

Image Processing Toolbox 6

Perform image processing, analysis, and algorithm development

Image Processing Toolbox provides a comprehensive set of reference-standard algorithms and graphical tools for image processing, analysis, visualization, and algorithm development. You can restore noisy or degraded images, enhance images for improved intelligibility, extract features, analyze shapes and textures, and register two images. Most toolbox functions are written in the open MATLAB® language, giving you the ability to inspect the algorithms, modify the source code, and create your own custom functions.

Image Processing Toolbox supports engineers and scientists in areas such as biometrics, remote sensing, surveillance, gene expression, microscopy, semiconductor testing, image sensor design, color science, and materials science. It also facilitates the learning and teaching of image processing techniques.

Working with Image Processing Toolbox

Image Processing Toolbox supports images generated by a wide range of devices, including digital cameras, frame grabbers, satellite and airborne sensors, medical imaging devices, microscopes, telescopes, and other scientific instruments. You can visualize, analyze, and process these images in many data types, including single- and double-precision floating-point and signed or unsigned 8-, 16-, and 32-bit integers.

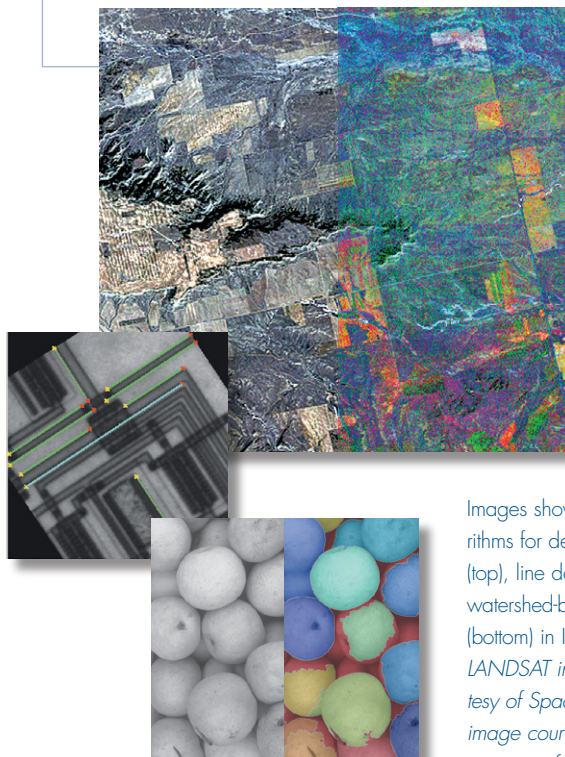
Importing and Exporting Images

There are several ways to import or export images into and out of the MATLAB environment for processing. You can use Image Acquisition Toolbox (available separately) to acquire live images from Web cameras, frame grabbers, DCAM-compatible cameras, and other devices. Using Database Toolbox (also available separately), you can access images stored in ODBC/JDBC-compliant databases.



KEY FEATURES

- Image enhancement, including filtering, filter design, deblurring, and contrast enhancement
- Image analysis, including feature detection, morphology, segmentation, and measurement
- Spatial transformations and image registration
- Image transforms, including FFT, DCT, Radon, and fan-beam projection
- Support for multidimensional image processing
- Support for ICC version 4 color management system
- Modular interactive tools, including ROI selections, histograms, and distance measurements
- Interactive image and video display
- DICOM import and export



Images showing the results of algorithms for decorrelation stretching (top), line detection (center), and watershed-based segmentation (bottom) in Image Processing Toolbox. LANDSAT image of Montana courtesy of Space Imaging, LLC. Circuit image courtesy of MIT. Pears image courtesy of Corel.

MATLAB supports standard data and image formats, including JPEG, TIFF, PNG, HDF, HDF-EOS, FITS, Microsoft Excel, ASCII, and binary files. It also supports multiband image formats, such as LANDSAT. Low-level I/O functions enable you to develop custom routines for working with any data format.

Image Processing Toolbox supports a number of specialized image file formats. For medical images, it supports the DICOM file format, including associated metadata, as well as the Analyze 7.5 and Interfile formats. The toolbox can also read geospatial images in the NITF format and high dynamic range images in the HDR format.

Pre- and Post-Processing Images

Image Processing Toolbox provides reference-standard algorithms for pre- and post-processing tasks that solve frequent system problems, such as interfering noise, low dynamic range, out-of-focus optics, and the difference in color representation between input and output devices.

Enhancing Images

Image enhancement techniques in Image Processing Toolbox enable you to increase the signal-to-noise ratio and accentuate image features by modifying the colors or intensities of an image. You can:

- Perform histogram equalization
- Perform decorrelation stretching
- Remap the dynamic range
- Adjust the gamma value
- Perform linear, median, or adaptive filtering

The toolbox includes specialized filtering routines and a generalized multidimensional filtering function that handles integer image types, multiple boundary padding options, and convolution and correlation. Predefined filters and functions for designing and implementing your own linear filters are also provided.

Deblurring Images

Image Processing Toolbox supports several fundamental deblurring algorithms, including blind, Lucy-Richardson, Wiener, and regularized filter deconvolution, as well as conversions between point spread and optical transfer functions. These functions help correct blurring caused by out-of-focus optics, movement by the camera or the subject during image capture, atmospheric conditions, short exposure time, and other factors. All deblurring functions work with multidimensional images.

Managing Device-Independent Color

Image Processing Toolbox enables you to accurately represent color independently from input and output devices. This is useful when analyzing the characteristics of a device, quantitatively measuring color accuracy, or developing algorithms for several different devices. With specialized functions in the toolbox, you can convert images between device-independent color spaces, such as sRGB, XYZ, xyY, L*a*b*, uvL, and L*ch.

Original image of rice grains with nonuniform background intensity.

Extraction of nonuniform background intensity using morphological opening.

Result of subtraction of non-uniformity from original.

Result of automatic thresholding with Otsu's method.

Each rice grain labeled as a unique object.

Histogram of grains sorted by size.

A typical session using MATLAB and Image Processing Toolbox to perform connected components analysis on an image with non-uniform background intensity.

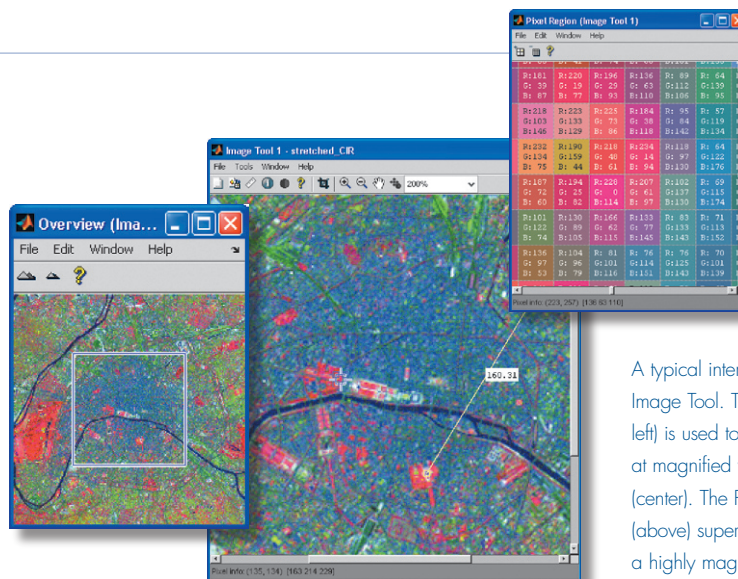
For more flexibility and control, the toolbox supports profile-based color space conversions using a color management system based on ICC version 4. For example, you can import n -dimensional ICC color profiles, create new or modify existing ICC color profiles for specific input and output devices, specify the rendering intent, and find all compliant profiles on your machine.

Image Transforms

Transforms such as FFT and DCT play a critical role in many image processing tasks, including image enhancement, analysis, restoration, and compression. Image Processing Toolbox provides several image transforms, including DCT, Radon, and fan-beam projection. You can reconstruct images from parallel-beam and fan-beam projection data (common in tomography applications). Image transforms are also available in MATLAB and in Wavelet Toolbox (available separately).

Image Conversions

Imaging applications often require conversion between data classes and image types. Image Processing Toolbox provides a variety of utilities for conversion between data classes, including single- and double-precision floating-point and signed or unsigned 8-, 16-, and 32-bit integers. The toolbox includes algorithms for conversion between image types, including binary, grayscale, indexed color, and truecolor. Specifically for color images, the toolbox supports a variety of color spaces such as YIQ, HSV, and YCrCb, Bayer pattern encoded, and high dynamic range images.



A typical interactive session using Image Tool. The Overview window (far left) is used to navigate when looking at magnified views in the Image Tool (center). The Pixel Region window (above) superimposes pixel values on a highly magnified view. *LANDSAT image of Paris courtesy of Space Imaging, LLC.*

Analyzing Images

Image Processing Toolbox provides a comprehensive suite of reference-standard algorithms and graphical tools for image analysis tasks such as statistical analysis, feature extraction, and property measurement.

Statistical functions let you analyze the general characteristics of an image by:

- Computing the mean or standard deviation
- Determining the intensity values along a line segment
- Displaying an image histogram
- Plotting a profile of intensity values

Edge-detection algorithms let you identify object boundaries in an image. These algorithms include the Sobel, Prewitt, Roberts, Canny, and Laplacian of Gaussian methods. The powerful Canny method can detect true weak edges without being “fooled” by noise.

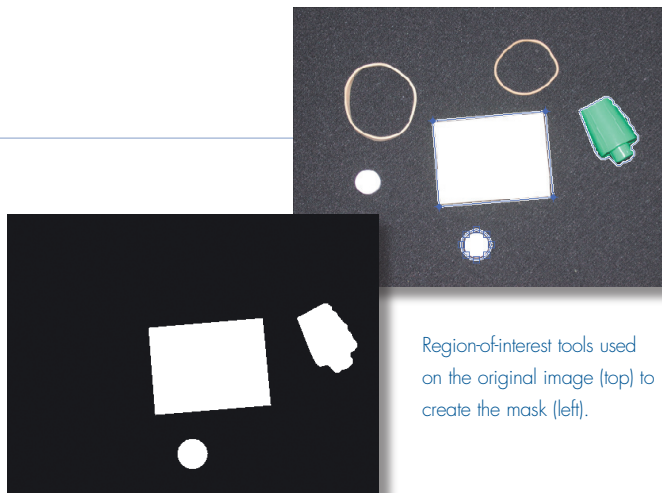
Image segmentation algorithms determine region boundaries in an image. You can explore many different approaches to image segmentation, including automatic thresholding, edge-based methods, and morphology-based methods such as the watershed transform, often used to segment touching objects.

Morphological operators enable you to detect edges, enhance contrast, remove noise, segment an image into regions, thin regions, or perform skeletonization on regions. Morphological functions in Image Processing Toolbox include:

- Erosion and dilation
- Opening and closing
- Labeling connected components
- Watershed segmentation
- Reconstruction
- Distance transform

Image Processing Toolbox also contains advanced image analysis functions that let you:

- Measure the properties of a specified image region, such as the area, center of mass, and bounding box
- Detect lines and extract lines segments from an image using the Hough transform
- Measure properties, such as surface roughness or color variation, using texture analysis functions

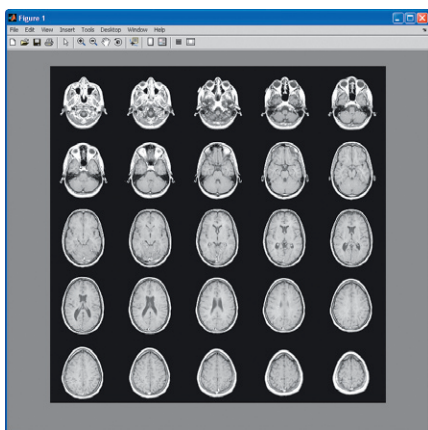


Region-of-interest tools used on the original image (top) to create the mask (left).

Displaying and Exploring Images and Video

Image Processing Toolbox provides a suite of tools for interactive image display and exploration. You can load an image from a file or from the MATLAB workspace, view image information, adjust the contrast, closely examine a region of pixels, and zoom and pan around the image. You can interactively place and manipulate ROIs, including points, lines, rectangles, polygons, ellipses, and freehand shapes. You can also interactively crop, create histograms and contours, and measure distances.

The toolbox includes tools for displaying video and sequences in either a time-lapsed video viewer or image montage. Volume visualization tools in MATLAB let you create isosurface displays of multidimensional image data sets.



A display of MRI slices using the montage function, which provides a flexible way to view a series of images in one display window.

Spatial Transformations and Image Registration

Spatial transformations alter the spatial relationships between pixels in an image by mapping locations in an input image to new locations in an output image. Image Processing Toolbox supports common transformational operations, such as resizing, rotating, and interactive cropping of images, as well as geometric transformations with arbitrary-dimensional arrays.

Image registration is important in remote sensing, medical imaging, and other applications where images must be aligned to enable quantitative analysis. Using Image Processing Toolbox, you can interactively select points in a pair of images and align the two images by performing a spatial transformation, such as linear conformal, affine, projective, polynomial, piecewise linear, or local weighted mean. You can also perform image registration using normalized 2-D cross-correlation.

Required Products

MATLAB

Related Products

Image Acquisition Toolbox. Acquire images and video from industry-standard hardware

Mapping Toolbox. Analyze and visualize geographic information

Signal Processing Toolbox. Perform signal processing, analysis, and algorithm development

Video and Image Processing Blockset.

Design and simulate video and image processing systems

For more information on related products, visit www.mathworks.com/products/image

Platform and System Requirements

For platform and system requirements, visit www.mathworks.com/products/image ■

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