

ANALYSIS OF IMAGE FEATURES

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Experiments on Feature Extraction and Matching:

Feature Extraction and Matching was carried out for frames of both indoor and outdoor sequences. Some specimen frames follow:

1. Outdoor -



2. Indoor -



Some experiments were set up, as described below, and the performance of different feature extraction algorithms was quantified using the following two metrics.

Metric 1:

This reports the following two numbers in the following format -

No. of 'Good' matches/Mean number of Keypoints detected in both the images

Where 'Good' matches refers to the matches that pass the ratio test (proposed by Dr. David Lowe in his SIFT paper) with a ratio of 0.8.

Thus, the algorithm having higher value of the Metric 1 *ratio* will be considered better.

Disclaimer: This specific ratio selected may be a bit incoherent in case of binary descriptors as in ORB, AKAZE and BRISK; but ignoring that fact still doesn't invite heck of a hell! (In other words, it's still practically meaningful, though not as much as the float ones)

Metric 2:

This is simply the total number of incorrect matches found (by *manual inspection*) out of the total number of 'Good' matches (20 if greater than 20) out of the total number of 'Good' matches found.

The *manual inspection* is done as follows:

1. **If the number of 'Good' matches is greater than 20:** The total number of incorrect matches found in *two randomly chosen subsets of 'Good' matches of size 10* is recorded.
2. **If the number of 'Good' matches is not greater than 20:** Simply the number of incorrect matches is recorded.

N.B. - Brute force matcher is used for all the tasks and it has the 'crossCheck' parameter set (wherever relevant).

Experiments:

From the given video sequences, a new sequence of frames was formed by selecting every 5th frame for outdoor and every 20th frame for indoor. The following tasks were done (using different feature extraction algorithms) for thus generated both indoor and outdoor sequences:

1. Feature Extraction and Matching was done for consecutive frames and the **Metric 1** scores are given below, for them.
2. Feature Extraction and Matching was done between the first frame and the training image and each of the rest of the frames in the sequence as the query image and the **Metric 2** scores are reported below, for each of them.

Note: The images on the data sequences have been downsampled for Experiment 2 for ease of viewing the matches on a laptop screen, which is required for manual inspection.

Results on Outdoor sequence:

Experiment 1: (Metric 1 scores)

Feature Extraction Algorithm	Frame No. 1-6	6 – 11	11 – 16	16 – 21	21 – 26	26 – 31	31 – 36	36 – 41	41 – 46
SIFT	2328 / 7520	2248 / 7461	190 / 8765	3512 / 10009	194 / 7750	1481 / 5661	169 / 6211	1532 / 6447	2457 / 6099
SURF	2297 / 5553	2090 / 5497	210 / 6152	2681 / 6777	252 / 5770	1668 / 4861	194 / 5195	1440 / 5238	2201 / 4956
ORB	135 / 500	110 / 500	15 / 500	187 / 500	23 / 500	149 / 500	15 / 500	91 / 500	165 / 500
AKAZE	1414 / 3047	1280 / 3057	103 / 3644	2077 / 4170	119 / 3459	1020 / 2810	83 / 2894	1043 / 2821	1573 / 2663
BRISK	2360 / 7295	2289 / 7240	98 / 8697	3451 / 10026	128 / 7989	1508 / 6072	103 / 6370	1747 / 6389	2694 / 6199

Experiment 2: (Metric 2 scores)

Keypoint Detection Algorithm	Frame No. 1-6	1-11	1-16	1-21	1-26	1-31	1-36	1-41	1-46
SIFT	1/20/ 808	0/20/ 509	7/20/ 64	9/20/ 47	8/20/ 64	8/20/ 60	12/20/ 27	14/20/ 45	15/20/ 34
SURF	0/20/ 845	2/20/ 574	14/20 /69	15/20 /61	15/20 /100	10/20 /86	19/20/ 56	18/20/ 67	20/20/ 73
ORB	0/20/ 236	0/20/ 152	4/16/ 16	3/11/ 11	4/20/ 26	9/20/ 29	10/12/ 12	7/8/8	4/5/5
AKAZE	1/20/ 413	1/20/ 286	10/20 /38	5/20/ 30	8/20/ 48	9/20/ 44	14/20/ 21	14/20/ 25	14/20/ 20
BRISK	0/20/ 1189	0/20/ 780	5/20/ 70	9/20/ 60	6/20/ 79	2/20/ 66	10/20/ 41	13/20/ 32	09/20/ 23

INFERENCES:

AS A RESULT, **BRISK** LOOKS BEST FOR THIS TASK AND SUCH OUTDOOR ENVIRONMENT.

Performance may be summarised as BRISK > ORB / AKAZE > SIFT > SURF

Results on Indoor sequence:

Experiment 1: (Metric 1 scores)

Feature Extracti on Algorit hm	1 - 21	21 - 41	41 - 61	61 - 81	81 - 101	101 - 121	121 - 141	141 - 161	161 - 181	181 - 201	201 - 221
SIFT	2613 / 3914	1506 / 3874	939 / 3684	576 / 3436	376 / 2533	246 / 1120	136 / 614	190 / 737	186 / 1130	1015 / 1514	996 / 1529
SURF	3876 / 5153	2610 / 5148	1669 / 4878	1228 / 4568	877 / 3831	562 / 2421	379 / 1978	500 / 2089	406 / 2584	2318 / 3289	2393 / 3308
ORB	439 / 500	296 / 500	175 / 500	119 / 500	66 / 500	38 / 500	111 / 500	124 / 500	99 / 500	442 / 500	436 / 500
AKAZE	2560 / 2907	2145 / 2891	1339 / 2728	962 / 2562	545 / 2086	363 / 1152	249 / 675	197 / 678	198 / 672	608 / 648	608 / 653
BRISK	5198 / 6849	3128 / 6832	1786 / 6353	978 / 5646	537 / 3968	305 / 1540	160 / 717	176 / 854	174 / 1071	1056 / 1292	1032 / 1288

INFERENCES:

AS A RESULT, **BRISK** LOOKS BEST FOR THIS TASK AND SUCH OUTDOOR ENVIRONMENT.

Performance may be summarised as BRISK > ORB/AKAZE > SIFT/SURF

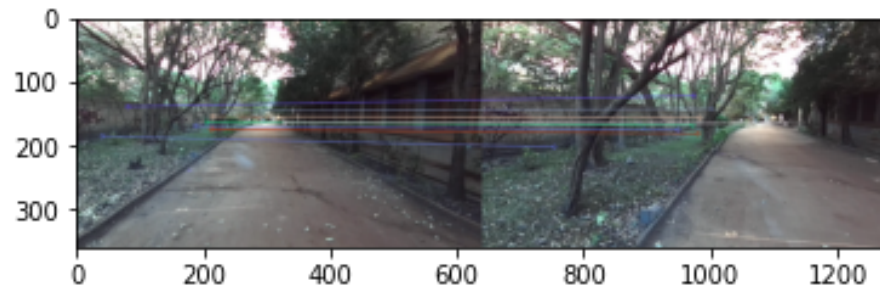
Experiment 2: (Metric 2 scores)

Couldn't complete due to lack of time.

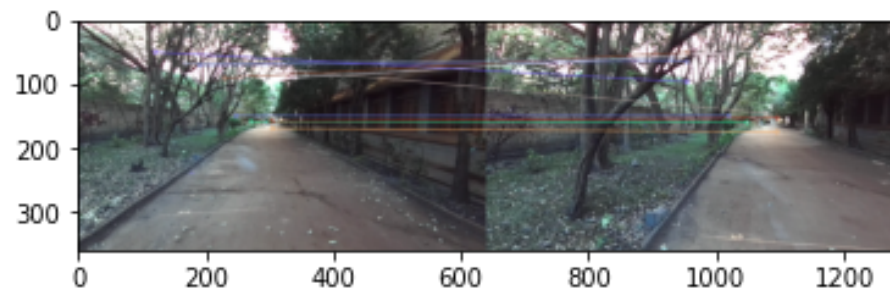
Some Visual Results - From the outdoor sequence

For each of the Feature Detection algorithms the top 10 matches that passed the ratio test are marked in frames 1 and 16 from the outdoor sequence.

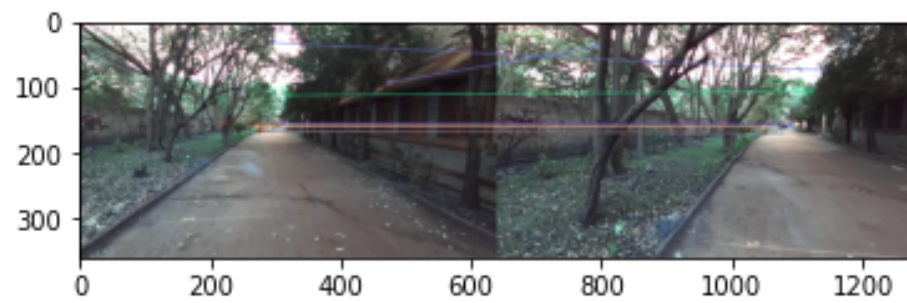
SIFT:



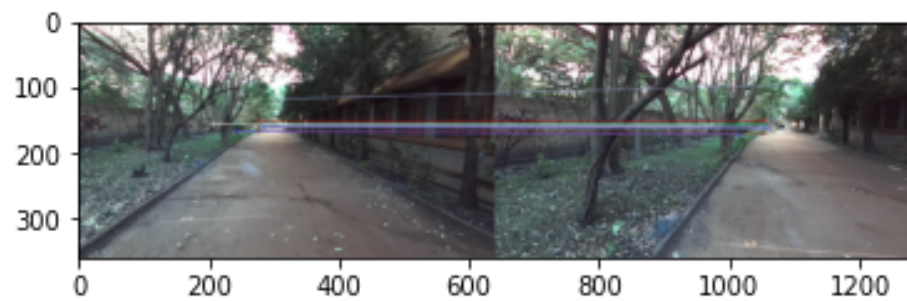
SURF:



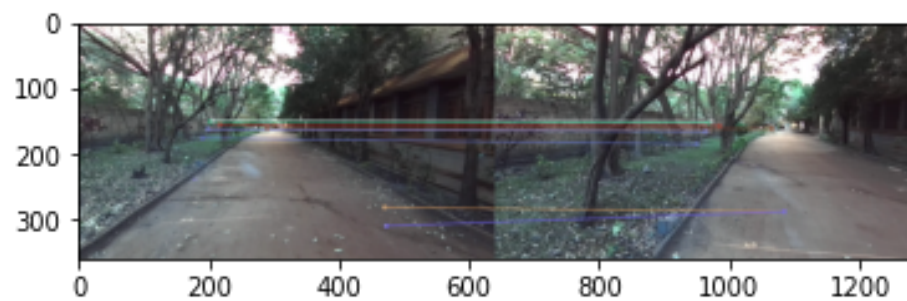
ORB:



AKAZE:



BRISK:



Experiment on Feature Tracking:

This experiment involved tracking the number of features, along with their identity (feature id for instance), from frame 1 that are retained until some specific subsequent frames (particularly the same sequence of frames 6, 11 etc.). This also entails comparison between different feature extraction algorithms, the ones stated before.

As this needs feature matching between consecutive frames itself (in one iteration), only those matches which pass the ratio test with a ratio of 0.9 are considered a part of 'retained' features. This annihilates, at least to some degree, the need of manual inspection for the correctness of the matches.

Results on Outdoor sequence:

Feature Extraction Algorithm	Number of features detected in frame 1	Number of features retained untill frame 6	Until frame 11	Until frame 16	Until frame 21	Until frame 26	Until frame 31	Until frame 36	Until frame 41	Until frame 46
SIFT	7464	4169	3212	2680	2658	2637	2637	2635	2635	2635
SURF	5592	3222	2326	1576	1538	1481	1478	1469	1469	1469
ORB	500	260	194	143	143	139	139	139	139	139
AKAZE	3034	1889	1345	702	682	630	628	619	618	618
BRISK	7326	3813	2949	2336	2319	2306	2305	2305	2304	2304

Results on Indoor sequence:

Feature Extraction Algorithm	Num of features detected in frame 1	Num of features retained until frame 21	Until frame 41	Until frame 61	Until frame 81	Until frame 101	Until frame 121	Until frame 141	Until frame 161	Until frame 181	Until frame 201	Until frame 221
SIFT	3913	1838	974	823	794	789	785	784	784	784	784	784
SURF	5121	2792	1372	942	792	730	691	676	668	666	666	666
ORB	500	365	86	26	19	16	16	16	16	16	16	16
AKAZE	2919	2215	1410	839	552	400	281	218	178	172	172	172
BRISK	6877	3774	1347	923	874	867	866	865	864	864	864	864

INFERENCES:

The following Inferences can be drawn out of this experiment:

1. SURELY, **BRISK** AND **SIFT** STAND OUT IN TERMS OF PRODUCING MORE NUMBER OF TRACKABLE FEATURES, FOR THIS TASK. IN OTHER WORDS, THEY DETECT CONSIDERABLY HIGHER NUMBER OF 'ROBUST' FEATURES (where Robustness is in the sense of trackability)

SURF > AKAZE > ORB follow in the order for such a performance metric.

2. Almost all of them settle down (only the 'Robust' features remain after some frames pass) at the same speed.
3. Another metric that can be proposed is number of 'Robust' features (remaining finally) over number of features detected initially. These are the values for such a metric:

Metric at point 3 in the inferences for OUTDOOR	Metric at point 3 in the inferences for INDOOR
0.353	0.200
0.262	0.130
0.278	0.032
0.204	0.059
0.314	0.126

THUS, HERE TOO **SIFT** FOLLOWED BY **BRISK** STAND OUT.

ORB > SURF > AKAZE follow for *outdoor*. Whereas ORB and AKAZE are worst for *indoor*. SURF does okay.

4. The metric 3 values for the indoor sequence are much lower than those for the outdoor sequence for each of the algorithms. This indicates scarcity of 'Robust' - trackable features in such indoor images.
5. Another thing that can be noticed is the fact that SIFT detects considerably lower number of features for the INDOOR sequence as compared to the OUTDOOR sequence.