Homework Assignment #5

Due Date: Friday, 01 November, 2013 at 11:59pm (MDT)

What to Submit

Please submit **ONE** appropriately-named **pdf file** via Learning Suite containing your solutions to the PROGRAMMING exercises (include the necessary plots and all code that you've written to complete the exercises).

PROGRAMMING EXERCISES

For this assignment, you will again need code for the Fourier Transform (I recommend that you modify your own DFT code to work in two dimensions ***if*** you're confident that it's correct, or if you prefer, you're welcome to use `fft2()` and `ifft2()` from Matlab or NumPy). You'll probably also want to use `fftshift()` which will give you the centered plots in the frequency domain (origin in center of "image").

Some of the frequency-domain images will be largely black (zero) with a few bright (non-zero) points, so be careful to look at them closely. You may find it easier to invert the images (black on white instead of white on black) when preparing your write-up.

PART A: Simple sines and cosines

1) Make a two-dimensional image that is a sinusoid in one direction and constant in the other:

   f[x,y] = sin(2 pi *s* x / N)

   (Don't let the fact that the equation uses only x and not y throw you--this just means that you have the same set of values in each row y.)

   Use N = 256 and various (3+) values of s. Display each image and the magnitude of their respective Fourier Transforms.

2) Create another two-dimensional image, again with a sinusoid in one direction and constant in the other, only swap the two directions: f[x,y] = sin(2 pi *s* y / N). Again use N = 256 but choose a different value for the frequency *s* than that used in Part (1). Again display the image and the magnitude of its Fourier Transform.

PART B: Addition

1) Add two of the images from part A together (one with sin(x), one with sin(y)).
2) Compute the Fourier Transform of the resulting sum and plot its magnitude. Explain why you get this result.

PART C: Rotation

1) Using the image created in Part B (that's the sum of the two sinusoids, one in x, one in y), rotate the image and display the result.
2) Compute the Fourier Transform of the rotated image and plot its magnitude. You can use Matlab (`imrotate()`), Python (either scipy or PIL), Photoshop or GIMP to do the rotation. Explain why you get this result.

PART D: Multiplication

1) Do the same thing as in Part B (combine the same two sinusoids, one with sin(x), one with sin(y)), only this time multiply the two images instead of adding them (be sure to use .* if you're in Matlab, not just *).
2) Explain why you get this result.

PART E: Magnitude and Phase

Using the two images *b(x,y)* = "ball.png" and *g(x,y)* = "gull.png":

1) Compute the Fourier Transform of each image (*B*(*u*,*v*) and *G*(*u*,*v*) respectively).
2) Extract the magnitude and phase parts for both *B* and *G*.
3) Pair the magnitude of one image with the phase of the other and vice-versa. In other words, pair the magnitude of *B* with the phase of *G* and vice-versa.
4) Invert both pairs and display the results.
5) The images you see now have the magnitude from one image and the phase from the other. Which of the two inputs does each most look like?

Make sure when you load the images that you only have one channel (your arrays should be 256x256) and you'll want to use double instead of uint8.

Programming Exercise Write-up

Please prepare a written write-up (submitted as a PDF) which includes the following:

- All code that you wrote for the exercises (parts A-E).
- The relevant plots and answers to questions from parts A-E.
- A brief explanation of what you did, any challenges you encountered, things that were difficult, unclear, etc.
- How long did the different parts (written, programming) of the assignment take you?