Digital Image Processing (CSE/ECE 478)
Monsoon-2018
Assignment-3 (200 points)
Posted on: 13/09/18
Due on: 24/09/18, 11:59 PM

Grade Table (for teacher use only)

Question	Points	Score
1	30	
2	20	
3	40	
4	80	
5	30	
Total:	200	

1. (30 points) FFT

    1. (10 points) Take any grayscale image (ideally with periodic textures or repeating objects - e.g. see `http://sipi.usc.edu/database/database.php?volume=textures`) and display the magnitude of its FFT. Display the transform so the zero-frequency point for both the horizontal and vertical frequency axes is in the center. Perform the appropriate range transformation so that the magnitude can be viewed in an intensity plot.
    2. (5 points) What happens if you apply the range transformation applied on the FFT to the image instead ?
    3. (15 points) Take the FFT of the FFT. You should get back to the original image but with one difference. What is that difference ? How can you fix this easily in the frequency domain ?

2. (20 points) Question 4.33 from G & W textbook

3. (40 points) Choose a 64×64 image and find its DFT. Now, add 64 columns and rows of zeros to the right and bottom side of the original image. Now find the DFT of this new image again. Repeat this process two more times each time doubling the image size and padding the pixels on the right and bottom by zeroes. You will therefore have 4 images – first one 64×64 with no zero padding and then 128×128, 256×256 and 512×512 after padding. Find the DFTs of all these images. Display the results and explain the relationship between the four DFTs you get. Justify the relationship you discover.

4. (80 points) DFT, IDFT, Padding, Powers of 2. NOTE: In the question below, use `fft` to compute the DFT.

1. (10 points) Pick two images f, h of same dimensions (for example, 'rice' image and 'cameraman' image in MATLAB examples are both 256×256). Compute their respective fourier transforms F, H. Verify that iDFT[FH] does NOT correspond to the center portion of $f * h$ (convolution). (For 256×256 images, iDFT[FH] would be 256×256 but $f * h$ would be 511×511. Compute the average of squared difference between pixel values in iDFT[FH] and the central 256×256 portion of $f * h$ to do this).

2. (20 points) Pick f and h of different dimensions, each not necessarily square, and verify the convolution theorem ($DFT[f * h] = F_z H_z$, where F_z and H_z are the 2D-DFT of the images f_z, h_z, with f_z, h_z being the images f and h,with appropriate zero-padding).

3. (30 points) In the above question, find the time required to compute the convolution directly (using `conv2`) and using the DFT (find F_e, H_e after zero-padding, multiply point-wise, and take inverse DFT). Use matlab functions (`tic, toc, cputime`) for calculating the time required for your operations. What are your observations for various different dimensions of f, h ?

4. (20 points) Suppose f, h are two images whose dimensions 256×256 and we wish to convolve these images. You may use two "real" images or simply define an arbitrary array of size 256×256. If we want to find $f * h$ using DFT, we need to zero-pad each array to be of size 511×511 and compute the DFTs of these 511×511 arrays. Find the time required for this computation, using 511×511 sized arrays. Find the time required to compute the convolution (again,using DFT) by zero padding the arrays f and h to be of size 512×512. Verify that all the values of the convolution result, outside a 511×511 sub-array are practically zero. Comment on your results.

5. (30 points) Aliasing: Consider the following 256×256 checkerboard image `http://in4k.untergrund.net/images/checkerboard6qi.png`. Sample this image at different spatial sampling frequencies n_x, n_y. By examining the corresponding centered Fourier transform's magnitude images, determine the highest sampling frequency N_x, N_y which can be used to recover the image. Show the resulting images and corresponding Fourier transform magnitude images.