McGill initiative in Computational Medicine

Image Processing in MATLAB

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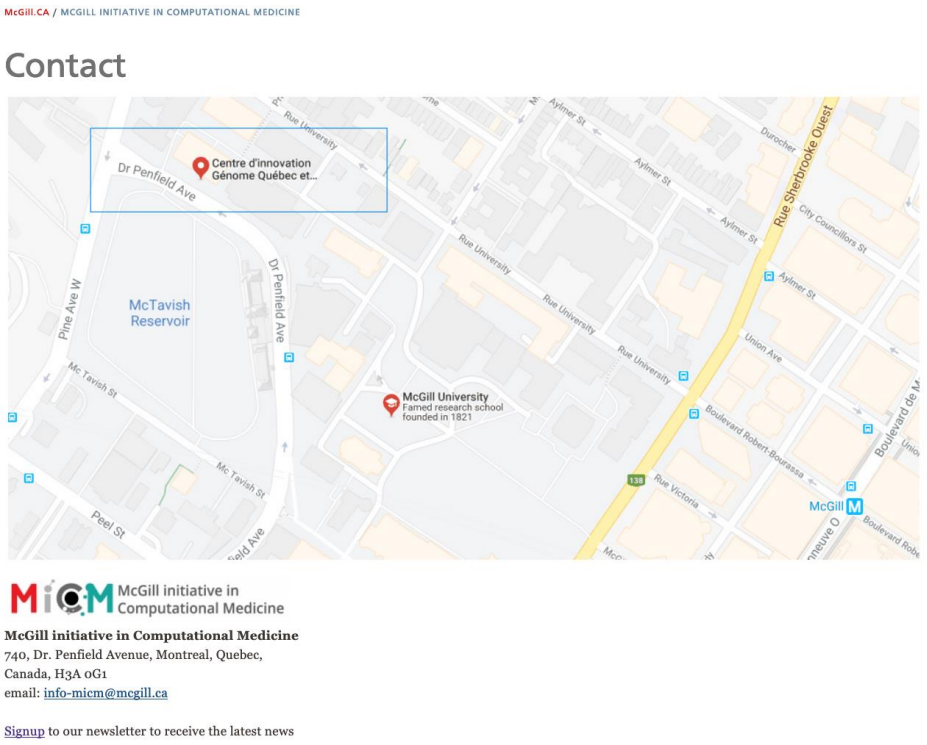
November 17, 2025

McGill | Quantitative Life Sciences | Sciences quantitatives du vivant

McGill initiative in Computational Medicine

Mission : aims to deliver inter-disciplinary research programs and empower the use of data in health research and health care delivery



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Outline

Module I:
Intro to Image Data in MATLAB

- What is an image?
- Image programming basics

Module II:
Pre-Processing and Segmenting Image Data

- Intro to segmentation and methods
- Importance of pre-processing and methods

Module III:
Performing Image Analyses

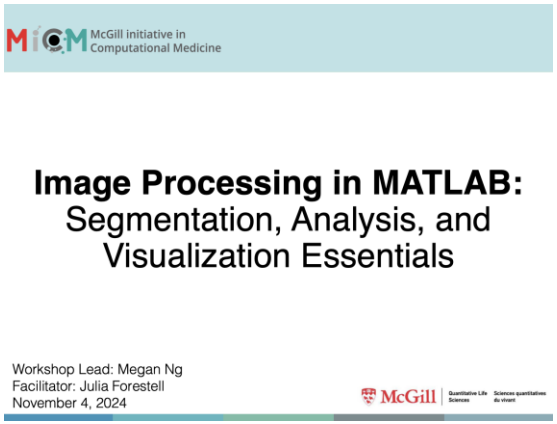
- What is structural image analysis?
- What kind of properties can we measure?

Module IV:
Visualizing Image Analysis Results

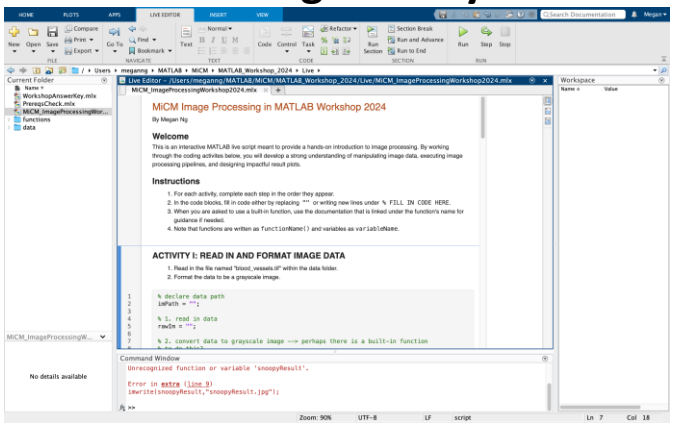
- Plotting functions and customizations
- Displaying results on images

Workshop Structure

Slides Content



Coding Activity



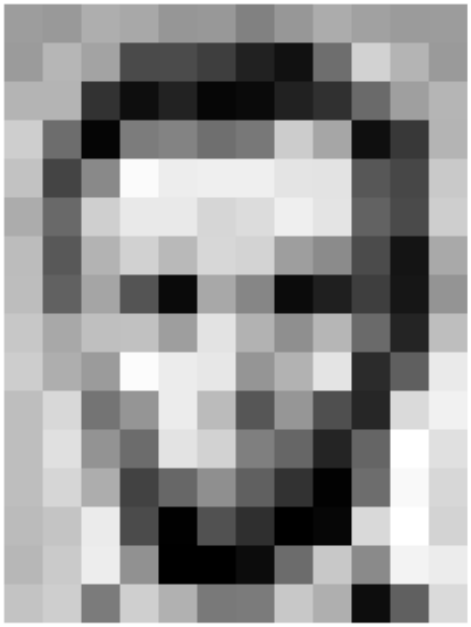
Module I:
Intro to Image Data in MATLAB

Match the Quote to Who Said it!

Quote	Who Said It
"A picture is worth a thousand words."	MATLAB, the programming language
"An image is a matrix of numeric data on which you can perform analysis."	Confucius, the Chinese Philosopher

What is an Image?

MATLAB Definition: An image is a matrix of numeric data on which you can perform analysis.



157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

How is an Image Stored in MATLAB?

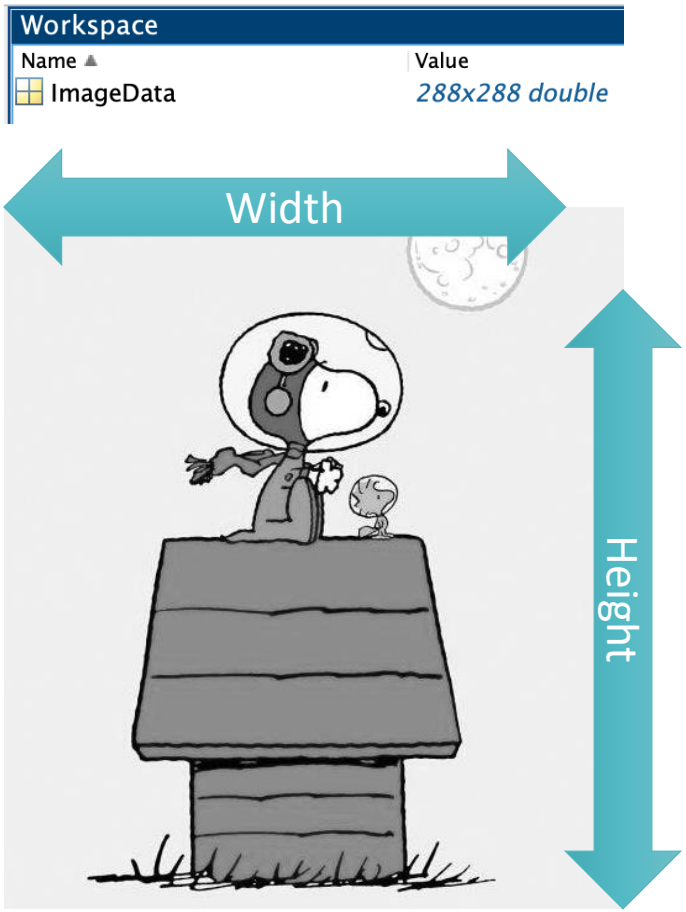
H x W matrix:

- **H** = height of the image
- **W** = width of the image
- **Value Range** = [0 1] or [0 255]

ImageData

288x288 double

	1	2	3	4	5
1	0.0185	0.0360	0.0083	0.0081	0.0117
2	0.0200	0.0220	0.0315	0.0032	0.0126
3	0.0245	0.0023	0.0158	0.0194	0.0213
4	0.0113	0.0171	0.0177	0.0160	0.0139
5	0.0328	0.0337	0.0228	0.0160	0.0277
6	0.0237	0.0175	0.0196	0.0207	0.0177



Greyscale vs RGB Images

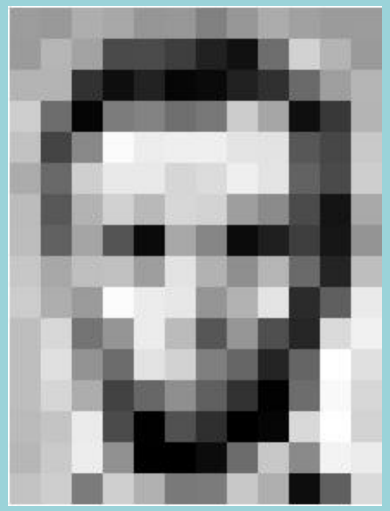
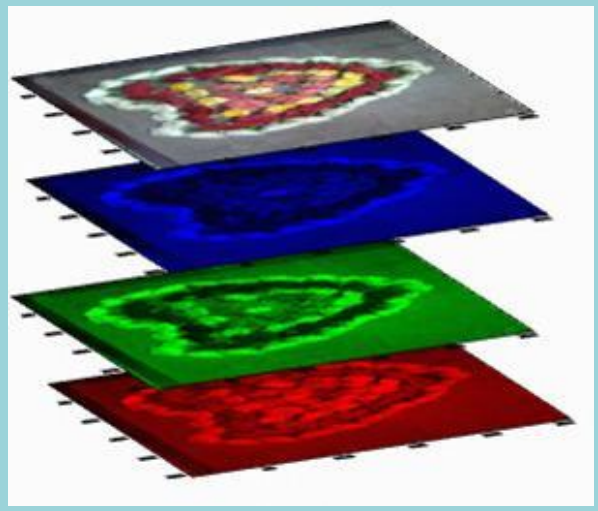
	Greyscale Image	RGB Image
Matrix Dimensions	height x width	height x width x 3
Matrix Value Range	[0 1] or [0 255]	[0 1] or [0 255]
Example		

Image Pre-processing Pipeline

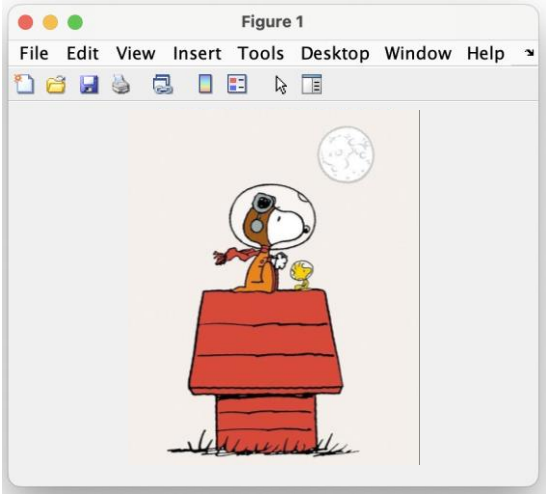
Reading and Viewing Images

imread(): Read in image from a graphics file.

```
snoopyIm = imread("snoopy.jpg");
```

imshow(): Display an image.

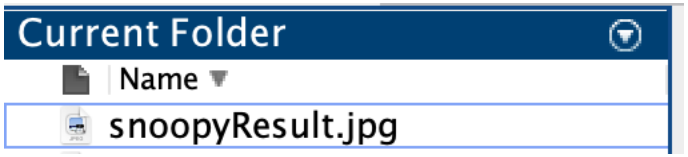
```
imshow(snoopyIm);
```



Saving Images

imwrite(): Save image to a graphics file.

```
imwrite(snoopyResult,"snoopyResult.jpg");
```



Activity I:
Read In, Format, and View an Image

Module II:
Pre-processing and Segmenting Image Data

Motivation: Structural Image Analysis Pipeline

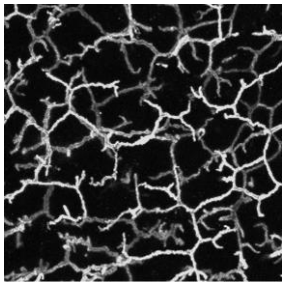
Pre-Process Image

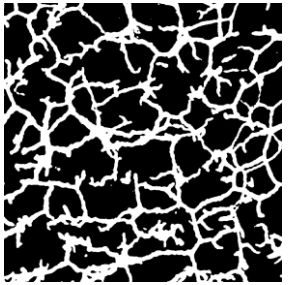
Improve quality of image to enable clean segmentation of feature of interest

Segment Region of Interest

Identify and isolate region of interest in image data.

Perform Structural Analysis on Feature of Interest





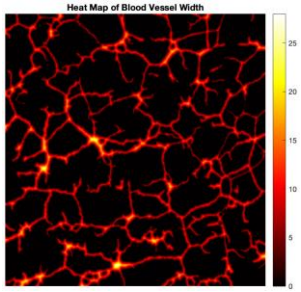


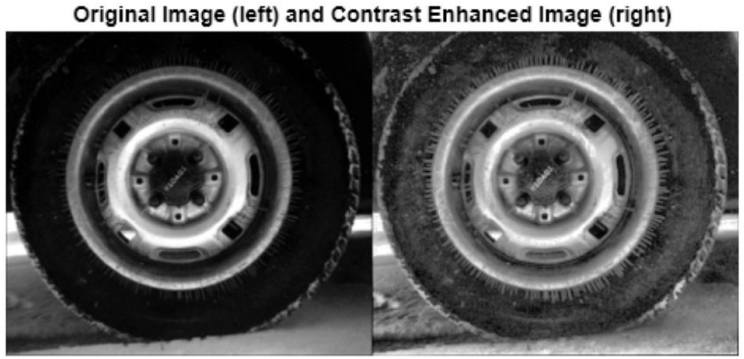
Image Pre-processing

What?

- Set of techniques employed to enhance the quality of images (noise reduction, contrast enhancement, thresholding, etc.)

Why?

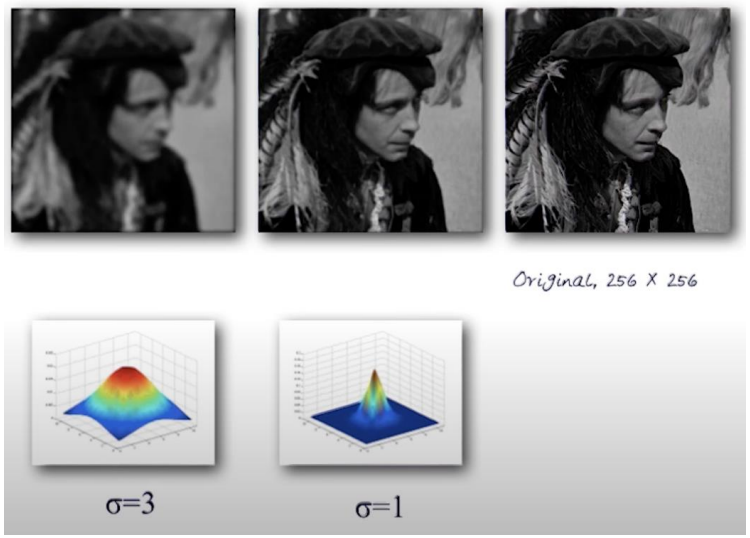
- The quality of an image determines the quality of image analysis algorithm results (segmentation in our case)



Example: Smoothing

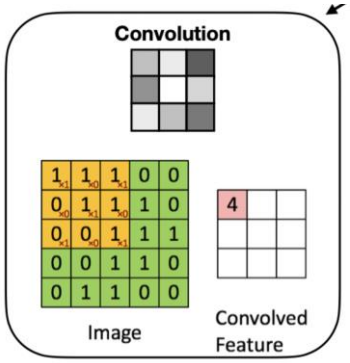
What?

- Technique used to reduce noise and fine details in an image
- Reduces the impact of small variations in pixel values



How?

- Filter image with a smoothing kernel (ex. Gaussian)
- Replaces each pixel value with an average value of its neighboring pixels



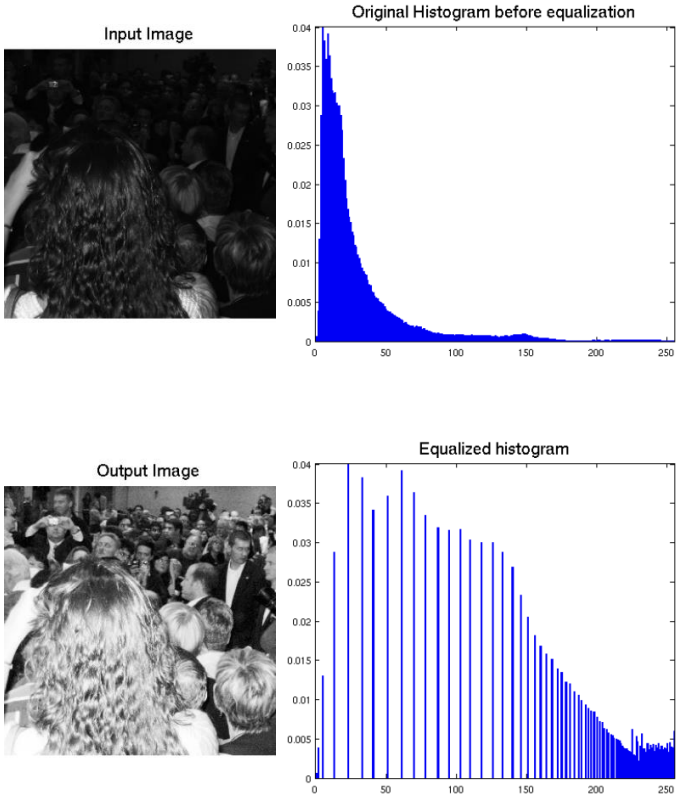
Example: Histogram Equalization

What?

- Technique to adjust the contrast of an image

How?

- Modifies the distribution of the image's pixel intensity value histogram
- Stretches out the intensity range of the image



Choosing Appropriate Techniques

How do we choose which technique(s) to use?

entropyfilt, fibermetric, imboxfilt, imboxfilt3, imfilter, imgaussfilt, imgaussfilt3, maxhessiannorm, medfilt2, medfilt3, modefilt, nlfilter, ordfilt2, padarray, rangefilt, roifilt2, stdfilt, wiener2, burstinterpolant, imbilatfilt, imdiffuseest, imdiffusefilt, imguidedfilter, imnlmfilt, gabor, imgaborfilt, bwareafilt, bwpropfilt, integralBoxFilter, integralBoxFilter3, integralImage, integralImage3, convmtx2, freqspace, freqz2, fsamp2, fspecial, fspecial3, ftrans2, fwind1, fwind2, adapthisteq, decorrstretch, histeq, imadjust, imadjustn, imcontrast, imflatfield, imhistmatch, imhistmatchn, imlocalbrighten, imnoise, imreducehaze, imsharpen, intlut, localcontrast, locallapfilt, localtonemap, stretchlim, AssistedFreehand, Circle, Crosshair, Cuboid, Ellipse, Freehand, Line, Point, Polygon, Polyline, Rectangle, drawassisted, drawcircle, drawcrosshair, drawcuboid, drawellipse, drawfreehand, drawline, drawpoint, drawpolygon, drawpolyline, drawrectangle, beginDrawingFromPoint, bringToFront, draw, inROI, reduce, wait, createMask, poly2mask, roipoly, inpaintCoherent, inpaintExemplar, reducepoly, regionfill, roicolor, roifilt2, bwhitmiss, bwmorph, bwmorph3, bwperim, bwskel, bwulterode, imbothat, imclearborder, imclose, imdilate, imerode, imfill, imkeepborder, imopen, imtophat, imextendedmax, imextendedmin, imhmax, imhmin, imimposemin, imreconstruct, imregionalmax, imregionalmin, conndef, iptcheckconn, offsetstrel, strel, applylut, bwlookup, makelut, bwpack, bwunpack, deconvblind, deconvlucy, deconvreg, deconvwnr, edgetaper, otf2psf, padarray, psf2otf, apply, bestblk, blockedImage, blockproc, col2im, colfilt, im2col, nlfilter, imabsdiff, imadd, imapplymatrix, imcomplement, imdivide, imlincomb, immultiply, imsubtract.

Choosing Appropriate Techniques

What process are we pre-processing the image data for?

Segmentation

What are the key image features to successfully perform this process?

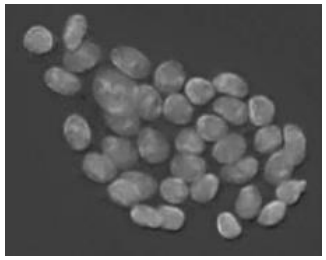
Defined edges of ROI and Minimal background noise

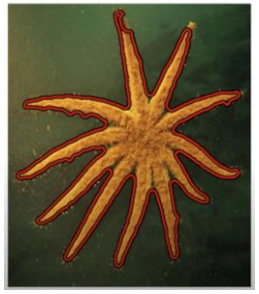
Choose techniques to ensure the presence of key image features

Segmentation

What?

- Technique to partition an image into multiple regions (ex. background and ROI)
- The result is a binary image where each pixel has value:
  - 1 = belonging to ROI
  - 0 = belonging to background





How?

- Thresholding
- Active contours
- Machine learning models
- Etc.

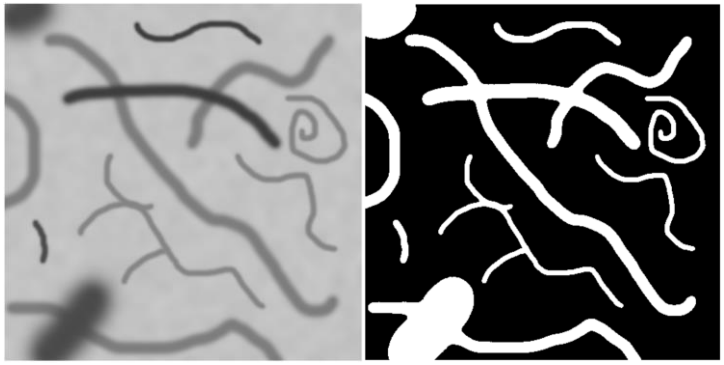
Activity II:
Segment a Feature of Interest

Module III:
Performing Image Analyses

Structural Image Analysis

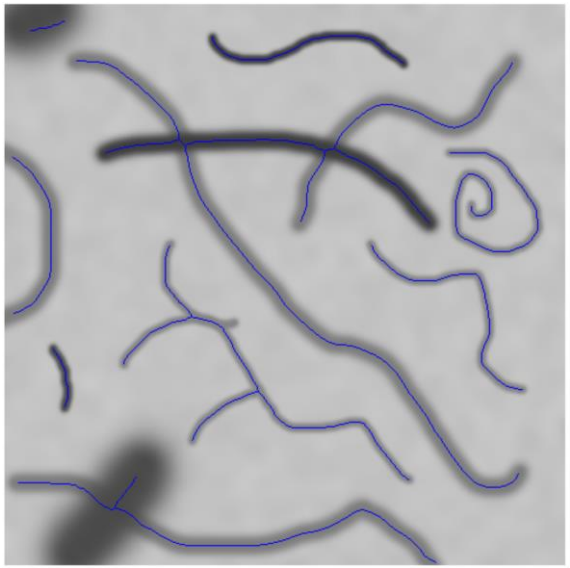
What?

- Set of techniques to measure various properties of a ROI by performing analyses on its binary mask



Property Examples

- Area
- Perimeter
- Radius
- Distance relationships
- Numerosity
- Geometry/shape
- Etc.



Activity III:
Perform a Structural Analysis on a Feature of Interest

Module IV:
Visualizing Image Analysis Results

Plotting in MATLAB

Wide range of tools

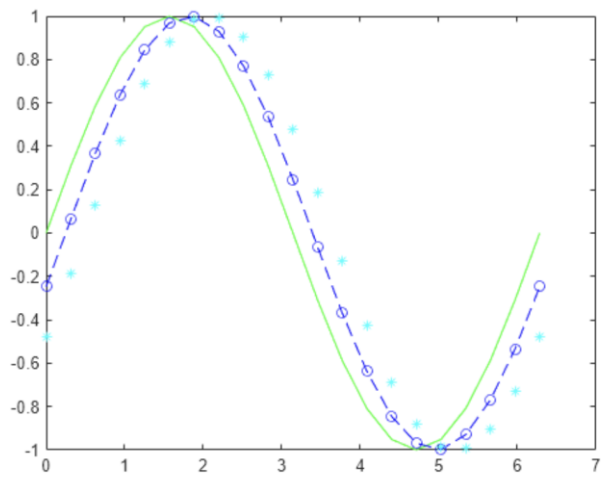
Line Plots	Scatter and Bubble Charts	Data Distribution Plots	Discrete Data Plots	Geographic Plots	Polar Plots	Contou
plot	scatter	histogram	bar	geoplot	polarplot	
plot3	scatter3	histogram2	barh	geoscatter	polarhistogram	
stairs	bubblechart	scatterhistogram	bar3	geobubble	polarscatter	
errorbar	bubblechart3	boxchart	bar3h		polarbubblechart	
area	swarmchart	swarmchart	pareto		compassplot	
stackedplot	swarmchart3	swarmchart3	stem		fpolarplot	
loglog	spy	piechart	stem3			
semilogx		donutchart	stairs			
semilogy		wordcloud				

3.html

Clear Documentation

```
x = 0:pi/10:2*pi;
y1 = sin(x);
y2 = sin(x-0.25);
y3 = sin(x-0.5);

figure
plot(x,y1,'g',x,y2,'b--o',x,y3,'c*')
```



Plotting Syntax

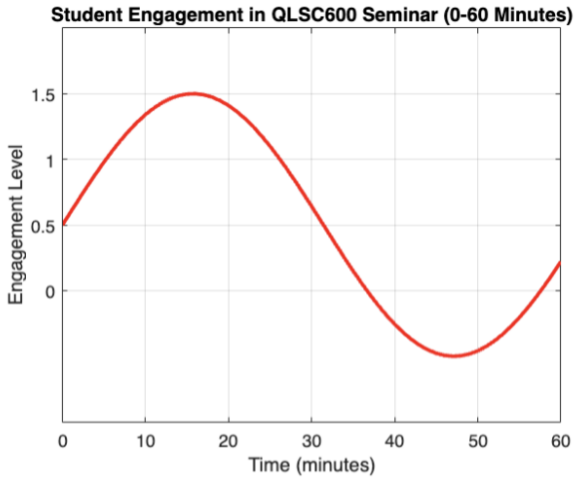
```
figure;

somePlottingFunction();

formatingSpec1();
...
formatingSpecN();
```

```
% --- Single Simple Plot: Engagement Level Over 60 Minutes ---
time = 0:1:60;
engagement = sin(time/10) + 0.5;

figure;
plot(time, engagement, 'r', 'LineWidth', 2);
title('Student Engagement in QLSC600 Seminar (0-60 Minutes)');
xlabel('Time (minutes)');
ylabel('Engagement Level');
xticks(0:10:60);
yticks(0:0.5:1.5);
ylim([-1 2]);
grid on;
```



Displaying Multiple Plots

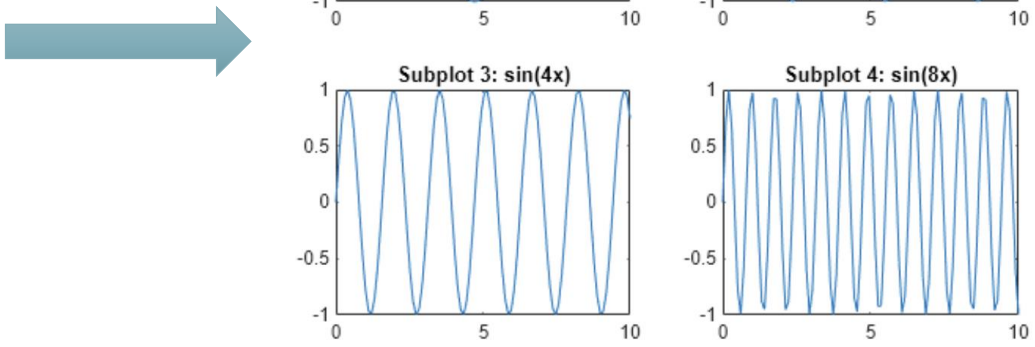
subplot(): Displays multiple plots in one figure.

```
subplot(2,2,1)
x = linspace(0,10);
y1 = sin(x);
plot(x,y1)
title('Subplot 1: sin(x)')

subplot(2,2,2)
y2 = sin(2*x);
plot(x,y2)
title('Subplot 2: sin(2x)')

subplot(2,2,3)
y3 = sin(4*x);
plot(x,y3)
title('Subplot 3: sin(4x)')

subplot(2,2,4)
y4 = sin(8*x);
plot(x,y4)
title('Subplot 4: sin(8x)')
```



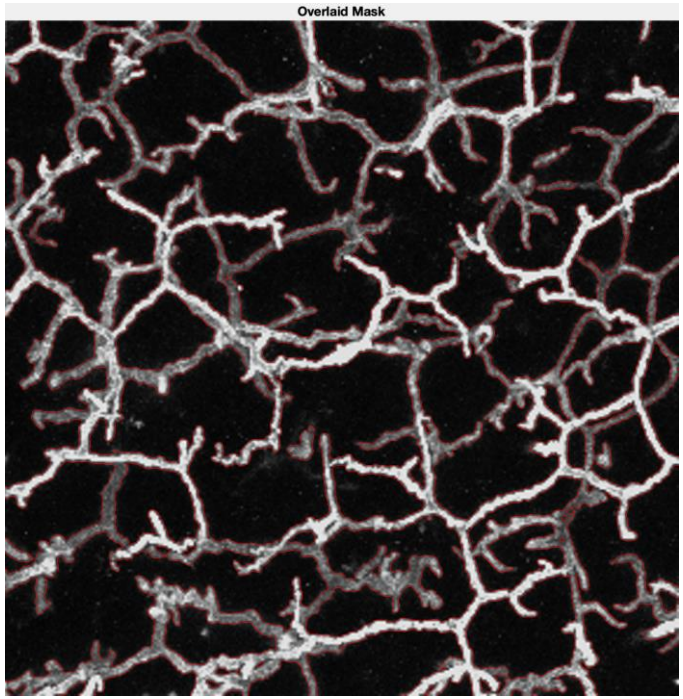
`subplot(m,n,p)` divides the current figure into an m-by-n grid and creates axes in the position specified by p. MATLAB® numbers subplot positions by row.

Overlaying Masks on Images

imoverlay(): Overlays a binary mask on an image.

```
function overlaidIm = overlayMaskOnImage(I,mask)
    % obtain mask edges
    maskEdges = edge(mask);

    % overlay edges on image
    overlaidIm = imoverlay(I, maskEdges, 'red');
end
```



Activity IV:
Visualize Image Analysis Results

Summary

✓ Feel comfortable with working with image data in MATLAB

✓ Pre-process and analyze image data

✓ Produce interpretable result figures

Now you are ready to:

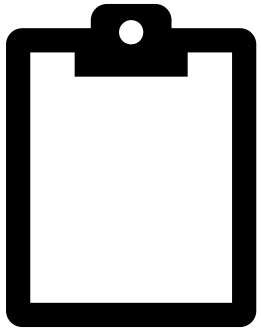
- Use MATLAB built-in functions for loading, manipulating, and saving image data
- Segment a feature of interest from an image
- Perform structural analyses on a feature of interest
- Create and customize plots
- Create informative figures by overlaying analysis results on an image

Thank you for attending!

1

Scan the QR code to confirm you attended today's workshop.

2



Fill out the feedback survey in the next 72h.

3

Get recognition for this workshop on your co-curricular record.