ECE 802-601 Take Home Exam 1 02/26/2008-02/28/2008

Instructions

- This exam is due on Thursday February 28, 2006 at 10:20 am. Please hand in your exam to me, do not leave it under a door or in a mailbox.
- During the exam you may use the lecture notes, the internet, any textbook in the library, and any software package. However, please make sure that you give proper citation for material quoted.
- Do not discuss the exam with anyone until at least 24 hours past the end of the examination period. Any such discussions, even between students who have completed their exams, will be treated as violations of the honor code.
- There are four questions on this exam. Please answer all questions as thoroughly as you can. To accelerate grading, please write only on one side of your papers, and start each problem at the top of a new piece of paper. For full credit, cross out any incorrect intermediate steps. If you need to make any additional assumptions in solving a problem, state them clearly. Legible writing will help when it comes to partial credit.
- Office Hours: Tuesday 1:00-2:30 p.m., Wednesday 1:00-3:00p.m.
- When appropriate, I will post the frequently asked questions and answers on the website.

1. [30] a) [10] Show that the spectrogram is not a scale invariant/covariant distribution.
   b) [5] State a necessary condition on the window function to make the spectrogram scale covariant.
   c) [5] Find a window function that satisfies the condition in part (b).
   d) [10] Using the window function in part c), compute the spectrogram of a Gabor logon, created by logon(32,0.4,128), and its scaled version (scale by a factor of 2). Include plots of the spectrogram for both cases and discuss your results.

2. [30] Consider a signal with frequency hops, generated by the time-frequency toolbox, x=freqhops(64,0,64,0.6,128,-0.6).
   a) [10] Compute the instantaneous frequency of this signal from its Wigner distribution using wigner function in the toolbox and your own instantaneous frequency code from HW 2.
   b) [5] Find an expression for a masking function, $M(t,\omega)$, in the time-frequency domain such that the product of this function with the original Wigner distribution gives you a distribution without any cross-terms.
   c) [10] Using the toolbox, compute the masked Wigner distribution and the corresponding instantaneous frequency. Compare this result with the instantaneous frequency of the signal found in part a).
   d) [5] Compare this method of masking in the time-frequency domain to masking in the ambiguity domain (kernel method), qualitatively. How do the two methods compare with respect to instantaneous frequency, the marginals, and resolution?

3. [20] a)[10] Given the kernel function, $\phi(\theta,\tau) = e^{j\theta\tau/2}$, for a time-frequency distribution belonging to Cohen's class, derive an expression for the corresponding distribution.
   b)[5] Does this distribution satisfy the marginals? Does this distribution reduce the cross-terms? Justify your answers.
   c) [5] Compare the resolution of this distribution to the resolution of Wigner distribution.

4. [20] Consider a signal that is a mixture of two signals, $x(t) = f(t)+g(t)$, where $f(t)$ is a low frequency piecewise constant signal and $g(t)$ is a high frequency sinusoid. Download the signal from the course web site.

In this problem, your goal is to obtain the components of $x(t)$ using Haar decomposition. You can use wavedec and waverec commands in MATLAB.

a) [3] Determine the number of levels of decomposition required to be able to separate the two signals from each other, i.e. determine the highest level decomposition such that the coefficients are non-zero.

b) [10] Plot the two signals and explain in detail how you separated them.

c) [3] Which subspace does $f(t)$ live in?

d) [4] Verify Parseval's identity for this signal.