



APPENDIX *Function Summary*

Preview

Section A.1 of this appendix contains a listing of all the functions in the Image Processing Toolbox, and all the new functions developed in the preceding chapters. The latter functions are referred to as *DIPUM* functions, a term derived from the first letter of the words in the title of the book. Section A.2 lists the MATLAB functions used throughout the book. All page numbers listed refer to pages in the book, indicating where a function is first used and illustrated. In some instances, more than one location is given, indicating that the function is explained in different ways, depending on the application. Some IPT functions were not used in our discussions. These are identified by a reference to online help instead of a page number. All MATLAB functions listed in Section A.2 are used in the book. Each page number in that section identifies the first use of the MATLAB function indicated.

A.1 IPT and DIPUM Functions

The following functions are loosely grouped in categories similar to those found in IPT documentation. A new category (e.g., wavelets) was created in cases where there are no existing IPT functions.

Function Category and Name	Description	Page or Other Location
Image Display		
colorbar	Display colorbar (MATLAB).	online
getimage	Get image data from axes.	online
ice (DIPUM)	Interactive color editing.	218
image	Create and display image object (MATLAB).	online
imagesc	Scale data and display as image (MATLAB).	online
immovie	Make movie from multiframe image.	online
imshow	Display image.	16
imview	Display image in Image Viewer.	online

montage	Display multiple image frames as rectangular montage.	online
movie	Play recorded movie frames (MATLAB).	online
rgbcube (DIPUM)	Display a color RGB cube.	195
subimage	Display multiple images in single figure.	online
truesize	Adjust display size of image.	online
warp	Display image as texture-mapped surface.	online

Image file I/O

dicominfo	Read metadata from a DICOM message.	online
dicomread	Read a DICOM image.	online
dicomwrite	Write a DICOM image.	online
dicom-dict.txt	Text file containing DICOM data dictionary.	online
dicomuid	Generate DICOM unique identifier.	online
imfinfo	Return information about image file (MATLAB).	19
imread	Read image file (MATLAB).	14
imwrite	Write image file (MATLAB).	18

Image arithmetic

imabsdiff	Compute absolute difference of two images.	42
imadd	Add two images, or add constant to image.	42
imcomplement	Complement image.	42, 67
imdivide	Divide two images, or divide image by constant.	42
imlincomb	Compute linear combination of images.	42, 159
immultiply	Multiply two images, or multiply image by constant.	42
imsubtract	Subtract two images, or subtract constant from image.	42

Geometric transformations

checkerboard	Create checkerboard image.	167
findbounds	Find output bounds for geometric transformation.	online
fliptform	Flip the input and output roles of a TFORM struct.	online
imcrop	Crop image.	online
imresize	Resize image.	online
imrotate	Rotate image.	472
imtransform	Apply geometric transformation to image.	188
intline	Integer-coordinate line drawing algorithm. (Undocumented IPT function).	43
makeresampler	Create resampler structure.	190
maketform	Create geometric transformation structure (TFORM).	183
pixeldup (DIPUM)	Duplicate pixels of an image in both directions.	168
tformarray	Apply geometric transformation to N-D array.	online
tformfwd	Apply forward geometric transformation.	184
tforminv	Apply inverse geometric transformation.	184
vistformfwd (DIPUM)	Visualize forward geometric transformation.	185

Image registration

cpstruct2pairs	Convert CPSTRUCT to valid pairs of control points.	online
cp2tform	Infer geometric transformation from control point pairs.	191
cpcorr	Tune control point locations using cross-correlation.	online
cpselect	Control point selection tool.	193
normxcorr2	Normalized two-dimensional cross-correlation.	online

Pixel values and statistics

corr2	Compute 2-D correlation coefficient.	online
covmatrix (DIPUM)	Compute the covariance matrix of a vector population.	476
imcontour	Create contour plot of image data.	online
imhist	Display histogram of image data.	77
impixel	Determine pixel color values.	online
improfile	Compute pixel-value cross-sections along line segments.	online
mean2	Compute mean of matrix elements.	75
pixval	Display information about image pixels.	17
regionprops	Measure properties of image regions.	463
statmoments (DIPUM)	Compute statistical central moments of an image histogram.	155
std2	Compute standard deviation of matrix elements.	415

Image analysis (includes segmentation, description, and recognition)

bayesgauss (DIPUM)	Bayes classifier for Gaussian patterns.	493
bound2eight (DIPUM)	Convert 4-connected boundary to 8-connected boundary.	434
bound2four (DIPUM)	Convert 8-connected boundary to 4-connected boundary.	434
bwboundaries	Trace region boundaries.	online
bwtraceboundary	Trace single boundary.	online
bound2im (DIPUM)	Convert a boundary to an image.	435
boundaries (DIPUM)	Trace region boundaries.	434
bsubsamp (DIPUM)	Subsample a boundary.	435
colorgrad (DIPUM)	Compute the vector gradient of an RGB image.	234
colorseg (DIPUM)	Segment a color image.	238
connectpoly (DIPUM)	Connect vertices of a polygon.	435
diameter (DIPUM)	Measure diameter of image regions.	456
edge	Find edges in an intensity image.	385
fchcode (DIPUM)	Compute the Freeman chain code of a boundary.	437
frdescp (DIPUM)	Compute Fourier descriptors.	459
graythresh	Compute global image threshold using Otsu's method.	406
hough (DIPUM)	Hough transform.	396
houghlines (DIPUM)	Extract line segments based on the Hough transform.	401
houghpeaks (DIPUM)	Detect peaks in Hough transform.	399
houghpixels (DIPUM)	Compute image pixels belonging to Hough transform bin.	401
ifrdescp (DIPUM)	Compute inverse Fourier descriptors.	459
imstack2vectors (DIPUM)	Extract vectors from an image stack.	476
invmoments (DIPUM)	Compute invariant moments of image.	472
mahalanobis (DIPUM)	Compute the Mahalanobis distance.	487
minperpoly (DIPUM)	Compute minimum perimeter polygon.	447
polyangles (DIPUM)	Compute internal polygon angles.	510
princomp (DIPUM)	Obtain principal-component vectors and related quantities.	477
qtdecomp	Perform quadtree decomposition.	413
qtgetblk	Get block values in quadtree decomposition.	413
qtsetblk	Set block values in quadtree decomposition.	online
randvertex (DIPUM)	Randomly displace polygon vertices.	510
regiongrow (DIPUM)	Perform segmentation by region growing.	409
signature (DIPUM)	Compute the signature of a boundary.	450
specxture (DIPUM)	Compute spectral texture of an image.	469
splitmerge (DIPUM)	Segment an image using a split-and-merge algorithm.	414
statxture (DIPUM)	Compute statistical measures of texture in an image.	467

<code>strsimilarity</code> (DIPUM)	Similarity measure between two strings.	509
<code>x2majoraxis</code> (DIPUM)	Align coordinate x with the major axis of a region.	457

Image Compression

<code>compare</code> (DIPUM)	Compute and display the error between two matrices.	285
<code>entropy</code> (DIPUM)	Compute a first-order estimate of the entropy of a matrix.	288
<code>huff2mat</code> (DIPUM)	Decode a Huffman encoded matrix.	301
<code>huffman</code> (DIPUM)	Build a variable-length Huffman code for symbol source.	290
<code>im2jpeg</code> (DIPUM)	Compress an image using a JPEG approximation.	319
<code>im2jpeg2k</code> (DIPUM)	Compress an image using a JPEG 2000 approximation.	327
<code>imratio</code> (DIPUM)	Compute the ratio of the bytes in two images/variables.	283
<code>jpeg2im</code> (DIPUM)	Decode an IM2JPEG compressed image.	322
<code>jpeg2k2im</code> (DIPUM)	Decode an IM2JPEG2K compressed image.	330
<code>lpc2mat</code> (DIPUM)	Decompress a 1-D lossless predictive encoded matrix.	312
<code>mat2huff</code> (DIPUM)	Huffman encodes a matrix.	298
<code>mat2lpc</code> (DIPUM)	Compress a matrix using 1-D lossless predictive coding.	312
<code>quantize</code> (DIPUM)	Quantize the elements of a UINT8 matrix.	316

Image enhancement

<code>adapthisteq</code>	Adaptive histogram equalization.	online
<code>decorrstretch</code>	Apply decorrelation stretch to multichannel image.	online
<code>gscale</code> (DIPUM)	Scale the intensity of the input image.	76
<code>histeq</code>	Enhance contrast using histogram equalization.	82
<code>intrans</code> (DIPUM)	Perform intensity transformations.	73
<code>imadjust</code>	Adjust image intensity values or colormap.	66
<code>stretchlim</code>	Find limits to contrast stretch an image.	online

Image noise

<code>imnoise</code>	Add noise to an image.	106
<code>imnoise2</code> (DIPUM)	Generate an array of random numbers with specified PDF.	148
<code>imnoise3</code> (DIPUM)	Generate periodic noise.	152

Linear and nonlinear spatial filtering

<code>adpmedian</code> (DIPUM)	Perform adaptive median filtering.	165
<code>convmtx2</code>	Compute 2-D convolution matrix.	online
<code>dftcorr</code> (DIPUM)	Perform frequency domain correlation.	491
<code>dftfilt</code> (DIPUM)	Perform frequency domain filtering.	122
<code>fspecial</code>	Create predefined filters.	99
<code>medfilt2</code>	Perform 2-D median filtering.	106
<code>imfilter</code>	Filter 2-D and N-D images.	92
<code>ordfilt2</code>	Perform 2-D order-statistic filtering.	105
<code>spfilt</code> (DIPUM)	Performs linear and nonlinear spatial filtering.	159
<code>wiener2</code>	Perform 2-D adaptive noise-removal filtering.	online

Linear 2-D filter design

<code>freqspace</code>	Determine 2-D frequency response spacing (MATLAB).	online
<code>freqz2</code>	Compute 2-D frequency response.	123
<code>fsamp2</code>	Design 2-D FIR filter using frequency sampling.	online
<code>ftrans2</code>	Design 2-D FIR filter using frequency transformation.	online
<code>fwind1</code>	Design 2-D FIR filter using 1-D window method.	online
<code>fwind2</code>	Design 2-D FIR filter using 2-D window method.	online

hpfilter (DIPUM)	Computes frequency domain highpass filters.	136
lpfilter (DIPUM)	Computes frequency domain lowpass filters.	131

Image deblurring (restoration)

deconvblind	Deblur image using blind deconvolution.	180
deconvlucy	Deblur image using Lucy-Richardson method.	177
deconvreg	Deblur image using regularized filter.	175
deconvwnr	Deblur image using Wiener filter.	171
edgetaper	Taper edges using point-spread function.	172
otf2psf	Optical transfer function to point-spread function.	142
psf2otf	Point-spread function to optical transfer function.	142

Image transforms

dct2	2-D discrete cosine transform.	321
dctmtx	Discrete cosine transform matrix.	321
fan2para	Convert fan-beam projections to parallel-beam.	online
fanbeam	Compute fan-beam transform.	online
fft2	2-D fast Fourier transform (MATLAB).	112
fftn	N-D fast Fourier transform (MATLAB).	online
fftshift	Reverse quadrants of output of FFT (MATLAB).	112
idct2	2-D inverse discrete cosine transform.	online
ifanbeam	Compute inverse fan-beam transform.	online
ifft2	2-D inverse fast Fourier transform (MATLAB).	114
ifftn	N-D inverse fast Fourier transform (MATLAB).	online
iradon	Compute inverse Radon transform.	online
para2fan	Convert parallel-beam projections to fan-beam.	online
phantom	Generate a head phantom image.	online
radon	Compute Radon transform.	online

Wavelets

wave2gray (DIPUM)	Display wavelet decomposition coefficients.	267
waveback (DIPUM)	Perform a multi-level 2-dimensional inverse FWT.	272
wavecopy (DIPUM)	Fetch coefficients of wavelet decomposition structure.	265
wavecut (DIPUM)	Set to zero coefficients in a wavelet decomposition structure.	264
wavefast (DIPUM)	Perform a multilevel 2-dimensional fast wavelet transform.	255
wavefilter (DIPUM)	Create wavelet decomposition and reconstruction filters.	252
wavepaste (DIPUM)	Put coefficients in a wavelet decomposition structure.	265
wavework (DIPUM)	Edit wavelet decomposition structures.	262
wavezero (DIPUM)	Set wavelet detail coefficients to zero.	277

Neighborhood and block processing

bestblk	Choose block size for block processing.	online
blkproc	Implement distinct block processing for image.	321
col2im	Rearrange matrix columns into blocks.	322
colfilt	Columnwise neighborhood operations.	97
im2col	Rearrange image blocks into columns.	321
nlfilter	Perform general sliding-neighborhood operations.	96

Morphological operations (intensity and binary images)

conndef	Default connectivity.	online
imbothat	Perform bottom-hat filtering.	373
imclearborder	Suppress light structures connected to image border.	366

<code>imclose</code>	Close image.	348
<code>imdilate</code>	Dilate image.	340
<code>imerode</code>	Erode image.	347
<code>imextendedmax</code>	Extended-maxima transform.	online
<code>imextendedmin</code>	Extended-minima transform.	online
<code>imfill</code>	Fill image regions and holes.	366
<code>imhmax</code>	H-maxima transform.	online
<code>imhmin</code>	H-minima transform.	374
<code>imimposemin</code>	Impose minima.	424
<code>imopen</code>	Open image.	348
<code>imreconstruct</code>	Morphological reconstruction.	363
<code>imregionalmax</code>	Regional maxima.	online
<code>imregionalmin</code>	Regional minima.	422
<code>imtophat</code>	Perform tophat filtering.	373
<code>watershed</code>	Watershed transform.	420

Morphological operations (binary images)

<code>applylut</code>	Perform neighborhood operations using lookup tables.	353
<code>bwarea</code>	Compute area of objects in binary image.	online
<code>bwareaopen</code>	Binary area open (remove small objects).	online
<code>bwdist</code>	Compute distance transform of binary image.	418
<code>bweuler</code>	Compute Euler number of binary image.	online
<code>bwhitmiss</code>	Binary hit-miss operation.	352
<code>bwlabel</code>	Label connected components in 2-D binary image.	361
<code>bwlabeln</code>	Label connected components in N-D binary image.	online
<code>bwmorph</code>	Perform morphological operations on binary image.	356
<code>bwpack</code>	Pack binary image.	online
<code>bwperim</code>	Determine perimeter of objects in binary image.	445
<code>bwselect</code>	Select objects in binary image.	online
<code>bwulterode</code>	Ultimate erosion.	online
<code>bwunpack</code>	Unpack binary image.	online
<code>endpoints (DIPUM)</code>	Compute end points of a binary image.	354
<code>makelut</code>	Construct lookup table for use with <code>applylut</code> .	353

Structuring element (STREL) creation and manipulation

<code>getheight</code>	Get strel height.	online
<code>getneighbors</code>	Get offset location and height of strel neighbors.	online
<code>getnhood</code>	Get strel neighborhood.	online
<code>getsequence</code>	Get sequence of decomposed strels.	342
<code>isflat</code>	Return true for flat strels.	online
<code>reflect</code>	Reflect strel about its center.	online
<code>strel</code>	Create morphological structuring element.	341
<code>translate</code>	Translate strel.	online

Region-based processing

<code>histroi (DIPUM)</code>	Compute the histogram of an ROI in an image.	156
<code>poly2mask</code>	Convert ROI polygon to mask.	online
<code>roicolor</code>	Select region of interest, based on color.	online
<code>roifill</code>	Smoothly interpolate within arbitrary region.	online
<code>roifilt2</code>	Filter a region of interest.	online
<code>roipoly</code>	Select polygonal region of interest.	156

Colormap manipulation

brighten	Brighten or darken colormap (MATLAB).	online
cmpermute	Rearrange colors in colormap.	online
cmunique	Find unique colormap colors and corresponding image.	online
colormap	Set or get color lookup table (MATLAB).	132
imapprox	Approximate indexed image by one with fewer colors.	198
rgbplot	Plot RGB colormap components (MATLAB).	online

Color space conversions

applycform	Apply device-independent color space transformation.	online
hsv2rgb	Convert HSV values to RGB color space (MATLAB).	206
iccread	Read ICC color profile.	online
lab2double	Convert L*a*b* color values to class double.	online
lab2uint16	Convert L*a*b* color values to class uint16.	online
lab2uint8	Convert L*a*b* color values to class uint8.	online
makecform	Create device-independent color space transform structure.	online
ntsc2rgb	Convert NTSC values to RGB color space.	205
rgb2hsv	Convert RGB values to HSV color space (MATLAB).	206
rgb2ntsc	Convert RGB values to NTSC color space.	204
rgb2ycbcr	Convert RGB values to YCBCR color space.	205
ycbcr2rgb	Convert YCBCR values to RGB color space.	205
rgb2hsi (DIPUM)	Convert RGB values to HSI color space.	212
hsi2rgb (DIPUM)	Convert HSI values to RGB color space.	213
whitepoint	Returns XYZ values of standard illuminants.	online
xyz2double	Convert XYZ color values to class double.	online
xyz2uint16	Convert XYZ color values to class uint16.	online

Array operations

circshift	Shift array circularly (MATLAB).	433
dftuv (DIPUM)	Compute meshgrid arrays.	128
padarray	Pad array.	97
paddedsize (DIPUM)	Compute the minimum required pad size for use in FFTs.	117

Image types and type conversions

changeclass	Change the class of an image (undocumented IPT function).	72
dither	Convert image using dithering.	199
gray2ind	Convert intensity image to indexed image.	201
grayscale	Create indexed image from intensity image by thresholding.	201
im2bw	Convert image to binary image by thresholding.	26
im2double	Convert image array to double precision.	26
im2java	Convert image to Java image (MATLAB).	online
im2java2d	Convert image to Java buffered image object.	online
im2uint8	Convert image array to 8-bit unsigned integers.	26
im2uint16	Convert image array to 16-bit unsigned integers.	26
ind2gray	Convert indexed image to intensity image.	201
ind2rgb	Convert indexed image to RGB image (MATLAB).	202
label2rgb	Convert label matrix to RGB image.	online
mat2gray	Convert matrix to intensity image.	26
rgb2gray	Convert RGB image or colormap to grayscale.	202
rgb2ind	Convert RGB image to indexed image.	200

Miscellaneous

conwaylaws (DIPUM)	Apply Conway's genetic laws to a single pixel.	355
manualhist (DIPUM)	Generate a 2-mode histogram interactively.	87
twomodegauss (DIPUM)	Generate a 2-mode Gaussian function.	86
uintlut	Compute new array values based on lookup table.	online

Toolbox preferences

iptgetpref	Get value of Image Processing Toolbox preference.	online
iptsetpref	Set value of Image Processing Toolbox preference.	online

A.2 MATLAB Functions

The following MATLAB functions, listed alphabetically, are used in the book. See the pages indicated and/or online help for additional details.

MATLAB Function	Description	Pages
A		
abs	Absolute value and complex magnitude.	112
all	Test to determine if all elements are nonzero.	46
ans	The most recent answer.	48
any	Test for any nonzeros.	46
axis	Axis scaling and appearance.	78
B		
bar	Bar chart.	77
bin2dec	Binary to decimal number conversion.	300
blanks	A string of blanks.	499
break	Terminate execution of a for loop or while loop.	49
C		
cart2pol	Transform Cartesian coordinates to polar or cylindrical.	451
cat	Concatenate arrays.	195
ceil	Round toward infinity.	114
cell	Create cell array.	292
celldisp	Display cell array contents.	293, 428
cellfun	Apply a function to each element in a cell array.	428
cellplot	Graphically display the structure of cell arrays.	293
cellstr	Create cell array of strings from character array.	499
char	Create character array (string).	61, 499
circshift	Shift array circularly.	433
colon	Colon operator.	31, 41
colormap	Set and get the current colormap.	132, 199
computer	Identify information about computer on which MATLAB is running.	48
continue	Pass control to the next iteration of for or while loop.	49
conv2	Two-dimensional convolution.	257

<code>ctranspose</code>	Vector and matrix complex transpose. (See <code>transpose</code> for real data.)	41
<code>cumsum</code>	Cumulative sum.	82
D		
<code>dec2base</code>	Decimal number to base conversion.	508
<code>dec2bin</code>	Decimal to binary number conversion.	298
<code>diag</code>	Diagonal matrices and diagonals of a matrix.	239
<code>diff</code>	Differences and approximate derivatives.	373
<code>dir</code>	Display directory listing.	284
<code>disp</code>	Display text or array.	59
<code>double</code>	Convert to double precision.	24
E		
<code>edit</code>	Edit or create an M-file.	40
<code>eig</code>	Find eigenvalues and eigenvectors.	478
<code>end</code>	Terminate <code>for</code> , <code>while</code> , <code>switch</code> , <code>try</code> , and <code>if</code> statements or indicate last index.	31
<code>eps</code>	Floating-point relative accuracy.	48, 69
<code>error</code>	Display error message.	50
<code>eval</code>	Execute a string containing a MATLAB expression.	501
<code>eye</code>	Identity matrix.	494
F		
<code>false</code>	Create false array. Shorthand for <code>logical(0)</code> .	38, 410
<code>feval</code>	Function evaluation.	415
<code>fft2</code>	Two-dimensional discrete Fourier transform.	112
<code>fftshift</code>	Shift zero-frequency component of DFT to center of spectrum.	112
<code>fieldnames</code>	Return field names of a structure, or property names of an object.	284
<code>figure</code>	Create a figure graphics object.	18
<code>find</code>	Find indices and values of nonzero elements.	147
<code>fliplr</code>	Flip matrices left-right.	472
<code>flipud</code>	Flip matrices up-down.	472
<code>floor</code>	Round towards minus infinity.	114
<code>for</code>	Repeat a group of statements a fixed number of times.	49
<code>full</code>	Convert sparse matrix to full matrix.	396
G		
<code>gca</code>	Get current axes handle.	78
<code>get</code>	Get object properties.	218
<code>getfield</code>	Get field of structure array.	540
<code>global</code>	Define a global variable.	292
<code>grid</code>	Grid lines for two- and three-dimensional plots.	132
<code>guidata</code>	Store or retrieve application data.	539
<code>guide</code>	Start the GUI Layout Editor.	528
H		
<code>help</code>	Display help for MATLAB functions in Command Window.	39
<code>hist</code>	Compute and/or display histogram.	150
<code>histc</code>	Histogram count.	299
<code>hold on</code>	Retain the current plot and certain axis properties.	81

I

<code>if</code>	Conditionally execute statements.	49
<code>ifft2</code>	Two-dimensional inverse discrete Fourier transform.	114
<code>ifftshift</code>	Inverse FFT shift.	114
<code>imag</code>	Imaginary part of a complex number.	115
<code>int16</code>	Convert to signed integer.	24
<code>inpolygon</code>	Detect points inside a polygonal region.	446
<code>input</code>	Request user input.	60
<code>int2str</code>	Integer to string conversion.	506
<code>int32</code>	Convert to signed integer.	24
<code>int8</code>	Convert to signed integer.	24
<code>interp1q</code>	Quick 1-D linear interpolation.	217
<code>inv</code>	Compute matrix inverse.	403
<code>is*</code>	See Table 2.9.	48
<code>iscellstr</code>	Determine if item is a cell array of strings.	48, 501
<code>islogical</code>	Determine if item is a logical array.	25

L

<code>ldivide</code>	Array left division. (See <code>mldivide</code> for matrix left division.)	41
<code>length</code>	Length of vector.	51
<code>linspace</code>	Generate linearly spaced vectors.	32
<code>load</code>	Load workspace variables from disk.	309
<code>log</code>	Natural logarithm.	68
<code>log10</code>	Base 10 logarithm.	68
<code>log2</code>	Base 2 logarithm.	68
<code>logical</code>	Convert numeric values to logical.	25
<code>lookfor</code>	Search for specified keyword in all help entries.	40
<code>lower</code>	Convert string to lower case.	62

M

<code>magic</code>	Generate magic square.	38
<code>mat2str</code>	Convert a matrix into a string.	507
<code>max</code>	Maximum element of an array.	42
<code>mean</code>	Average or mean value of arrays.	362
<code>median</code>	Median value of arrays.	105
<code>mesh</code>	Mesh plot.	132
<code>meshgrid</code>	Generate X and Y matrices for three-dimensional plots.	55
<code>mfilename</code>	The name of the currently running M-file.	533
<code>min</code>	Minimum element of an array.	42
<code>minus</code>	Array and matrix subtraction.	41
<code>mldivide</code>	Matrix left division. (See <code>ldivide</code> for array left division.)	41
<code>mpower</code>	Matrix power. (See function <code>power</code> for array power.)	41
<code>mrdivide</code>	Matrix right division. (See <code>rdivide</code> for array right division.)	41
<code>mtimes</code>	Matrix multiplication. (See <code>times</code> for array multiplication).	41

N

<code>nan</code> or <code>NaN</code>	Not-a-number.	48
<code>nargchk</code>	Check number of input arguments.	71
<code>nargin</code>	Number of input function arguments.	71
<code>nargout</code>	Number of output function arguments.	71

<code>ndims</code>	Number of array dimensions.	37
<code>nextpow2</code>	Next power of two.	117
<code>norm</code>	Vector and matrix norm.	485
<code>numel</code>	Number of elements in an array.	51

O

<code>ones</code>	Generate array of ones.	38
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P

<code>patch</code>	Create patch graphics object.	196
<code>permute</code>	Rearrange the dimensions of a multidimensional array.	486
<code>persistent</code>	Define persistent variable.	353
<code>pi</code>	Ratio of a circle's circumference to its diameter.	48
<code>plot</code>	Linear 2-D plot.	80
<code>plus</code>	Array and matrix addition.	41
<code>pol2cart</code>	Transform polar or cylindrical coordinates to Cartesian.	451
<code>pow2</code>	Base 2 power and scale floating-point numbers.	300
<code>power</code>	Array power. (See <code>mpower</code> for matrix power.)	41
<code>print</code>	Print to file or to hardcopy device.	23
<code>prod</code>	Product of array elements.	98

R

<code>rand</code>	Uniformly distributed random numbers and arrays.	38, 145
<code>randn</code>	Normally distributed random numbers and arrays.	38, 147
<code>rdivide</code>	Array right division. (See <code>mrdivide</code> for matrix right division.)	41
<code>real</code>	Real part of complex number.	115
<code>realmax</code>	Largest floating-point number that your computer can represent.	48
<code>realmin</code>	Smallest floating-point number that your computer can represent.	48
<code>regex</code>	Match regular expression.	502
<code>regexpi</code>	Match regular expression, ignoring case.	503
<code>regexprep</code>	Replace string using regular expression.	503
<code>rem</code>	Remainder after division.	256
<code> repmat</code>	Replicate and tile an array.	264
<code>reshape</code>	Reshape array.	300
<code>return</code>	Return to the invoking function.	49
<code>rot90</code>	Rotate matrix multiples of 90 degrees.	94
<code>round</code>	Round to nearest integer.	22

S

<code>save</code>	Save workspace variables to disk.	301
<code>set</code>	Set object properties.	78
<code>setfield</code>	Set field of structure array.	546
<code>shading</code>	Set color shading properties. We use the <code>interp</code> mode in the book.	135
<code>sign</code>	Signum function.	326
<code>single</code>	Convert to single precision.	24
<code>size</code>	Return array dimensions.	15
<code>sort</code>	Sort elements in ascending order.	293
<code>sortrows</code>	Sort rows in ascending order.	433

<code>sparse</code>	Create sparse matrix.	395
<code>spline</code>	Cubic spline data interpolation.	218
<code>sprintf</code>	Write formatted data to a string.	52
<code>stem</code>	Plot discrete sequence data.	79
<code>str*</code>	String operations. See Table 12.2.	500
<code>str2num</code>	String to number conversion.	60
<code>strcat</code>	String concatenation.	503
<code>strcmp</code>	Compare strings.	62, 504
<code>strcmpi</code>	Compare strings ignoring case.	504
<code>strfind</code>	Find one string within another.	505
<code>strjust</code>	Justify a character array.	505
<code>strmatch</code>	Find possible matches for a string.	505
<code>strncmp</code>	Compare the first n characters of two strings.	504
<code>strncmppi</code>	Compare first n characters of strings ignoring case.	316, 505
<code>strread</code>	Read formatted data from a string.	61
<code>strep</code>	String search and replace.	506
<code>strtok</code>	First token in string.	506
<code>strvcat</code>	Vertical concatenation of strings.	504
<code>subplot</code>	Subdivide figure window into array of axes or subplots.	249
<code>sum</code>	Sum of array elements.	35
<code>surf</code>	3-D shaded surface plot.	134
<code>switch</code>	Switch among several cases based on expression.	49

T

<code>text</code>	Create text object.	79
<code>tic, toc</code>	Stopwatch timer.	57
<code>times</code>	Array multiplication. (See <code>mtimes</code> for matrix multiplication.)	41
<code>title</code>	Add title to current graphic.	79
<code>transpose</code>	Matrix or vector transpose. (See <code>ctranspose</code> for complex data.)	30, 41
<code>true</code>	Create true array. Shorthand for <code>logical(1)</code> .	38, 410
<code>try...catch</code>	See Table 2.11.	49

U

<code>uicontrol</code>	Create user interface control object.	534
<code>uint16</code>	Convert to unsigned integer.	24
<code>uint32</code>	Convert to unsigned integer.	24
<code>uint8</code>	Convert to unsigned integer.	24
<code>uiresume</code>	Control program execution.	540
<code>uiwait</code>	Control program execution.	540
<code>uminus</code>	Unary minus.	41
<code>uplus</code>	Unary plus.	41
<code>unique</code>	Unique elements of a vector.	433
<code>upper</code>	Convert string to upper case.	62

V

<code>varargin</code>	Pass a variable number of arguments.	72
<code>varargout</code>	Return a variable number of arguments.	72
<code>version</code>	Get MATLAB version number.	48
<code>view</code>	Viewpoint specification.	132

W

warning	Display warning message.	159
while	Repeat statements an indefinite number of times.	49
whitebg	Change background color.	198
whos	List variables in the workspace.	16

X

xlabel	Label the x-axis.	79
xlim	Set or query x-axis limits.	80
xor	Exclusive or.	46
xtick	Set horizontal axis tick.	78

Y

ylabel	Label the y-axis.	79
ylim	Set or query y-axis limits.	80
ytick	Set vertical axis tick.	78

Z

zeros	Generate array of zeros.	38
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