ELEC 431
Digital Signal Processing
Homework 13

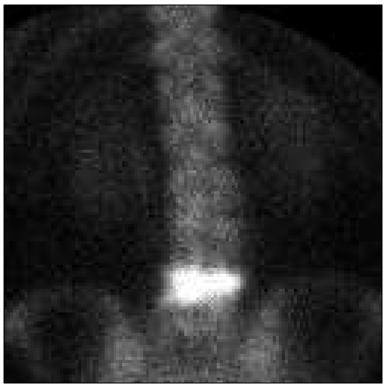
Monday, April 14, 2003

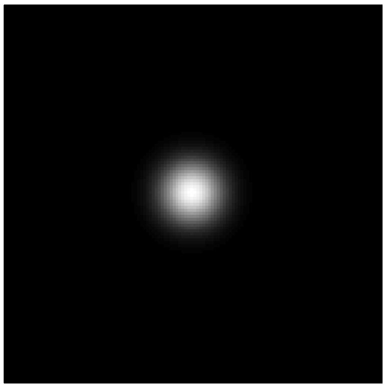
Note: Homework, tests and solutions from previous offerings of this course are off limits, under the honor code.

Nuclear medicine imaging systems can be modeled as a blurring process (convolution) plus additive noise:

$$x[m,n] = g[m,n] * s[m,n] + w[m,n],$$

where $g[m,n]$ is blurring point spread function (PSF), $s[m,n]$ is the desired medical imaging, and $w[m,n]$ is the noise power. The figure below shows an actual nuclear medicine image of a spine and the 2-d Fourier transform $G(\omega_1, \omega_2)$ of the blurring PSF. The spine image (spine.mat) and the DFT of the PSF $G[k_1, k_2]$ (psf.mat) can be downloaded from course homework webpage. Notice that the spine appears to be noisy and blurred. Also note that the Fourier transform of the blurring PSF is clearly lowpass in nature.





a. Assume that the power spectral density function for medical images has the form

$$S_{ss}(\omega_1, \omega_2) = \frac{\sigma_s^2}{(\sqrt{1+\omega_1^2+\omega_2^2})^\alpha},$$

for some $1 \leq \alpha \leq 3$ and DC power level σ_s^2. Also, assume that the noise is white with power σ_w^2. Derive an expression for the optimal Wiener filter in terms of α and the ratio $R = \sigma_s^2/\sigma_w^2$.

b. Implement the Wiener restoration filter in Matlab using the 2-D FFT.

i. Experiment with different choices of the parameters α and R. Plot the radial frequency characteristic for different parameter settings and describe the effects α and R have on the overall frequency response of the filter.

ii. Describe the effects of different parameter settings in terms of resulting image quality.

iii. Plot the what you feel is the best looking image and the radial frequency response of the corresponding Wiener filter.