Programming Assignment 3
CS 111: Digital Image Processing (Fall 2016)
Due: Nov 14. Midnight

In this assignment, you will be working in MATLAB environment. The image processing library in MATLAB provides a rich set of functions for image manipulations in spatial and frequency domain. A quick guide to start and work with the DFT of images in MATLAB is in http://matlabgeeks.com/tips-tutorials/how-to-do-a-2-d-fourier-transform-in-matlab.

Part 1: Discrete Fourier Transform

a) Step1: Create a 512×512 pixel image.
Step2: Assume that X and Y are the coordinates of pixels in the above image. Calculate the value of each pixel using the following equation:

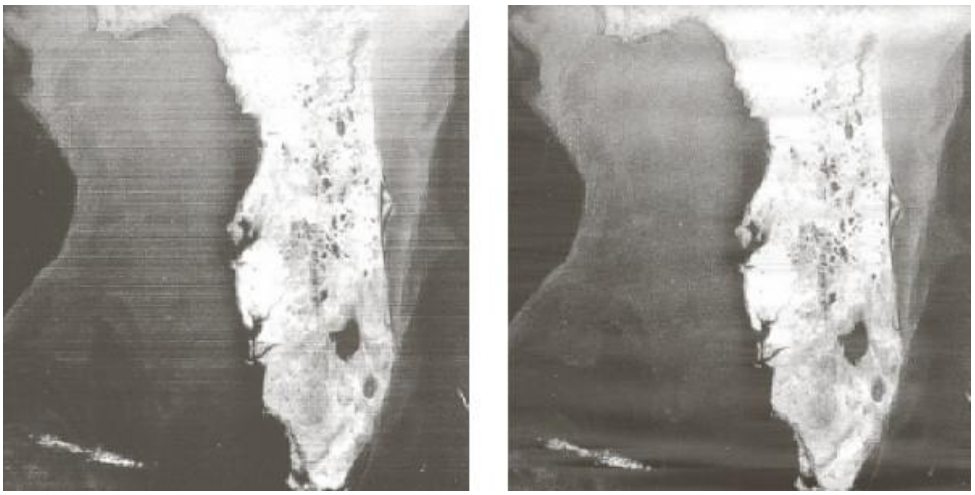
$$I(x,y) = \sin(0.1x) + \sin(0.2x) + \cos(0.4x) + \sin\left(\sqrt{x^2+y^2}\times 0.15\right) + \sin\left(\sqrt{x^2+y^2}\times 0.35\right)$$

Show your image in the pdf file.
Step3: Compute the Discrete Fourier Transform of this image. And show the magnitude and phase of DFT for this image. You can use MATLAB functions to calculate the DFT. You should rearrange the result to show the zero frequency in the center of the image. For this purpose, you can use "fftshift" function in MATLAB.

Step4: Multiply the magnitude of DFT by 2.0 and calculate the inverse Discrete Fourier Transform of it and show the result and explain the difference between the first image that you created in step 2 with this image.

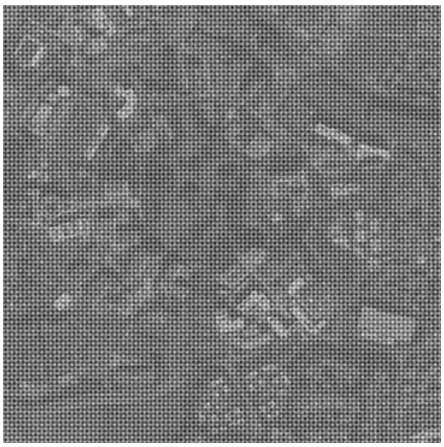
Part 2: Notch Filter

A band-stop filter is a filter that passes most frequencies, but attenuates those in a specific range to very low levels. A notch filter is a band-stop filter with a narrow stopband. These filters are using to remove periodic noise that can be approximated as two-dimensional sinusoidal functions from the image.



For example, in the above figure at left you can see the satellite image of Florida showing horizontal scan lines, and at right you can see the result of applying a notch filter.

Use the images from the image gallery (on the website) and try to develop your own band-stop filter to remove the noise. For this purpose, you should calculate the DFT of the image and remove a specific range of frequencies and then calculate the inverse DFT. You need to test different frequency intervals to find the best filter.



Deliverables:

Please submit all your code and the PDF file containing the relevant input and output images in the dropbox on EEE.

Tips:

- The output of the DFT of the images are complex numbers. For finding the magnitude of DFT you should use `abs()` function.
- The band-pass or band-stop filters in 2D are rings. For band pass the values at the band are 1 and zero elsewhere. For band-stop the values at the band are zero and 1 elsewhere.
- Once you find the DFT of an image, the DC component is at (1,1) coordinate of matrix (Equivalent to (0,0) in other programming languages). After applying the `fftshift()` function, the DC component is moved to the center of the matrix.
- Since DC component is the highest value in DFT of images (add of all pixel values), it makes difficult to visualize the magnitude of DFT. For this reason, you can store the DC value in another variable and set the DC value to zero, and then plot the DFT of the image.