BME 790: Engineering Programming and Signal Processing
Fall 2013

Homework Assignment #4
Assigned Monday, October 28, 2013
Due: Friday, November 8, 2013

Read chapter 3 of Hayden, 2nd edition, and then complete the following problem.

1. Problem 3.54 (b) and (e). Please indicate what kind of filters these are.
2. Problem 3.55 part (a), (b), and (c). Please indicate what kind of filters these are.
3. An entreprenuerial BME 790 student decides to build a filter that can be specified by the following equation: $X(j\omega) = -sin(\pi\omega)$ in the range $\omega = (1, 2)$ and in the range $\omega = (-2, -1)$. Otherwise $X(j\omega)$ is 0. Answer the following questions about this filter.
   (a) Hand plot $|X(j\omega)|$ and $\angle X(j\omega)$.
   (b) What kind of filter is this?
   (c) Calculate x(t), the time domain equivalent of $X(j\omega)$.
   (d) Is this filter able to be practically realized in time? Why or why not? Give at least 2 reasons to justify your answer.
   (e) How could you modify x(t) so that it could be practically realized in the time domain? How would those modifications affect $X(j\omega)$?
4. Now let's explore images in the frequency domain!
   (a) Download Austin.mat from the course Sakai site and import it into MATLAB. Create a subplot where the original image is displayed in the 1st row, and the 2 dimensional FFT (fast Fourier Transform) is displayed in the 2nd row.
   (b) Where is the majority of the frequency information stored? In low or high frequencies? Please note: MATLAB starts plotting from 0 DC to 2 times the max frequency represented by the image. If you'd like to center the image about 0 DC (from -max freq to max freq) use the fftshift command. You will need to fftshift it back for all reconstruction purposes.
   (c) Make an ideal 2D low pass filter (variable name Lowpass) in frequency space (a square of 100 pixels). Multiply your ideal low pass filter with the 2D fftshifted fft of the image. Take the inverse Fourier Transform and display the result in the 2nd column, 1st row.
   (d) Take the inverse of the ideal low pass filter (i.e. 1-Lowpass). What kind of filter is this? Multiply it by the fftshifted frequency space of the image and take the inverse Fourier Transform and display the result in the 2nd column, 2nd row.

(e) Take the magnitude of the frequency space of the original image and take the inverse Fourier Transform. Display the result on a new figure. Can you resolve the original image? What does this mean as to the importance of the magnitude of the frequency components as it pertains to recreating an image?

(f) Take 1 pixel of the original frequency space of the image and set it to an artificially high value. Take the inverse Fourier Transform and show the result. How did this one modification affect the overall reconstructed image?