EE416 Final Project 2017

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Abstract

This describes the 2017 final project. Work in groups of two students. Frank will provide group identification numbers. Your main contact for the project is our EE416 TA Frank Peng. I will be out of the office for about one week, and cannot answer email for most of that time.

1 Random Slopes Project Tasks

The goal of this project is to observe a noisy signal and develop an algorithm determine the time index of the transition points. Your project report should contain the following sections. Each is required and used in our grading criterion.

1. A title page including the Group Members, title, project name.
2. A short Abstract. One paragraph.
3. A short summary of your *results*. Just a list of your results - often called the executive summary.
4. A explanation of how this type of signal can arise in engineering practice. I need this section from every group. One page max.
5. An explanation, using figures, of how the random slopes program operates. Use hyou own copy of the code for this.

   Develop a flow chart with comments.

   In particular discuss the random slope generation and how it tends to produce alternating slopes. A Markov diagram is useful.

   Also, discuss the additive noise, and show how you can test that it comes from a Gaussian Distribution. How can you determine the mean is zero and estimate the variance. Think about the *residual*.
6. Use a (low pass?) filter. The results of low pass filtering the noisy signal. Explain the trade-off between noise reduction and tracking the dynamics of the random slopes. Show figures. This is a separate section from the next section on detection.
7. Develop an Detection Algorithm that can *find all and only all* the transition times between slopes of opposite sign; i.e. the alternating slopes. You are not asked to find transitions that between slope of the same sign.

   Describe the algorithm with figures and calculations.

   Include the code as an m-file. It must have comments throughout.
8. Download your group file giving the noisy signal. It is different, but similar, for each Group. Please upload your detection points, as specified. We can test these against the ground truth.
9. All references you used. You can use any references, so long as they are cited here.
10. Appendices. As needed. You may find it easier to put some background here.

2 Supporting RandSlopes Code

Please refer to the `randslopes1.m` program for the algorithm used to generate the signal. From this you can generate sample random sequences. A typical call would be

```
randslopes1(1e+03,20,0.9,20,1,1);
```

The program help is

```
function [x,r] = randslopes1( T, sigman,pctdD,L,Aslp,Nspls2);
```

One part of the project is for you to dissect this code and explain it. Any supporting code you write must be m-files and not scripts.

You will also have about 20 segments, but not all these are alternating. We described the process in detail in class.

Your noisy signal can be read from the ascii file `insignal-n.txt` where n is your group number. There are many different files on the website. Once this is loaded, simply `>> y=load('insignal-n.txt')` and the resulting `y` will be a list of all the elements in the signal. The *length of each signal set is slightly different*, since they were created randomly. The reason is that the duration of each slopes vary slightly. But, they are all roughly around 1000 points.

You are to return to us the file `filtsignal-n.txt` which is your estimate of the underlying signal. We will compute the mean square error between your signal and the actual generating signal, to determine your error.

Also please *return to use a list contain the transition times you have detected.* Call this `detect-n.txt`

3 Strategies

The project is meant to be open-ended. SO you must use your engineering judgment to develop a good algorithm. You should test your algorithm on randomly generated test data.

Each signal consists of

$$r_n = x_n + \sigma w_n$$

The w_n is WGN, of zero mean and unit variance. The signal x_n is what you are trying to estimate, given the noisy r_n.

The structure of x_n will be useful to you. It consists of about $L = 20$ segments. Each segment is a constant slope, of *random duration.* The segments are concatenated to yield the x_n.

The slopes are are random, but are chosen from the set

$$\{-A, +A\}$$

3.1 Transition Detection

There are several approaches. You can filter the signal, and that is a required task. However, you will see that this is not that useful in detected the transition points. This is the reason we examine the filtering first.

Another approach is template matching. Look for a feature of interest and search for matches. In signal processing this is called matched filtering. Typically it works better.

There are more sophisticated approaches. For example, you will see that you can predict whether the next slope up or down, since the generating process is Markov. This can be useful as well.

The goal is to produce a z_n that is a close as possible to x_n, given only your observation of r_n. Thus, your submitted z_n should be the same length as your r_n. Also, we want the *list of transition points.*

4 Grading

You will be graded on the list given above. **Fundamentally we determine both the quality and completeness of your submission.**

It is fairly easy to determine how well different groups share the work. It is my expectation that all members share all the work. We will have some questions about the project on the final exam.

I want your report to provide three levels of discussion on this problem.

1. First, show your ability to identify the problem and break it into subproblems. That is, what are the components of the algorithm.

2. Second, you should formulate the algorithm itself, and describe it

3. Third, you should solve the problem through a MATLAB mfile.

Finally, discuss the results - strengths and weaknesses of your approach, etc.