Problems Week 5

Due Thursday, November 2, 2017

1. **Compute two spectra.** For this problem set, please generate a 10,000 element data set with Gaussian white noise. Use your white noise to generate a second data set using an autoregressive (AR1) process. In Matlab you can do this as follows:

   ```
   a=randn(10000,1);
   b(1)=b(1)=a(1);
   for i=2:length(a)
     b(i)=.5*b(i-1)+a(i);
   end
   ```

   Now compute spectra for the white noise and autoregressive data sets by breaking the data up into segments. (You can do this by reshaping your data vector as a 500×20 matrix, which will give you 20 segments, each 500 points long.) What are the differences between the spectra?

2. **Add error bars to your spectra.** Use the χ^2 formulation to compute uncertainties for your spectra, and show this on your plot.

3. **Use Monte Carlo simulation to verify the χ^2 error bar.** To check the error bars, you'll want to generate multiple ensembles of data and compute spectra for each of them. I would suggest using 200 matrices that are 500×20 elements each. Compute spectra for each of them. Examine the pdf of your values. (Because we're looking at Gaussian white noise, you can merge all the frequencies for this.) Is the pdf consistent with your expectations for a variable with a χ^2 distribution? //

   Now, for each frequency, sort the 200 realizations of the pdf by size (e.g. using the "sort" command in Matlab. Since you are looking for the 95% confidence range, you'll want to find the limits that exclude the lowest 2.5% and the highest 2.5% of your data—presumably the 6th and 195th points in each sorted set of pdfs.) What is the ratio of the upper limit to the lower limit? Are the error bars derived using the Monte Carlo process consistent with those from question 1?

4. **Evaluate whether windowing alters degrees of freedom.** Now apply a Hanning window to your data and repeat the analysis in question 3. Does the use of a Hanning window change the estimated uncertainties?