CS552 Homework 3 — Due Tuesday Feb 8, 2005

Part 1

(a): Fire up Matlab and implement the function $f(x) = 1$ for $x = 0 : 12$, and 0 for $x = 13 : N - 1$ where $N = 128$ (this is true in the following as well). Plot f together with the real and imaginary parts of its Fourier transform F, as well as the Fourier spectrum, i.e., $|F|$. Use the `fft` command to compute the 1D forward Fourier transform.

(b): Determine how to shift f such that we get rid of the imaginary part. Create a plot similar to the one from (a).

(c): Now shift the resulting complex Fourier transform N/4 positions to the right. Compute the 1D inverse Fourier transform using the `ifft` command. Plot the real part of the shifted Fourier transform followed by the real part, the imaginary part, and the magnitude of the recovered signal. Explain what happened.

Part 2

(a): Plot the two window functions

- $H(u) = |u/N| \operatorname{sinc}(u/N)$ for $u = -N/2 : N/2 - 1$;
- $G(u) = 1/\sqrt{1 + (u/4)^2}$ for $u = -N/2 : N/2 - 1$.

Here $\operatorname{sinc}(x) = \sin(\pi\, x)/(\pi\, x)$ and $\operatorname{sinc}(0) = 1$. Finally, h and g are the inverse Fourier transforms of H and G, respectively.

(b): Use the `load` command to read the ascii file `~jgregor/cs552/matlab/p.mat`. The gives you function p. Create a plot similar to that of f and F in Part 1a of p and its Fourier transform P.

(c): Compute the products PH and PG. Use the `fftshift` command to align P, H, and G such that their DC components line up. Compute and plot the inverse Fourier transform of PH and PG.

(d): Now truncate h and g to obtain 11-point wide filter kernels, and compute and plot the convolution thereof with p. Use the `conv` command. Experiment with the kernel width. Explain what happens as you go from using h and g in their entirety to using more and more narrow kernels.

Part 3

(a): Load the binary file `~jgregor/cs552/matlab/fspec.mat`. Use the `mesh` command to plot the magnitude of the complex signal M that you just loaded; manipulate it to have DC centered in the middle as opposed to at the upper left hand corner. Use the `imagesc` command to produce a logarithmically weighted spectrum image of M.

(b): Using nothing but the 1D Fourier transform (the `fft` command), derive code for computing the inverse 2D Fourier transform. Use this code to convert M into an image which you display. What does the image show?

Miscellaneous

Use the `subplot` command to pack multiple plots into a single figure. Change the axis layout by providing the right input to the `plot` command as well as by using the `axis` command. Refer to the Matlab on-line manual and your class notes for details.