351,00	1 335,00
4	1 333,00	175,00	4 856,00	2 757,00	1500,00	1 360,00	1 305,00
5	1 284,00	479,00	4 899,00	2 695,00	1500,00	1 347,00	1 370,00
6	1 322,00	86,00	4 870,00	2 715,00	1500,00	1 363,00	1 396,00
7	1 366,00	231,00	4 868,00	2 628,00	1500,00	1 331,00	1 382,00
8	1 389,00	184,00	4 996,00	2 639,00	1500,00	1 357,00	1 463,00
9	1 339,00	324,00	4 997,00	2 672,00	1500,00	1 331,00	1 422,00

Appendix 2 - Table 2 - Number of keypoints on preceding car (filtered by coordinates)

Image	SHITOMASI	HARRIS	FAST	BRISK	ORB	AKAZE	SIFT
0	125,00	17,00	419,00	264,00	236	166,00	138,00
1	118,00	15,00	427,00	282,00	244	157,00	132,00
2	123,00	20,00	404,00	282,00	266	161,00	124,00
3	120,00	20,00	423,00	277,00	268	155,00	137,00
4	120,00	26,00	386,00	297,00	272	163,00	134,00

5	113,00	49,00	414,00	279,00	287	164,00	140,00
6	114,00	17,00	418,00	289,00	285	173,00	137,00
7	123,00	32,00	406,00	272,00	287	175,00	148,00
8	111,00	27,00	396,00	266,00	281	177,00	159,00
9	112,00	35,00	401,00	254,00	278	179,00	137,00

Appendix 3 - Table 3 - Processing time

Image	SHITOMASI	HARRIS	FAST	BRISK	ORB	AKAZE	SIFT
0	15,53	17,32	2,69	40,12	25,803	87,74	124,74
1	17,15	12,79	2,24	40,35	8,989	69,85	127,92
2	17,14	12,49	2,21	39,96	12,385	72,13	132,14
3	16,58	12,85	2,17	40,31	11,391	73,04	129,47
4	15,97	13,34	2,32	40,49	8,832	76,73	128,51
5	17,21	35,51	2,19	39,96	10,704	72,18	129,68
6	16,92	12,47	2,23	39,69	11,8	75,83	130,13
7	17,08	15,05	2,21	38,61	10,526	74,51	130,14
8	16,50	13,48	2,35	39,23	10,879	75,19	131,04
9	16,51	21,32	2,14	39,51	11,811	68,89	127,86

Appendix 4 - Table 4 - Descriptors performance (time, ms)

	SHITOMASI	HARRIS	FAST	BRISK	ORB	AKAZE	SIFT
BRISK	2,13	0,69	4,38	3,27	3,61	2,40	1,79
BRIEF	1,74	0,34	2,22	1,51	2,07	1,32	0,83
ORB	1,50	1,00	2,06	4,55	6,62	2,97	
FREAK	39,67	38,60	42,54	41,49	49,62	40,63	40,06
AKAZE						62,82	
SIFT	16,26	14,22	32,45	41,64	95,78	25,69	79,09

Appendix 5 - Table 5 - Matched keypoints

	SHITOMASI	HARRIS	FAST	BRISK	ORB	AKAZE	SIFT
BRISK	77,11	11,67	204,67	146,67	165,22	124,22	59,89
BRIEF	91,00	15,33	246,44	150,78	106,56	120,78	67,00

ORB	85,56	7,56	233,22	106,89	130,78	103,67	
FREAK	63,78	11,00	177,44	122,33	84,00	108,56	56,78
AKAZE						130,00	
SIFT	103,11	14,89	310,33	183,89	191,67	141,44	88,89

Appendix 6 - Table 6 - Overall processingl time

	SHITOMASI	HARRIS	FAST	BRISK	ORB	AKAZE	SIFT
BRISK	20,78	17,78	12,96	47,38	19,89	79,44	132,94
BRIEF	20,21	17,37	10,03	45,02	18,74	78,05	131,70
ORB	20,05	18,08	10,01	48,13	23,37	79,81	129,16
FREAK	58,26	55,67	51,30	85,24	64,48	117,68	171,16
AKAZE						139,88	129,16
SIFT	35,49	31,41	43,07	86,96	113,54	103,55	210,96