

EBME 461/361

Homework 06: FT

Satish Viswanath, Ph.D; Pallavi Tiwari, Ph.D.

Department of Biomedical Engineering

Due Date: March 20

This is a simple project just to experiment with image processing in the Fourier domain. For this homework, we ask that you try and work individually on this assignment.

Please submit the work via Canvas. EACH problem should include:

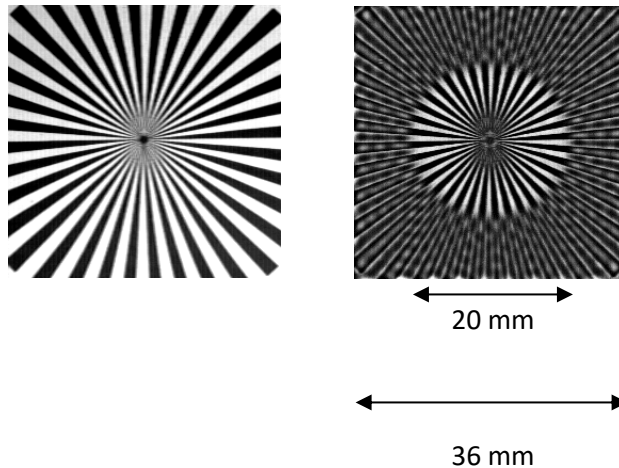
- A short discussion of each problem (*code/images alone will not suffice. A brief description/explanation of what you did/found should accompany each image/algorithm*).
- Any processed images
- All Matlab code used to generate results and images [*NOTE: Matlab code may be randomly tested by TA for functionality*]. You should write your code so that someone versed in Matlab can use it easily

Please paste all generated images and Matlab code into one organized document with your discussion text and submit as a single .pdf, titled something like "[caseID]_HW06.pdf"

The following files will be provided by the TA:

edges.tif
wheel.tif
image1.tif
lena.bmp
iris-illustration.bmp

1. Basic Fourier Stuff: The image on the left is filtered in the Fourier domain to obtain the image on the right. The outer data in the image on the right is much depressed, even though there is structure visible. The data in the middle is unaffected. *Note: No digital image processing is required for this problem!*
 - a. ~~Is the filter a high-pass or low-pass filter?~~
 - b. ~~Sketch a generic plot of the transfer function of this type of filter. Be sure to still label axes & standard units!~~
 - c. Determine the cut-off frequency for this particular filter. To do this:
 - i. ~~At what circle radius (in mm) is the cutoff?~~
 - ii. ~~How many cycles are there?~~
 - iii. ~~Convert this to cycles/pixel assuming a pixel size of 0.5 mm.~~



2. ~~We will now investigate low-pass filtering in the frequency domain using the images WHEEL.TIF and EDGES.TIF. For both images do the steps below.~~
 - a. ~~Apply an ideal low-pass filter at a frequency which is 1/3 the maximum frequency.~~
 - b. ~~Apply a low-pass Gaussian filter with a 1/2 width at half maximum amplitude which is 1/3 the maximum frequency. Recall the equation for a 2D Gaussian filter you had to use in Hw2 Prob 4a.~~
 - c. Print out these images for report
 - i. The 2 original images before filtering in Cartesian domain
 - ii. The 2 original images before filtering in frequency domain
 - iii. The 2 images after ideal low-pass filtering in Cartesian domain
 - iv. The 2 images after ideal low-pass filtering in frequency domain
 - v. The 2 images after Gaussian low-pass filtering in Cartesian domain
 - vi. The 2 images after Gaussian low-pass filtering in frequency domain
 - vii. 1 of your ideal low-pass filters in frequency domain
 - viii. 1 of your Gaussian low-pass filters in frequency domain
 - d. Compare the two filters and explain results: *Which yields less ringing artifacts? Which yields better smoothing/blurring?*
 - e. Obviously the low-pass filters are reducing high frequencies. What are the high frequencies in these images?

- f. *Use your previous results to answer this.* Let's just say my image was a single white dot on a black background (i.e. a 2D impulse function). Describe, sketch, or program what would happen to that dot if I applied (i) an ideal-low pass filter? (ii) a low-pass Gaussian filter? *NOTE: This would be called the impulse response function, or "point spread function".*
3. We want to analyze the energy distributions of different types of images (lena.bmp and iris-illsutration.bmp). *The energy distribution in images refers to the magnitudes of frequencies it contains.*
 - ~~a. First, convert the input color image to the grayscale format.~~
 - ~~b. Plot the log magnitude of the 2D DFT of the grayscale image, with center shifted.~~
 - ~~c. Then apply the truncation windows to keep 30%, 15%, and 5% of the DFT coefficients. Plot each of these truncated windows.~~
 - ~~d. Apply the 2D inverse DFT to reconstruct the image for each of the truncated spectra. Print out both images reconstructed using each of these truncation windows.~~
 - e. Compute the SNR value for each of the reconstructed images. *What happens to SNR as you truncate more data?*
 - f. Discuss any differences in the energy distribution seen between these two types of images, i.e., natural photos vs. diagrams.

EXTRA stuff (for fun. No extra credit).

4. Filter IMAGE1.TIF by convolving it with the spatial filter function below. Perform the convolution in the spatial domain and in the frequency domain. For the filter kernel below, the origin is at the center. Please normalize it to have a dc gain of 1 before using it. Compare filtered images.

1	1	1	1	1
1	1	1	1	1
1	1	(10)	1	1
1	1	1	1	1
1	1	1	1	1