Spring 2014   EE 445S Real-Time Digital Signal Processing Laboratory   Prof. Evans

Homework #7

Channel Equalization and Automatic Gain Control

Assigned on Saturday, April 19th, 2014
Due on Friday, April 25th, 11:00am sharp

Homework submitted after 11:00am will be subject to a penalty of 2 points per minute late.

Reading: Johnson, Sethares & Klein, sections 6.6-6.8 and 13.1-13.3

This assignment is intended to continue building our foundation for transmitter and receiver design.

Office hours for the teaching assistants and Prof. Evans; **bold** indicates a 30-minute timeslot:

Time Slot	Monday	Tuesday	Wednesday	Thursday	Friday
9:30 am					**Jia (ENS 137)**
10:00 am					**Jia (ENS 137)**
10:30 am					
11:00 am	Evans (ETC 5.148)		Evans (ETC 5.148)		Evans (ETC 5.148)
12:00 pm	**Evans (ETC 5.148)**		**Evans (ETC 5.148)**		**Evans (cafe)**
12:30 pm				**Evans (ENS 433B)**	**Evans (cafe)**
1:00 pm				Evans (ENS 433B)	
2:00 pm				**Evans (ENS 433B)**	
2:30 pm			**Sinno (ENS 137)**		
3:00 pm			**Sinno (ENS 137)**		
3:30 pm			**Sinno (ENS 137)**	**Jia (ENS 137)**	
4:00 pm			**Sinno (ENS 137)**	**Jia (ENS 137)**	
4:30 pm				**Jia (ENS 137)**	
5:00 pm				**Jia (ENS 137)**	
5:30 pm				**Sinno (ENS 137)**	
6:00 pm				**Sinno (ENS 137)**	

You may use any computer program to help you solve these problems, check answers, etc. ***Please submit any MATLAB code that you have written for the homework solution.*** The MATLAB code in the Johnson, Sethares and Klein book also runs in LabVIEW Mathscript and GNU Octave. Please see the note on page vii of the SRD book for more information

As stated on the course descriptor, "Discussion of homework questions is encouraged. Please be sure to submit your own independent homework solution."

Please fully justify your answers on each homework problem using Matlab code, Matlab plots, and mathematical analysis.

7.1 Channel Equalization Using a Least Squares FIR Design. 30 points.

Johnson, Sethares & Klein, problem 13.3, on page 280, but use a training signal `s` that is a pseudo-noise sequence of length `m=1023` and the channel impulse response

```
b = [1 0.68 0.54 0.25 0.32 0.42 0.82 0.9];
```

Plot magnitude and phase of the channel frequency response using the freqz command. The equalizer will seek to compensate the magnitude and phase response of the channel so that the cascade of the channel and equalizer would give (approximately) an ideal channel of a cascade of gain and delay.

Estimate the computational complexity and memory usage to design the channel equalizer coefficients when using a training sequence of *m* samples and an FIR equalizer of *n* coefficients.

Please see the online hints.

7.2 Channel Equalization Using an Adaptive FIR Design. 30 points.

Johnson, Sethares & Klein, problem 13.9, on page 289, but use a training signal `s` that is a pseudo-noise sequence of length `m=1023` and the channel impulse response

```
b = [1 0.68 0.54 0.25 0.32 0.42 0.82 0.9];
```

Estimate the computational complexity and memory usage to design the channel equalizer coefficients when using a training sequence of *m* samples and an FIR equalizer of *n* coefficients.

Please see the online hints.

7.3 Automatic Gain Control. 40 points.

Johnson, Sethares & Klein, problem 6.29, on page 126. Replace the Gaussian noise signal generated by the `randn` command with a signal that is BPSK (2-PAM) transmission plus Gaussian noise. For the BPSK transmission, randomly generate symbol amplitudes using $d = 2$; i.e., amplitudes are -1 and +1. Line 3 in `agcgrad.m` would change as follows:

```
r=(sqrt(vr)/sqrt(2))*(randn(n,1) + sign(randn(n,1)));  % generate BPSK plus noise
```

Plot the error surface using `agcerrorsurf.m`. with the following definition of `r`:

```
r=randn(n,1) + sign(randn(n,1));  % generate BPSK plus noise
```

Describe the error surface and any issues with the initial guess for the gain `a`.