

# Evaluations on Descriptor Calculation Times for 21 Descriptors and 7 Different Keypoint Detectors

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**Abstract.** In this document, we present additional results on average descriptor calculation runtimes. The evaluations are performed several times on 7 different keypoints using the first 10 image pairs of the KITTI 2015 flow dataset [1]. Thus, for every image pair and keypoint type, the average runtime for calculating one descriptor is calculated. This procedure is repeated 20 times to get the minimum runtime for one image pair.

Descr./Keyp.	AKAZE		KAZE		SIFT		MSD		FAST		BRISK		ORB	
	$t_0$	$t_f$	$t_0$	$t_f$	$t_0$	$t_f$	$t_0$	$t_f$	$t_0$	$t_f$	$t_0$	$t_f$	$t_0$	$t_f$
BOLD	153	5.2	175	5.1	64	5.4	174	4.8	0	5.4	292	5.0	172	5.2
BGM HARD	1375	16.4	466	17.4	1668	15.5	775	15.8	1750	16.9	1023	17.2	2065	15.4
BINBOOST 256	1528	52.4	1632	51.2	1732	50.5	2286	45.9	7701	49.8	2045	52.5	5163	47.0
LATCH	1757	46.9	1515	44.8	1411	45.4	988	44.9	5251	44.5	877	45.7	2410	44.2
BINBOOST 64	1833	34.8	1224	35.2	834	34.8	1918	31.1	9101	32.5	2630	35.1	6540	28.6
BINBOOST 128	2139	39.7	1224	40.6	1732	38.9	1008	40.9	8401	38.3	2338	40.9	4475	36.3
BGM BILINEAR	2979	16.9	525	19.4	1475	17.7	988	17.3	2450	18.6	584	19.8	1893	17.5
BGM	3666	58.5	2856	58.7	1860	58.8	1763	58.1	18902	54.1	5406	59.2	8950	51.6
LBGM	3666	94.2	2157	96.5	3336	92.3	1938	93.5	18552	89.4	4529	95.6	7745	88.9
ORB	6568	2.3	7927	1.6	-	-	10405	1.8	2100	1.3	9059	1.9	9122	0.7
VGG 80	12984	427.2	8568	429.7	5902	423.3	8836	435.6	37804	416.5	20163	424.2	18760	417.7
VGG 48	13671	385.3	12415	379.2	7249	379.8	11684	388.2	29753	377.6	18263	383.7	18760	376.3
VGG 64	14053	423.8	6994	428.1	7570	421.1	8022	440.1	37804	415.8	16948	426.9	13769	424.1
VGG 120	14817	426.9	8976	430.3	6864	426.8	8254	444.6	42354	418.9	17825	431.6	16178	425.9
SIFT	46818	69.8	48319	37.4	214452	48.7	-	-	46554	82.8	55228	212.8	272967	1166.3
FREAK	51401	7.4	55080	2.3	53565	6.8	51987	6.4	56355	4.5	54060	6.2	53871	6.7
RIFF	67363	0.3	62249	8.9	64214	3.6	var	var	67556	2.5	var	var	59550	11.3
AKAZE	var	var	-	-	-	-	-	-	-	-	-	-	-	-
BRISK	294656	7.2	var	var	var	var	var	var	307330	4.0	var	var	var	var
DAISY	var	var	var	var	var	var	var	var	412690	1.8	391421	7.4	var	var
KAZE	-	-	-	-	-	-	-	-	-	-	-	-	-	-

**Table 1.** Fixed time budgets  $t_0$  per image and descriptor type in addition to average times  $t_f$  for calculating one descriptor in  $\mu s$ . Accuracies of  $t_f$  are  $\pm 8\%$  or  $\pm 3\mu s$  and the accuracy  $t_0$  varies according to the accuracy of  $t_f$  and the number of keypoints per image.  $t_0$  depends on the image characteristics and the used keypoint type. Time measurements were performed using the smallest runtime of 20 runs of every image pair on an Intel Xeon E5-1620 v3 3.5GHz CPU and the minimum, median, and maximum runtimes over the first 10 image pairs of the KITTI 2015 flow dataset [1]. For keypoint-descriptor combinations marked by “var”, no calculation of  $t_0$  and  $t_f$  was possible due to a too large variance in  $t_f$  over the tested image pairs. Some cells are empty due to an incompatible keypoint-descriptor combination.

Descr./Keyp.	AKAZE	BRISK	FAST	KAZE	MSD	ORB	SIFT
BOLD	5.4	5.3	5.4	5.3	5.5	5.4	5.5
ORB	9.0	10.0	1.9	11.3	44.4	10.1	-
BGM HARD	17.8	18.1	17.4	18.0	19.0	17.5	17.6
BGM BILINEAR	19.9	20.3	19.3	20.0	21.4	19.4	19.6
BINBOOST 64	36.7	37.4	35.1	36.7	39.0	35.3	35.9
BINBOOST 128	41.9	43.0	40.7	42.1	45.0	40.9	41.1
LATCH	48.7	46.5	46.0	46.7	49.0	46.7	47.2
BINBOOST 256	54.0	54.3	52.0	53.2	55.3	52.3	52.7
FREAK	59.6	54.5	20.8	69.8	219.5	62.0	75.5
BGM	62.2	64.0	59.6	62.2	65.3	60.8	61.2
RIFF	68.8	61.0	22.1	85.2	273.2	72.4	85.9
LBGM	97.9	99.6	94.8	99.1	101.4	96.9	96.6
SIFT	117.4	262.1	96.3	96.6	-	1446.6	323.6
AKAZE	151.2	-	-	-	-	-	-
BRISK	306.6	270.9	93.0	374.9	1211.5	319.8	396.4
VGG 48	399.2	400.0	386.2	394.4	436.1	395.6	389.1
DAISY	408.9	356.9	121.4	498.0	1642.8	421.6	515.3
VGG 64	438.1	442.0	426.8	436.7	473.0	438.2	430.8
VGG 80	440.4	442.2	427.5	440.2	471.8	437.0	430.9
VGG 120	442.0	447.5	431.2	441.3	478.4	442.5	435.6
KAZE	-	-	-	613.9	-	-	-

**Table 2.** Minimum average descriptor computation times  $\bar{t}_f$  in  $\mu s$  for one descriptor and various keypoints. Time measurements were performed using the smallest runtime of 20 runs of every image pair on an Intel Xeon E5-1620 v3 3.5GHz CPU and the minimum runtimes over the first 10 image pairs of the KITTI 2015 flow dataset [1].

Descr./Keyp.	AKAZE	BRISK	FAST	KAZE	MSD	ORB	SIFT
BOLD	5.5	5.5	5.4	5.5	5.8	5.4	5.6
ORB	12.4	13.3	2.2	17.3	65.7	12.6	-
BGM HARD	18.6	18.5	17.6	18.3	20.6	18.0	18.3
BGM BILINEAR	20.6	20.5	19.6	20.4	22.6	19.9	20.3
BINBOOST 64	37.4	38.2	36.1	37.6	41.6	36.8	36.3
BINBOOST 128	42.6	43.7	41.6	43.1	47.8	42.2	42.0
LATCH	49.9	46.8	46.4	47.6	51.5	47.7	48.5
BINBOOST 256	54.7	55.0	52.8	54.5	59.2	53.6	53.6
BGM	63.8	65.5	61.8	64.3	70.1	62.8	62.1
FREAK	89.9	73.9	28.3	109.3	341.1	75.6	99.2
LBGM	99.4	101.0	97.1	100.7	107.0	98.5	98.3
RIFF	108.2	86.0	31.1	131.8	415.6	88.5	117.8
SIFT	145.6	280.9	102.4	132.4	-	1504.9	418.3
AKAZE	240.9	-	-	-	-	-	-
VGG 48	406.1	407.6	390.9	403.3	457.7	400.6	394.2
VGG 64	445.5	447.8	430.8	442.3	492.8	441.0	434.4
VGG 80	447.8	450.3	432.9	445.0	494.1	443.2	435.6
VGG 120	451.9	454.6	436.9	450.4	498.4	448.4	439.4
BRISK	478.1	380.0	133.8	587.7	1901.5	394.7	532.5
DAISY	636.5	502.4	177.6	781.9	2555.6	518.5	694.8
KAZE	-	-	-	982.7	-	-	-

**Table 3.** Mean over the average descriptor computation times  $\bar{t}_f$  in  $\mu s$  for one descriptor and various keypoints. Time measurements were performed using the smallest runtime of 20 runs of every image pair on an Intel Xeon E5-1620 v3 3.5GHz CPU and the average runtimes over the first 10 image pairs of the KITTI 2015 flow dataset [1].

Descr./Keyp.	AKAZE	BRISK	FAST	KAZE	MSD	ORB	SIFT
BOLD	5.5	5.5	5.4	5.5	5.8	5.4	5.6
ORB	12.2	13.4	2.1	16.9	63.6	12.7	-
BGM HARD	18.5	18.5	17.6	18.3	20.4	18.0	18.2
BGM BILINEAR	20.3	20.5	19.6	20.3	22.3	19.9	20.1
BINBOOST 64	37.2	38.2	36.1	37.5	40.8	36.7	36.2
BINBOOST 128	42.3	43.5	41.5	43.0	47.8	42.2	41.8
LATCH	50.0	46.8	46.2	47.3	51.5	48.0	48.7
BINBOOST 256	54.5	55.0	52.7	54.6	58.3	53.5	53.5
BGM	63.6	65.3	61.5	64.0	69.1	62.5	61.9
FREAK	86.0	74.5	28.2	104.0	329.3	74.3	94.8
LBGM	99.1	100.8	97.2	100.8	107.0	98.2	97.9
RIFF	103.4	85.7	31.1	124.5	401.6	87.2	111.1
SIFT	142.9	281.9	102.3	128.0	-	1497.3	398.3
AKAZE	235.1	-	-	-	-	-	-
VGG 48	405.1	407.7	390.9	401.9	456.4	399.6	393.9
VGG 64	443.9	448.1	430.2	441.6	493.4	440.4	434.2
VGG 80	446.8	450.7	432.9	444.4	495.6	443.3	435.4
VGG 120	450.8	453.6	436.0	450.9	497.8	449.9	438.5
BRISK	459.9	386.5	132.3	551.4	1833.4	394.6	497.1
DAISY	610.3	506.4	171.7	746.9	2470.3	511.4	659.7
KAZE	-	-	-	925.8	-	-	-

**Table 4.** Median over the average descriptor computation times  $\tilde{t}_f$  in  $\mu s$  for one descriptor and various keypoints. Time measurements were performed using the smallest runtime of 20 runs of every image pair on an Intel Xeon E5-1620 v3 3.5GHz CPU and the median runtimes over the first 10 image pairs of the KITTI 2015 flow dataset [1].

Descr./Keyp.	AKAZE	BRISK	FAST	KAZE	MSD	ORB	SIFT
BOLD	5.6	5.5	5.4	5.6	6.4	5.5	5.6
ORB	17.6	16.2	2.5	24.9	98.1	15.4	-
BGM HARD	19.6	18.8	17.9	18.8	23.0	18.7	20.2
BGM BILINEAR	23.8	20.7	20.0	20.9	26.5	20.5	21.9
BINBOOST 64	39.1	39.2	37.7	38.8	48.9	39.1	37.2
BINBOOST 128	44.7	44.6	43.1	44.2	50.2	43.5	43.8
LATCH	51.0	47.1	47.5	49.3	54.1	48.1	49.4
BINBOOST 256	56.0	55.7	54.2	56.0	67.1	55.3	55.4
BGM	67.0	67.7	65.0	67.1	74.4	66.0	64.1
LBGM	102.7	102.7	100.1	102.8	111.4	101.4	101.8
FREAK	126.9	91.5	36.9	164.3	487.8	93.3	159.0
RIFF	157.0	108.2	41.4	192.0	596.4	107.0	186.0
SIFT	178.7	299.9	109.6	179.5	-	1605.2	657.9
AKAZE	331.0	-	-	-	-	-	-
VGG 48	417.1	412.5	394.7	415.7	496.4	406.5	400.4
VGG 64	456.5	453.6	437.6	448.7	514.4	446.2	442.6
VGG 80	457.4	456.0	438.3	454.9	517.4	447.9	440.1
VGG 120	461.4	459.7	443.3	456.7	521.0	451.9	446.3
BRISK	692.4	471.5	180.8	894.0	2809.4	480.9	877.6
DAISY	928.6	624.8	239.3	1164.7	3759.4	640.4	1126.1
KAZE	-	-	-	1492.6	-	-	-

**Table 5.** Maximum average descriptor computation times  $\hat{t}_f$  in  $\mu s$  for one descriptor and various keypoints. Time measurements were performed using the smallest runtime of 20 runs of every image pair on an Intel Xeon E5-1620 v3 3.5GHz CPU and the maximum runtimes over the first 10 image pairs of the KITTI 2015 flow dataset [1].

Descriptor	Mean	Median	Min	Max
BOLD	5.4	5.4	5.3	5.5
ORB	14.4	10.1	1.9	44.4
BGM HARD	17.9	17.8	17.4	19.0
BGM BILINEAR	20.0	19.9	19.3	21.4
BINBOOST 64	36.6	36.7	35.1	39.0
BINBOOST 128	42.1	41.9	40.7	45.0
LATCH	47.3	46.7	46.0	49.0
BINBOOST 256	53.4	53.2	52.0	55.3
BGM	62.2	62.2	59.6	65.3
FREAK	80.2	62.0	20.8	219.5
RIFF	95.5	72.4	22.1	273.2
LBGM	98.0	97.9	94.8	101.4
AKAZE	151.2	151.2	151.2	151.2
SIFT	390.4	189.8	96.3	1446.6
VGG 48	400.1	395.6	386.2	436.1
BRISK	424.7	319.8	93.0	1211.5
VGG 64	440.8	438.1	426.8	473.0
VGG 80	441.4	440.2	427.5	471.8
VGG 120	445.5	442.0	431.2	478.4
DAISY	566.4	421.6	121.4	1642.8
KAZE	613.9	613.9	613.9	613.9

**Table 6.** Statistics for the minimum average descriptor computation times  $\tilde{t}_f$  in  $\mu s$  for one descriptor and various keypoints. Time measurements were performed using the smallest runtime of 20 runs of every image pair on an Intel Xeon E5-1620 v3 3.5GHz CPU and the minimum runtimes over the first 10 image pairs of the KITTI 2015 flow dataset [1]. The statistic is generated over the resulting runtimes for various keypoint detectors.

Descriptor	Mean	Median	Min	Max
BOLD	5.5	5.5	5.4	5.8
BGM HARD	18.6	18.3	17.6	20.6
BGM BILINEAR	20.6	20.4	19.6	22.6
ORB	20.6	13.0	2.2	65.7
BINBOOST 64	37.7	37.4	36.1	41.6
BINBOOST 128	43.3	42.6	41.6	47.8
LATCH	48.3	47.7	46.4	51.5
BINBOOST 256	54.8	54.5	52.8	59.2
BGM	64.3	63.8	61.8	70.1
LBGM	100.3	99.4	97.1	107.0
FREAK	116.8	89.9	28.3	341.1
RIFF	139.9	108.2	31.1	415.6
AKAZE	240.9	240.9	240.9	240.9
VGG 48	408.6	403.3	390.9	457.7
SIFT	430.8	213.3	102.4	1504.9
VGG 64	447.8	442.3	430.8	492.8
VGG 80	449.8	445.0	432.9	494.1
VGG 120	454.3	450.4	436.9	498.4
BRISK	629.8	478.1	133.8	1901.5
DAISY	838.2	636.5	177.6	2555.6
KAZE	982.7	982.7	982.7	982.7

**Table 7.** Statistics for the mean runtimes over the average descriptor computation times  $\bar{t}_f$  in  $\mu s$  for one descriptor and various keypoints. Time measurements were performed using the smallest runtime of 20 runs of every image pair on an Intel Xeon E5-1620 v3 3.5GHz CPU and the mean runtimes over the first 10 image pairs of the KITTI 2015 flow dataset [1]. The statistic is generated over the resulting runtimes for various keypoint detectors.



Descriptor	Mean	Median	Min	Max
BOLD	5.5	5.5	5.4	5.8
BGM HARD	18.5	18.3	17.6	20.4
ORB	20.2	13.1	2.1	63.6
BGM BILINEAR	20.4	20.3	19.6	22.3
BINBOOST 64	37.5	37.2	36.1	40.8
BINBOOST 128	43.2	42.3	41.5	47.8
LATCH	48.4	48.0	46.2	51.5
BINBOOST 256	54.6	54.5	52.7	58.3
BGM	64.0	63.6	61.5	69.1
LBGM	100.1	99.1	97.2	107.0
FREAK	113.0	86.0	28.2	329.3
RIFF	134.9	103.4	31.1	401.6
AKAZE	235.1	235.1	235.1	235.1
VGG 48	407.9	401.9	390.9	456.4
SIFT	425.1	212.4	102.3	1497.3
VGG 64	447.4	441.6	430.2	493.4
VGG 80	449.9	444.4	432.9	495.6
VGG 120	453.9	450.8	436.0	497.8
BRISK	607.9	459.9	132.3	1833.4
DAISY	811.0	610.3	171.7	2470.3
KAZE	925.8	925.8	925.8	925.8

**Table 8.** Statistics for the median runtimes over the average descriptor computation times  $\tilde{t}_f$  in  $\mu s$  for one descriptor and various keypoints. Time measurements were performed using the smallest runtime of 20 runs of every image pair on an Intel Xeon E5-1620 v3 3.5GHz CPU and the median runtimes over the first 10 image pairs of the KITTI 2015 flow dataset [1]. The statistic is generated over the resulting runtimes for various keypoint detectors.

Descriptor	Mean	Median	Min	Max
BOLD	5.7	5.6	5.4	6.4
BGM HARD	19.6	18.8	17.9	23.0
BGM BILINEAR	22.0	20.9	20.0	26.5
ORB	29.1	16.9	2.5	98.1
BINBOOST 64	40.0	39.1	37.2	48.9
BINBOOST 128	44.9	44.2	43.1	50.2
LATCH	49.5	49.3	47.1	54.1
BINBOOST 256	57.1	55.7	54.2	67.1
BGM	67.3	67.0	64.1	74.4
LBGM	103.3	102.7	100.1	111.4
FREAK	165.7	126.9	36.9	487.8
RIFF	198.3	157.0	41.4	596.4
AKAZE	331.0	331.0	331.0	331.0
VGG 48	420.5	412.5	394.7	496.4
VGG 64	457.1	448.7	437.6	514.4
VGG 80	458.9	454.9	438.3	517.4
VGG 120	462.9	456.7	443.3	521.0
SIFT	505.1	239.7	109.6	1605.2
BRISK	915.2	692.4	180.8	2809.4
DAISY	1211.9	928.6	239.3	3759.4
KAZE	1492.6	1492.6	1492.6	1492.6

**Table 9.** Statistics for the maximum average descriptor computation times  $\hat{t}_f$  in  $\mu s$  for one descriptor and various keypoints. Time measurements were performed using the smallest runtime of 20 runs of every image pair on an Intel Xeon E5-1620 v3 3.5GHz CPU and the maximum runtimes over the first 10 image pairs of the KITTI 2015 flow dataset [1]. The statistic is generated over the resulting runtimes for various keypoint detectors.

## References

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