ECE 732
Project 2
Estimating Power Spectra of Natural Images

Due: 5pm, 18 November 2003

This project investigates power spectral density models for natural images. Many studies have suggested that the power spectra of images tends to have a "1/f" characteristic (for example, see "Modelling the power spectra of natural images: statistics and information," by A. van der Schaaf and J.H. van Hateren, Vision Res. 36, pp. 2759-2770, 1996.) Your goal is to determine a reasonable power spectral density model for a class of images of your choosing.

1. Find an on-line database of a class of natural images (e.g., satellite images, medical images, images of animals, people, or landscapes). The collection of images you have selected above can serve as an "ensemble" (e.g., an ensemble of face images). You can use this ensemble to study the power spectral characteristics of this class of images.

   a. Estimate the power spectral density using ensemble averaging techniques.

   b. Study the power spectral characteristics. Is the power spectrum rotationally invariant? Does the spectrum decay like a 1/f process?

2. Consider estimating the power spectrum from a single image. Apply and compare periodogram and Blackman-Tukey estimators with parametric estimators based on a 1/f model. How do these estimators compare with the ensemble-based estimator above?

3. Simulate an image deblurring problem. Using a known blurring function of your choice, blur images from the database you selected. Design a Wiener restoration filter using the power spectral density model derived above.

4. Design a linear-shift-invariant filter $H(f_1, f_2)$ that matches the shape of the power spectral density model $\Gamma(f_1, f_2)$ you derived above. That is, design $H(f_1, f_2)$ so that $\Gamma(f_1, f_2) = \sigma^2 |H(f_1, f_2)|^2$. Synthesize images by passing a white noise process through this filter. The synthesized images should have the same power spectrum as the images from the class you have chosen. Do the synthetic images look like images from that class? Discuss.