# ECE-497/BME-491: Applied Biomedical Signal Processing
## Laptop Day #6
## Due at the end of class, January 12, 2007

Today we have the following goals

- select a template from an EEG signal

- compute the crosscorrelation of an EEG signal

- estimate the cross spectral density of a signal

*At the end of class you should turn in three plots.*

1) Go to the class website and download the programs *laptop6.m* and the data files *eeg1-p3.dat*, *eeg1-o2.dat*, and *eeg1-f4.dat*.

2) The first thing we need to do is get a template to use. The program *select_eeg_template.m* will help you do this. The only argument to this program is the name of the file you want to use. In our case, this will initially be *eeg1-p4.dat*, so you should type:

```
template = select_eeg_template('eeg1-p3.dat');
```

For this example, you should select your template to be the part of the signal from 4720 to 5710 milliseconds. The template is the segment of the data we will be analyzing to determine if the *alpha* rhythm is present.

3) The program *laptop6.m* has four input arguments:

- the template to use (analyze). You determined this in part 2.

- the name of the $x$-data file to use, in quotes. This is the same data file used to construct the template.

- the name of the $y$-data file to use, in quotes.

- the starting index in the file. This contains the index the template starts at. Since the data is sampled at 100 Hz, in our example this will be 472.

If you type

```
laptop6(template,'eeg1-p3.dat','eeg1-p4.dat',472);
```

you should get the plot like the top three shown in Figure 1.

4) Now you need to make some modifications to compute the cross correlation and the autocorrelations needed for normalization. We will be extending the template and using data from the remainder of the signal as needed to compute the autocorrelation. We will be using the formulas

$$R_{xx}(k) = \frac{1}{N} \sum_{n=0}^{n=N-1} x(n)x(n+k)$$

$$R_{yy}(k) = \frac{1}{N} \sum_{n=0}^{n=N-1} y(n)y(n+k)$$

$$R_{xy}(k) = \frac{1}{N} \sum_{n=0}^{n=N-1} x(n)y(n+k)$$

However you need to be careful, since Matlab starts with indices at 1. (*Hint: Write out a few terms*). Your code should be written in terms of *Nt*.

5) In order to compute the normalized crosscorrelation, we need to divide the autocorrelations

$$\rho_{xy}(k) = \frac{R_{xy}(k)}{\sqrt{R_{xx}(0)}\sqrt{R_{yy}(0)}}$$

However, in Matlab $R_{xx}(0)$ and $R_{yy}(0)$ will actually be $R_{xx}(1)$ and $R_{yy}(1)$. This will tell us how to scale the cross correlation to get the normalized cross correlation.

6) If you have done everything correctly, and you uncomment the plotting commands for the *subplot(6,1,5)*, you should get at plot like the first three graphs shown in Figure 1.

7) Finally, you need to use the program *baf_fft.m* to compute the discrete-time Fourier transform of the cross correlation (not the normalized cross correlation). Once you have the magnitude of the spectrum (all we care about), normalize it by the maximum of the magnitude, so the maximum of the power spectrum will be 0 dB. Modify the code and uncomment the *subplot(6,1,6)* and you should get the entire plot shown in Figure 1. *Turn it your plot.*

8) Utilize files *eeg1-c3.dat* and *eeg1-o2.dat*, exam data from 5.00-5.70 seconds. Go through the above steps. *Turn in your plot.*

9)Utilize files *eeg1-f3.dat* and *eeg1-f4.dat*, exam data from 4.13-4.96 seconds. Go through the above steps. *Turn in your plot.*
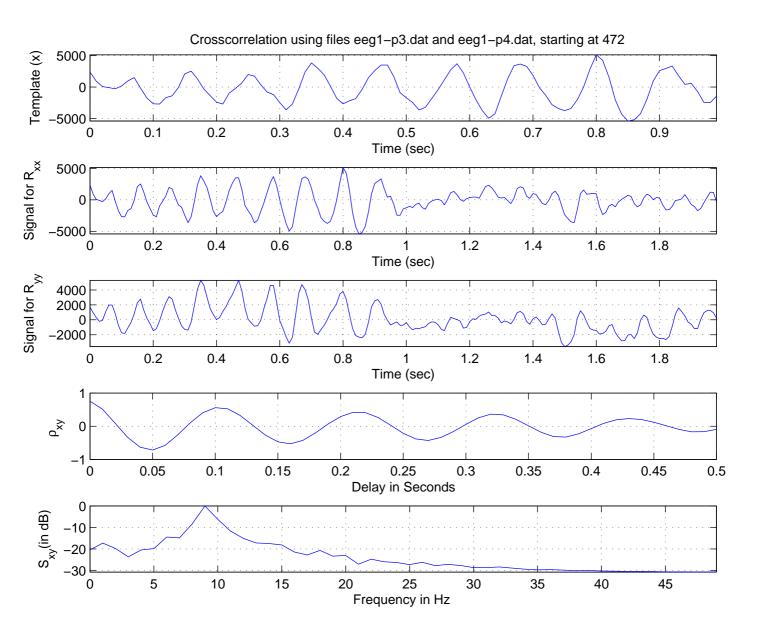
*Turn in your code.*

Figure 1: Original template, extended signal for $x$, extended signal for $y$, cross correlation, and cross spectral density for *eeg1-p3.dat* and *eeg1-p4.dat* from 4.72-5.71 seconds.