EEL4930/EEL5840 Fall 2016 - Homework 2
Adaptive Filtering

September 20, 2016

Due: September 27, 2016, 11:59 PM

Instructions

Make sure you download and decompress the data files necessary to solve this homework:

- The file *HW2.zip* contains 4 segments including a not noisy training set (*training.mat*), not noisy validation set (*validate.mat*), and both noisy and not noisy test sets (*testnoisy.mat* and *test.mat*). Use these segments to train, test and validate your algorithm.

The files are given in MATLAB format. If you are to use Python, simply load these files the following way:

```
import scipy.io as sio
mat_data = sio.loadmat('filename.mat')
```

For this homework, please show any plots, tables and your explanations. Do **not** include code. However, you should **mention** whether you programmed the solutions yourself or if you downloaded a package online and from which website.

Remember that commenting your results is very important. It is expected of you to systematically discuss your results. If no explanation is given, your grade will be penalized.

Your homework submission must cite any references used (including articles, books, code, websites, and personal communications). All solutions must be written in your own words, and you should program the algorithms yourself (unfortunately, you only understand the details when you do it yourself!). If you do work with others, you must list the people you worked with. Submit your solutions as a **single PDF file** to the course website in http://elearning.ufl.edu/.

If you have any questions address them to:

- Catia Silva (TA) – catiaspsilva@ufl.edu
- Isaac Sledge (TA) – isledge@ufl.edu

1. (10 points) The **least squares regression algorithm** is a class of **adaptive filter** used to mimic a desired filter by finding the filter coefficients that relate to producing the least mean squares of the error signal (difference between the desired and the actual signal).

For this problem, you were given the file *HW2.zip* that contains 4 segments including a not noisy training set (*training.mat*), not noisy validation set (*validate.mat*), and both noisy and not noisy test sets (*testnoisy.mat* and *test.mat*). See figure 1 to see their plots.

Optimize an **adaptive filter** to **predict** the next point in the time series, using least square regression (analytic solution). Since this data is experimental, you may need to use the regularized solution ($W^* = (\mathbf{R} + \lambda \mathbf{I})^{-1}\mathbf{P}$). Use the training data set to find your parameters; the validation data set to validate the hyper parameters (filter order and regularization) you have introduced in the solution; and the test data set to evaluate how good of approximation your algorithm gives you.

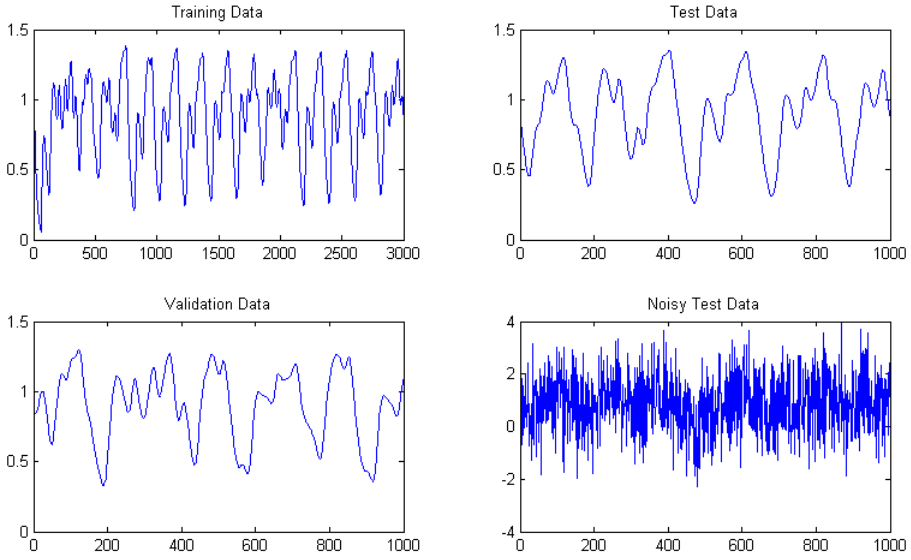

Figure 1: Four segments compressed into the file *HW2.zip*. Top left: not noisy training set segment of 3000 points. Top right: not noisy test set segment of 1000 points. Bottom left: not noisy validation set segment of 1000 points. And bottom right: noisy test set segment of 1000 points.

1.1. (5 points) Select the hyperparameters for this adaptive filter, namely, filter order and regularization parameter (using *validate.mat*). The idea is to experiment several different values in training and select the one that provides the best mean square error in the validation set. Present a plot of the validation set in the 2-d space of filter order and regularization parameter.

1.2 (3 points) Plot both the filter input and the prediction error over time (using the test set *test.mat*) for fixed weights and a filter order of 4, 8, 30, along with the best value you determined in 2.1, to see if the validation was correct. Why is the error not constant across time?

1.3 (2 points) Quantify the performance in the MSE-sense of your algorithm using filter orders 4, 8 and 30 in the noisy data (*testnoisy.mat*). Which filter order works better for this noisy data? Explain the results.