ECE 4429a – Advanced Digital Signal Processing
Fall 2020
MATLAB experiments on Correlation & Spectrum Analysis
October 14, 2020

NOTES:

1. Lab reports must be submitted individually. **Due Date: October 21, 2020, 6:30 pm. No email submissions, only Dropbox submissions allowed.**
2. Create a folder labeled "Lab2" on your Drop Box space in the course OWL site and upload your report and associated code to that directory.
3. Create a Word document that contains MATLAB figures, results, and your comments for each problem. Upload this document to the Lab2 folder.
4. Make sure you clearly label the axes for all MATLAB figures. Failing to do so may result in penalties!
5. Check the volume control before playing the signals through the headphones!

Correlation Experiments

1. (5 marks) Generate 300 samples of a 500 Hz sinusoidal signal with a peak amplitude of 1 and sampled at 8000 Hz. Then, generate 300 samples of white Gaussian noise and scale it to have an RMS value of 0.75. Add the sine and noise samples together.
    a. Plot the noisy sine wave and include it in your report. Do you see any periodicity? Write your observations in the report, along with the SNR for this example.
    b. Compute and plot the autocorrelation of the noisy sine. Include this plot in your report. Do you see periodicity now? Can you estimate the period from the autocorrelation? Write your thoughts in the report.

2. (7 marks) Download the two wav files, "m1.wav" and "f1.wav", from "Resources -> Labs -> Lab2". These .wav files contain sustained vowel samples by a male and a female talker respectively. Load these files into MATLAB (use the "audioread" command) and determine the fundamental frequency (F_0) (in Hz) of these voice samples using the autocorrelation method. Include in your report:
    a. plots of the autocorrelation function for both the samples.
    b. brief description of the procedure you followed to determine the F_0 from the autocorrelation function.

Spectrum analysis of a few real-world signals (8 marks)

1. Load the same "m1.wav" and "f1.wav" files from #2 above and run FFT on them. Using subplot, plot the waveform and magnitude spectrum on the same figure (male & female separate figures). <u>Important: the x-axis must be in Frequency (Hz) units for the magnitude spectrum plot.</u> From the magnitude spectra, identify the fundamental frequencies for male and female samples. Include the plots, the fundamental frequencies,

and your comments on the spectra in the report. Do the fundamental frequencies calculated using the autocorrelation and FFT methods match? Briefly explain.

2. Download “ecg.dat” from the directory mentioned above and load it into MATLAB. This file contains Electrocardiogram (ECG) data sampled at 500 Hz. Once again, plot the waveform and magnitude spectrum on the same figure using the subplot command. What is the approximate frequency range of the ECG signal? Do you see any artifacts in this ECG spectrum? Include the plot and your observations in the report.
3. Download “seismic.dat” from the directory mentioned above and load it into MATLAB. This file contains seismic data sampled at 15 Hz. Once again, plot the waveform and magnitude spectrum on the same figure using the subplot command. What is the approximate frequency range of this signal? What is the dominant frequency? Include the plot and your observations in the report.
4. Download “vbrdata.dat” from the directory mentioned above and load it into MATLAB. This file contains the vibration signal of the acceleration response from a simple supported beam, sampled at 1000 Hz. Once again, plot the waveform and magnitude spectrum on the same figure using the subplot command. What are the four dominant frequencies (modes)? Include the plot and your observations in the report.

(Bonus) Cross-Correlation Experiment

1. (3 marks) Download “sensor_data.mat” from the same directory as #2 and load it into MATLAB. You should see three signals – *s1, s2,* and *s3* – in the MATLAB workspace. These signals were acquired from three different sensors and need to be time-aligned.
    a. Use the cross-correlation procedure to estimate the delay between each pair of sensor signals and tabulate them in your report. Include the cross-correlation plots. Briefly explain in your report how you measured these delays.
    b. Now that you know the delays, write a MATLAB script to time-align the three sensor signals. Upload your script to the report folder. Briefly explain in your report how you did this time-alignment.