EECS 551 Fall 1997

PROBLEM SET #8

ASSIGNED: November 6, 1997. No reading assignment this week! (Catch up).
DUE DATE: November 13, 1997. This week's theme: Applications of wavelets.

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1. *Image coding using 2-D wavelets*
   The MATLAB program BELOW implements a 2-D subband coder using the separable 2-D Haar basis (for simplicity).
   The "image" is the Hilbert matrix $x(i,j) = 1/(i+j-1)$.
   Why this? See part (b) below.
   a. Type in and run the MATLAB program below.
      Arrange the various subband images as in Fig. 7.26 (p.420).
   b. Show ANALYTICALLY using $x(i,j) = 1/(i+j-1)$ that 3 of the 4 subbands at each decomposition are close to 0.
   c. Replace the Hilbert matrix used in (a) and (b) as an image with any image OF YOUR CHOICE (e.g., of your face).

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2. *Wavelet-based "denoising"*
   a. The Haar-based subband coder MATLAB program ABOVE includes both an analysis part and a synthesis part.
      Change the signal $x(n)$ to $x(n) = \sin(128/\sqrt{|513-n|+1}), 1 \leq n \leq 1024$.
      Plot the 3 wavelet transforms of $x(n) : x00(n), x01(n), x1(n)$ vs. n.
      Discuss how the varying frequency of x(n) appears in the various transforms.
   b. Now add noise $0.1 * rand(1,1024)$ to $x(n)$.
      Try filtering the noisy $x(n)$ with lowpass filters with various cutoff frequencies.
      Why doesn't this work for all parts of $x(n)$? NOTE: Zoom in on $500 \leq n \leq 525$.
   c. Use the MATLAB program to compute wavelet coefficients of the noisy $x(n)$.
      Threshold the wavelet coefficients $x01(n), x1(n)$ by inspection.
      Reconstruct a filtered $x(n)$ from the thresholded coefficients $x00(n), x01(n), x1(n)$.
      Compare to the results of (b). Why does this work better?
      Again, zoom in on $500 \leq n \leq 525$. Make plots of noisy and reconstructed $x(n)$.
   d. (ungraded) The MATLAB wavelets toolbox has a nice GUI for doing this using Haar, Daubechies, and a couple of other wavelet bases. Try using it.

"An optimist is an accordion player with a beeper"–Ted Koppel