

Image Processing Toolbox 5

Perform image processing, analysis, visualization, and algorithm development

The 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. This means that you can inspect the algorithms, modify the source code, and create your own custom functions.

The 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 the Image Processing Toolbox

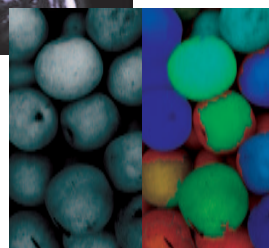
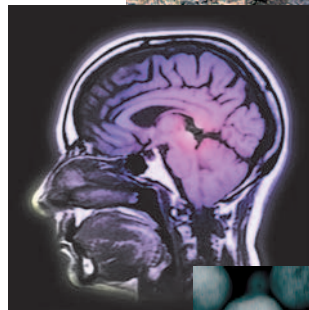
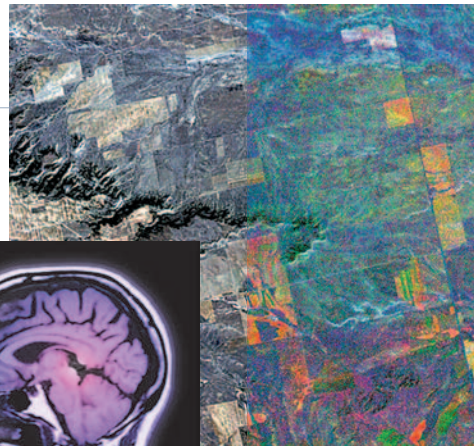
The Image Processing Toolbox supports images generated by a wide range of devices, including digital cameras, frame grabbers, satellite and airborne sensors, medical imaging devices, microscopes, telescopes, and other scientific instruments. You can visualize, analyze, and process these images in many 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 the Image Acquisition Toolbox (available separately) to acquire live images from Web cameras, frame grabbers, DCAM-compatible cameras, and other devices. Using the Database Toolbox (also available separately), you can access images stored in ODBC/JDBC-compliant databases.

KEY FEATURES

- Image enhancement, including linear and nonlinear filtering, filter design, deblurring, and automatic contrast enhancement
- Image analysis, including texture analysis, line detection, morphology, edge detection, segmentation, region-of-interest (ROI) processing, and feature measurement
- Color image processing, including color space conversions and device-independent ICC profile import and export
- Spatial transformations and image registration, including a graphical tool for control-point selection
- Image transforms, including FFT, DCT, Radon, and fan-beam projection
- DICOM import and export
- Interactive image display and modular tools for building image GUIs
- Support for multidimensional image processing



The Image Processing Toolbox includes algorithms for decorrelation stretching (top), color image processing (center), and watershed-based segmentation (bottom). Pears image courtesy of Corel. LANDSAT image of Montana courtesy of Space Imaging, LLC.

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.

For medical imaging, the Image Processing Toolbox supports the DICOM file format. You can read and write DICOM images and associated metadata and create custom data dictionaries in MATLAB.

Pre- and Post-Processing Images

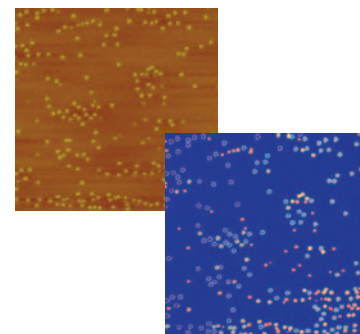
The Image Processing Toolbox provides reference-standard algorithms for pre- and post-processing tasks that solve frequent system problems, such as interfering noise, low dynamic range, out-of-focus optics, and the difference in color representation between input and output devices.

Enhancing Images

Image enhancement techniques in the 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:

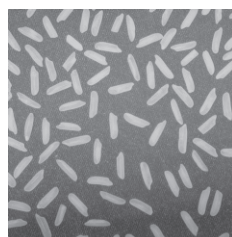
- Perform histogram equalization
- Perform decorrelation stretching
- Remap the dynamic range
- Adjust the gamma value
- Perform linear, median, or adaptive filtering

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.

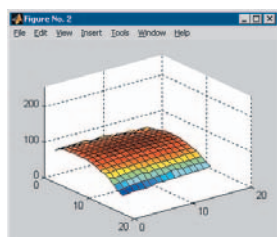


WATERSHED SEGMENTED IMAGE
Image courtesy of Ian Farrer, University of Cambridge.

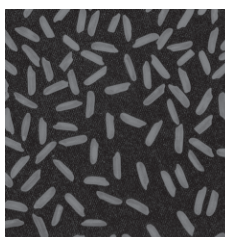
Atomic force microscope image of quantum semiconductor dots formed during the deposition of indium arsenide onto gallium arsenide (left) and the image segmented using the watershed transform in the Image Processing Toolbox (right).



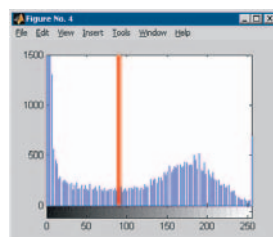
Original image of rice grains with nonuniform background intensity.



Extraction of nonuniform background intensity using morphological opening.



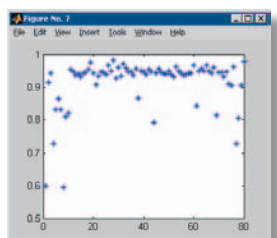
Result of subtraction of nonuniformity from original.



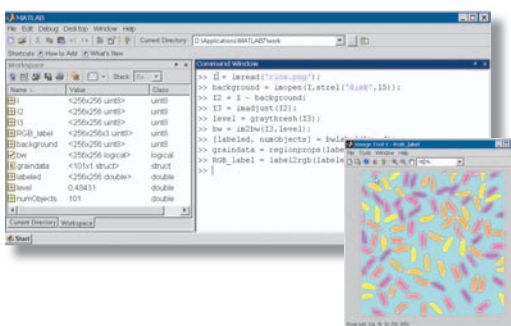
Histogram plot of resultant image with automatic thresholding.



Binary thresholded image.



Measuring region properties, such as the eccentricity of the rice grains.



A typical interactive session using MATLAB and the Image Processing Toolbox to perform connected components analysis on an image with nonuniform background intensity.

Deblurring Images

The 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

The Image Processing Toolbox enables you to accurately represent color independently from input and output devices. This is useful when developing algorithms for several different devices or when analyzing the characteristics of a particular device. Specialized functions in the toolbox let you:

- Convert images between color spaces, such as RGB, sRGB, YCrCb, XYZ, Lab, and HSV
- Import n-dimensional ICC color profiles to convert images to a device-independent color space
- Create new ICC color profiles for specific input and output devices
- Apply user-defined colormaps to RGB images to reduce the number of colors

Image Transforms

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

Analyzing Images

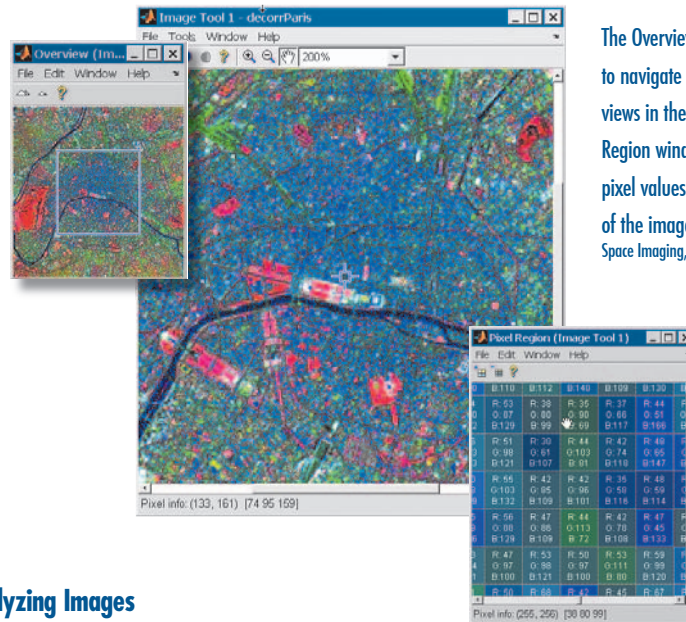
The Image Processing Toolbox provides a comprehensive suite of reference-standard algorithms and graphical tools for image analysis tasks such as statistical analysis, feature extraction, and property measurement.

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 or 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.



The Overview window (top left) is used to navigate when looking at magnified views in the Image Tool (center). The Pixel Region window (bottom) superimposes pixel values on a highly magnified view of the image. LANDSAT image of Paris courtesy of Space Imaging, LLC.

Morphological operators enable you to detect edges, enhance contrast, remove noise, segment an image into regions, thin regions, or perform skeletonization on regions.

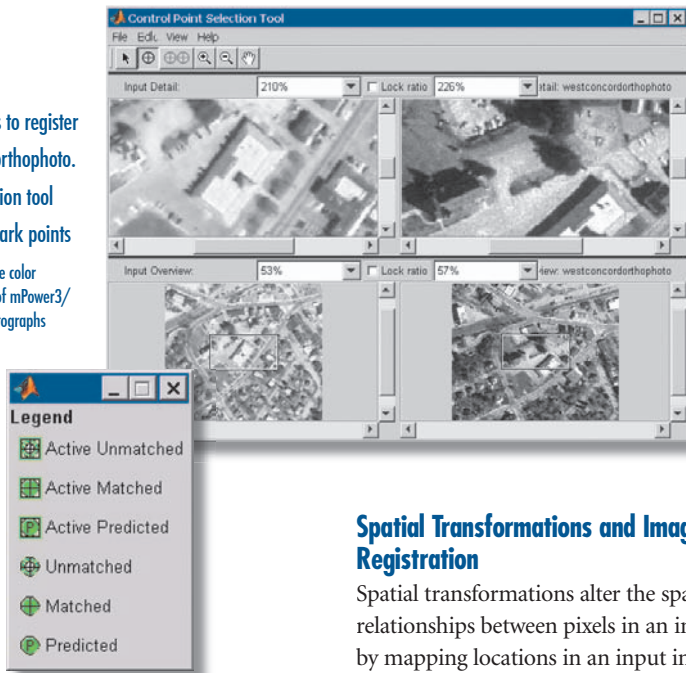
Morphological functions in the Image Processing Toolbox include:

- Hole filling
- Peak and valley detection
- Watershed segmentation
- Reconstruction
- Distance transform

The 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

Choosing control points to register an aerial photo to an orthophoto. The control point selection tool helps you select landmark points and align images. Visible color aerial photographs courtesy of mPower3/Emerge. Orthoregistered photographs courtesy of MassGIS.



Visualizing Images

The Image Processing Toolbox provides an integrated environment for interactive image display and exploration. You can load an image from a file or from the MATLAB workspace, adjust the contrast, examine a region of pixels, view image information, zoom and pan around the image, and track your location in a large image using an overview window. The image display environment is modular and open, enabling you to customize the tools provided and add your own.

MATLAB visualization tools let you represent the information in your image data as histograms, contour plots, montages, pixel profiles, transparent overlays, and images that are texture-mapped onto surfaces. You can view and measure image attributes, such as the location and value of pixels in an image, or display color bars to view the mapping of colors to values. Volume visualization tools in MATLAB let you create isosurface displays of multidimensional image data sets.

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. The 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 the 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.

Developing Algorithms

MATLAB and the Image Processing Toolbox provide a comprehensive platform for interacting with image data and developing image processing algorithms. The toolbox adds reference-standard image processing and analysis algorithms and image-specific graphical tools to the high-level language, basic mathematical functions, development tools, and visualization capabilities of MATLAB.

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 and components

Platform and System Requirements

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

For demos, application examples, tutorials, user stories, and pricing:

- Visit www.mathworks.com

- Contact The MathWorks directly

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