

BMI/CS 567 Medical Image Analysis
University of Wisconsin-Madison
Assignment #1

Instructor: Jeanette Mumford
Due Feb 1, 2018 *before* class begins

For this assignment you should turn in a single pdf file containing your code and the specific output requested for each problem. It shouldn't be necessary to run your code to grade the assignment. Name it `hwk1_yourname.pdf` (html is fine too). It should be submitted via canvas. The late homework will not be graded. Use sections and comments to explain which question and part your code refers to and you may also use comments in the few places I have requested written responses. Provide enough detailed justification and reasoning. For instance, a simple *yes* or *no* answer without justification or code will result in 0 points.

(1) (4 points) Working with numbers in matrices.

- (a) Create a 4×4 matrix of numbers sampled from a standard Normal distribution. It is highly unlikely, but if your random matrix only has positive or negative values, generate a new one with both positive and negative values. The probability of this happening is < 0.001 , so if it does happen to you make sure you're generating normal values. Display the values.
- (b) Extract the values that are positive and put them in a vector. Display the values. Do not use a loop.
- (c) Use the `find` function to extract the row and column indices of the positive values. You may need to use Google or the MATLAB help to figure this out. Display these values.
- (d) Create a 4×4 matrix that has values of 0 where your original matrix was non-positive and 1 where it was positive. Display the values.

(2) (3 points) Calculating Euclidean distance. The Euclidean distance between two vectors, $x = [x_1, x_2, \dots, x_n]$ and $y = [y_1, y_2, \dots, y_n]$ is defined as

$$d(x, y) = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2 + \dots + (x_n - y_n)^2}.$$

So the distance between $x = [1, 2]$ and $y = [3, 5]$ is $\sqrt{(1-3)^2 + (2-5)^2} = \sqrt{13}$ (note that is in 2D). We will use Euclidean distance many times in this class to see how close a pixel magnitude in a image is to some value. For your matrix in problem 1a, create a new matrix where each entry is the Euclidean distance from the entry in the first row/first column. Do this without using a loop.

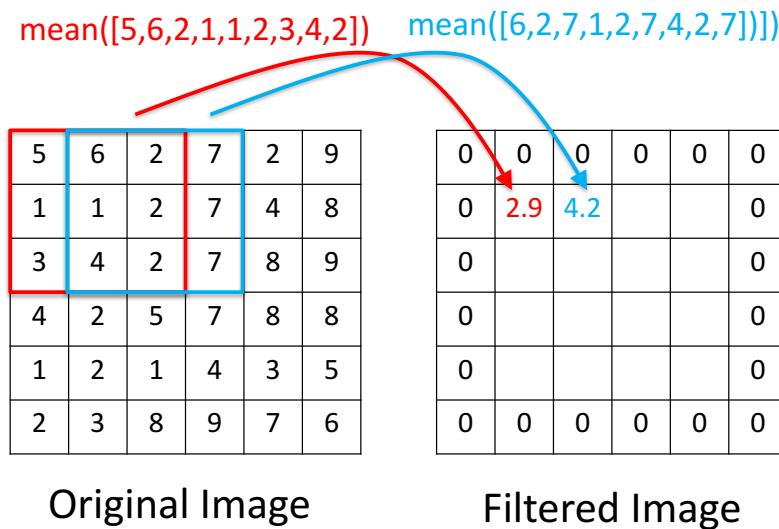
(3) (7 points) Reading in a ppm file and differentiating between image display options in MATLAB.

- (a) (3 points) Use Google or the MATLAB help to read in the `img_001.ppm` image that was distributed with this assignment. You *cannot* use a downloaded MATLAB function to do

this, but must use a built in MATLAB function. After reading in the image, display the dimension of the image and describe what each dimension represents. What is the range of values in the image?

- (b) (2 points) Use Google or the MATLAB help to learn about the differences between `imshow`, `image` and `imagesc`. For each one describe how it differs from the other 2, including when it is optimal to use that specific function to display an image. Make 3 separate figures, where each one displays `img_001.ppm` using each of these commands. Note: Do not use a multipanel plot for this exercise.
- (c) (2 points) Using a multipanel plot (1×3) and `imagesc()` to display each of the 605×700 images, separately in grayscale. Use a proper plot title to describe what the image is showing. I'm looking for more than 1, 2 and 3. I'd like the meaning of the image. You may need to google how to display in grayscale. How is `imagesc` working differently here than it did in the previous part (aside from the fact that I had you change it to grayscale)? Tip, the `axis('square')` command may make the plot look a little nicer.

(4) (10 points) Filtering an image. We will learn numerous ways to smooth an image and to practice manipulating matrices, you will mean filter the image from the previous problem. Specifically, use the red channel portion of the image (`img_001.ppm`). Importantly please change the values to double precision array using the `double()`. If you don't your new image will only have integer values and they should be real number values. The following image describes how the mean filter works. The left hand side is the starting image and right hand side is the filtered image. For now, we'll ignore the edges and simply put 0s for the edges and fill in the rest. For each pixel (entry in the matrix) construct a 3×3 neighborhood around the pixel. The center of this neighborhood is the target in the new matrix (where your value will go) and the value is the mean of the 9 values in the neighborhood. The image illustrates the first two pixels. You may not use any built in MATLAB filtering functions or convolution functions for this problem, but must code it from scratch using a loop (unless you can think of a way to avoid the loop). Filter the image and print out the first 5 entries in the first 5 rows (if the image is called `img_filt`, then use `img_filt(1,1:5)`). Also make a 1×2 panel plot where the left panel is the original image and the right panel is the filtered image.



(5) (4 points) In this problem you will make a 3 dimensional plot using the `imagesc` command. The result should be a word commonly used to greet people. The first two dimensions are x and y and describe the location of a pixel (2D unit of an image) while the third dimension can be thought of as a pixel magnitude. Step 1 is to create the grid of x and y coordinates. Step 2 will create the the pixel magnitude.

- (a) Create a and b as vectors that go from -3 to 3 in increments of 0.1.
- (b) You'll be evaluating a function over the values of a and b in all pairwise combinations. Use the `meshgrid` command, `[A, B]=meshgrid(a,b);`. Print the size of A to the screen and using `imagesc` create a 1×2 panel plot that shows A on the left and B on the right. Describe what `meshgrid` did in one or two sentences. Don't just say it created a mesh grid :) Explain what it is doing. It might help to look at the output from `[testA, testB]=meshgrid(1:2, 1:3)` as well.
- (c) Create Z according to $Z = \exp^{-A^2-B^2/2}\cos(4A) + \exp^{-3((A+0.5)^2+B^2/2)}$. Change values in Z that are greater than 0.001 to 0.001 and less than -0.001 to -0.001. Plot the result using `imagesc`. If you don't see a commonly used word to greet people, you've made a mistake.
- (d) What are the 3 dimensions in this image? Specifically, describe them and give their ranges.