UCLA
Dept. of Electrical and Computer Engineering
ECE 114, Fall 2019
Computer Assignment 6: 2D DFT

Introduction: In this assignment, you will experiment with the two-dimensional Fourier Transform of digital images.

The following tools in Matlab will be useful in this assignment:

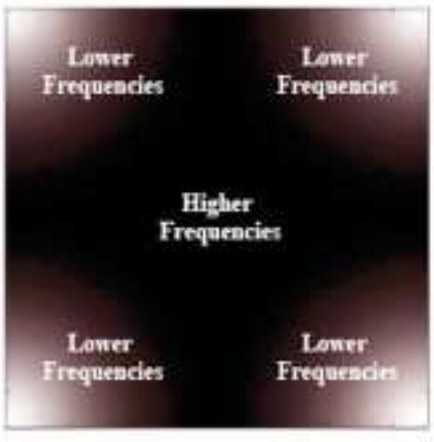
Fast Fourier Transform of a 2D image (fft2**)**: The Fourier Transform of a 2D image can be performed by fft2:

```
a_ft = fft2(image);
```

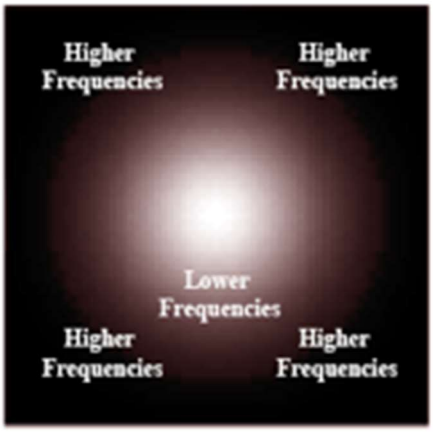
Inverse Fast Fourier Transform of a 2-D image (ifft2**)**: The Inverse Fourier Transform of a 2-D array can be performed by ifft2:

```
image = ifft2(a_ft);
```

Shift (imcrop **and** ifftshift**)**: The coefficient array produced by the Fourier Transform has the lower frequency components at the corners of the 2D array and the higher frequency components at the center as shown in the figure below.



fftshift performs a 2D circular shift that moves the zero-frequency component of fast Fourier transform to center of the array as shown in the next figure.



ifftshift undoes the operation of fftshift.

Important note: the fftshift function is used only for displaying purposes. For example:

imagesc(fftshift(a_ft)); colormap(gray);

Do not use it in your actual calculations, or, if you do, don't forget to shift back with ifftshift, before you go on.

Tasks: The **boldface** text indicates what you need to turn in for completion of your computer assignment. You also need to turn in all the Matlab code that you write.

1. **Display the image and its FT**. Load and display the ca6 image.tif file. Try to display it with the correct aspect ratio, and print out the image on a printer. Please turn in the ca6_image.tif printed from Matlab.

   Perform the Fourier transform and display the amplitude of transform coefficients as described below.

   Because the amplitude of the coefficients usually spans a wide range, it is often helpful to convert to a log scale before display. One formula that often leads to good scaling for display is:

$$D = \frac{\left(10g_{10}\left(\frac{|coeff|}{max}+0.000001\right)+c\right)255}{c}$$

   where coeff is the coefficient value, and max is the maximum amplitude among all the coefficients. The constant c is set to 6.0 for this assignment. Adding 0.000001 to the amplitude ensures that the log function does not get a zero input.

Note: This scaling is only to be done immediately before an image is displayed. All other manipulations of the image such as filtering, inverse transform of the filtered images, etc. should be done on data that has not been scaled using the above equation.

Print and turn in the scaled amplitude FT coefficient array printed from Matlab.

2. **Modify the coefficients and observe the effects**. Take the FT of the original image ca6_image.tif and set the value of all coefficients outside the window spanning the range (horizontally and vertically) [−128,+127] about the origin to the value 0.0001. In other words, the coefficients within the window should be left unchanged, and those outside the window should be set to 0.0001.

Print and turn in the reconstructed image.

Calculate the PSNR of the reconstructed image relative to the original image. You may do this using MATLAB's built in psnr() function. Note that the inputs should be in uint8.

3. **More processing**. Repeat Task 2 but with coefficients retained only in the window bounded by [−64,+63]. Repeat again using the window bounded by [−32,+31]. Compute the PSNR and turn in the reconstructed image for both cases.