A Performance Comparison of Image Processing Functions in O-Matrix and Matlab®

All benchmarks were performed on an Intel Core2 Duo 1.86GHz using O-Matrix 6.3, IPT 1.0, Matlab 7.3

Color Transformations

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain[fold]
Gamma transformation	GammaFwd	uint8	1280x960x3	64.33	N/A	N/A
Gamma transformation	GammaFwd	single	1280x960x3	356.1	N/A	N/A
Inverse Gamma transformation	GammaInv	uint8	1280x960x3	54.64	N/A	N/A
Inverse Gamma transformation	GammaInv	single	1280x960x3	316.4	N/A	N/A
RGB to graylevels	RGB2Gray	uint8	1280x960x3	13.36	49.75	3.72
RGB to graylevels	RGB2Gray	single	1280x960x3	21.55	65.8	3.05
RGB to Hue-Saturation-Value (HSV)	RGB2HSV	uint8	1280x960x3	75.95	1057	13.92
RGB to Hue-Saturation-Value (HSV)	RGB2HSV	single	1280x960x3	213	960.3	4.51
Hue-Saturation-Value (HSV) to RGB	HSV2RGB	uint8	1280x960x3	73.84	1197	16.21
Hue-Saturation-Value (HSV) to RGB	HSV2RGB	single	1280x960x3	147.3	1208	8.20
RGB to Hue-Luminance-Saturation (HLS)	RGB2HLS	uint8	1280x960x3	71.75	N/A	N/A
RGB to Hue-Luminance-Saturation (HLS)	RGB2HLS	single	1280x960x3	143.1	N/A	N/A
Hue-Luminance-Saturation (HLS) to RGB	HLS2RGB	uint8	1280x960x3	75.53	N/A	N/A
Hue-Luminance-Saturation (HLS) to RGB	HLS2RGB	single	1280x960x3	140.8	N/A	N/A
RGB to YUV color space	RGB2YUV	uint8	1280x960x3	63.19	N/A	N/A
RGB to YUV color space	RGB2YUV	single	1280x960x3	90.53	N/A	N/A
YUV color space to RGB	YUV2RGB	uint8	1280x960x3	62.88	N/A	N/A
YUV color space to RGB	YUV2RGB	single	1280x960x3	90.32	N/A	N/A
RGB to YCbCr color space	RGB2YCbCr	uint8	1280x960x3	64.73	161.9	2.50
RGB to YCbCr color space	RGB2YCbCr	single	1280x960x3	120.5	294.2	2.44

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain[fold]
YCbCr to RGB color space	YCbCr2RGB	single	1280x960x3	71.6	162.4	2.27
YCbCr to RGB color space	YCbCr2RGB	single	1280x960x3	120.3	329.1	2.74
RGB to NTSC color space	RGB2NTSC	uint8	1280x960x3	62.82	309.1	4.92
RGB to NTSC color space	RGB2NTSC	single	1280x960x3	100.3	195.7	1.95
NTSC to RGB color space	NTSC2RGB	uint8	1280x960x3	62.86	313.4	4.99
NTSC to RGB color space	NTSC2RGB	single	1280x960x3	90.4	312.9	3.46
RGB to CIE XYZ color space	RGB2XYZ	uint8	1280x960x3	67.14	2729	40.65
RGB to CIE XYZ color space	RGB2XYZ	single	1280x960x3	131.5	2059	15.66
CIE XYZ to RGB color space	XYZ2RGB	uint8	1280x960x3	67.4	2652	39.35
CIE XYZ to RGB color space	XYZ2RGB	single	1280x960x3	130.7	2078	15.90
RGB to CIE Lab color space	RGB2Lab	uint8	1280x960x3	106.6	4376	41.05
RGB to CIE Lab color space	RGB2Lab	single	1280x960x3	154	3842	24.95
CIE Lab to RGB color space	Lab2RGB	uint8	1280x960x3	80.01	4400	54.99
CIE Lab to RGB color space	Lab2RGB	single	1280x960x3	152.7	3819	25.01
RGB to CIE Luv color space	RGB2Luv	uint8	1280x960x3	106.3	3159	29.72
RGB to CIE Luv color space	RGB2Luv	single	1280x960x3	137.4	2415	17.58
CIE Luv to RGB color space	Luv2RGB	uint8	1280x960x3	73.15	2401	32.82
CIE Luv to RGB color space	Luv2RGB	single	1280x960x3	167.2	2399	14.35
CIE XYZ to CIE Lab color space	XYZ2Lab	single	1280x960x3	129	2715	21.05
CIE Lab to CIE XYZ color space	Lab2XYZ	uint8	1280x960x3	95.74	3220	33.63
CIE Lab to CIE XYZ color space	Lab2XYZ	single	1280x960x3	121	2570	21.24
CIE Lab to CIE LCH color space	Lab2LCH	single	1280x960x3	111.4	800.4	7.18
CIE Lab to CIE LCH color space	Lab2LCH	single	1280x960x3	120.9	487.4	4.03

Geometric Transformations

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain [fold]
Image Rotation (30 degrees), nearest neighbors interpolation	ImRotate	uint8	1280x960	5.896	1748	296.47
Image Rotation (30 degrees), bilinear interpolation	ImRotate	uint8	1280x960	15.85	2187	137.98
Image Rotation (30 degrees), bicubic interpolation	ImRotate	uint8	1280x960	51.51	3242	62.94
Image Rotation (30 degrees), nearest neighbors interpolation	ImRotate	single	1280x960	10.77	1718	159.52
Image Rotation (30 degrees), bilinear interpolation	ImRotate	single	1280x960	22.31	2196	98.43
Image Rotation (30 degrees), bicubic interpolation	ImRotate	single	1280x960	72.06	3324	46.13
General coordinate transformation, nearest neighbors interpolation	ImRemap	uint8	1280x960	22.78	N/A	N/A
General coordinate transformation, bilinear interpolation	ImRemap	uint8	1280x960	29.45	N/A	N/A
General coordinate transformation, bicubic interpolation	ImRemap	uint8	1280x960	49.05	N/A	N/A
General coordinate transformation, nearest neighbors interpolation	ImRemap	single	1280x960	26.16	458.4	17.52
General coordinate transformation, bilinear interpolation	ImRemap	single	1280x960	33.7	670.6	19.90
General coordinate transformation, bicubic interpolation	ImRemap	single	1280x960	62.54	1995	31.90
Image size reduction by factor 4, nearest neighbors interpolation	ImResize	uint8	1280x960	0.12	1.818	15.15
Image size reduction by factor 4, bilinear interpolation	ImResize	uint8	1280x960	0.2692	322.6	1198.37
Image size reduction by factor 4, bicubic interpolation	ImResize	uint8	1280x960	1.101	399	362.40
Image size reduction by factor 4, super-sampling	ImResize	uint8	1280x960	0.9575	N/A	N/A
Image size reduction by factor 4, nearest neighbors interpolation	ImResize	single	1280x960	1.782	2.681	1.50
Image size reduction by factor 4, bilinear interpolation	ImResize	single	1280x960	0.8566	292	340.88
Image size reduction by factor 4, bicubic interpolation	ImResize	single	1280x960	1.842	367	199.24
Image size reduction by factor 4, super-sampling	ImResize	single	1280x960	1.704	N/A	N/A
Affine coordinate transformation, nearest neighbors interpolation	ImAffine	uint8	1280x960	4.553	1208	265.32
Affine coordinate transformation, bilinear interpolation	ImAffine	uint8	1280x960	13.93	1649	118.38
Affine coordinate transformation, bicubic interpolation	ImAffine	uint8	1280x960	49.17	2562	52.10
Affine coordinate transformation, nearest neighbors interpolation	ImAffine	single	1280x960	6.274	1219	194.29
Affine coordinate transformation, bilinear interpolation	ImAffine	single	1280x960	18.08	1899	105.03
Affine coordinate transformation, bicubic interpolation	ImAffine	single	1280x960	67.47	3179	47.12
Perspective coordinate transformation, nearest neighbors interpolation	ImPerspective	uint8	1280x960	7.108	1318	185.42
Perspective coordinate transformation, bilinear interpolation	ImPerspective	uint8	1280x960	10.43	1754	168.17

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain [fold]
Perspective coordinate transformation, nearest neighbors interpolation	ImPerspective	single	1280x960	8.552	1320	154.35
Perspective coordinate transformation, bilinear interpolation	ImPerspective	single	1280x960	16.83	1993	118.42
Perspective coordinate transformation, bicubic interpolation	ImPerspective	single	1280x960	25.85	3255	125.92

BW Morphology

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain[fold]
Binary image morphological dilation (3x3 structuring element)	BwDilate	logical	255x149	0.09028	2.423	26.84
Binary image morphological erosion (3x3 structuring element)	BwErode	logical	255x149	0.09221	2.471	26.80
Binary image morphological opening (3x3 structuring element)	BwOpen	logical	255x149	0.1366	4.743	34.72
Binary image morphological closing (3x3 structuring element)	BwClose	logical	255x149	0.1383	4.856	35.11
Binary image morphological top-hat (3x3 structuring element)	BwTopHat	logical	255x149	0.3736	4.942	13.23
Binary image morphological bottom-hat (3x3 structuring element)	BwBotHat	logical	255x149	0.3987	4.993	12.52
Isolated pixels removal	BwClean	logical	255x149	0.2626	2.438	9.28
Interior pixels removal	BwRemove	logical	255x149	0.2502	2.434	9.73
Find perimeter pixels	BwPerim	logical	255x149	0.1168	3.134	26.83
Fill isolated holes	BwFill	logical	255x149	0.2493	2.426	9.73
Compute morphological skeleton	BwSkeleton	logical	255x149	16.48	844	51.21
Shrink objects to points	BwShrink	logical	255x149	60.73	241	3.97
Shrink objects to lines	BwThin	logical	255x149	22.8	520.6	22.83
Add boundary pixels while maintaining connectivity	BwThicken	logical	255x149	15.4	212.2	13.78
Remove spur pixels	BwRemoveSpur	logical	255x149	0.915	89.07	97.34
Area of object in a binary image	BwArea	logical	255x149	0.2026	2.025	10.00
Remove small objects from a binary image	BwAreaOpen	logical	255x149	0.4067	14.69	36.12
Compute the Euler number	BwEuler	logical	255x149	0.2478	2.573	10.38

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain[fold]
Distance transform, cityblock metric	BwDist	logical	255x149	0.2405	12.34	51.31
Distance transform, chessboard metric	BwDist	logical	255x149	0.3125	17.82	57.02
Distance transform, fastmarching Euclidean metric	BwDist	logical	255x149	1.358	N/A	N/A
Ultimate erosion, Euclidean metric	BwUltErode	logical	255x149	4.385	20.17	4.60
Ultimate erosion, cityblock metric	BwUltErode	logical	255x149	2.265	31.45	13.89
Ultimate erosion, chessboard metric	BwUltErode	logical	255x149	2.29	33.37	14.57
Ultimate erosion, fastmarching Euclidean metric	BwUltErode	logical	255x149	3.408	N/A	N/A
Label connected components	BwLabel	logical	255x149	0.5118	2.052	4.01
Select connected components	BwSelect	logical	255x149	0.3931	83.32	211.96
Hit-miss transform	BwHitMiss	logical	255x149	0.4136	9.71	23.48

Gray Morphology

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain
Morphological dilation, (5x5 structuring element)	ImDilate	logical	1280x960	11.87	24.84	2.09
Morphological dilation, (5x5 structuring element)	ImDilate	uint8	1280x960	12.12	170	14.03
Morphological dilation, (5x5 structuring element)	ImDilate	single	1280x960	30.18	232.7	7.71
Morphological erosion, (5x5 structuring element)	ImErode	logical	1280x960	10.31	27.71	2.69
Morphological erosion, (5x5 structuring element)	ImErode	uint8	1280x960	10.62	172.6	16.25
Morphological erosion, (5x5 structuring element)	ImErode	single	1280x960	29.34	234.8	8.00
Morphological opening, (5x5 structuring element)	ImOpen	logical	1280x960	19.07	24.53	1.29
Morphological opening, (5x5 structuring element)	ImOpen	uint8	1280x960	18.33	331.6	18.09
Morphological opening, (5x5 structuring element)	ImOpen	single	1280x960	50.64	453.1	8.95
Morphological closing, (5x5 structuring element)	ImClose	logical	1280x960	19.07	24.85	1.30
Morphological closing, (5x5 structuring element)	ImClose	uint8	1280x960	18.27	333.3	18.24
Morphological closing, (5x5 structuring element)	ImClose	single	1280x960	61.73	453.7	7.35
Morphological top-hat, (5x5 structuring element)	ImTopHat	logical	1280x960	19.7	29.37	1.49

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain
Morphological top-hat, (5x5 structuring element)	ImTopHat	single	1280x960	64.56	461.7	7.15
Morphological bot-hat, (5x5 structuring element)	ImBotHat	logical	1280x960	21.31	30.81	1.45
Morphological bot-hat, (5x5 structuring element)	ImBotHat	uint8	1280x960	22.21	334.4	15.06
Morphological bot-hat, (5x5 structuring element)	ImBotHat	single	1280x960	65.33	462.7	7.08
Morphological reconstruction	MorphRecon	logical	1280x960	11.5	626	54.43
Morphological reconstruction	MorphRecon	uint8	1280x960	14.39	809	56.22
Morphological reconstruction	MorphRecon	single	1280x960	23.66	918.8	38.83
H-Max transform	ImHMax	uint8	1280x960	20.57	728	35.39
H-Max transform	ImHMax	single	1280x960	41.28	887.5	21.50
H-Min transform	ImHMin	uint8	1280x960	24.14	715.3	29.63
H-Min transform	ImHMin	single	1280x960	49.39	858	17.37
Find local maximas	ImLocalMax	uint8	1280x960	104.9	461.9	4.40
Find local maximas	ImLocalMax	single	1280x960	119.6	482.5	4.03
Find local minimas	ImLocalMin	uint8	1280x960	106.6	463.8	4.35
Find local minimas	ImLocalMin	single	1280x960	125.2	499.2	3.99
Extended max transform	ImExtendedMax	uint8	1280x960	113.1	1150	10.17
Extended max transform	ImExtendedMax	single	1280x960	145.1	1299	8.95
Extended min transform	ImExtendedMin	uint8	1280x960	114.9	1153	10.03
Extended min transform	ImExtendedMin	single	1280x960	148.6	1266	8.52
Suppress light structures connected to image border	ImClearBorder	uint8	1280x960	26.39	1275	48.31
Suppress light structures connected to image border	ImClearBorder	single	1280x960	54.02	1399	25.90
Impose minima	ImImposeMin	uint8	1280x960	53.53	993	18.55
Impose minima	ImImposeMin	single	1280x960	87.77	1372	15.63
Fill image selected regions and holes	ImFill	uint8	1280x960	28.21	986.5	34.97
Fill image selected regions and holes	ImFill	single	1280x960	55.5	1306	23.53

Edge Detection

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain
Edge detection using Sobel derivatives	EdgeSobel	single	1280x960	76.1	669.9	8.80
Edge detection using Roberts derivatives	EdgeRoberts	single	1280x960	76.24	666.6	8.74
Edge detection using Prewitt derivatives	EdgePrewitt	single	1280x960	75.15	669.8	8.91
Edge detection using Canny method	EdgeCanny	single	1280x960	147.6	2855	19.34
Edge detection using zero-crossing	EdgeZeroCross	single	1280x960	107.3	649.7	6.05

Image Enhancement

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain
Generating Poisson noise from image	PoissonNoise	single	1280x960	235.6	630	2.67
Adding gaussian noise to an image	GaussianNoise	single	1280x960	83.98	143.4	1.71
Adding gaussian noise with local variance to an image	LocalVarNoise	single	1280x960	108.6	346.7	3.19
Adding uniform noise to an image	UniformNoise	single	1280x960	18.51	N/A	N/A
Add multiplicative noise to an image	SpeckleNoise	single	1280x960	23.18	159.1	6.86
Generate "salt & pepper" noise to an image	SPNoise	single	1280x960	28.12	170.6	6.07
Wiener noise reduction filter, 7x7 mask size.	WienerFilter	uint8	1280x960	40.53	913.4	22.54
Wiener noise reduction filter, 7x7 mask size.	WienerFilter	single	1280x960	43.6	861.5	19.76
Median filter, 3x3 mask size.	MedianFilter	uint8	1280x960	3.378	171.6	50.80
Median filter, 3x3 mask size.	MedianFilter	single	1280x960	210.1	252.1	1.20
Order statistics filter, 3x5 mask size.	OSFilter	uint8	1280x960	141.5	290.3	2.05
Order statistics filter, 3x5 mask size.	OSFilter	single	1280x960	180.9	428.7	2.37
Histogram equalization of an image	HistEq	uint8	1280x960	4.183	21.29	5.09
Histogram equalization of an image	HistEq	single	1280x960	8.826	79.98	9.06
Wiener deconvolution	DeconvWiener	single	444x291	297.7	2102	7.06
Lucy-Richardson deconvolution (10 iterations)	DeconvLR	single	444x291	1364	14500	10.64
Blind deconvolution (10 iterations)	DeconvBlind	single	444x291	3303	41304	12.50

Image Analysis

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain[fold]
Hough transform, angular resolution = 0.5 degrees	Hough	logical	292x438	18.81	163.9	8.71
Find peaks in Hough transform	HoughPeaks	double	292x438	6.763	49.85	7.37
Extract line segments based on Hough transform	HoughLines	logical	292x438	1.158	5.539	4.78
Local entropy, 5x5 neighborhood	EntropyFilter	single	292x438	43.97	322.6	7.34
Local standard deviation, 5x5 neighborhood	StdFilter	single	292x438	3.715	60.2	16.20
Local graylevel range, 5x5 neighborhood	RangeFilter	uint8	292x438	0.5172	39.6	76.57
Local graylevel range, 5x5 neighborhood	RangeFilter	single	292x438	2.229	51.81	23.24
Image histogram	ImHist	uint8	292x438	0.2585	0.5675	2.20
Image histogram	ImHist	single	292x438	0.4576	8.149	17.81
Normalized cross correlation, 100x100 template image	NCC2	single	292x438	15.6	387	24.81
Normalized sum of square differences, 100x100 template image	SSD2	single	292x438	8.675	N/A	N/A
Image L1 norm	ImNorm	uint8	292x438	0.07345	N/A	N/A
Image L1 norm	ImNorm	single	292x438	0.2613	N/A	N/A
Image L2 norm	ImNorm	uint8	292x438	0.9155	N/A	N/A
Image L2 norm	ImNorm	single	292x438	0.2523	N/A	N/A
Image L_inf norm	ImNorm	uint8	292x438	0.07449	N/A	N/A
Image L_inf norm	ImNorm	single	292x438	0.2708	N/A	N/A
Mutual infromation of two images	ImNorm	uint8	292x438	2.037	N/A	N/A
Mutual infromation of two images	ImNorm	single	292x438	2.987	N/A	N/A
Image quality index	ImNorm	uint8	292x438	0.2622	N/A	N/A
Image quality index	ImNorm	single	292x438	0.3878	N/A	N/A
Co-occurrence matrix, 256 levels	GCM	single	292x438	0.9625	100.5	104.42
Porpositions based of the Co-occurrence matrix	GCMProps	single	292x438	3.562	23.52	6.60

Linear Filters/Transforms

Description	Function Name	Data Type	Image Size	O-Matrix Time [msec]	Matlab Time [msec]	Performance Gain [fold]
General linear filter, kernel size 7x7	ImFilter	uint8	1280x960	16.84	40.63	2.41
General linear filter, kernel size 7x7	ImFilter	single	1280x960	18.14	54.25	2.99
Linear filter with Gaussian kernel, kernel size 7x7	FixedFilter	uint8	1280x960	16.92	N/A	N/A
Linear filter with Gaussian kernel, kernel size 7x7	FixedFilter	single	1280x960	18.21	N/A	N/A
Linear filter with Laplacian kernel, kernel size 3x3	FixedFilter	uint8	1280x960	5.304	N/A	N/A
Linear filter with Laplacian kernel, kernel size 3x3	FixedFilter	single	1280x960	10.11	N/A	N/A
Linear filter with unsharp kernel, kernel size 3x3	FixedFilter	uint8	1280x960	5.186	N/A	N/A
Linear filter with unsharp kernel, kernel size 3x3	FixedFilter	single	1280x960	10.5	N/A	N/A
Linear filter with lowpass kernel, kernel size 3x3	FixedFilter	uint8	1280x960	3.5	N/A	N/A
Linear filter with lowpass kernel, kernel size 3x3	FixedFilter	single	1280x960	8.524	N/A	N/A
Linear filter with highpass kernel, kernel size 3x3	FixedFilter	uint8	1280x960	2.813	N/A	N/A
Linear filter with highpass kernel, kernel size 3x3	FixedFilter	single	1280x960	9.512	N/A	N/A
Linear filter with averaging kernel, kernel size 9x11	FixedFilter	uint8	1280x960	3.988	N/A	N/A
Linear filter with averaging kernel, kernel size 9x11	FixedFilter	single	1280x960	10.55	N/A	N/A
Linear filter with Sobel x-derivative kernel, kernel size 3x3	FixedFilter	uint8	1280x960	12.16	N/A	N/A
Linear filter with Sobel x-derivative kernel, kernel size 3x3	FixedFilter	single	1280x960	8.37	N/A	N/A
Linear filter with Prewitt x-derivative kernel, kernel size 3x3	FixedFilter	uint8	1280x960	12.69	N/A	N/A
Linear filter with Prewitt x-derivative kernel, kernel size 3x3	FixedFilter	single	1280x960	9.005	N/A	N/A
Linear filter with Scharr x-derivative kernel, kernel size 3x3	FixedFilter	uint8	1280x960	12.2	N/A	N/A
Linear filter with Scharr x-derivative kernel, kernel size 3x3	FixedFilter	single	1280x960	8.242	N/A	N/A
Linear filter with Roberts up-derivative kernel, kernel size 3x3	FixedFilter	uint8	1280x960	12.95	N/A	N/A
Linear filter with Roberts up-derivative kernel, kernel size 3x3	FixedFilter	single	1280x960	8.874	N/A	N/A
Discrete cosine transform	DCT2	single	1280x960	180.8	632.9	3.50
Discrete inverse cosine transform	iDCT2	single	1280x960	183.4	1217	6.64
Radon transform, angular resolution = 0.5 degrees	Radon	single	256x256	2036	1621	0.80
Radon reconstruction using backprojection	iRadon	single	256x256	203.5	3994	19.63