# EECS 203A: HOMEWORK #4

**Due: May 9, 2019**

Submit your homework to the class dropbox as a single pdf that includes the images.

1. Let $h(x, y)$ be the $64 \times 64$ filter defined by

$$h(x, y) = 1 + 2\cos(0.125\pi x) \quad x = 0, 1, 2, \ldots, 63 \quad y = 0, 1, 2, \ldots, 63$$

a) Compute the DFT $H(u, v)$ for $u = 0, 1, 2, \ldots, 63 \quad v = 0, 1, 2, \ldots, 63$.

b) Suppose that $H(u, v)$ from part a) is used to filter a $64 \times 64$ input image using multiplication in the frequency domain. Describe the set of all input images for which applying the filter $H(u, v)$ will not change the input image.

2. Consider a transform from an $M \times N$ input digital image $f(x, y)$ to an $M \times N$ output digital image $g(x, y)$ defined by

$$g(x, y) = 0.25\,[f(x, y + 1) + f(x + 1, y) + f(x - 1, y) + f(x, y - 1)]$$

a) Let $F(u, v)$ denote the DFT of $f(x, y)$. The DFT of $f(x - x_0, y - y_0)$ is given by

$$F(u, v)e^{-j2\pi(ux_0/M \; + \; vy_0/N)}$$

Use this relationship to find $G(u, v)$ as a function of $F(u, v)$.

b) What is the transfer function $H(u, v) = G(u, v)/F(u, v)$ for the transform?

c) Find the magnitude response $|H(u, v)|$ for the transform?

d) Generate a surface plot of $|H(u, v)|$.

e) Is this transform best described as lowpass or highpass or neither? Explain your answer.

3. Consider the Laplacian filter with -4 at the center of the mask.

a) Find the frequency response of the filter.

b) Generate a surface plot of the magnitude response of the filter.

c) Is this filter best described as lowpass or highpass or neither? Explain your answer.

**Computer Problems:**

a) Apply the $3 \times 3$ Laplacian filter with the -8 in the center to the triangle image and the cat image. You can ignore the border regions where the convolution sum cannot be computed so that the output image will be smaller than the input image. Add a constant to the image so that the smallest negative value becomes zero and then scale into the range 0-255. Also apply the sharpening filter defined as the input image minus the Laplacian to the cat and triangle images. Submit the four displayable filtered images.

b) Generate an image of the DFT magnitude $|F(u, v)|$ with the DC in the center for the cat and triangle images. Submit the two images.