



Index

Symbols

4-connectivity 515
 8-connectivity 515
 : (colon in MATLAB) 33
 . (dot) 46
 ... (dots for long equations) 24
 .mat. *See* MAT-file
 @ operator 63
 >> (prompt) 8
 ; (semicolon in MATLAB) 16

A

abs 168
 adapthisteq 108
 Adjacency 515
 adpmedian 235
 aggfcn 149
 AND 53
 elementwise 53
 scalar 53
 angle 171
 annotation 102
 ans 55
 appcoef2 398
 applycform 344
 applylut 507
 approxfcn 152
 Arctangent 165, 367
 four quadrant 165, 367. *See also*
 atan2
 Array 15, 42. *See also* Matrix
 operations 47
 preallocating 65

 selecting dimension 42
 standard 43
 vs. matrix 15
 atan2 170
 Autocorrelation 682
 Average image power 241
 axis 96
 axis ij (moves axis origin) 96
 axis off 191
 axis on 191
 axis xy (moves axis origin) 96

B

Background 489, 498, 509, 514, 557,
 498
 nonuniform 527, 532, 549, 558, 571
 bandfilter 199
 bar 95
 bayesgauss 685
 bellmf 145, 157
 Binary image. *See* Image
 bin2dec 438
 Bit depth. *See* Color image processing
 blanks 692
 Blind deconvolution. *See* Image
 restoration
 blkproc 459
 Book web site 7
 Border. *See* Boundary, Region
 bound2eight 605
 bound2four 605
 bound2im 600
 Boundaries
 functions for extracting 598

Boundary 598. *See also* Region
 axis (major, minor) 626
 basic rectangle 626
 changing direction of 599
 connecting 605
 defined 598
 diameter 626
 eccentricity 626
 length 625
 minimally connected 598
 minimum-perimeter polygons 610
 ordering a random sequence of
 boundary points 605
 segments 622
 break 58, 61
 bsubsamp 605
 bsxfun 676
 bwboundaries 599
 bwdist 589
 bwhitmiss 505
 bwlabel 515
 bwmorph 511
 bwperim 598

C

cart2pol 621
 Cartesian product 487
 Cassini spacecraft 206
 cat 319
 CDF. *See* Cumulative distribution
 function
 ceil 171
 cell 392, 431
 Cell arrays 74

- example 76
- celldisp 75, 431
- cellfun 75
- cellplot 431
- cellstr 692
- Cellular complex 612
- Center of frequency rectangle 171
- Center of mass 516, 643
- cform structure 344
- Chain codes. *See* Representation and description
- char 26, 73
- checkerboard 238
- circshift 604
- Circular convolution. *See* Convolution
- Classes. *See also* Image classes
 - converting between 28
 - list 26
 - terminology 28
- Classification. *See* Recognition
- c1c 9
- clear 9
- Clipping 30
- C MEX-file 442
- cnotch 202
- Code. *See also* Function, Programming
 - combining statements 32
 - long lines 24
 - modular 216
 - optimization 65
 - preallocation 65
 - vectorization 68
- col2im 460
- colfilt 118
- colon 33
- colorgrad 369
- Colon notation. *See* Notation
- Color image processing
 - basics of 349
 - bit depth 318
 - brightness 340
 - chromaticity 340
 - chromaticity diagram 341
 - CIE 341
 - color balancing 358
 - color correction 358
 - color edge detection 366
 - color editing 352
 - color gamut 347
 - color image segmentation 372
 - color map 321
 - color map matrix 321
 - color maps 324
 - color profile 331, 346
 - color space
 - CMY 330
 - CMYK 330
 - device independent 340
 - HSI 331
 - HSV 329
 - L*a*b* 344
 - L*c*h 344
 - NTSC 328
 - RGB 319
 - sRGB 343
 - u'v'L 344
 - uvL 344
 - xyY 341
 - XYZ 341
 - YCbCr 329
 - color transformations 350
 - converting between CIE and sRGB 344
 - converting between color spaces 328
 - converting between RGB, indexed, and gray-scale images. 324
 - converting HSI to RGB 334
 - converting RGB to HSI 334
 - dithering 323, 326
 - extracting RGB component images 319
 - full-color transformation 351
 - gamut mapping 347
 - gradient of a vector 368
 - gradient of image 366
 - graphical user interface (GUI) 353
 - gray-level slicing 325
 - gray-scale map 321
 - histogram equalization 359
 - hue 328, 332, 340
 - ICC color profiles 346, 347
 - image sharpening 365
 - image smoothing 360
 - indexed images 321
 - intensity 332
 - luminance 320
 - line of purples 342
 - manipulating RGB and indexed images 323
 - perceptual uniformity 343
 - primaries of light 319
 - pseudocolor mapping 351
 - RGB color cube 319
 - RGB color image 318
 - RGB values of colors 322
 - saturation 328, 332, 340
 - secondaries of light 319
 - shade 329
 - soft proofing 347
 - spatial filtering 360
 - tint 329
 - tone 329
 - trichromatic coefficients 340
 - tristimulus values 340
- colormap 191, 323
- colorseg 373
- Column vector. *See* Vector
- Command-function duality 24
- compare 423
- computer 55
- Conjugate transpose 33
- Connected
 - component 515, 597
 - pixels 597
 - set 598
- connectpoly 605
- continue 58, 62
- Contour. *See* Boundary
- Contrast
 - enhancement. *See* Image enhancement
 - measure of, 667
 - stretching. *See* Image enhancement
- Control points. *See* Geometric transformations
- conv2 393
- converting between linear and subscript 40
- Convex
 - deficiency 622
 - hull 622
 - vertex 612
- Convolution
 - circular 174
 - expression 114, 244
 - filter 110
 - frequency domain 173
 - kernel 110
 - mask 110
 - mechanics 110
 - spatial 80
 - theorem 173
- Convolution theorem 173
- conwaylaws 509
- Co-occurrence matrix. *See* Representation and description
 - image 14
 - MATLAB 14
- Coordinates 14
 - Cartesian 192, 621
 - image 13
 - pixel 14
 - polar 257, 621, 654
 - row and column 14
 - spatial 14
- copper 323
- Corner 633
- Corner detection. *See* Representation and description
- cornermetric 638

cornerprocess 638
 Correlation 114, 681
 coefficient 312, 682
 expression 114
 mechanics 110
 normalized cross-correlation 312
 spatial 110
 theorem 242
 Correlation coefficient.
 See Correlation
 Covariance matrix 684
 approximation 662
 function for computing 663
 covmatrix 663
 cpselect 306
 Cross-correlation 312, 682. *See also*
 Recognition
 CT 251
 cumsum 101
 Cumulative distribution function 99,
 212
 transformation 99
 table of 214
 Current directory. *See* MATLAB
 Curvature. *See* Representation and
 description
 Custom function 2, 7
 cv2tifs 483
 Cygnus Loop 587

D

dc component 165
 dec2base 700
 dec2bin 436, 446
 deconvblind 250
 deconvlucy 247
 Deconvolution. *See* Image restoration
 deconvreg 245
 deconvnr 241
 defuzzify 149
 Descriptor. *See* Representation and
 description
 detcoef2 398
 DFT. *See* Discrete Fourier transform
 dftfilt 179
 dftuv 186
 diag 374
 diameter 626
 diff 529
 Digital image. *See* Image
 Digital image processing, definition 3
 Dimension
 array 16
 singleton 17
 Directory 16
 Discrete cosine transform (DCT) 456
 Discrete Fourier transform (DFT)

centering 167, 168
 computing 168
 defined 164, 165
 filtering. *See* Frequency domain
 filtering
 inverse 165
 periodicity 166
 phase angle 165
 power spectrum 166
 scaling issues 172
 spectrum 165
 visualizing 168
 wraparound error 174
 disp 71
 Displacement variable 114
 Distance 372
 computing in MATLAB 675
 Euclidean 343, 372, 675
 Mahalanobis 373, 678, 684
 transform 589
 dither 323
 Division by zero 47
 doc 10
 Don't care pixel 506
 Dots per inch. *See* Dpi
 double 26
 Dpi 24
 dwtmode 387

E

edge 542
 Edge detection. *See* Image
 segmentation
 edgetaper 242
 edit 46
 eig 665
 Eigenvalues 637, 663
 for corner detection 637
 Electromagnetic spectrum 2
 Elementwise operation. *See*
 Operation.
 else 58
 elseif 58
 end 34
 End point 507
 endpoints 507
 Entropy 645, 651
 eps 55
 error 59
 eval 694
 Extended minima transform 595
 eye 44

F

Faceted shading 193
 false 44, 587

False contouring 23
 fan2para 274
 fanbeam 269
 Fast wavelet transform (FWT) 380
 fchcode 607
 Features 306, 625, 674. *See also*
 Representation and
 description
 fft2 168
 fftshift 169
 Fields. *See* Structures
 figure 19
 filter 575
 Filter(ing)
 frequency domain. *See* Frequency
 domain filtering
 morphological. *See* Morphology
 spatial. *See* Spatial filtering
 find 215
 fix 152
 flip1r 262
 flipud 262
 Floating point number. *See* Number
 floor 171
 for 58, 59
 Foreground 489, 490, 503, 507, 557,
 598
 format 56
 Fourier
 coefficients 165
 descriptors 627
 Slice theorem 257
 spectrum 165
 transform. *See* Discrete Fourier
 transform (DFT)
 fplot 98, 156
 frdescp 629
 Freeman chain codes. *See*
 Representation and
 description
 Frequency
 domain 165
 convolution 173
 rectangle 165
 rectangle center 171
 variables 165
 Frequency domain filtering
 bandpass 199
 bandreject 199
 basic steps 178
 constrained least squares 244
 convolution 173
 direct inverse 240
 fundamentals 173
 high-frequency emphasis 197
 highpass 194
 lowpass 187

M-function for 179
 notchpass 202
 notchreject 202
 periodic noise reduction 236
 steps 178
 Wiener 240
 Frequency domain filters. *See*
 also Frequency domain
 filtering
 bandpass 199
 bandreject 199
 Butterworth bandreject 199
 Butterworth highpass 195
 Butterworth lowpass 187
 constrained least squares 244
 converting to spatial filters 181
 direct inverse 240
 from spatial filters 180
 Gaussian highpass 195
 Gaussian lowpass 188
 generating directly 185
 high-frequency emphasis 197
 highpass 194
 ideal bandreject 199
 ideal highpass 195
 ideal lowpass 187
 notchreject 202
 padding 174
 periodic noise reduction 236
 plotting 190
 pseudoinverse. *See* Image
 restoration
 Ram-Lak 259, 266
 sharpening 194
 Shepp-Logan 259
 smoothing 187
 transfer function 173
 Wiener 240
 zero-phase-shift 179
 freqz2 181
 fspecial 120
 full 43
 Function
 body 45
 comments 45
 custom 7
 decision 679
 discriminant 679
 factories 141
 function-generating 141
 H1 line 45
 handle 63, 66, 119
 anonymous 64
 named 63
 simple 63
 help text 45
 M-file 4, 10
 components of 45

M-function 4, 44
 nested, 140
 programming. *See* Programming
 subfunction 45
 windowing. *See* Windowing
 functions
 wrapper 298
 fuzzyfilt 162
 Fuzzy processing
 aggregation 135, 138
 aggregation, function for 149
 custom membership functions 143
 definitions 129
 defuzzification 136, 138
 defuzzification, function for 149
 degree of membership 129
 ELSE rule 139
 fuzzification 133
 fuzzy set 129
 general model 139
 IF-THEN rules 133
 antecedent 133
 conclusion 133
 consequent 133
 firing level 139
 premise 133
 strength level 139
 implication 134, 137
 implication, function for 147
 improving performance 151
 inference 134
 intensity transformations 155
 lambda functions 146
 linguistic value 133
 linguistic variable 133
 logical operations 137
 membership function 129, 131
 overall system function 150
 rule strength, function for 146
 spatial filtering 158
 universe of discourse 129
 using fuzzy sets 133
 fuzzysysfnc 150

G

Gaussian bandreject 199
 gca 96
 Generalized delta functions. *See*
 Image reconstruction
 Geometric transformations
 affine transformations 283
 affine matrix 284
 similarity transformations 285
 applying to images 288
 control points 306, 351
 controlling the output grid 297

forward transformation (mapping)
 278
 global transformations 306
 homogeneous coordinates 284
 horizon line 288
 image coordinate systems 291
 input space 278
 interpolation 299
 1-D 299
 2-D 302
 bicubic 302
 bilinear 302
 comparing methods 302
 cubic 302
 kernels 300
 linear 301
 nearest-neighbor 302
 resampling 300
 local transformations 306
 inverse transformation (mapping)
 279, 288
 output image location 293
 output space 278
 shape-preserving 285
 projective transformations 287
 tiles 107
 vanishing points 288
 get 56, 353
 getsequence 496
 global 430
 Gradient
 defined 366
 morphological 524
 used for edge detection. *See* Image
 segmentation
 Graphical user interface (GUI) 353
 gray2ind 325
 graycomatrix 648
 graycoprops 649
 Gray level. *See also* Intensity
 definition 2, 13, 27
 transformation function 81
 grayslice 325
 graythresh 562
 grid off 191
 grid on 191
 gscale 92

H

H1 line 45
 Handle. *See* Function handle
 help 46
 hilb 39
 Hilbert matrix 39
 hist 220
 histc 437

- histeq 100
 - Histogram. *See also* Image enhancement
 - bimodal 558
 - contrast-limited 107
 - defined 94
 - equalization 99
 - equalization of color images 359
 - matching 102
 - normalized 94
 - plotting 94
 - specification 102
 - unimodal 558
 - histroi 227
 - hold on 98
 - Hole. *See also* Morphology, Region definition 598
 - filling 520
 - Hotelling transform 662
 - hough 553
 - Hough transform. *See also* Image segmentation
 - accumulator cells 552
 - functions for computing 552
 - line detection 556
 - line linking 556
 - parameter space 551
 - houghlines 555
 - houghpeaks 555
 - hpfilt 195
 - hsi2rgb 338
 - hsv2rgb 330
 - huff2mat 440
 - huffman 429
 - hypot 187
 - Hysteresis thresholding. *See* Image segmentation
- I**
- i 55
 - i2percentile 567
 - ICC. *See* International Color Consortium
 - color profiles 346
 - iccread 347
 - ice 352
 - Icon notation. *See also* Notation custom function 7
 - MATLAB Wavelet Toolbox 377
 - Image Processing Toolbox 7
 - IDFT. *See* Inverse discrete Fourier transform
 - if 58
 - IF-THEN rule. *See* Fuzzy processing
 - ifanbeam 272
 - ifft2 172
 - ifftshift 170
 - ifrdescp 629
 - illumination bias 575
 - im2bw 29, 31
 - im2col 460
 - im2double 29
 - im2frame 473
 - im2jpeg 457
 - im2jpeg2k 466
 - im2minperpoly 617
 - im2single 29
 - im2uint8 29
 - im2uint16 29
 - imadjust 82
 - imag 170
 - Image 2
 - amplitude 2
 - analysis 3
 - as a matrix 15
 - average power 241
 - binary 27, 598
 - classes 26
 - converting between 23
 - columns 14
 - coordinates 13
 - definition 2
 - description. *See* Representation and description
 - digital 2, 14
 - displaying 18
 - dithering 323
 - element 2, 15
 - format extensions 17
 - formats 17
 - gray level. *See* Gray level, Intensity
 - gray-scale 27
 - indexed 27
 - intensity. *See* Intensity
 - interpolation. *See* Geometric transformations
 - monochrome 13
 - multispectral 666, 686
 - origin 14
 - padding 110, 118, 174
 - picture element 2
 - representation. *See* Representation and description
 - resolution 24
 - RGB 13, 27
 - rows 14
 - size 14
 - spatial coordinates 2
 - Tool 19
 - types 27
 - understanding 3
 - writing 21
 - Image compression
 - background 421
 - coding redundancy 424
 - compression ratio 421
 - decoder 421
 - encoder 421
 - error free 423
 - Huffman 427
 - code 427
 - block code 428
 - decodable 428
 - instantaneous 428
 - codes 427
 - decoding 439
 - encoding 433
 - improved gray-scale (IGS) quantization 453
 - information preserving 423
 - inverse mapper 424
 - irrelevant information 453
 - JPEG 2000 compression 464
 - coding system 464
 - subbands 464
 - JPEG compression
 - discrete cosine transform (DCT) 456
 - JPEG standard 456
 - lossless 423
 - lossless predictive coding 449
 - predictor 449
 - quantization 453
 - quantizer 424
 - reversible mappings 449
 - rms 423
 - root mean square error 423
 - spatial redundancy 446
 - interpixel redundancy 448
 - symbol coder 424
 - symbol decode 424
 - video compression 472
 - image sequences in MATLAB 473
 - motion compensation 476
 - movies in MATLAB 473
 - multiframe TIFF files 472
 - temporal redundancy 472, 476
 - video frames 472
 - Image enhancement 80, 164
 - color. *See* Color image processing
 - contrast enhancement, stretching 84, 85, 90, 529
 - frequency domain filtering 164
 - high-frequency emphasis 197
 - periodic noise removal 204
 - sharpening 194
 - smoothing 188
 - histogram
 - adaptive equalization 107
 - equalization 99
 - matching (specification) 102
 - processing 93

- intensity transformations 81
 - arbitrary 86
 - contrast-stretching 84
 - functions for computing 82, 89
 - logarithmic 84
- spatial filtering
 - geometric mean 119
 - noise reduction 127
 - sharpening 120
 - smoothing (blurring) 116
- using fuzzy sets 155
- Image Processing Toolbox 1, 4, 7
- Image reconstruction
 - absorption profile 252
 - background 252
 - backprojection 253, 259
 - center ray 268
 - computed tomography 251
 - fan-beam 259
 - fan-beam data 268
 - filter implementation 258
 - filtered projection 258
 - Fourier slice theorem 257
 - generalized delta functions 258
 - parallel-ray beam 255
 - Radon transform 254
 - Ram-Lak filter 259, 266
 - ray sum 254
 - Shepp-Logan filter 259
 - Shepp-Logan head phantom 261
 - sinogram 263
 - slice 254, 257
 - windowing functions. *See* Windowing functions
- Image registration
 - area-based 311
 - automatic registration 316
 - basic process 306
 - control points 306
 - correlation coefficient 312
 - feature detector 316
 - inferring transformation
 - parameters 307
 - inliers 317
 - manual feature selection 306
 - manual matching 306
 - mosaicking 316
 - normalized cross-correlation 312
 - outliers 317
 - similarity metrics 314
- Image restoration
 - adaptive spatial filters 233. *See also* Spatial filters
 - deconvolution 210
 - blind, 237, 250
 - direct inverse filtering 240
 - iterative 247
 - linear 210
 - Lucy-Richardson algorithm 246
 - model 210
 - noise models 211. *See also* Noise noise only 229
 - nonlinear 247
 - constrained least squares filtering 244
 - optical transfer function 210
 - parametric Wiener filter 241
 - periodic noise reduction 236
 - point spread function 210
 - pseudoinverse 240
 - spatial noise filters. *See also* Spatial filters
 - regularized filtering 244
 - Wiener filtering 240
- Image segmentation
 - edge detection 541
 - Canny detector 546
 - double edges 542, 546
 - gradient angle 541
 - gradient magnitude 541
 - gradient vector 541
 - Laplacian 542
 - Laplacian of a Gaussian (LoG) detector 545
 - location 542
 - masks 544
 - Prewitt detector 543, 545
 - Roberts detector 543, 545
 - Sobel detector 542
 - using function edge 541
 - zero crossings 543
 - zero-crossings detector 546
 - image thresholding
 - using local statistics 571
 - line detection 538
 - masks 538
 - using the Hough transform 549
 - nonmaximal suppression 546
 - oversegmentation 591
 - point detection 536
 - region-based 578
 - logical predicate 578
 - region growing 578
 - region splitting and merging 582
 - edge map 549
 - thresholding 557
 - background point 557
 - basic global thresholding 559
 - hysteresis 546
 - local statistics 571
 - object (foreground) point 557
 - Otsu's (optimum) method 561
 - separability measure 562
 - types of 558
 - using edges 567
 - using image smoothing 565
 - using moving averages 575
 - using watersheds 588
 - catchment basin 588
 - marker-controlled 593
 - using gradients 591
 - using the distance transform 589
 - watershed 588
 - watershed transform 588
- Image Tool 19
- imapprox 321
- imbothat 529
- imclearborder 521
- imclose 501
- incomplement 83
- imdilate 492
- imerode 500
- imextendedmin 595
- imfilter 114
- imfill 521, 603
- imfinfo 23
- imhist 94, 156
- imhmin 531
- imimposemin 595
- imlincomb 50
- imnoise 126, 211
- imnoise2 216
- imnoise3 221
- imopen 501
- implay 407, 474
- implfncs 147
- imratio 421
- imread 15
- imreconstruct 518
- imregionalmin 593
- imrotate 291, 659
- imshow 18, 69
- imstack2vectors 663
- imtool 19
- imtophat 529
- imtransform 288
- imtransform2 298
- imwrite 21
- ind2gray 325
- ind2rgb 326
- ind2sub 40
- Indexing 33
 - linear 39
 - logical 38
 - matrix 35
 - row-column 40
 - single colon 37
 - subscript 33
 - vector 33
- Inf 47
- InitialMagnification 510
- inpolygon 616
- input 72
- int2str 699

int8 26
 int16 26
 int32 26
 Intensity. *See also* Gray level
 definition 2, 13, 27
 scaling 92
 transformation function 81
 arbitrary 86
 contrast-stretching 84
 fuzzy 155
 histogram. *See* Histogram
 logarithmic 84
 thresholding 85
 utility M-functions 87
 transformations 80
 International Color Consortium 346
 Interpolation. *See* Geometric
 transformations
 interp1 86
 interp1q 351
 interpn 153
 intline 606
 intrans 89, 157
 invmoments 658
 iptsetpref 291
 iradon 263
 iscell 54
 iscellstr 54, 694
 ischar 54
 isempty 54
 isequal 54
 iseven 203
 isfield 54
 isfinite 54
 isinf 54
 isinteger 54
 isletter 54
 islogical 28, 54
 ismember 54
 isnan 54
 isnumeric 54
 isodd 203
 isprime 54
 isreal 54
 isscalar 54
 isspace 54
 issparse 54
 isstruct 54
 isvector 54
 Inverse discrete Fourier transform
 165

J

j 55
 jpeg2im 461
 jpeg2k2im 468
 JPEG compression 456

L

Label matrix 515
 lambdafens 146
 Laplacian
 defined 120
 mask for 121, 122
 of a Gaussian (LoG). *See* Image
 segmentation
 of color images 365
 of vectors 365
 used for edge detection. *See* Image
 segmentation
 Laplacian of a Gaussian (LoG) 545
 LaTeX-style notation 553
 length 59
 Line
 detection. *See* Image segmentation,
 Hough transform
 linking. *See* Hough transform
 normal representation 551
 slope-intercept representation 551
 Line detection. *See* Image
 segmentation
 linspace 34, 157
 load 11
 localmean 572
 localthresh 573
 log 84
 log2 84
 log10 84
 logical 26, 27
 Logical
 array 27
 class 27
 indexing 38, 216
 mask 125, 225, 587
 operator 52
 long 57
 Long lines. *See* Code
 long e 57
 long eng 57
 long g 57
 lookfor 46
 Lookup table 87, 506
 lower 201
 lpc2mat 451
 lpfilter 189
 Lucy-Richardson algorithm. *See*
 Image restoration

M

magic 44
 Magic square 44
 mahalnobis 678
 makecform 344
 makecounter 141

makefuzzyedgesys 161
 makelut 507
 maketform 279
 Mammogram 83
 manualhist 105
 Marker image 518, 567, 584, 593. *See also* Morphology
 Mask. *See* Logical mask, Spatial mask,
 Morphological
 reconstruction
 mat2gray 29, 30
 mat2huff 436
 mat2str 699
 Matching. *See* Recognition
 MAT-file 11
 MATLAB 1, 2
 background 4
 command history 9
 command window 8
 coordinate convention 14
 current directory 8
 current directory field 8
 definition 4
 desktop 7
 desktop tools 9
 editor/debugger 10
 function factories 141
 function-generating functions 141
 function plotting 93
 help 10
 help browser 10
 image coordinate systems 291
 M-file. *See* Function
 M-function. *See* Function
 nested functions. *See* Function
 plotting 190
 prompt 16
 retrieving work 11
 saving work 11
 search path 9
 string operations 692
 toolboxes 4
 workspace 8
 workspace browser 8
 Matrix
 as an image 15
 interval. *See* Morphology
 operations 47
 sparse 42
 vs. array 15
 Matrix vs. array 15
 max 48, 686
 Maximum likelihood 250
 mean 76, 517
 mean2 76, 92
 Mean vector 684
 approximation 662
 function for computing 663

medfilt2 126
 Median 126. *See also* Spatial filtering, Spatial filters
 mesh 190
 meshgrid 69
 Metacharacters 695
 mexErrMsgTxt 445
 MEX-file 442
 min 48
 Minima imposition 595
 Minimum-perimeter polygons 610, 703. *See also* Representation and description
 Moiré pattern 203
 Moment(s)
 about the mean 224
 central 224
 invariants 656
 statistical 632
 used for texture analysis 644
 Monospace characters 15
 montage 474
 Morphology, Morphological
 4-connectivity 515
 8-connectivity 515
 closing 500
 combining dilation and erosion 500
 connected component 514
 definition 515
 labeling 514
 label matrix 515
 dilation 490
 erosion 497
 filtering 503, 524, 526
 gradient 524
 gray-scale morphology
 alternating sequential filtering 526
 bottomhat transformation 529
 close-open filtering 526
 closing 524
 dilation 521
 erosion 521
 granulometry 529
 open-close filtering 526
 opening 524
 reconstruction 530
 closing-by-reconstruction 531
 h-minima transform 531
 opening-by-reconstruction 531
 tophat-by-reconstruction 532
 surface area 529
 tophat transformation 528
 hit-or-miss transformation 503
 interval matrix 506
 lookup table 506

 matching 503
 opening 500
 pruning 512
 parasitic components 512
 reconstruction 518
 clearing border objects 521
 filling holes 520
 mask 518
 marker 518
 opening by reconstruction 518
 reflection of set 488
 shrinking 512
 skeleton 511
 spurs 512
 structuring element 486, 490
 decomposition 493
 flat 522
 origin 488, 491, 492
 strel function 494
 thickening 512
 thinning 511
 translation of set 488
 view of binary images 489
 Mosaicking 316
 movie2avi 475
 movingthresh 576
 movie2tifs 475
 MPP. *See* Minimum-perimeter polygons
 mxArray 445
 mxMalloc 445
 mxCreate 445
 mxGet 445

N

NaN 47, 55
 nargchk 88
 nargin 87
 nargout 87
 ndims 42
 Neighborhood processing 80, 109
 Nested function. *See* Function
 nextpow2 175
 nlfilt 117
 Noise
 adding 211
 application areas 213
 average power 241
 density 215
 Erlang 214
 parameter
 estimating 224
 scaling 211
 exponential 214

 filters. *See* Filter(ing)
 gamma. *See* Erlang above
 Gaussian 214
 lognormal 214
 models 211
 multiplicative 211
 periodic 220
 Poisson 211, 247
 Rayleigh 212, 214
 salt and pepper 214, 215
 speckle 211
 uniform 214
 with specified distribution 212
 Noise-to-signal power ratio 241
 norm 675
 Norm. *See* Vector norm
 Normalized cross-correlation.
 See Correlation
 normxcorr2 313, 682
 NOT 53
 Notation
 colon 33
 function listing 7
 icon 7
 LaTeX-style 553
 ntrop 426
 ntsc2rgb 329
 Number
 exponential notation 56
 floating point 55
 format types 57
 precision 55
 representation 55
 numel 59

O

Object recognition. *See* Recognition
 onemf 146
 ones 44
 Operation
 array 47
 elementwise 47
 matrix 47
 Operator
 arithmetic 46
 logical 52
 relational 50
 OR 53
 elementwise 53
 scalar 53
 ordfilt2 125
 Ordering boundary points 605
 OTF (optical transfer function) 210
 otf2psf 210
 otsuthresh 564

P

padarray 118
 paddedsize 174
 Padding. *See* Image padding
 Panning 604
 para2fan 275
 patch 320
 Pattern recognition. *See* Recognition
 PDF. *See* probability density function
 Pel 2, 15. *See also* Pixel
 Percentile 567
 percentile2i 567
 permute 677
 persistent 507
 phantom 261
 pi 55
 Picture element 2, 15
 Pixel
 coordinates 14
 definition 2, 15
 pixeldup 238
 Pixel(s)
 adjacent 515
 connected 515, 597
 connecting 605
 ordering along a boundary 605
 path 515
 straight digital line between two points 606
 Pixels(s)
 orientation of triplets 612
 plot 41, 98
 Plotting 93, 98
 surface 190
 wireframe 190
 Point detection. *See* Image segmentation
 pointgrid 282
 pol2cart 621
 polyangles 704
 Polymersome cells 563
 pow2 438
 Preallocating arrays 65. *See also* Code
 Predicate
 function 585
 logical 578
 Predicate (logical) 578
 Principal components
 for data compression 667
 for object alignment 670
 transform 662
 principalcomps 664
 print 26
 Probability. *See also* Histogram
 density function 99
 for equalization 99

 specified 103
 table of 214
 of intensity level 94
 prod 119
 Programming. *See also* Code, Function
 break 61
 code optimization 65
 commenting code 45
 continue 58, 61
 floating-point numbers 55
 flow control 57
 function body 45
 function definition line 45
 H1 line 45
 help text 45
 if construct 58
 interactive I/O 71
 M-Function 44
 loops 59, 60
 number formats 57
 operators 46
 switch 62
 values 55
 variable number of inputs and outputs 87
 vectorizing 68
 wrapper function 298
 Prompt 8
 PSF (point spread function) 210
 psf2otf 210

Q

qtdecomp 584
 qtgetblk 584
 quad 64
 Quadimages 583
 Quadregions 583
 Quadtree 583
 Quantization 14
 quantize 454

R

radon 260
 Radon transform 254
 rand 44, 215
 randn 44, 215
 Random
 variable 211, 224
 number generator 213
 randvertex 704
 RANSAC 316
 real 170
 realmax 55
 realmin 55

Recognition

 decision boundary 679
 decision function 679
 decision-theoretic methods 679
 adaptive learning systems 691
 Bayes classifier 684
 correlation 681
 correlation template 681
 minimum-distance classifiers 680
 discriminant function 679
 distance measures 675
 feature 674
 hyperplane 681
 matching. *See also* Cross-correlation
 correlation 681
 minimum-distance 680
 morphological. *See* Morphology
 template 312, 681
 pattern 674
 pattern class 674
 pattern vector 674, 680
 structural methods 691
 regular expressions 694
 string matching 693, 701
 string registration 701, 704
 working with pattern strings in MATLAB 692
 reflect 492
 regexp 695
 regexpi 696
 regexprep 696
 Region
 adjacent 578
 background points 598
 border 598
 boundary 598
 contour 598
 functions for extracting 598
 interior point 59, 598
 of interest 225
 Regional descriptors.
 See Representation and description
 regiongrow 580
 Region growing. *See* Image segmentation
 Region merging. *See* Image segmentation
 regionprops 642
 Region splitting. *See* Image segmentation
 Regular expressions 694
 rem 152, 392
 Representation and description
 background 597
 description approaches 625

- boundary descriptors 625
 - axis (major, minor) 626
 - basic rectangle 626
 - corners 633
 - curvature 703
 - diameter 626
 - Fourier descriptors 627
 - length 625
 - shape numbers 626
 - statistical moments 632
 - regional descriptors
 - co-occurrence matrices 647
 - function regionprops 642
 - moment invariants 656
 - principal components 661
 - texture 644
 - region and boundary extraction 598
 - representation approaches
 - boundary segments 622
 - chain codes 606
 - Freeman chain codes 606
 - normalizing 606
 - minimum-perimeter polygons 610, 703
 - normalizing chain codes 606
 - signatures 619
 - reprototype 303
 - Resampling 300
 - reshape 401, 438
 - Resolution. *See* Image
 - return 58
 - rgb2gray 326
 - rgb2hsi 337
 - rgb2hsv 330
 - rgb2ind 325
 - rgb2ntsc 328
 - rgb2ycbcr 329
 - rgbcube 320
 - Ringing 187, 242
 - ROI. *See* Region of interest
 - roipoly 225
 - rot90 115
 - round 25
 - Row vector. *See* Vector
- S**
- Sampling
 - definition 14
 - save 11
 - Scalar 15
 - Scripts 44
 - Scrolling 604
 - seq2tifs 475
 - set 96
 - Set
 - element 128
 - fuzzy. *See* Fuzzy processing
 - theory 128
 - shading interp 193
 - Shape 597, 621, 623, 626. *See also* Representation and description
 - short 57
 - short e 57
 - short eng 57
 - short g 57
 - showmo 483
 - Sifting 112, 255
 - sigmamd 144, 156
 - signature 620
 - Signatures 619
 - single 26
 - Singleton dimension 17
 - size 16
 - Skeleton 623
 - medial axis transformation 623
 - morphological 623
 - smf 144
 - Soft proofing 347
 - sort 431
 - sortrows 604
 - sparse 42
 - Sparse matrix 42
 - Spatial
 - convolution. *See* Convolution
 - coordinates 13
 - correlation. *See* Correlation
 - domain 80, 165
 - filter. *See* Spatial filters
 - kernel 110
 - mask 110, 681
 - neighborhood 81
 - template 110, 311, 681
 - Spatial filtering 109
 - fuzzy 158
 - linear 109, 114
 - mechanics 110
 - morphological. *See* Morphology
 - nonlinear 117, 124
 - of color images 360
 - Spatial filters. *See also* Spatial filtering
 - adaptive 233
 - adaptive median 233
 - alpha-trimmed mean 230
 - arithmetic mean 230
 - average 121
 - conharmonic mean 230
 - converting to frequency domain filters 181
 - disk 121
 - gaussian 121
 - geometric mean 230
 - harmonic mean 230
 - iterative nonlinear 246
 - laplacian 121, 122. *See also* Laplacian
 - linear 120
 - log 121
 - max 126, 230
 - median 126, 230
 - midpoint 230
 - min 126, 230
 - motion 121
 - morphological. *See* Morphology
 - noise 229
 - order statistic 124. *See also* ordfilt2
 - prewitt 121
 - rank 124. *See also* ordfilt2
 - sobel 121
 - unsharp 121
 - Spectrum. *See* Fourier spectrum
 - specxtexture 655
 - spfilt 229
 - spline 352
 - splitmerge 585
 - sprintf 60
 - sqrt 64
 - Square brackets 30, 33, 35, 45
 - statmoments 225
 - statxtexture 645
 - stdfilt 572
 - stem 96
 - strcat 696
 - strcmp 73, 697
 - strncmpi 74, 400, 454, 697
 - strel 494
 - Strings. *See* Recognition
 - strel object 496
 - stretchlim 84
 - strfind 698
 - strjust 698
 - strncmp 697
 - strncmpi 698
 - stread 73
 - strep 698
 - strsimilarity 701
 - strtok 699
 - Structure 74
 - example 77
 - fields 77
 - variable 23
 - Structuring element. *See* Morphology
 - strvcat 697
 - sub2ind 40
 - subplot 384
 - Subscript 33
 - sum 37
 - surf 193
 - switch 58, 62

T

Template matching. *See* Recognition
text 96
Texture. *See also* Regional descriptors
 spectral measures of 654
 statistical approaches 644
tform structure 279, 345
tofloat 32
tformfwd 281
tforminv 281
tform structure 279
THEN 156
Thresholding. *See* Image
 segmentation
tic 65
tifs2cv 480
tifs2movie 475
tifs2seq 475
timeit 66
title 96
toc 65
Transfer function. *See* Frequency
 domain filters
Transformation function. *See*
 Intensity
transpose 33
trapezmf 143
triangmf 143, 156
true 44, 587
truncgaussmf 145
try...catch 58
twomodegauss 104
Types. *See* Image types

U

uint8 26
uint16 26
uint32 26
unique 604
unravel.c 443
unravel.m 444
Until stability 511
upper 201

V

varargin 88
varargout 88
Vector
 column 13, 15
 norm 245, 675
 row 13, 15
ver 55
version 55
Vertex

adding noise to 704
concave 612
convex 612
of minimum-perimeter polygon
 612
view 191
Vision 2
 computer 3
 high-level 3
 human 3
 low-level 3
 mid-level 3
visreg 309
vistform 283
visualizing aligned images 308

W

waitbar 151
watershed 590
Watersheds. *See* Image segmentation
waveback 409
wavecopy 402
wavecut 401
wavedec2 385
wavedisplay 404
wavefast 391
wavefilter 388
wavefun 382
waveinfo 382
Wavelets
 approximation coefficients 381
 background 377
 custom function 394
 decomposition coefficients 404
 displaying 404
 editing 399
 decomposition structures 396
 downsampling 380
 expansion coefficients 378
 FWTs using MATLAB's Wavelet
 Toolbox 381
 FWTs without the Wavelet Toolbox
 387
 Haar 383
 scaling function 383
 wavelet function 385
 wavelet functions 383
 highpass decomposition filter 380
 image processing 414
 edge detection 414
 progressive reconstruction 417
 smoothing 415
 inverse fast wavelet transform 408
 kernel 378
 lowpass decomposition filter 380
 mother wavelet 379

properties 379
scaling 380
scaling function 379
support 384
 transform domain variables 377
wavepaste 403
waverec2 409
wavework 399
wavezero 415
wfilters 381
while 58, 60
whitebg 322
whos 17
Windowing functions
 cosine 259
 Hamming 259
 Hann 259
 Ram-Lak 259
 Shep-Logan 259
 sinc 259
Wraparound error. *See* Discrete
 Fourier transform
wthcoef2 398

X

x2majoraxis 627
xlabel 96
xlim 98
xtick 96

Y

ycbr2rgb 329
ylabel 96
ylim 98
ytick 96
Z
zeromf 145
zeros 44

Z

Zero-phase-shift filters. *See*
 Frequency domain filters