



The following benchmarks provide a performance overview for a range of imaging operations running on different platforms. A brief description of all functions, parameters and images used are included. Note that the benchmarks assume full processor and memory bandwidth (i.e., no other system activity), and include command overheads.

Note: Operations executed on 512 x 512 images¹.

	1.3 GHz Celeron™ M 512KB L2 Cache 400 MHz FSB PC2700 SDRAM (Marrox 45ight M)	2.0 GHz Pentium™ M 2MB L2 Cache 400 MHz FSB PC2700 SDRAM (Marrox 45ight M)	2.6 GHz Opteron™ 1 MB L2 Cache DDR1-400 SDRAM	3.6 GHz Xeon™ 1 MB L2 Cache 800 MHz FSB DDR2-400 SDRAM	Helios XA / XCL 133 MHz PA (with 3.6 GHz Xeon™)
Image Processing					
Point-to-point Add two 8-bit images and store results in an 8-bit destination image.	0.58 ms	0.08 ms	0.08 ms	0.05 ms	0.23 ms ²
Edge Detection (sobel) Perform an edge detection (sobel) on an 8-bit source image and store results in an 8-bit destination image.	1.4 ms	0.74 ms	0.51 ms	0.74 ms	0.17 ms ²
Convolution (3 x 3) Perform a general 3 x 3 convolution with arbitrary coefficients on an 8-bit source image and store results in an 8-bit destination image. Results are saturated.	1.8 ms	1.1 ms	0.63 ms	0.54 ms	0.15 ms ²
Convolution (5 x 5) Same as above except with a 5 x 5 kernel.	4.6 ms	2.9 ms	1.6 ms	1.5 ms	0.21 ms ²
Convolution (11 x 11) Same as above except with a 11 x 11 kernel.	19.8 ms	12.7 ms	7.1 ms	5.8 ms	0.96 ms ²
Erosion/Dilation (3 x 3, predefined, binary) Perform a binary erosion/dilation on a 1-bit source image using a predefined 3 x 3 structuring element and store results in a 1-bit destination image.	0.08 ms	0.05 ms	0.04 ms	0.04 ms	0.09 ms ²
Erosion/Dilation (3 x 3, predefined, grayscale) Same as above except perform a grayscale operation.	3.5 ms	0.17 ms	0.13 ms	0.16 ms	0.16 ms ²
Erosion/Dilation (3 x 3, user-defined, binary) Perform a binary erosion/dilation on a 1-bit source image using an arbitrary 3 x 3 structuring element and store results in a 1-bit destination image.	0.34 ms	0.22 ms	0.15 ms	0.14 ms	0.10 ms ²
Erosion/Dilation (3 x 3, user-defined, grayscale) Same as above except perform a grayscale erosion/dilation operation.	0.92 ms	0.51 ms	0.39 ms	0.51 ms	0.16 ms ²
Erosion/Dilation (5 x 5, user-defined, binary) Perform a binary erosion/dilation on a 1-bit source image using an arbitrary 5 x 5 structuring element and store results in a 1-bit destination image.	1.4 ms	0.88 ms	0.58 ms	0.55 ms	0.09 ms ²
Erosion/Dilation (5 x 5, user-defined, grayscale) Same as above except perform a grayscale erosion/dilation.	1.8 ms	1.1 ms	0.75 ms	1.1 ms	0.22 ms ²
LUT map Perform a point-to-point LUT mapping operation for an 8-bit source image and store results in an 8-bit destination image.	0.59 ms	0.33 ms	0.54 ms	0.24 ms	0.28 ms ²
Histogram Calculate the histogram of an 8-bit source image and store result in a 32-bit buffer.	0.58 ms	0.38 ms	0.28 ms	0.31 ms	0.31 ms



Image Processing (cont.)

	1.3 GHz Celeron™ M 512Kb L2 Cache 400 MHz FSB PC2700 SDRAM (Matrox 45light M)	2.0 GHz Pentium™ M 2Mb L2 Cache 400 MHz FSB PC2700 SDRAM (Matrox 45light M)	2.6 GHz Opteron™ 1 Mb L2 Cache DDR1-400 SDRAM	3.6 GHz Xeon™ 1 Mb L2 Cache 800 MHz FSB DDR2-400 SDRAM	Helios XA / XCL 133 MHz PA (with 3.6 GHz Xeon™)
Lossy JPEG Compression (monochrome) Perform lossy JPEG compression on an 8-bit source image and store results in an 8-bit destination image.	2.5 ms	1.6 ms	1.2 ms	1.5 ms	1.5 ms
Lossless JPEG Compression (monochrome) Perform lossless JPEG compression on an 8-bit source image and store results in an 8-bit destination image.	2.9 ms	1.9 ms	2.2 ms	2.3 ms	2.3 ms
Rotate (30°) Rotate by 30° an 8-bit source image and store results in 8-bit destination image.	1.2 ms	0.64 ms	0.90 ms	0.69 ms	0.69 ms
Warp Polynomial Warping using a first-order polynomial mapping with nearest neighbor interpolation on an 8-bit source image and store results in an 8-bit destination image.	1.2 ms	0.64 ms	0.90 ms	0.69 ms	0.69 ms

Geometric Model Finder^{3,4}

Find a Model (1 model, 1 occurrence, very high speed, limited scaling) Find a single 128 x 128 model in an 8-bit image. The whole image is searched for a model rotated within 0-360° and scaled within 90-110% using the highest speed (lowest robustness and accuracy) setting.	6.2 ms	3.7 ms	2.8 ms	3.4 ms	3.4 ms
Find a Model (1 model, 1 occurrence, medium speed, limited scaling) Find a single 128 x 128 model in an 8-bit image. The whole image is searched for a model rotated within 0-360° and scaled within 90-110% using medium speed setting.	15.6 ms	10.2 ms	6.5 ms	8.1 ms	8.1 ms
Find a Model (1 model, 1 occurrence, medium speed, max. scaling) Find a single 128 x 128 model in an 8-bit image. The whole image is searched for a model rotated within 0-360° and scaled within 50-200% using medium speed setting.	16.2 ms	10.7 ms	7.1 ms	8.5 ms	8.5 ms
Find Models (1 model, 4 occurrences, medium speed, limited scaling) Same as above except find four occurrences of a single 128 x 128 model.	21.6 ms	13.5 ms	9.3 ms	11.8 ms	11.8 ms
Find Models (4 models, 4 occurrences, medium speed, limited scaling) Same as above except find a single occurrence of four 128 x 128 models.	25.6 ms	15.7 ms	11.1 ms	14.2 ms	14.2 ms

Pattern Matching (Normalized Grayscale Correlation)^{3,4}

Find a Model (128 x 128, non-rotated) Find a 128 x 128 model in an 8-bit grayscale image. The whole image is searched for a model that is not rotated.	0.42 ms	0.19 ms	0.16 ms	0.19 ms	0.19 ms
Find a Model (128 x 128, -5° to +5°) Find a 128 x 128 model located at 0° in an 8-bit grayscale image. The whole image is searched for a a model rotated within +/-5°.	1.7 ms	0.89 ms	0.70 ms	0.89 ms	0.89 ms
Find a Model (32 x 32, non-rotated) As above except perform a pattern match of a 32 x 32 model.	2.1 ms	1.0 ms	0.71 ms	0.83 ms	0.83 ms
Find a Model (32 x 32, -5° to +5°) As above except perform a pattern match of a 32 x 32 model.	3.4 ms	1.8 ms	1.2 ms	1.4 ms	1.4 ms



Edge Finder (4000 edge elements or edgels)⁴

	1.3 GHz Celeron™ M 512KB L2 Cache 400 MHz FSB PC2700 SDRAM (Matrox 45light M)	2.0 GHz Pentium™ M 2MB L2 Cache 400 MHz FSB PC2700 SDRAM (Matrox 45light M)	2.6 GHz Opteron™ 1 MB L2 Cache DDR1-400 SDRAM	3.6 GHz Xeon™ 1 MB L2 Cache 800 MHz FSB DDR2-400 SDRAM	Helios XA / YCL 133 MHz PA (with 3.6 GHz Xeon™)
Extract contours	15.4 ms	9.0 ms	6.2 ms	8.0 ms	8.0 ms
Extract thin line crests	68.3 ms	24.3 ms	19.5 ms	24.8 ms	24.0 ms

Blob Analysis (100 blobs that occupy 25% of area)⁴

Calculate Area	0.24 ms	0.15 ms	0.15 ms	0.12 ms	0.12 ms
Calculate Area and Binary Center of Gravity	0.28 ms	0.18 ms	0.17 ms	0.15 ms	0.15 ms
Calculate Area and Grayscale Center of Gravity	0.86 ms	0.56 ms	0.43 ms	0.45 ms	0.45 ms

Measurement

Find an Edge Locate an edge in a 16 x 4 measurement region of an 8-bit image.	0.06 ms	0.02 ms	0.03 ms	0.07 ms	0.08 ms
Find Multiple Stripes Locate 24 stripes in a 128 x 16 measurement region of an 8-bit image.	0.17 ms	0.08 ms	0.08 ms	0.09 ms	0.15 ms

String Reader

String Reading Read a 6 character string using a 28 character font within a 512 x 512 image region.	42.7 ms	26.4 ms	20.3 ms	25.0 ms	25.0 ms
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OCR

OCR Reading Read an unknown string of twelve 33 x 21 characters (no grammar rules) within a 404 x 54 image region.	10.6 ms	6.6 ms	4.9 ms	5.8 ms	5.8 ms
Verification Verify that a known string of 12 SEMI font characters (33 x 21) within a 404 x 54 image region can be read properly.	4.0 ms	0.83 ms	0.59 ms	0.84 ms	0.84 ms

Bar and Matrix Code Recognition

Bar Code Reading Read a EAN13 bar code (no rotation).	0.28 ms	0.18 ms	0.15 ms	0.18 ms	0.27 ms
DataMatrix Reading Read a DataMatrix code.	3.7 ms	1.6 ms	2.1 ms	2.2 ms	2.3 ms

1. Benchmarks for larger images do not necessarily scale linearly due to CPU cache effects.
2. Performed using PA.

3. Faster search speeds can be obtained by reducing accuracy.
4. Search speeds will vary with image content.



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