# EE420 – Digital Image Processing

# Homework-1

**Assigned: Jan 19, 2021 Due: Jan 28, 2021**

**Maximum Possible Grade: 50 points**

# General guidelines

· Please upload your response to Canvas as a ZIP file with the following filename convention

o Name of ZIP file FIRSTNAME\_LASTNAME\_HW1.zip

o Replace FIRSTNAME with your first name

o Replace LAST NAME with your last name

**Failure to adhere to the filename convention will result in deduction of points.**

· Provide a detailed response to each question, including supporting mathematical arguments. Include screenshots of image before and after image processing. Failure to do will result in deduction of points.

# Submitting your solutions

Please ensure that the ZIP file uploaded to Canvas, includes the following components:

* PDF file of your write-up including response to all questions.
* MATLAB Source code for
  1. HW1\_Denoising\_by\_Averaging.m
  2. HW1\_Image\_Tampering.m
  3. HW1\_HistogramEqualization\_Part1.m
  4. HW1\_HistogramEqualization\_Part2.m

**Failure to adhere to the filename convention will result in deduction of points.**

# 1. Modeling the imaging process (5 points)

A CCD camera chip of dimensions 7\*7 mm, and having 1024\*1024 elements, is focused on a square, flat area, located 0.5 m away. How many line pairs per mm will this camera be able to resolve? The camera is equipped with a 35-mm lens. (Hint: Model the imaging process as the image in lecture 2 slide 26)

# 2. Image denoising (20 points)

For this portion of the assignment you will be simulating image denoising by averaging. Please use the Sombrero Galaxy image (**sombrero-galaxy-original.tif**) supplied with the assignment to complete the assignment. Note that the supplied image is free of noise. You are required to simulate corruption of the image by adding white Gaussian noise. The noise should have zero mean and a standard deviation of 16 gray levels. The task may be accomplished using the randn function, following the approach suggested in Slide-36 of Lecture-3.

Please refer to the MATLAB help (help randn) for details on simulating zero mean white-Gaussian noise with a prescribed standard deviation.

*Generating noisy observations*

Generate 100 independent realizations of Gaussian noise (call randn() repeatedly in a loop) and follow the approach suggested in Slide-36 of Lecture-3 to generate 100 noisy observations of the Sombrero Galaxy image.

**WARNING:** You may not use the MATLAB function imnoise to simulate noisy image measurements.

*Denoising by averaging*

Attempt to denoise the image by computing the average of

· the first 25 noisy images

· the first 50 noisy images

· all 100 noisy images

*Assessing the quality of denoising*

A useful metric for assessing the quality of denoising is the Mean Squared Error (MSE) between the original image and the result of denoising. It is defined as mean value of the squared difference in image intensity for each pixel in the original and denoised images. A MSE of zero means that the two images are identical.

To compute the MSE between the original and denoised images (say im\_original, im\_denoised), use the MATLAB commands:

>> err = im\_original – im\_denoised;

>> mse = mean(err(:).^2);

**MATLAB tips:** The following functions will prove to be useful in your efforts: imread, randn, imshow, max, min. Remember to typecast the output of imread to double before adding simulated noise using the randn function.

im\_original = double(imread('sombrero-galaxy-original.tif'));

**Deliverables & Questions**

1. MATLAB code for this portion of the assignment made available as a function or script with the name HW1\_Denoising\_by\_Averaging.m. (10 points)

2. What are the largest and smallest intensities in the original image? (1 point)

3. What makes the noise Gaussian and white? (3 points)

4. Does the result of denoising improve with averaging more realizations/images?

How does your answer compare with the MSE for each case? (3 points)

5. Screenshots of the original image and the 3 denoised images. Label each screenshot clearly.

Failure to do so will result in deduction of points. (3 points)

# 3. Detecting image tampering by image differencing (10 points)

For this portion of the assignment you will be using the starter MATLAB code **HW1\_ImageTampering.m** supplied with the assignment. The purpose is to detect tampering of an image by subtracting the image suspected of tampering from the original image. In this case, the original image is a picture of Van Gogh’s Starry Night. The image has been borrowed from<https://en.wikipedia.org/wiki/The_Starry_Night>.

Your task is to compute the difference between the original image (im\_original) and the tampered image (im\_tampered) and check for evidence of tampering. Please bear in mind that im\_original, im\_tampered are uint8 (unsigned 8-bit integer) variables. Failure to cast these variables to double prior to computation of the difference will result in erroneous results.

To see what I mean, try displaying the difference image abs(im\_tampered - im\_original) using the MATLAB command imshow. Remember to use the [] option when invoking imshow.

Now attempt to fix the problem by casting im\_tampered and im\_original to double format (using the double command) before computing the difference image. If you have done things correctly, you should see clear evidence of tampering, upon displaying the difference image using imshow.

**WARNING:** Do not attempt to verify your answers with a friend as each person will get a difference answer.

**Deliverables & Questions**

1. Completed MATLAB code for HWK1\_Image\_Tampering.m. (5 points)

2. What message is hidden in your painting? (2 points)

3. Provide screenshots of the original image, the tampered image, the difference image with and without typecasting into double format. Label each screenshot clearly. Failure to do so will result in deduction of points. (3 points)

# 4. Histogram Equalization (15 points)

## **Part-I** (5 points)

It is common knowledge that the visibility of lane markings, road signs, and obstacles on roads is significantly reduced at nighttime. Your task is to develop a contrast enhancement algorithm based on the principles of histogram equalization. For this portion of the assignment you will be using the image Dark\_Road.jpg.

Please perform the following operations on the image and document the results in your writeup:

a) Plot and submit histogram of the original image (lookup MATLAB tips below). (1 point)

b) Briefly comment on the shape of the histogram. Does the histogram explain why the image appears dark? (1 point)

c) Apply histogram equalization to the original image (use MATLAB function: histeq).

Display and submit the result of enhancement. (1 point)

d) Plot and submit the histogram of the enhanced image. (1 point)

e) Comment on desirable/undesirable enhancements in the image (1 point)

**MATLAB tips:** Use the MATLAB function imhist to compute the image histogram. The MATLAB function plot may be used to plot the resulting histogram. Lookup MATLAB help for these functions before using them.

**MATLAB Deliverables**

Please furnish the MATLAB code you developed for Part-I of this assignment as a MATLAB script or function HW1\_HistogramEqualization\_Part1.m.

## **Part-II** (10 points)

The second part of the assignment tests your understanding of the principles governing histogram equalization. For this portion of the assignment you will be using the binary image Checkerboard.png. Notice that the squares in the image are either black or white. This fact may be confirmed by examining the gray levels and plotting the histogram of the image.

Please perform the following operations on the image and document the results in your writeup:

a) Plot and submit histogram of the original image. (1 point)

b) Comment on the structure of the histogram? (1 point)

c) Apply histogram equalization to the original image (use MATLAB function: histeq).

Display and submit the result of enhancement. (1 point)

d) Plot and submit the histogram of the enhanced image. (1 point)

e) What happened to the intensity of the black and white squares? (1 point)

f) Provide a mathematical justification for why the result makes sense. (HINT: Lookup slide-22 from Lecture-4). (5 points)

**WARNING:** When displaying your results in MATLAB, avoid using the [] flag for imshow. Failure to do so will result in erroneous interpretation of results for Part-II of the assignment.

**MATLAB Deliverables**

Please furnish the MATLAB code you developed for Part-II of this assignment as a MATLAB script or function HW1\_HistogramEqualization\_Part2.m.