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# EE4820: Biomedical Signal Processing
# Problem Set 3: Correlation

Department of Electrical and Computer Engineering
California State University, Los Angeles

DUE: Monday 2/21

1. Semmlow P2.28

2. Semmlow P2.32

3. In this problem, we will look at the correlation between oxygen consumption, as measured by $VO_2$, and heart rate as well as with muscle EMG signals. We need to first align the data in time.

   (a) Load the data in `corrData.mat`. The heart rate and VO2 were collected synchronously on one system; four channels of EMG on another. These data were collected while the subject was performing exercises.

   (b) Create a figure to show how well the raw heart rate is aligned with VO2 and how well EMG channel 4 is aligned with VO2: A) one subplot should show the VO2 and HR vs time superimposed. B) the second subplot should show VO2 and EMG Ch. 4 superimopsed. Visually, how well are the HR and EMG aligned to VO2?

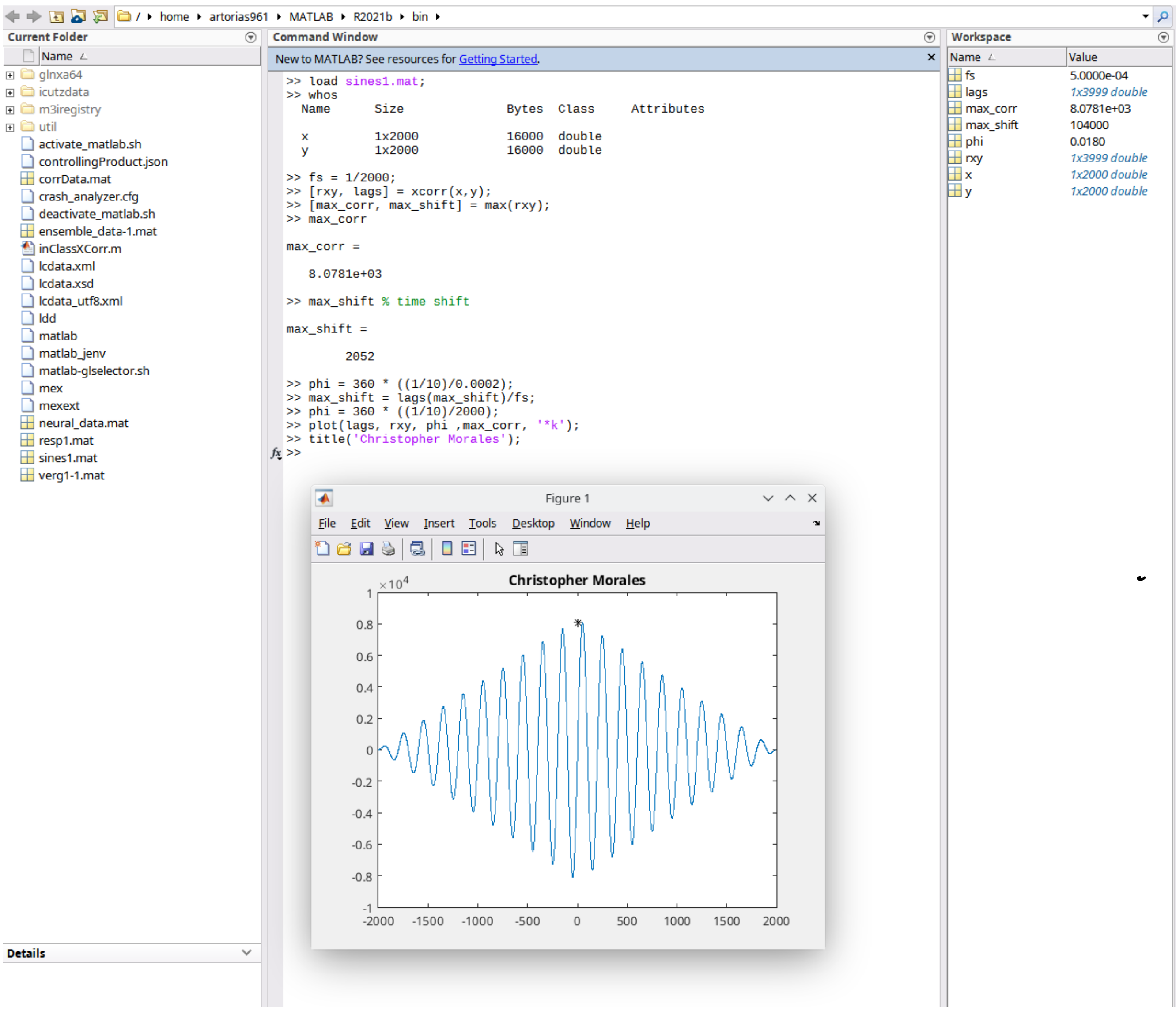
   (c) Now compute the Pearson's correlation coefficients in a matrix which shows how VO2 is correlated to heart rate as well as each of the four EMG channels, and how all those signals correlate with each other.

   (d) Let's focus on VO2's relationship with EMG Ch. 4. How correlated do they appear visually?

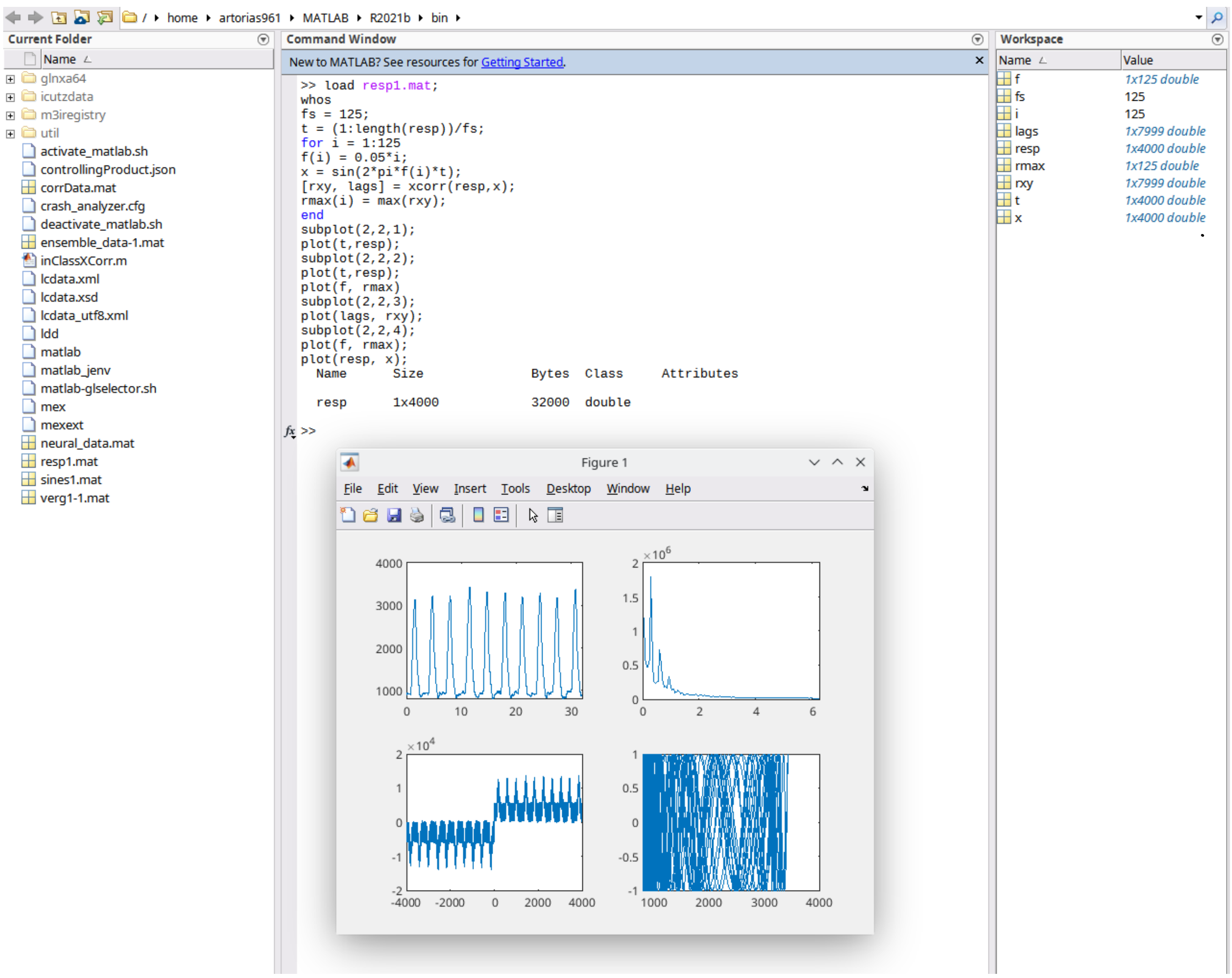
   (e) Using MATLAB's `xcorr` command, try to find the time shift that would be applied to either the HR or EMG to best align the signals in time..

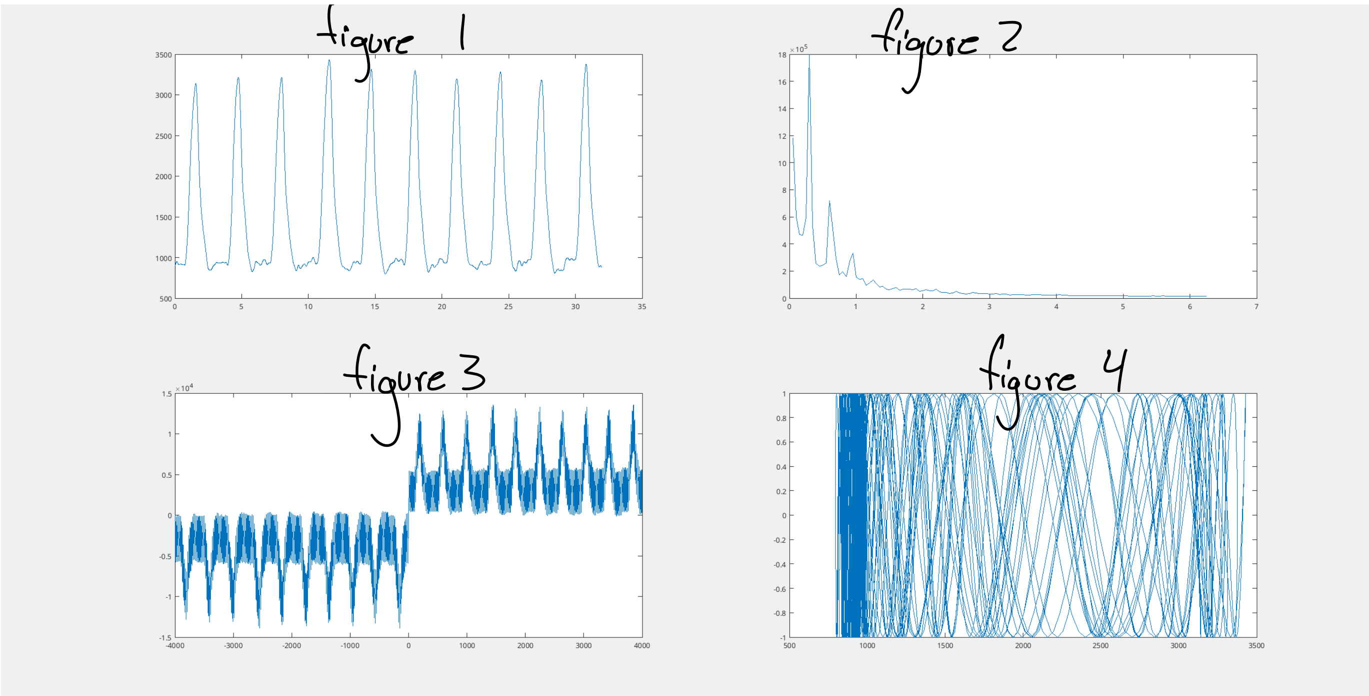
   (f) Apply that time shift to the signals. What is the correlation coefficient between VO2 and EMG channel 4 now, after the time shift? Plot the signals after shifting, and discuass whether and how your signals visually agree with the change you saw quantitatively in the change in correlation coefficient.

2.28 Use MATLAB and cross-correlation to find the *phase shift* between 10-Hz sinusoids found as variables x and y in file `sines1.mat`. Assume a sample frequency of 2 kHz. Plot the cross-correlation function and find the lag at which the maximum (or minimum) correlation occurs. [Hint: Determine the time shift using the approach in Example 2.9. To convert that time shift into a phase shift, note that the period of $x[n]$ is 1/10 s and the phase in deg is the ratio of the time delay to the period, times 360.]



2.32 Modify Example 2.10 to probe the respiratory signal in file `resp1.mat`. The variable `resp` contains a 32-s recording of respiration ($f_s = 125$ Hz). Use cross-correlation to find the maximum correlation of this signal and a number of sinusoids ranging in frequency between 0.05 and 1.25 Hz. (The respirator signal components are slower than those of the EEG signal so you need to modify the frequency range of the probing sinusoids.) Plot the respiratory signal and the maximum correlation as a function of the sinusoidal frequency. The major peak corresponds to the frequency of the base respiratory rate. Determine the respirator rate in breaths/min from this peak frequency. (Note: There are 125 (32) = 4000 points in the signal array and since the code in Example 2.10 is not optimized, the program will take some time to run.) Repeat this problem correlating the signal with cosine waves.






Sadly I could not replicate an cross correlation however from comparing figure 2 and 4, we notice that all the cosine from figure 4 is circulating at the beginning while figure 2 we can see the highest peaks at the beginning.

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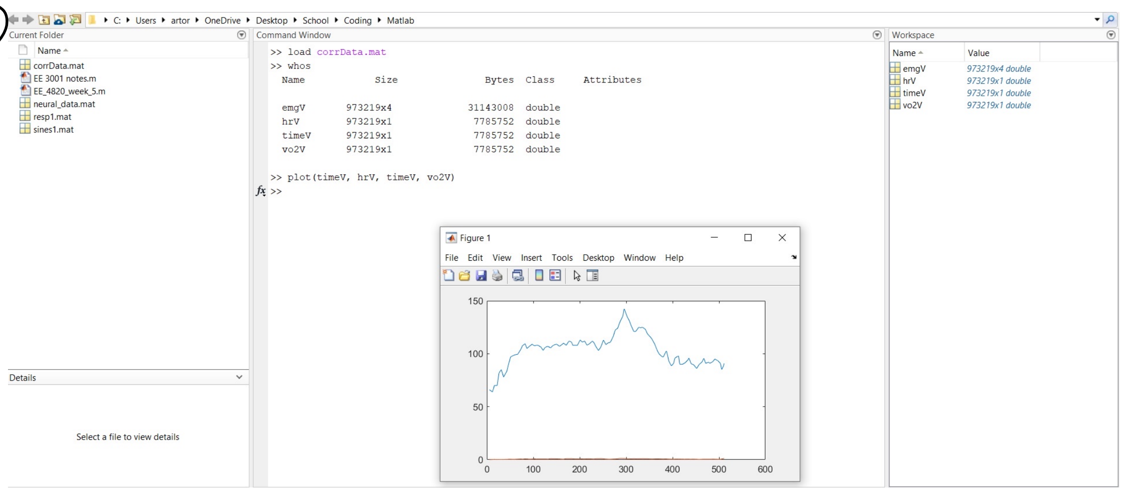
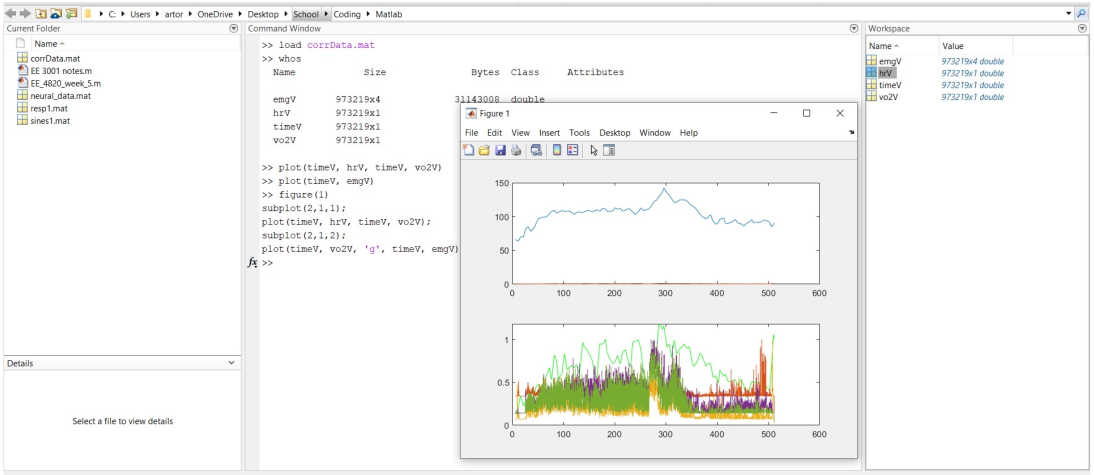
a)



B)





- look at all the emg channels, we can see all the activity that is being picked up but if we isolate every channel from emgV then the source will look a lot cleaner

- By looking at the hrV, we can see in figure One is keeping all the high Values while not keeping the 4 channels in the figure such as in figure 2 (look like noise while figure 1 is a clean version of the signal)