TeraSoft
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Image Processing with MATLAB®

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Application Engineer

MathWorks
Accelerating the pace of engineering and science

Why should you use MATLAB for image processing ?

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Since…

Image data is formed by matrix

- which is specific suitable for MATLAB doing vector/matrix arithmetic operation

Great environment for developing algorithm to work interactively with your image/video data

- Workspace
- Visualization
- GUI Tool (APP)

Easy Way of Programming

- Abundant functions with verified and trusted algorithms
- Fewer low-level details required to manage than C/C++
- Without compilation step for debugging

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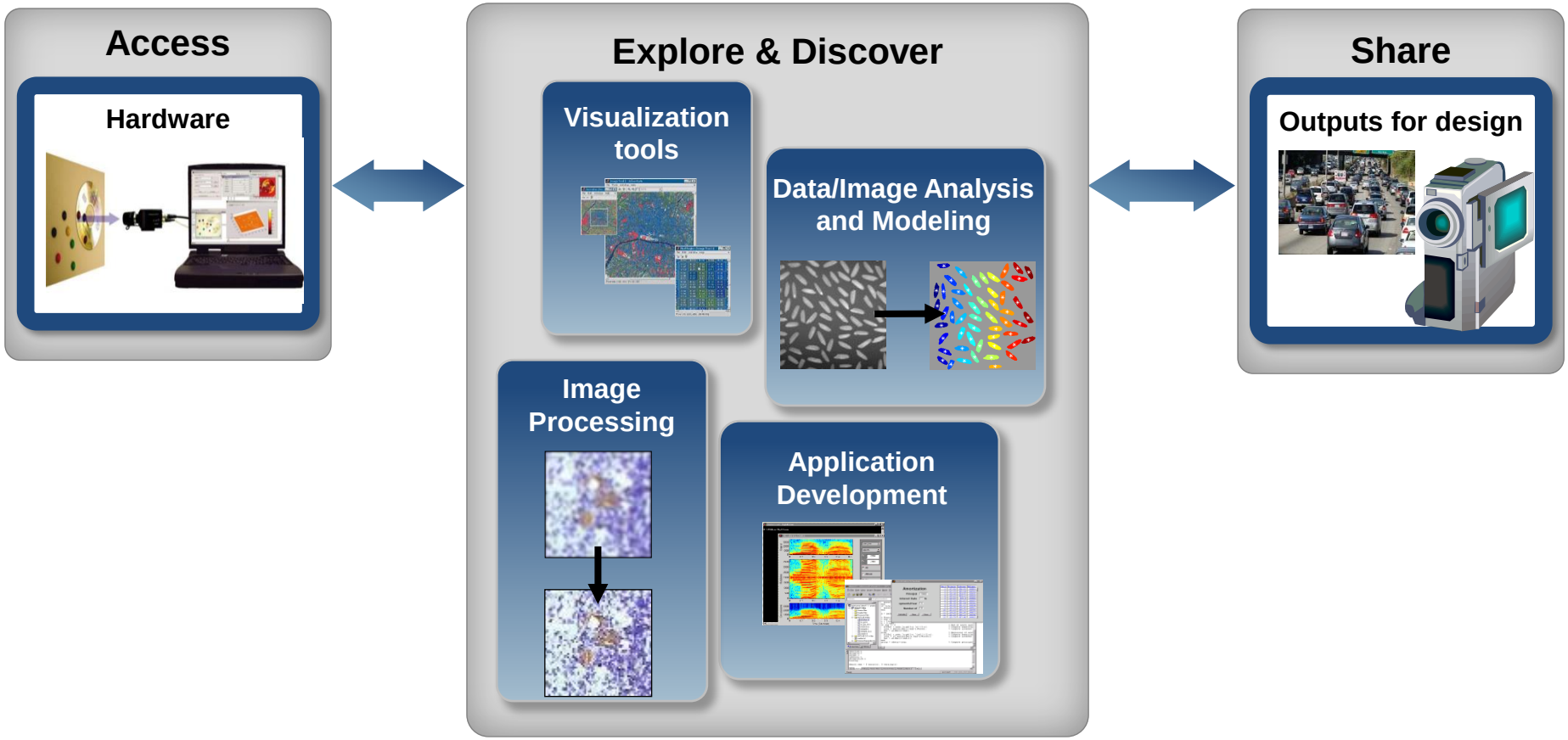
Workflow: Image and Video Processing



- Multiple file formats
- Large data sets

- Custom visualizations
- Create and modify algorithms
- Labor intensive, repetitive analyses

- Share results

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Outlines

- Images in MATLAB
- Image Enhancement
- Edge and Line Detection
- Segmentation & Feature Extraction

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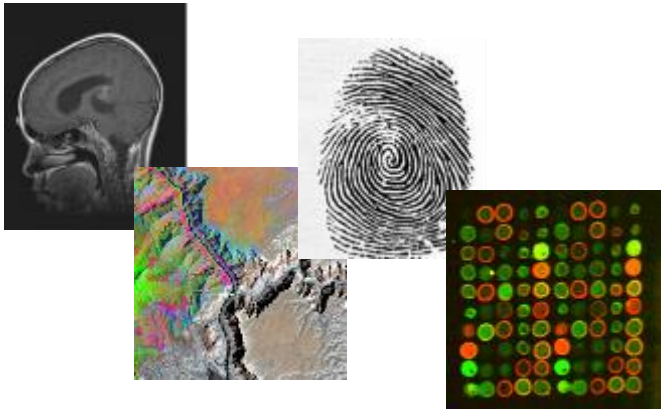
Images in MATLAB



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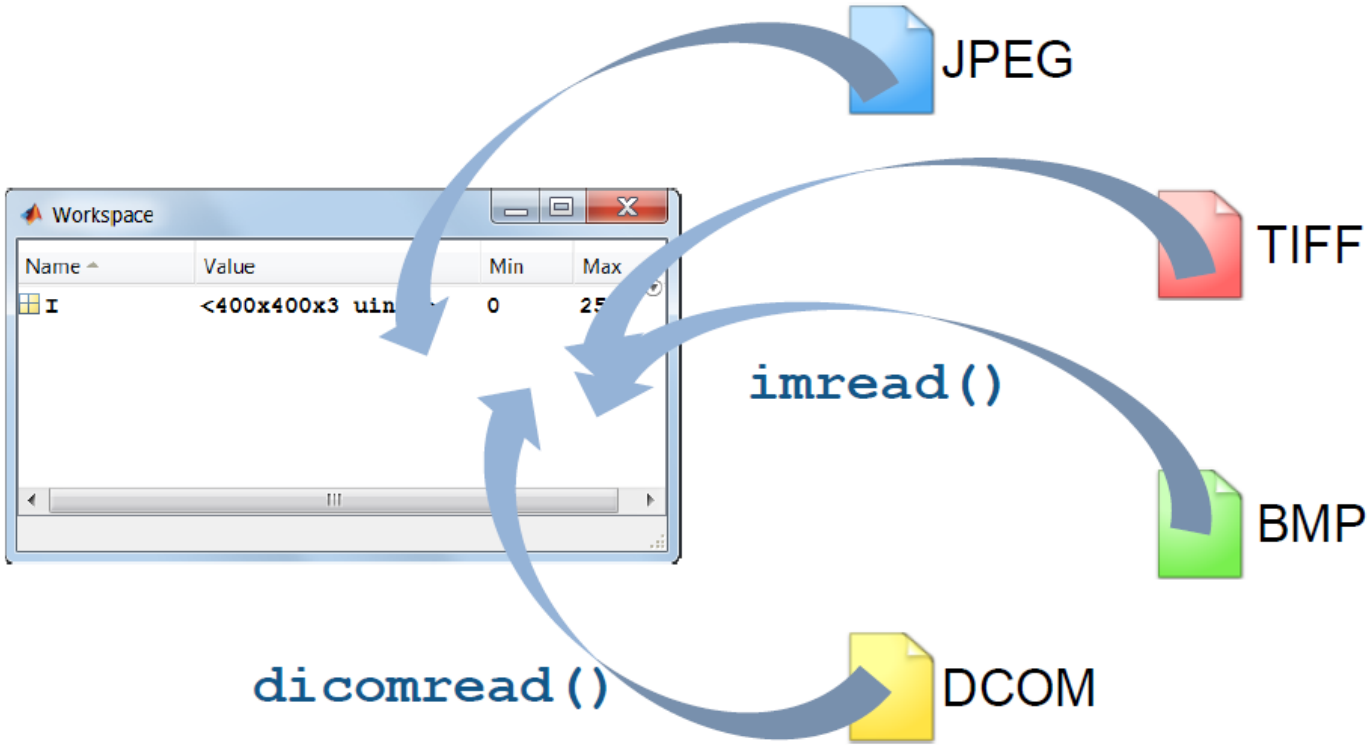
Supported Image Files




```
>> docsearch('Supported File Formats')
>> edit Image_in_matlab.m
```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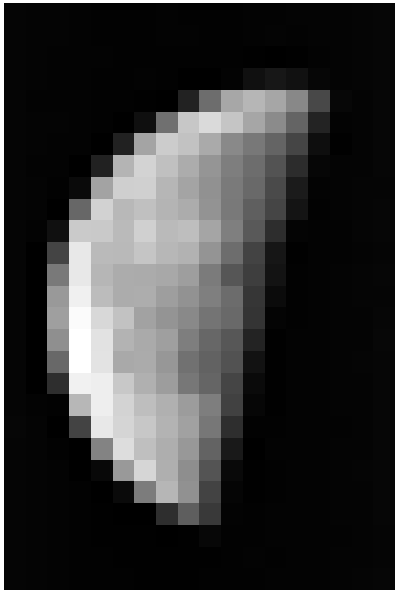
Basic Knowledge of Image

- Uint8:

0 ~ 255

- Resolution (dpi)

537*358



27*18

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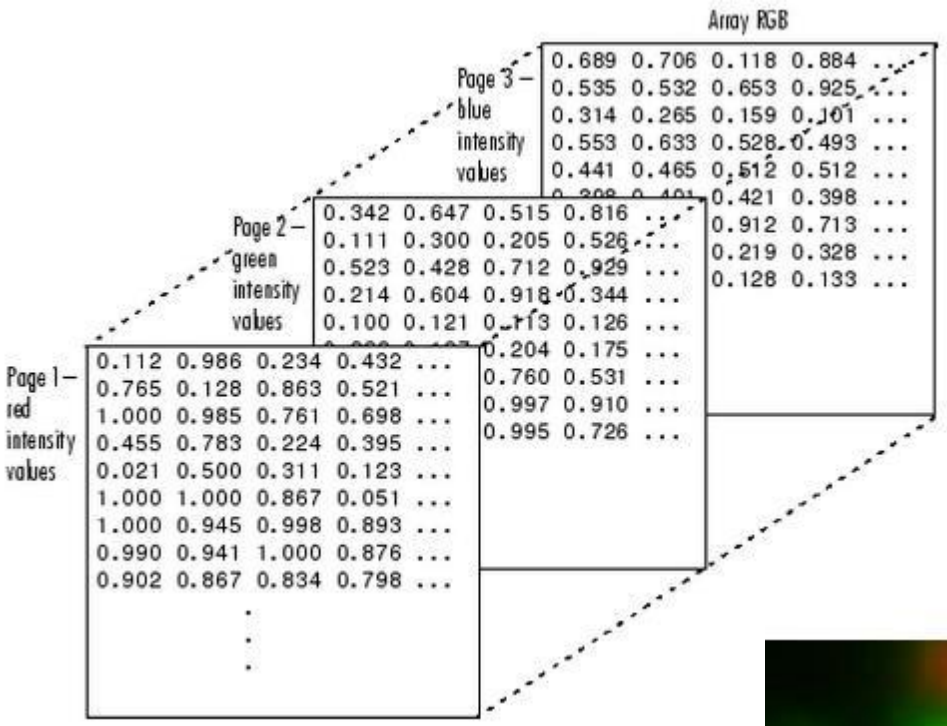
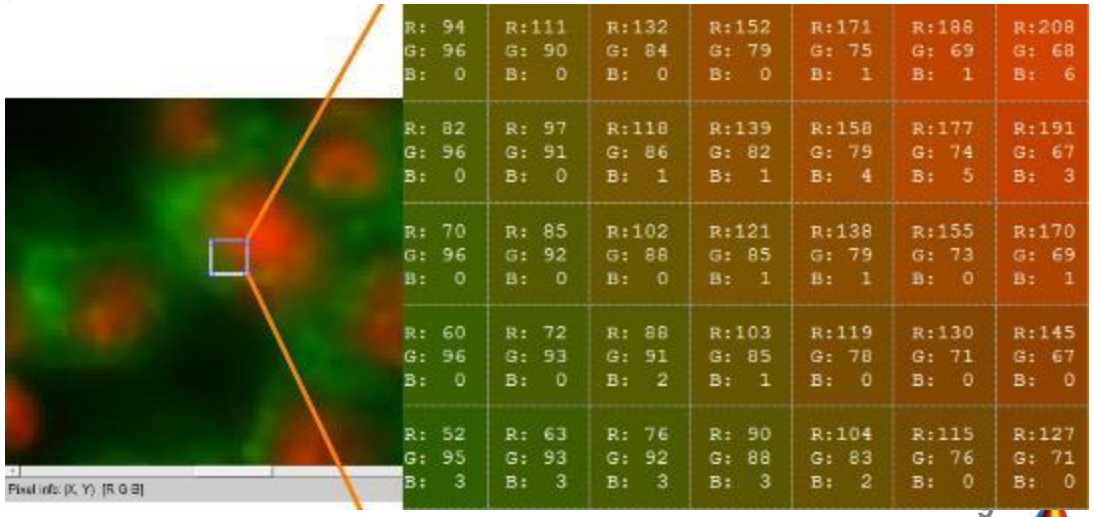
Image is Formed by Matrix





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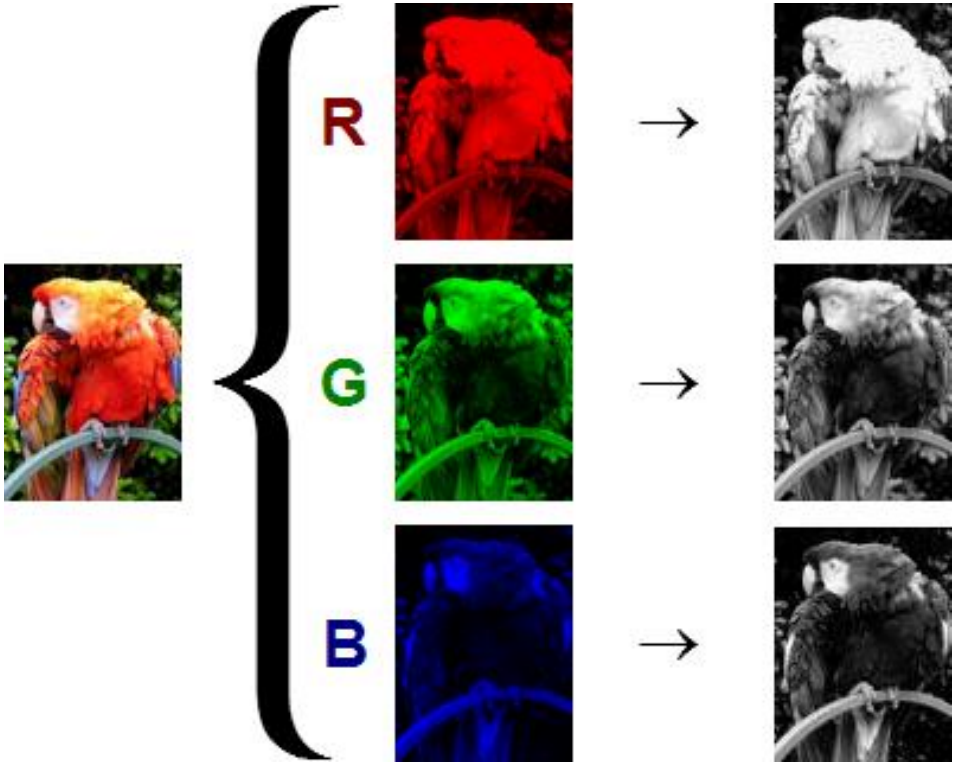
Basic Knowledge of Image



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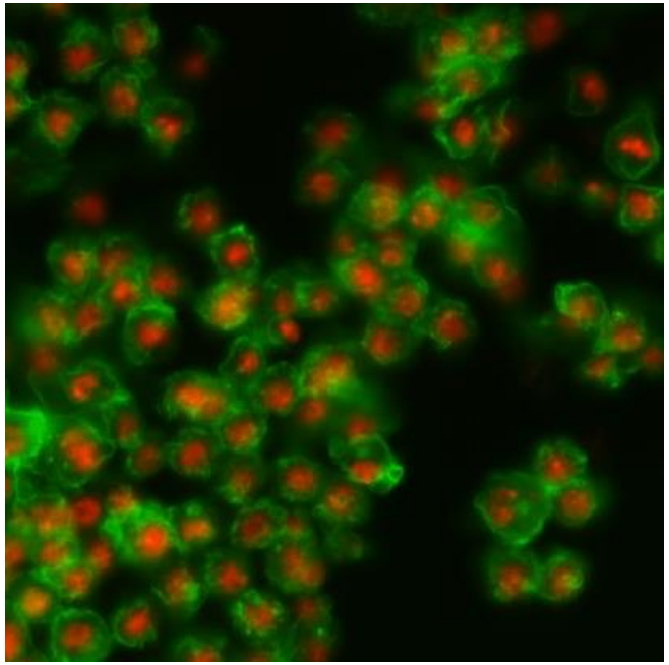
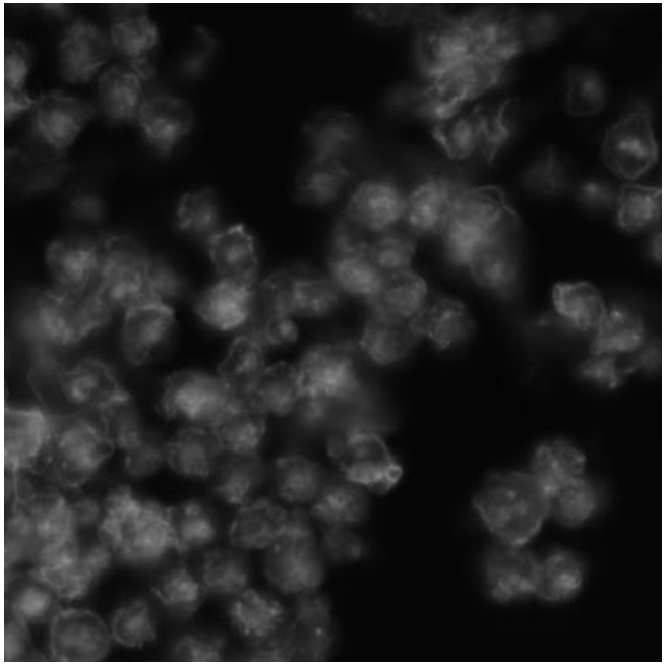
Grayscale(Intensity) Images



rgb2gray

gray2rgb



Reference:
http://www.mathworks.com/matlabcentral/fileexchange/28111-gray2rgb
http://stackoverflow.com/questions/2619668/how-to-convert-a-grayscale-matrix-to-an-rgb-matrix-in-matlab
http://www.mathworks.com/matlabcentral/fileexchange/8214-gray-image-to-color-image-conversion

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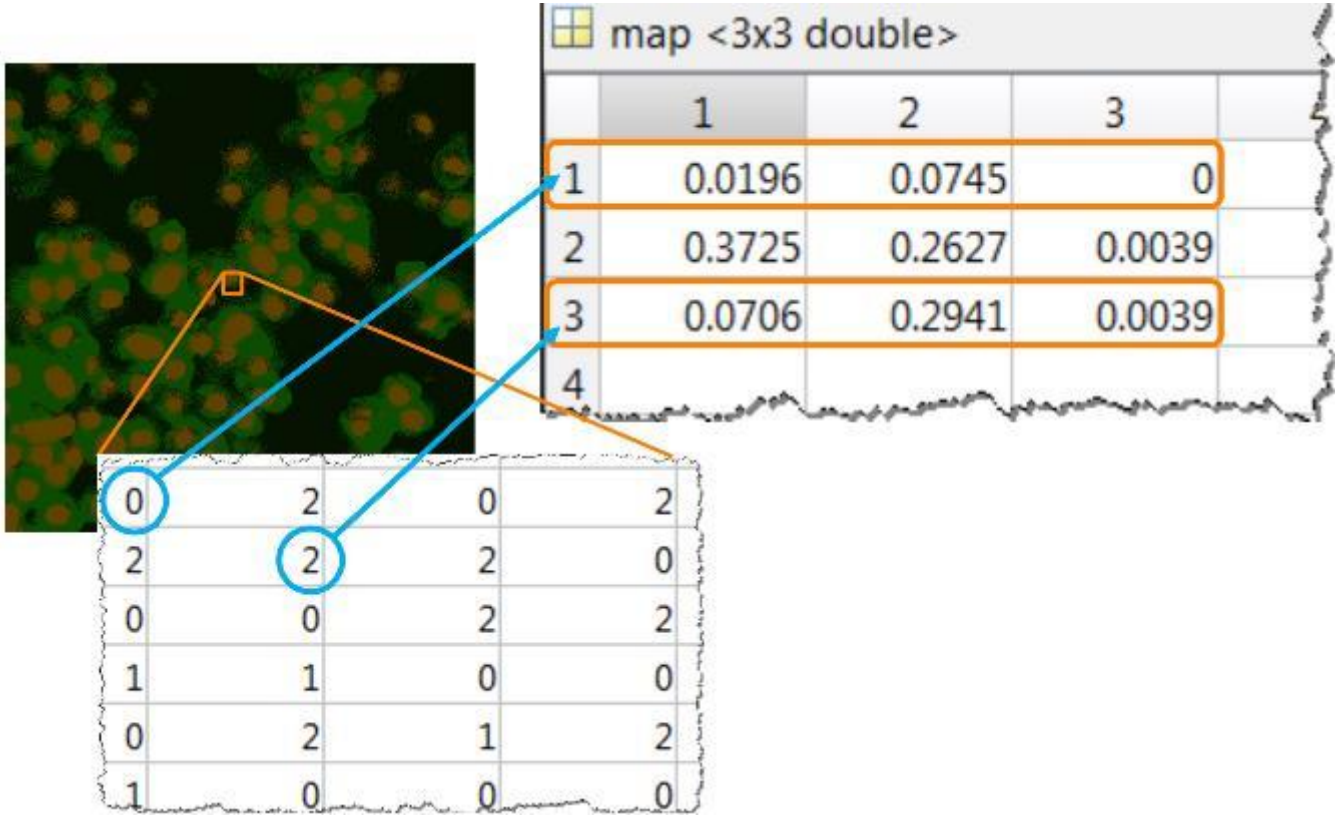
Indexed Images



>>edit im_indexed

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The Advantages of Indexed Images

$$
\begin{array}{cc}
 & B \begin{bmatrix} 10 & 85 & 46 \\ 73 & 216 & 99 \end{bmatrix} \\
G \begin{bmatrix} 35 & 2 & 5 \\ 44 & 92 & 126 \end{bmatrix} & \\
R \begin{bmatrix} 21 & 0 & 55 \\ 80 & 200 & 153 \end{bmatrix} &
\end{array}
$$

$$
\begin{bmatrix} 1 & 4 & 5 \\ 4 & 2 & 2 \\ 4 & 2 & 3 \end{bmatrix}
\qquad
\begin{array}{c}
\begin{array}{ccc} R & G & B \end{array} \\
\begin{bmatrix} 0.01 & 0.251 & 0.455 \\ 0.026 & 0.004 & 0.651 \\ 0.22 & 0.31 & 0.54 \\ 0.25 & 0.53 & 0.55 \\ 0.217 & 0.334 & 0.591 \\ 0.673 & 0.238 & 0.951 \end{bmatrix}
\end{array}
$$

Truecolor

Indexed

Less memory

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Importing Indexed Images

```
>> imfinfo('cell_indexed1.png')
```

Extra output variable needed

```
>> [I2,map2] = imread('cell_indexed1.png');
>> imshow(I2, map2)
```

map

map <3x3 double>

	1	2	3
1	0.0196	0.0745	0
2	0.3725	0.2627	0.0039
3	0.0706	0.2941	0.0039

map2

map2 <3x3 double>

	1	2	3
1	0.0196	0.0745	0
2	0.3725	0.2627	0.0039
3	0.0706	0.2941	0.0039

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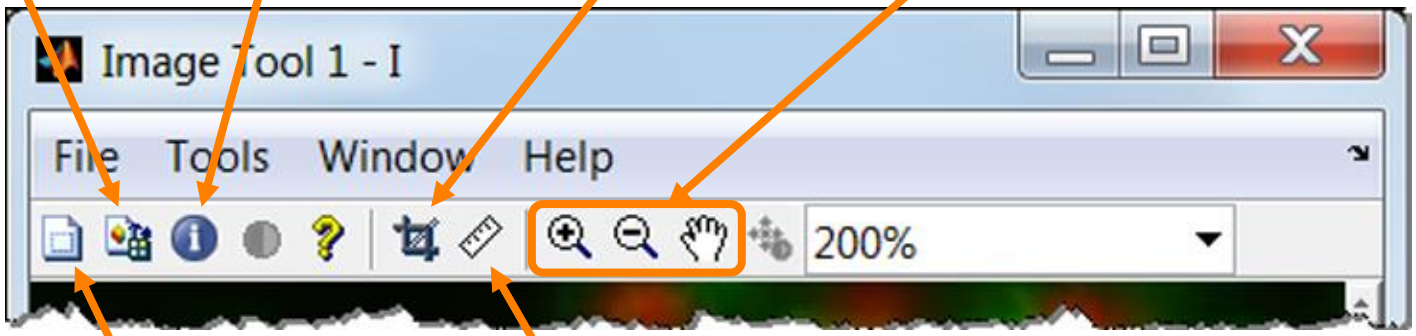
Exploring Images Using Image Tool

Display Image information

Zoom and Pan

Inspect Pixel Values

Crop Image



Navigate Image Using Overview

Measure Distance

```
>> imtool('canoe.tif')
```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Images Type Summary

Binary	**Matrix of 0s and 1s**	$\begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}$
Grayscale	**Matrix of integers or floating-point numbers**	$\begin{bmatrix} 21 & 0 & 55 \\ 44 & 92 & 126 \\ 80 & 200 & 153 \end{bmatrix}$
Indexed	**Matrix of numbers with integer values that point to a colormap entry**	$\begin{bmatrix} 1 & 4 & 5 \\ 4 & 2 & 2 \\ 4 & 2 & 3 \end{bmatrix}$ $\begin{array}{c} \begin{array}{ccc} R & G & B \end{array} \\ \begin{bmatrix} 0.01 & 0.251 & 0.455 \\ 0.026 & 0.004 & 0.651 \\ 0.22 & 0.31 & 0.54 \\ 0.25 & 0.53 & 0.55 \\ 0.217 & 0.334 & 0.591 \\ 0.673 & 0.238 & 0.951 \end{bmatrix} \end{array}$
Truecolor	**3-D array of numbers of size *m*-by-*n*-by-3**	B $\begin{bmatrix} 10 & 85 & 46 \\ 73 & 99 \end{bmatrix}$ G $\begin{bmatrix} 35 & 2 & 5 \\ 216 & 144 \end{bmatrix}$ R $\begin{bmatrix} 21 & 0 & 55 \\ 44 & 92 & 126 \\ 80 & 200 & 153 \end{bmatrix}$

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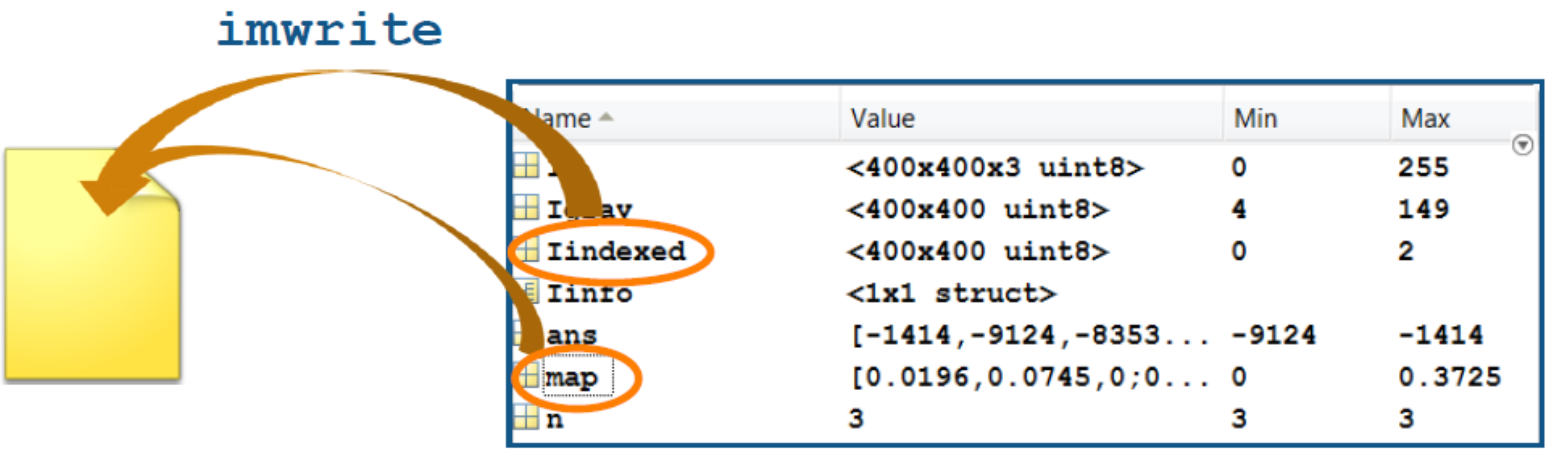
Exporting Images



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Test Your Knowledge

1. Which function provides information about the type of an image (truecolor, indexed, grayscale, etc.)?

2. (Select all that apply) Which of the following syntaxes can be used to import an image foo.tif?

A. I = imread('foo.tif');
B. [I,map] = imread('foo.tif');
C. I = import('foo.tif');
D. None of the above

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Image Enhancement

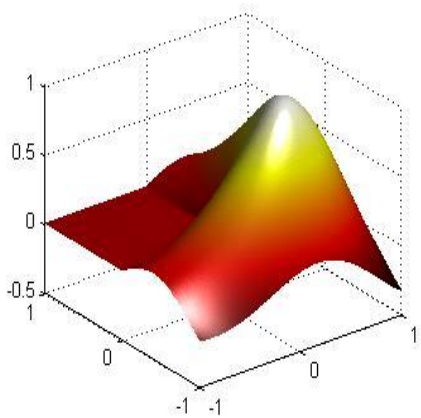

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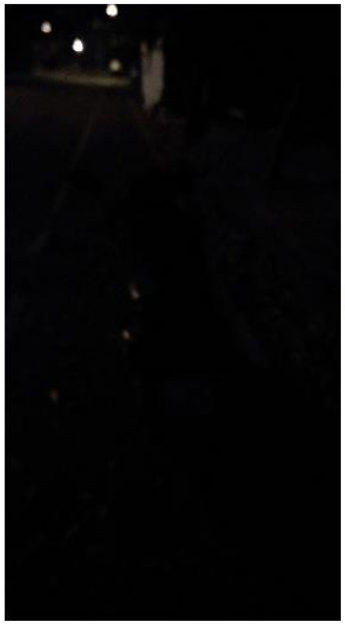
Image Enhancement



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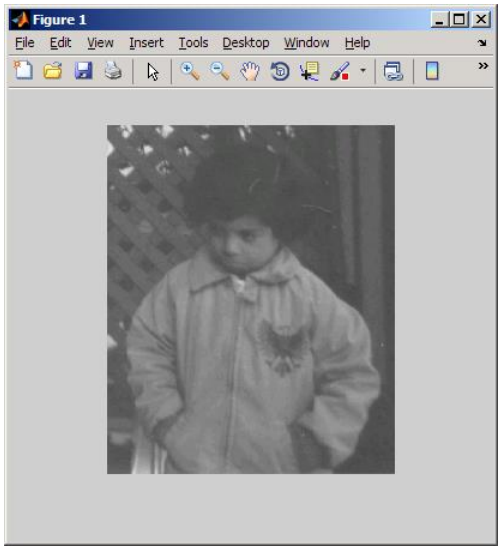
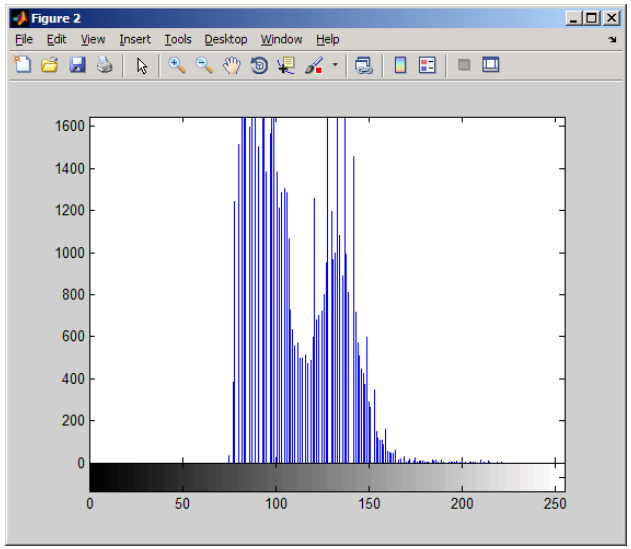
Adjusting Image Contrast

- One of the most basic ways to enhance an image is to change its brightness and its contrast. This can be done by
  - Stretching the color distribution
  - Equalizing the distribution of colors to use the full range (*histeq*)
  - Adaptive Histogram Equalization (*adapthisteq*)
  - Adjusting the scaling of the colors (imadjust)






```
>>edit contrast_adjustment
```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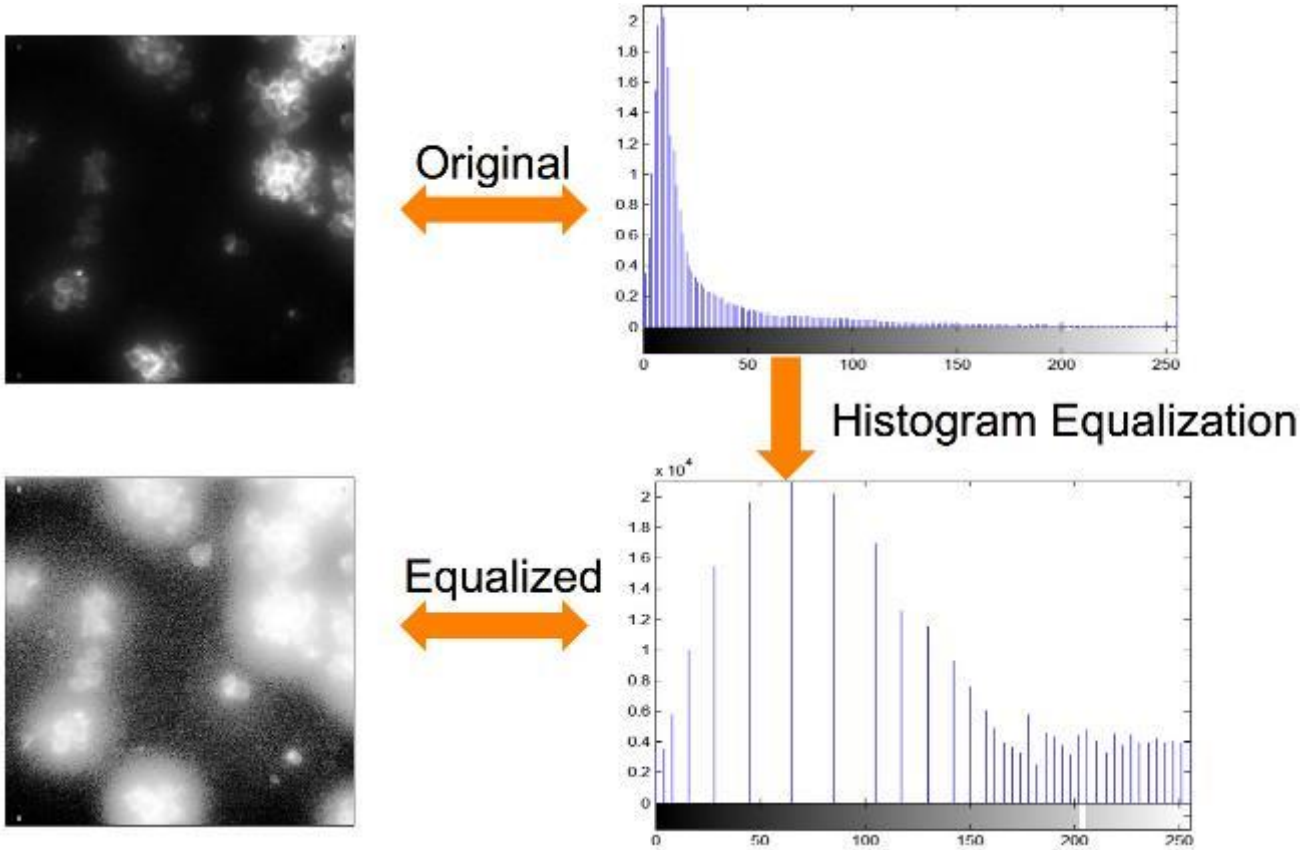
Histogram Equalization



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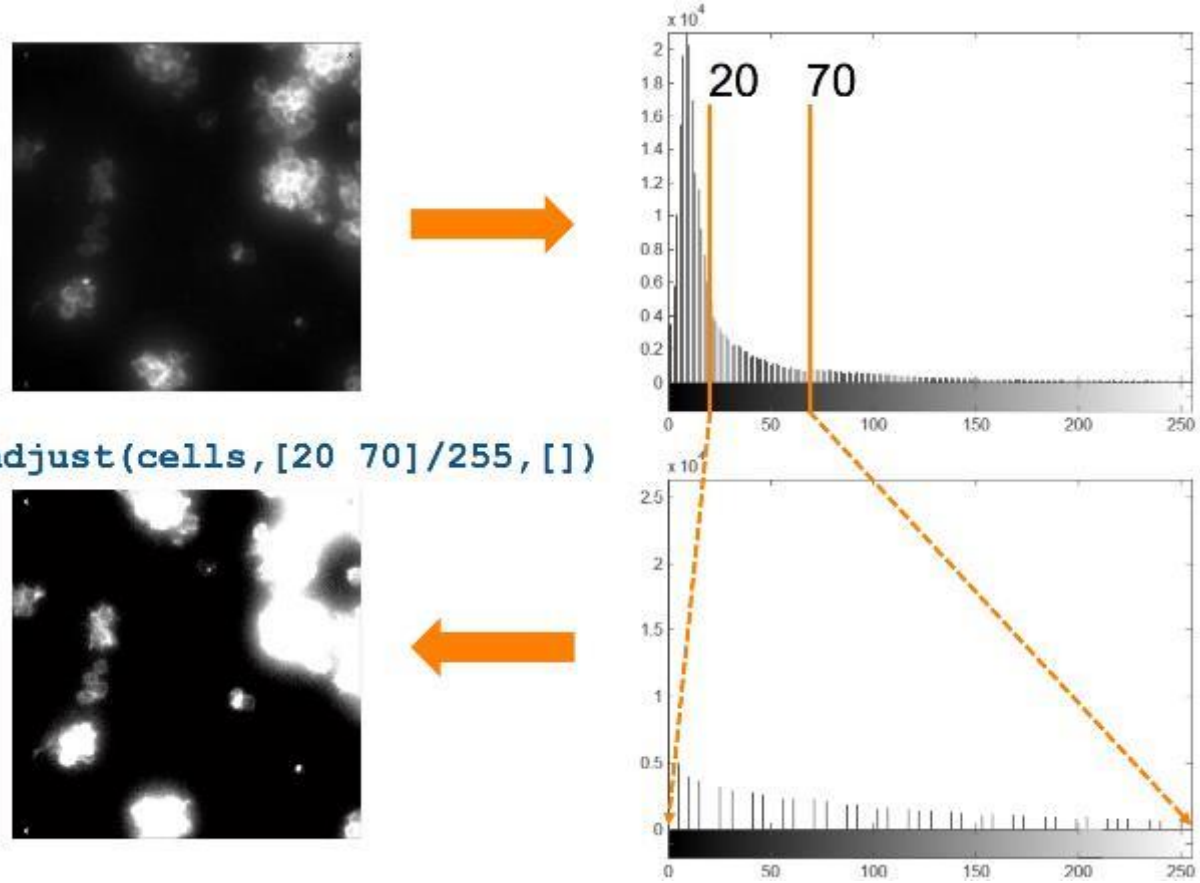
Histogram Adjustment




```
imadjust(cells,[20 70]/255,[])
```

```
>> cd <PATH_TO_Example_Folder>/2_Enhancement
>> edit ContrastAdjustment.m
```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Exercise: Intensity Adjustment

- Can you see what the image is of? Enhance the picture by adjusting the image intensity.

  1. Load the image darkimage.jpg.
  2. Convert the image to an intensity image (grayscale).
  3. Determine the range for the intensity adjustment.
  4. Adjust the image intensity.

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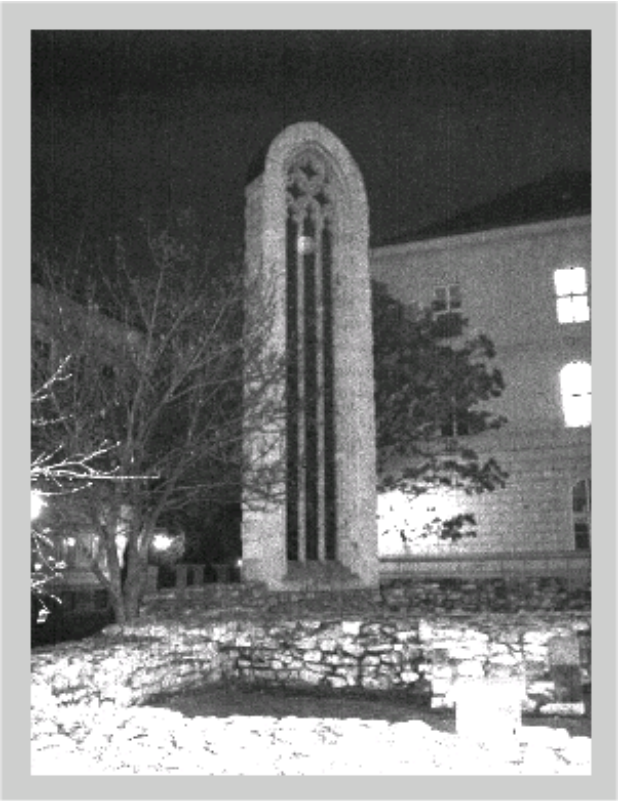
Solution: Intensity Adjustment

```
%% Load and convert image
jpg = imread('darkimage.jpg');
I = rgb2gray(jpg);
imshow(I)
%% Compute mean and std
mu = mean2(I)
sigma = std2(I)
low_in = (mu-sigma)/255;
if low_in < 0, low_in = 0; end
high_in = (mu+sigma)/255;
if high_in > 1, high_in = 1; end
%% Adjust image
J = imadjust(I,...
   [low_in high_in],[0 1]);
figure, imshow(J)
```



Remnant of a stain glass in Budapest, Hungary.

```
>> image_intensity
```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Filtering Applications

- Many filtering techniques can be used to solve problems with or enhance images

- Common filtering image tasks:
  - Removing or reducing noise from images
  - Smoothing images
  - Sharpening images
  - Detecting edges

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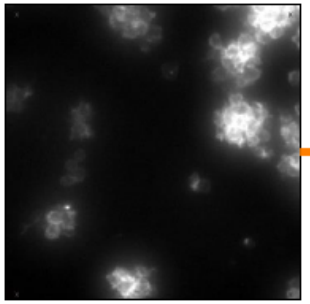
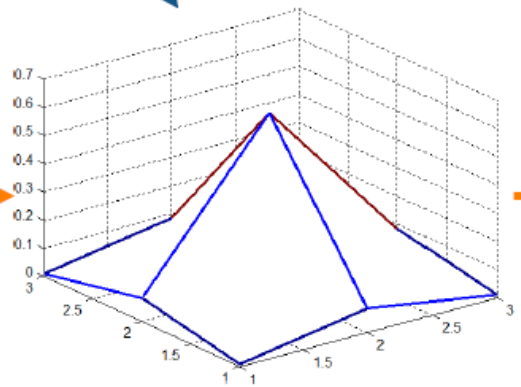
Linear Filtering

Create spatial filter
(`fspecial`)

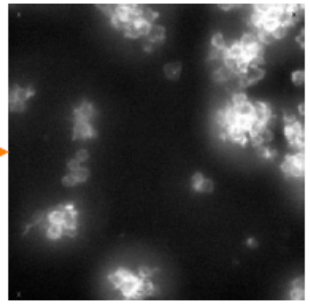
Filter the image
(`imfilter`)



Input image



Filter kernel



Output image

```
>> edit FilterTechniques.m
```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Computing Linear Filter Output

$$1\times8+8\times1+15\times6+7\times3+14\times5+16\times7+19\times4+20\times9+22\times2=609$$

Filter kernel

$$\begin{bmatrix} 8 & 1 & 6 \\ 3 & 5 & 7 \\ 4 & 9 & 2 \end{bmatrix}$$

17	24	1^{*8}	8^{*1}	15^{*6}
23	5	7^{*3}	14^{*5}	16^{*7}
4	6	19^{*4}	20^{*9}	22^{*2}
10	12	19	21	3
11	18	25	2	9

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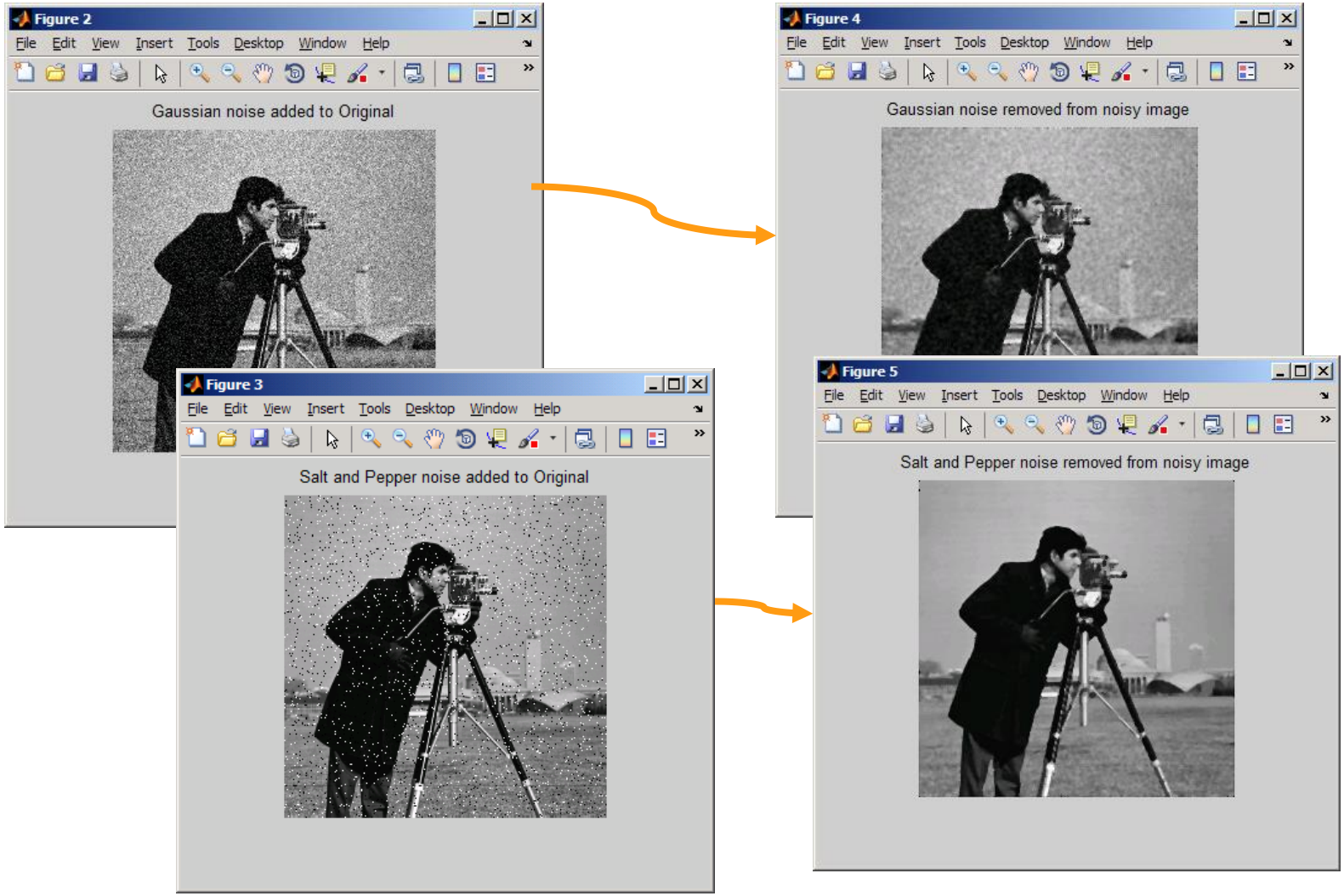
Example: Noise and Removing Noise



>> avg_filt

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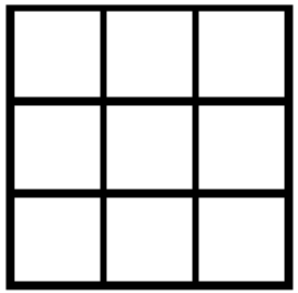
Nonlinear Filtering

Assign median value: 1,7,8,14,15,16,19,20,22



neighborhood

17	24	1	8	15
23	5	7	14	16
4	6	19	20	22
10	12	19	21	3
11	18	25	2	9

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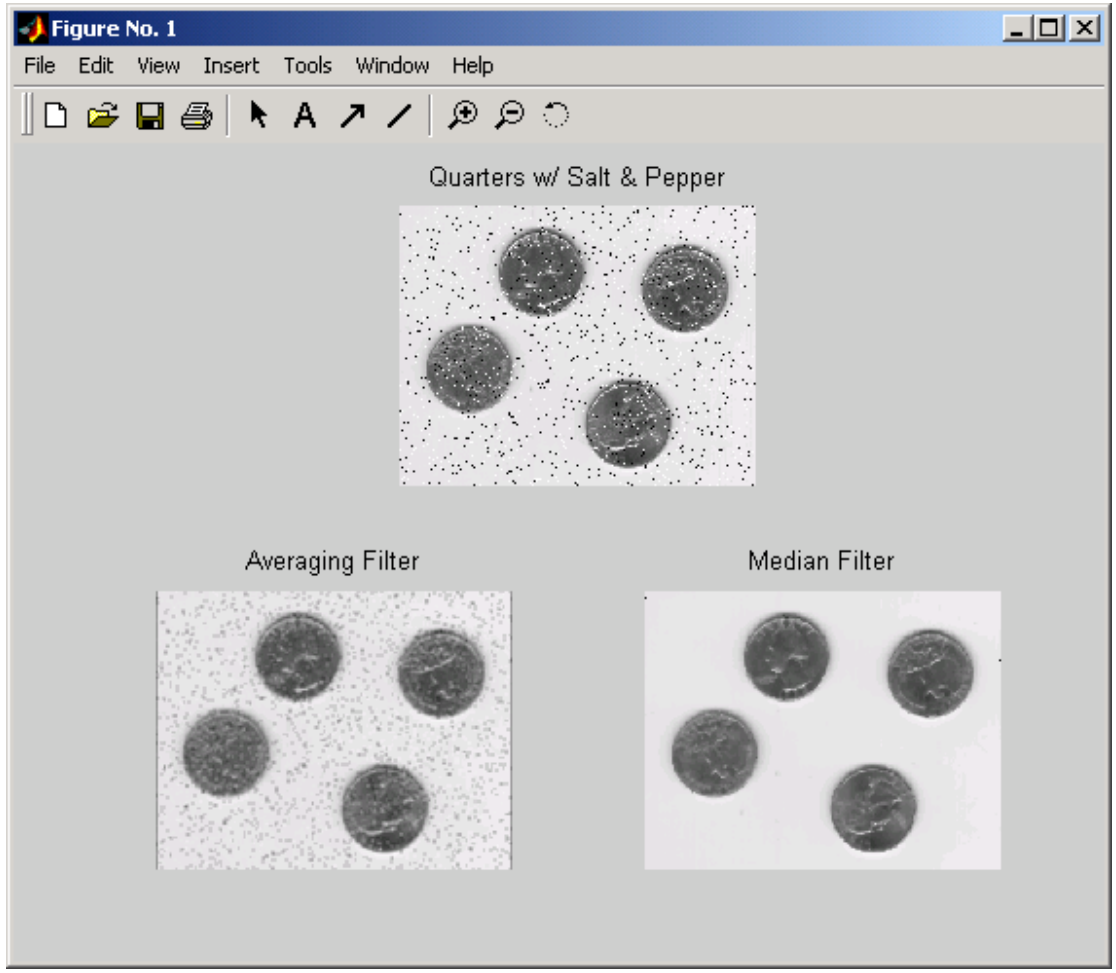
Example: Median Filter



>> quarters_medfilt

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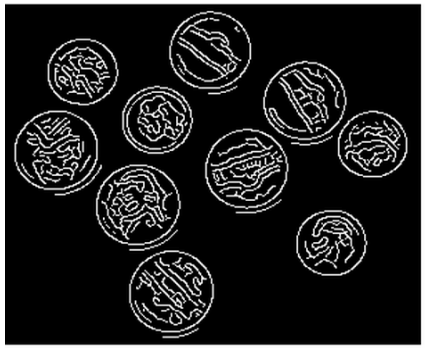
Edge and Line Detection



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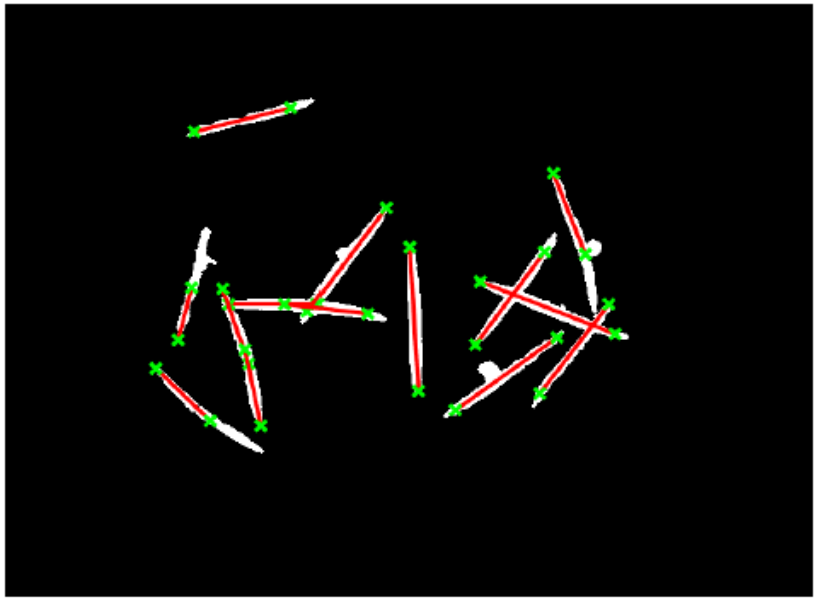
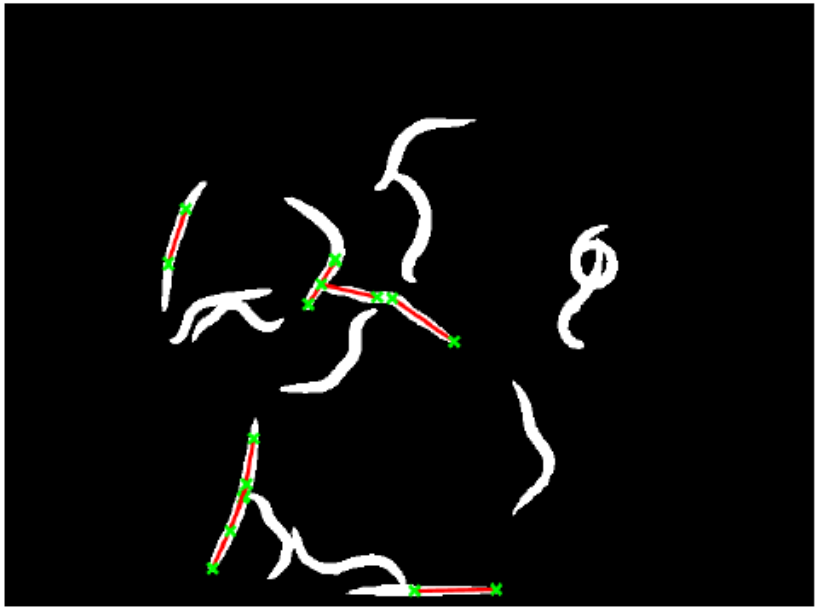
Course Example: Identifying Dead Worms



Original Image



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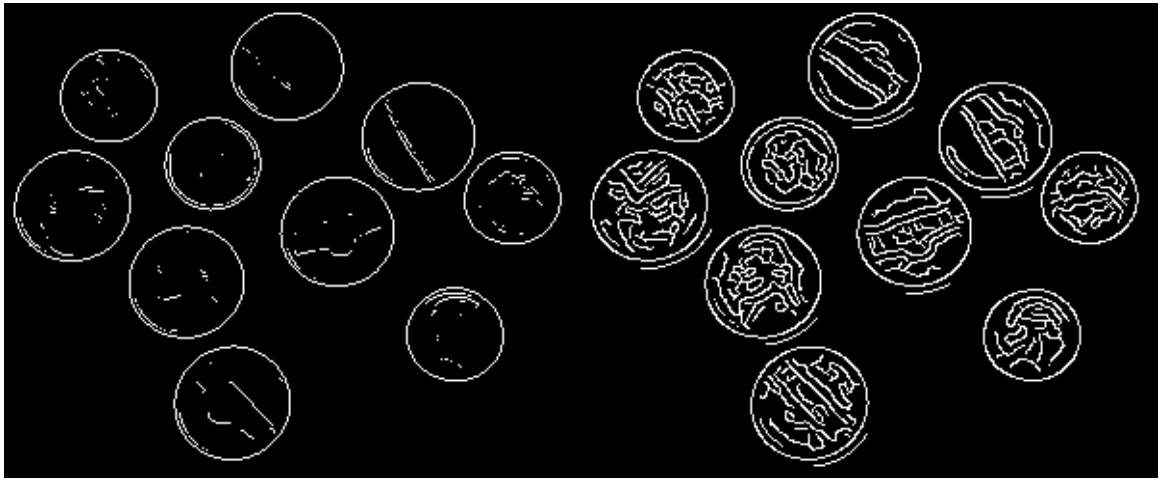
Edge Detection

- Edges are often associated with the boundaries of objects in a scene.
- Applicable Method: Sobel, Prewitt, LoG, Canny, …

Sobel Filter **Canny Filter**



```
>> BW = edge(I, 'sobel');
```

```
>> cd <PATH_TO_Example_Folder>/3_EdgeLine
>> edit edgeworm.m
```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Edge Detection with the Sobel Method

$$\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * \qquad * \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$$

Gradient in Y-direction

G_y

Gradient in X-direction

G_x

$$G = \sqrt{G_x^{\,2} + G_y^{\,2}}$$

G > Threshold

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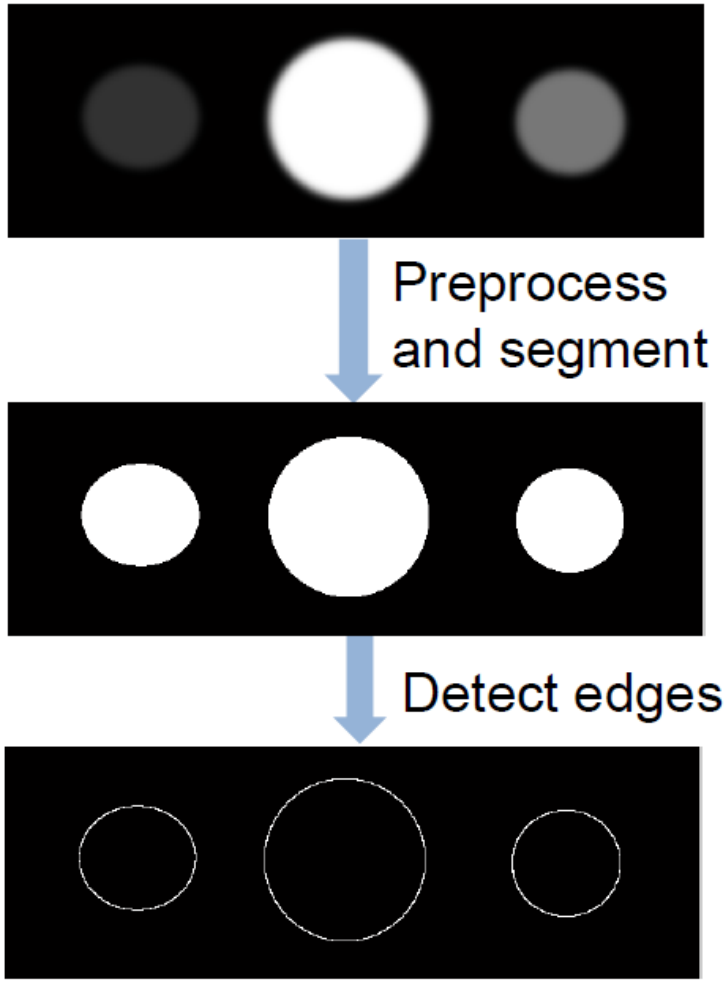
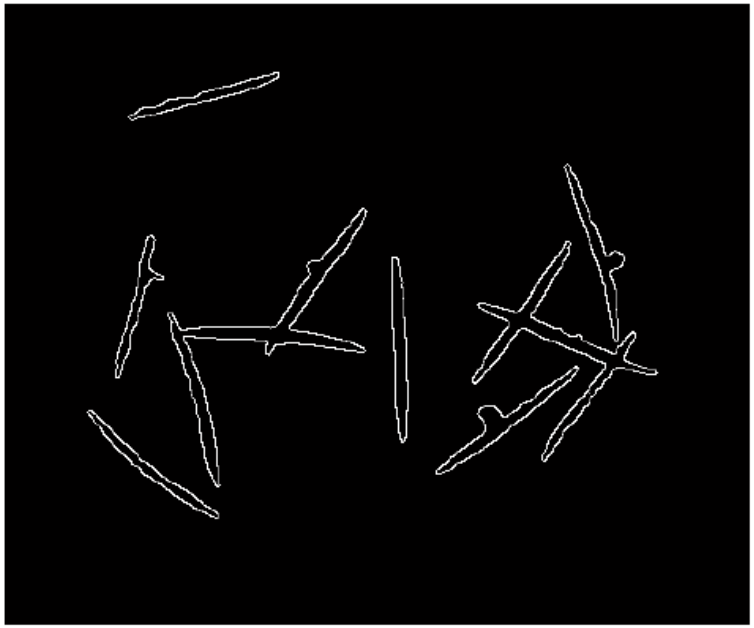
Edge Detection on Binary Images





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Tracing Object Boundaries

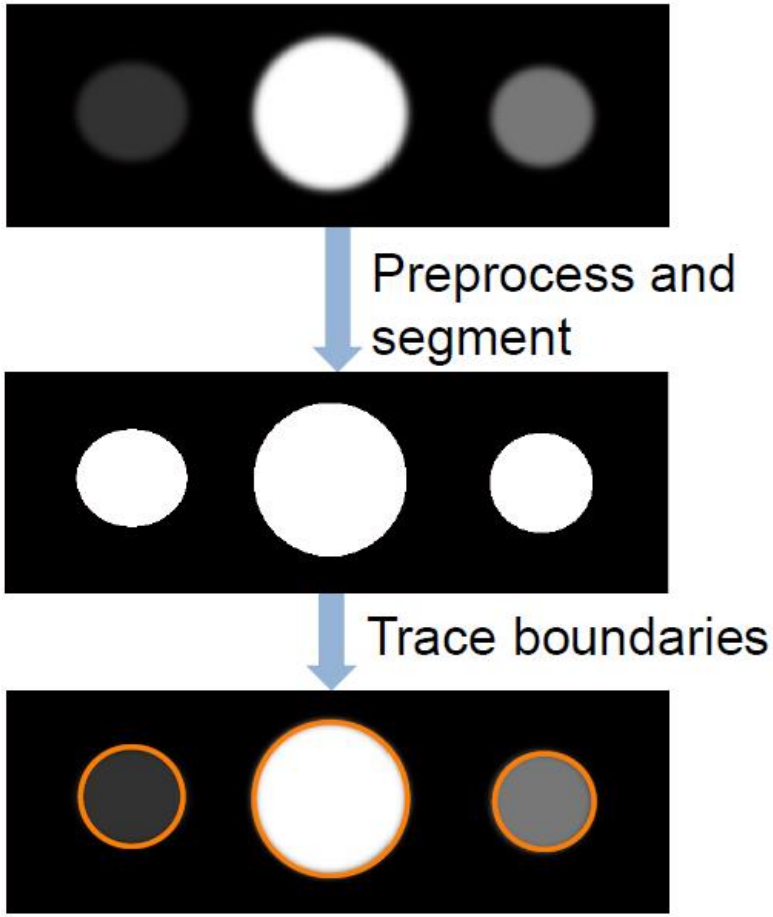

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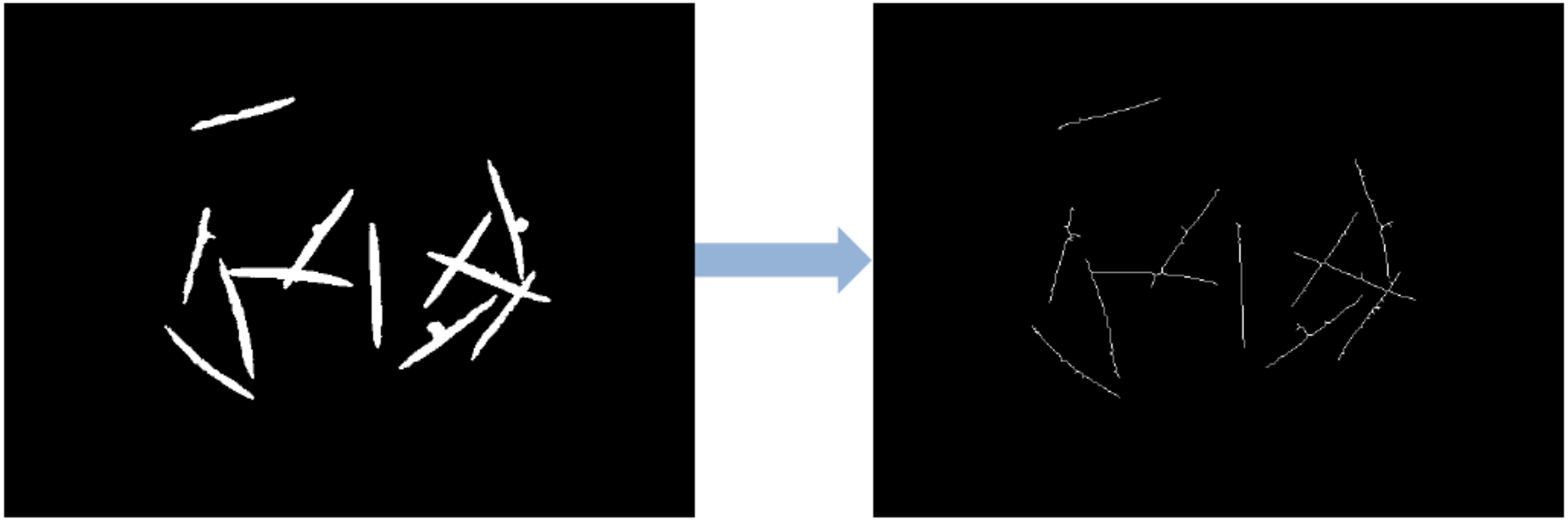
Image Skeletonization



```
>> wormSkel = bwmorph(worms,'skel',Inf);
```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Extracting Line Segments Using Hough Transform

Create Hough transform matrix (`hough`)

↓

Locate peaks in the Hough transform matrix (`houghpeaks`)

↓

Extract line segments corresponding to peaks in the Hough transform matrix (`houghlines`)

```
>> edit detectLines
```


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Classifying Worms Images

These worms are dead

median length = 69.34

These worms are alive

median length = 46.57

median length > 58 ➡ dead

```
>> edit judgeworms.m
```


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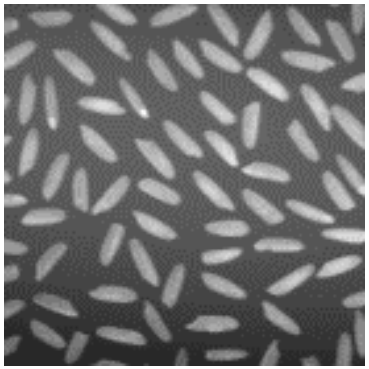
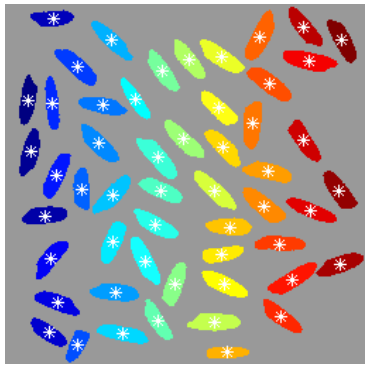
Segmentation & Feature Extraction





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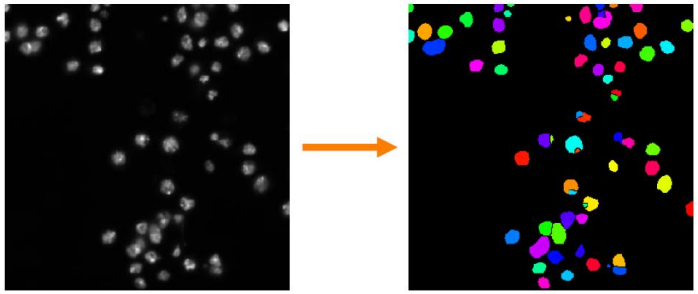
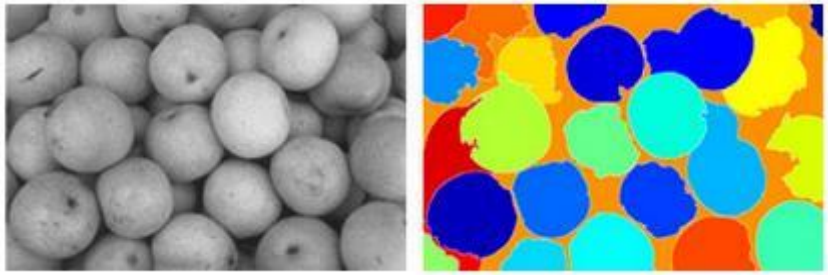
Segmentation

– Divide image into objects and background

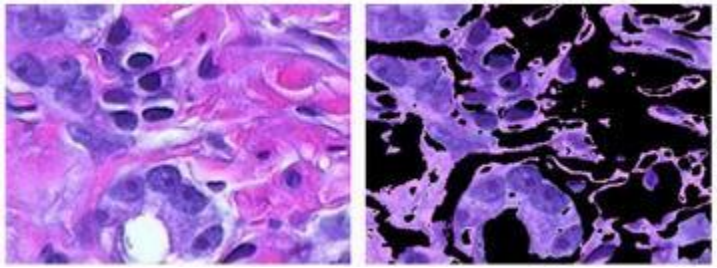
- Thresholding method



- Transform methods



- Color-based method



- Texture methods

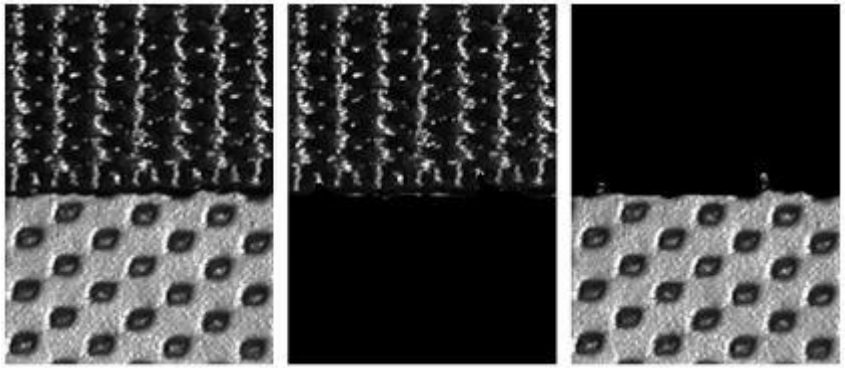


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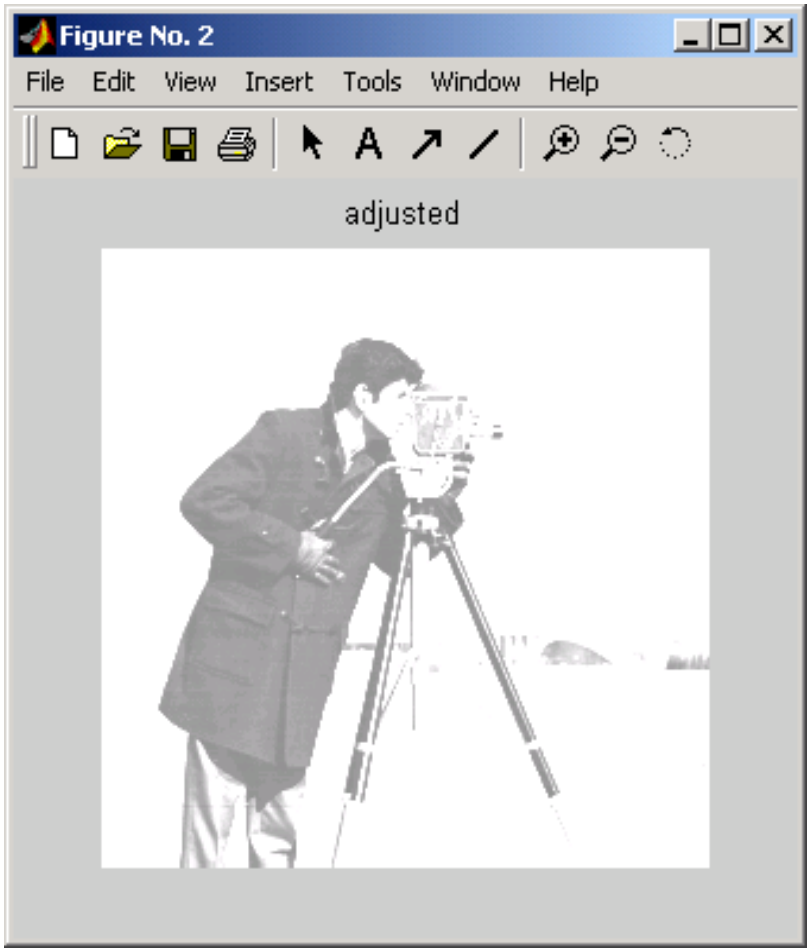
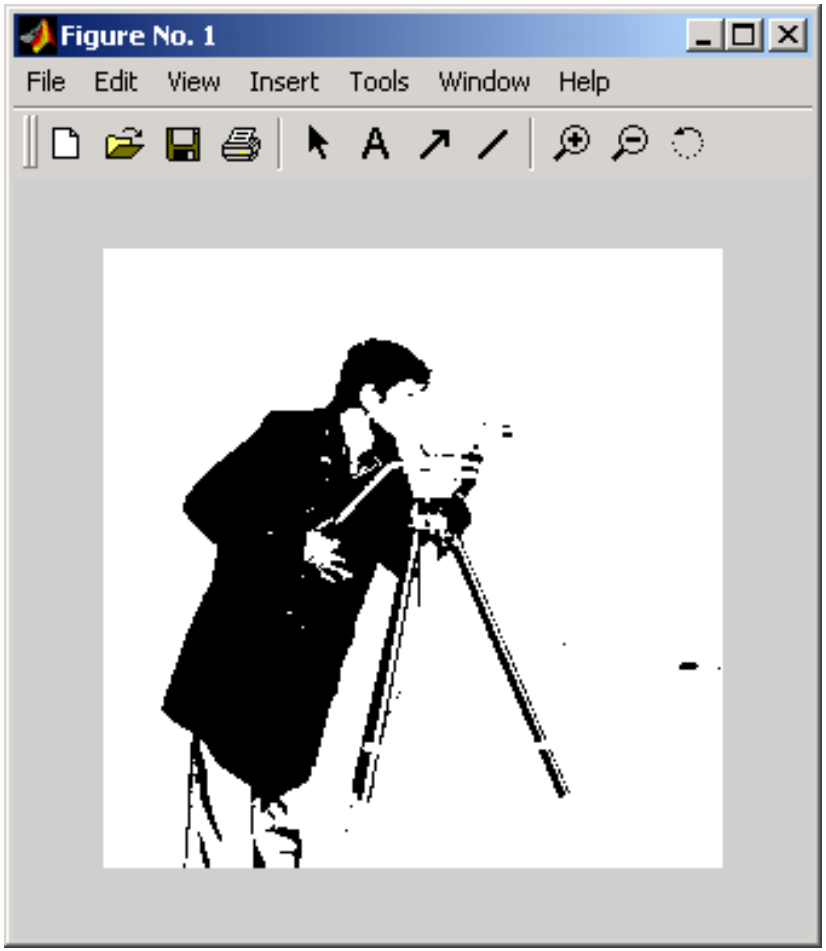
Image Thresholding





>> edit Otsu_segmentation

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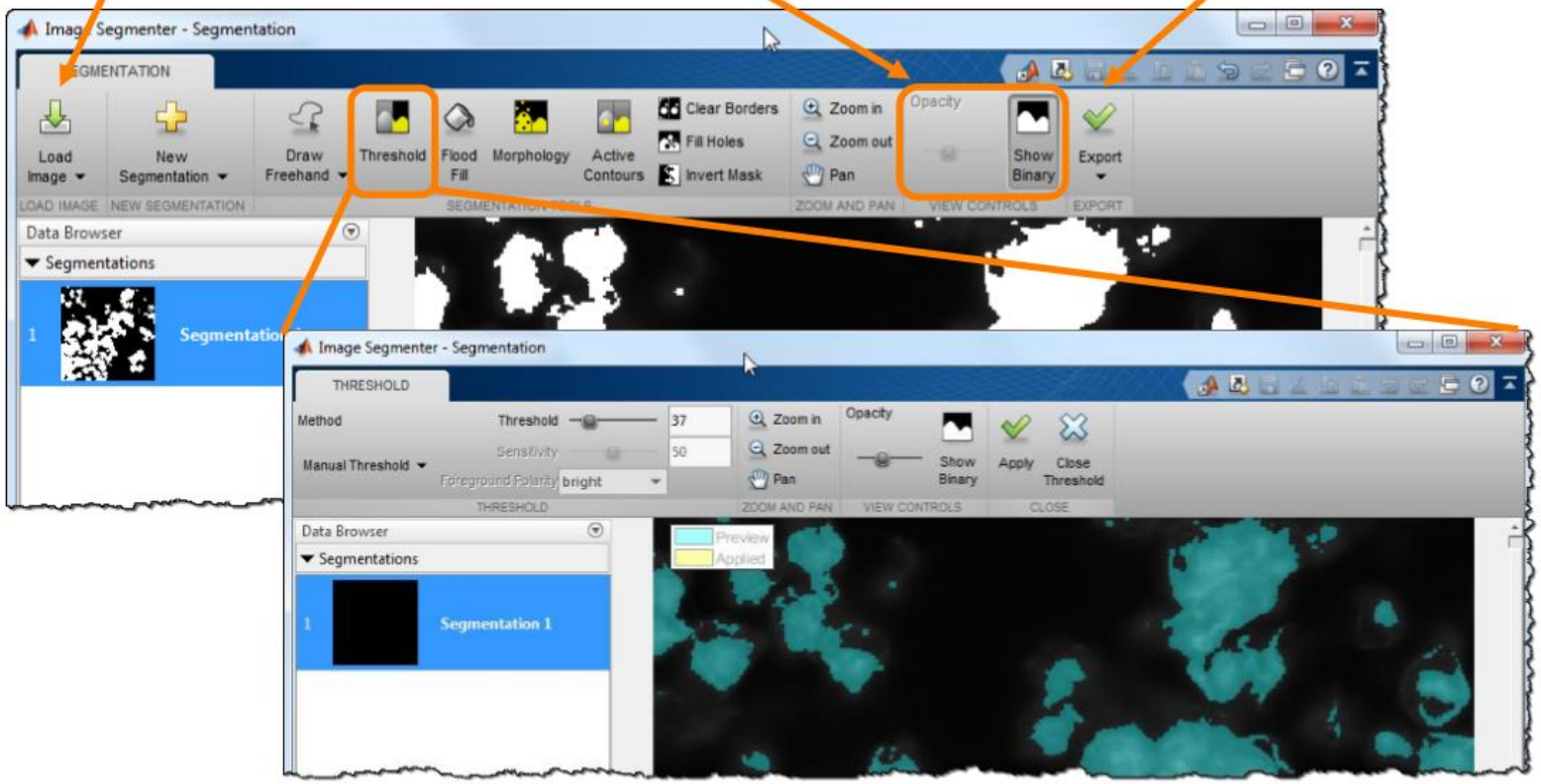
Using the Image Segmenter App

Import image from file or workspace

Visualization options

Export image
Generate function



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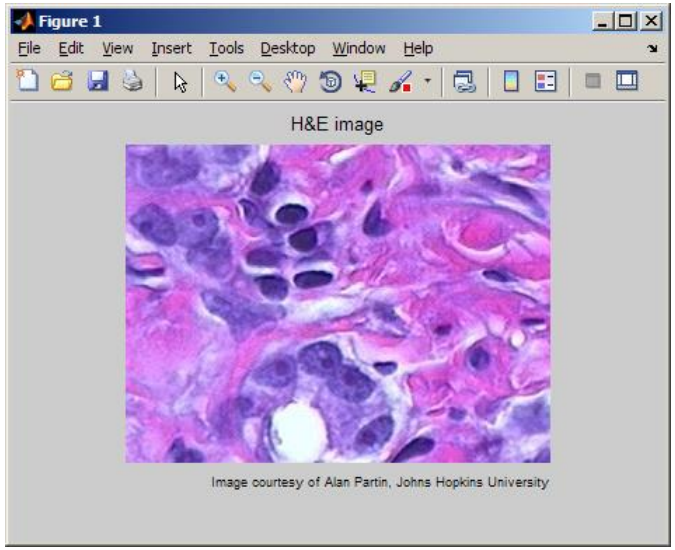
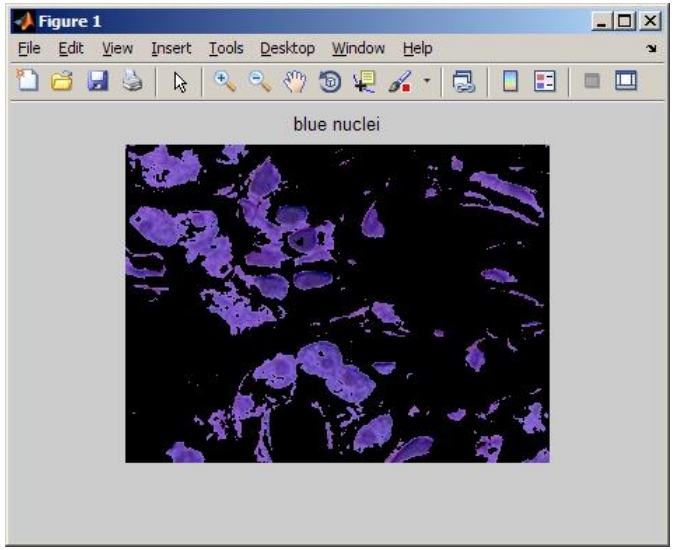
Color-Based Segmentation

- Various approaches for performing color-based segmentation use different techniques such as :
  - K-means clustering
  - Neural networks
  - Taking Euclidean distances between colors





>>color_segment

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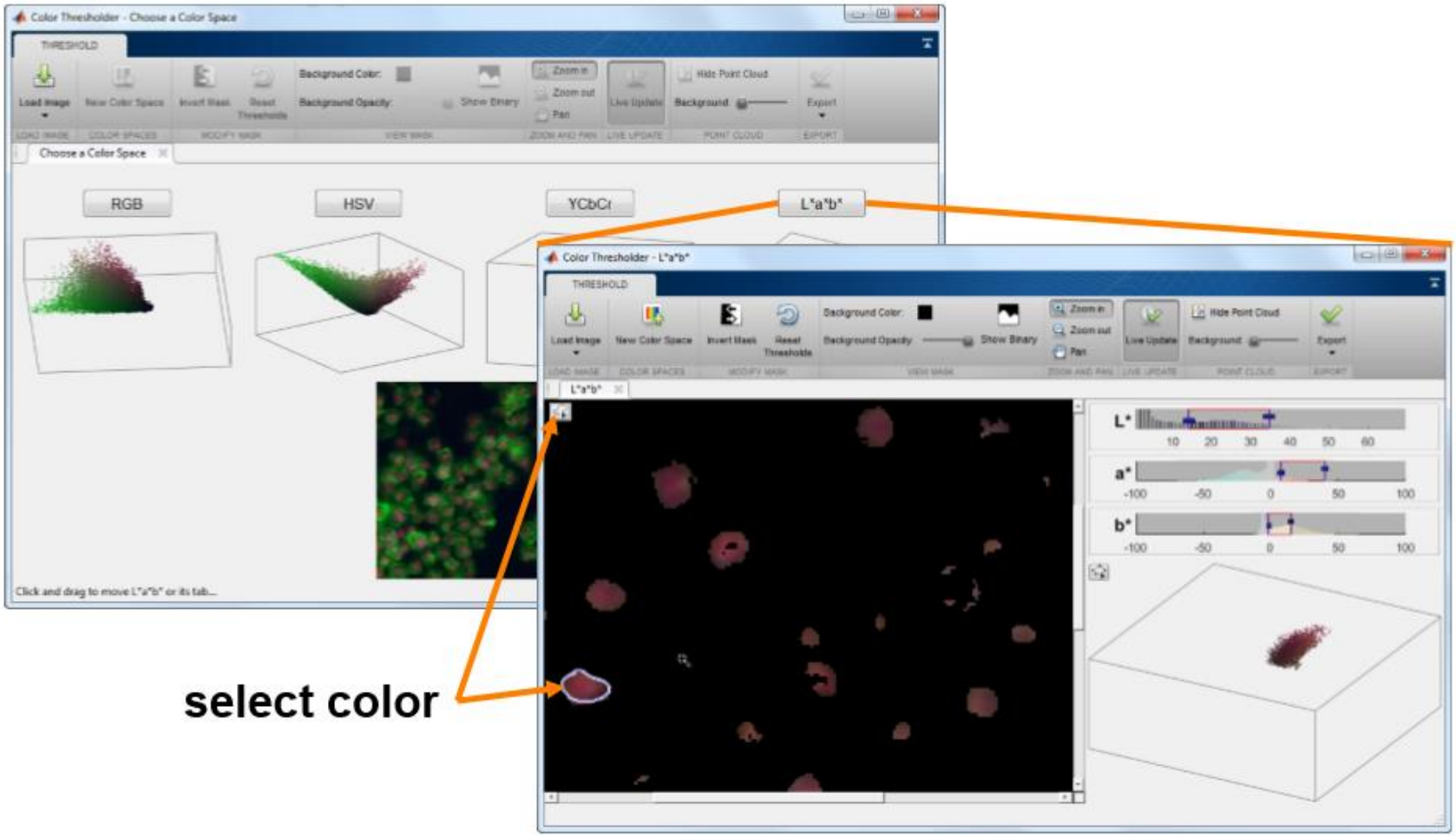
Image Segmentation Using the Color Thesholder App



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Morphology and Segmentation

- Morphological techniques can help to identify and segment objects in images
  - Morphology – technique used for processing image based on shapes.
  - Segmentation – the process used for identifying objects in an image.

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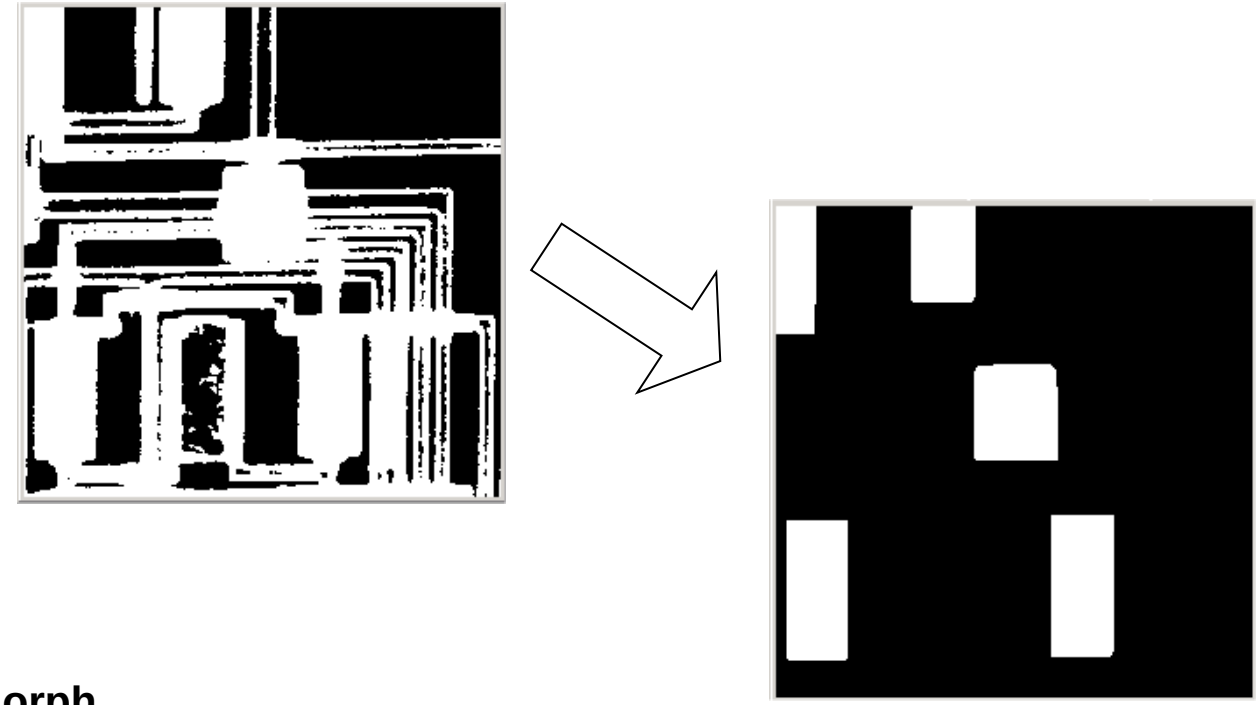
Example Problem: Morphology

- We are assigned to locate all the rectangular chips on a black and white integrated circuit image, but how?



>> circuit_morph

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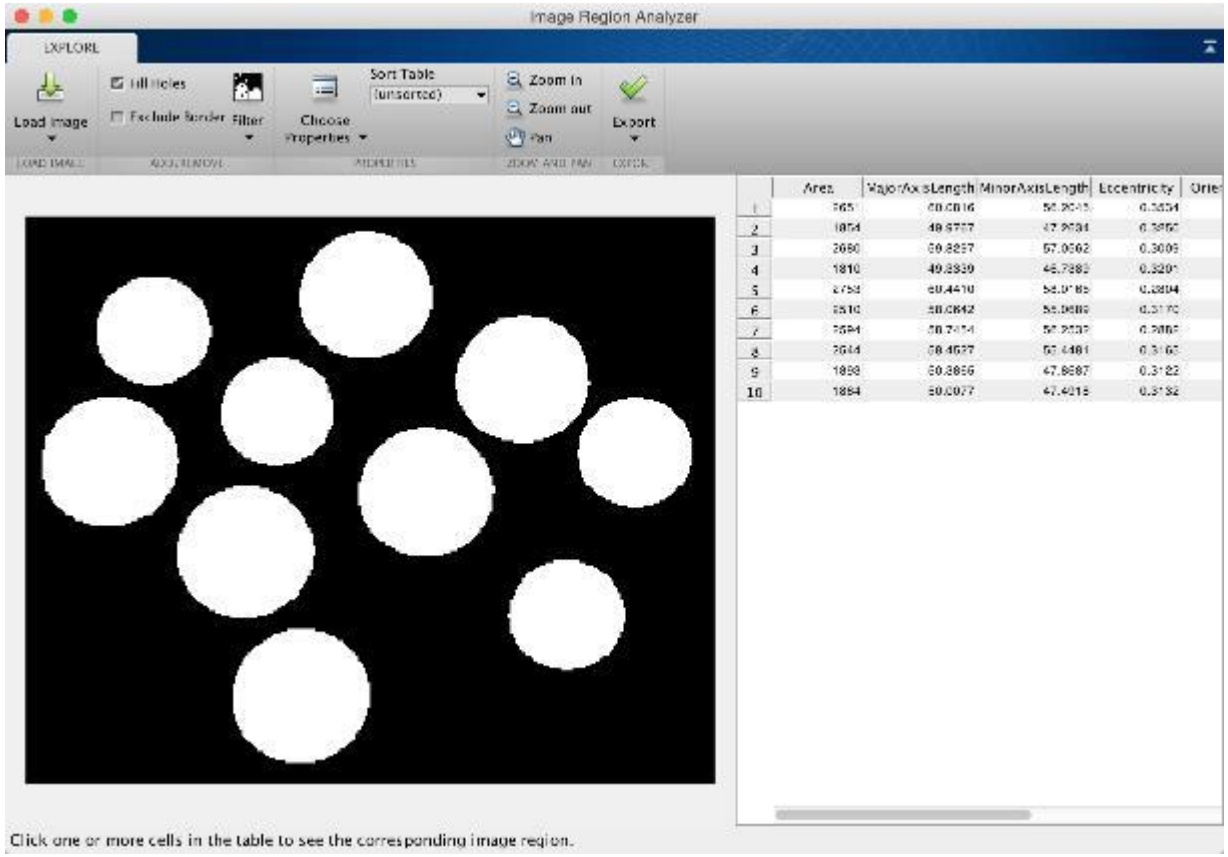
Image Region Analyzer APP

- App for analyzing the properties of each foreground object
- Only consider measurable properties, such as Area, Axis length, etc.



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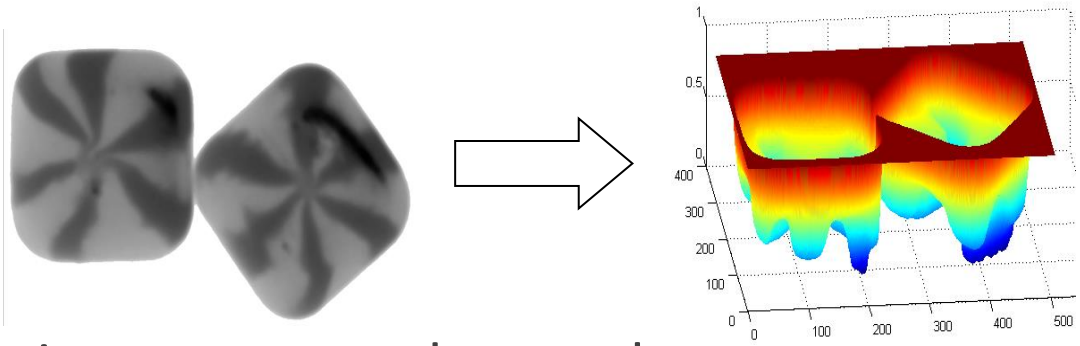
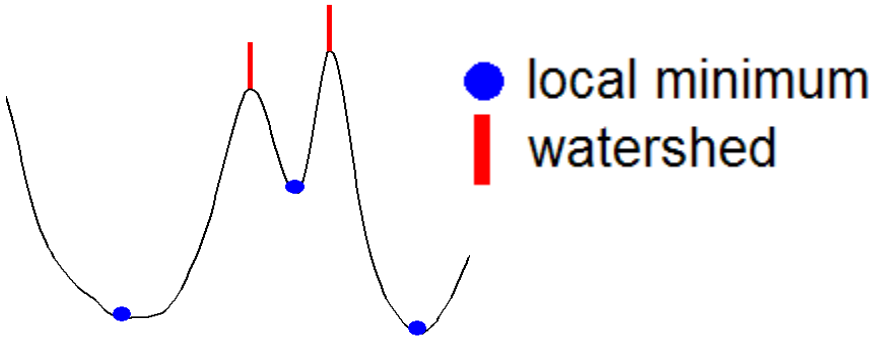
Watershed Segmentation

- Used to segment images with touching objects.
- Image is considered as topological surface.



- Local minima correspond to catchment basins (objects).



>>watershed_marker

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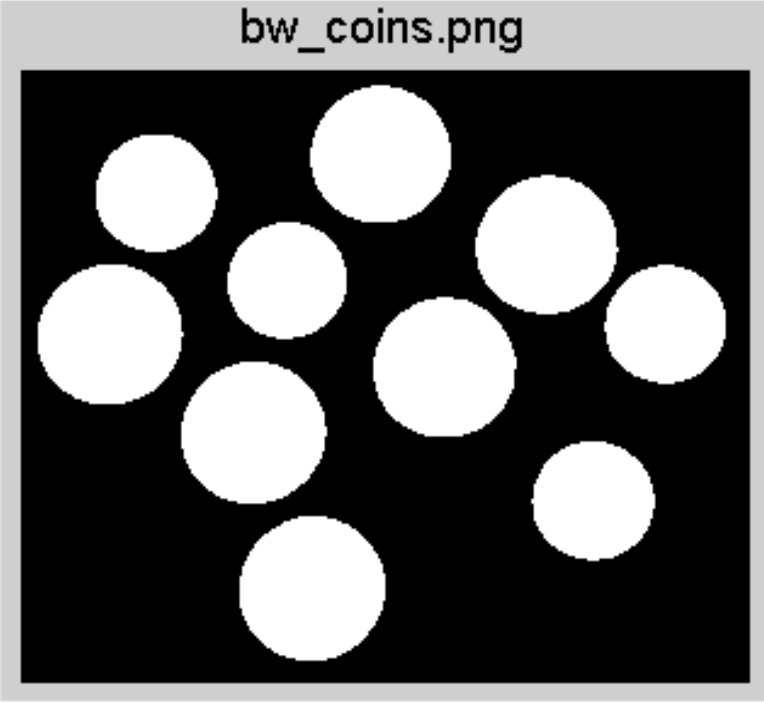
Exercise: How Many Dimes?

- Count the number of dimes in the `coins.png` image by using the preprocessed binary image (`bw_coins.png`).



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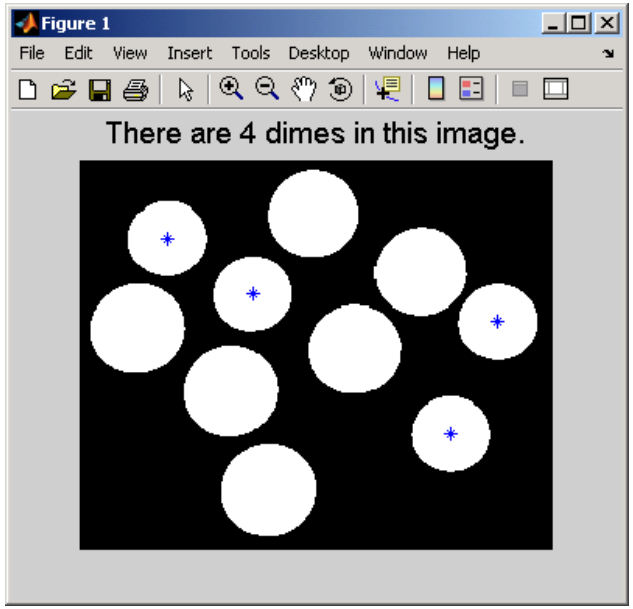
Solution: How Many Dimes?

- Label the connected components of the image – **`bwlabel`** or **`bwconncomp`**
- Find the area and centroid of the of the coins – **`regionprops`**
- Use the area information to count the dimes




```
>> count_dimes
```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