EEL 6504 - Adaptive Signal Processing

Project I

Due March 15, 2022

Note: I suggest a team of two students to complete this project.

The purpose of this project is to design and evaluate the performance of a machine learning algorithm using the APA family that will clean on line the desired input (speech plus noise) from the machine noise (input). This is an example of the interference canceling problem explained as follows:
Speech data is collected by two microphones in a noisy room with a loud vacuum cleaner: one placed on a table that captures speech with the vacuum cleaner noise (used as d(n)) and the other very close to the vacuum cleaner (used as input n(n)) that basically has no speech. Even if you listen to d(n) the speech is barely audible, and the speech message is not understandable. The goal is to denoise d(n) and be able to understand the speech. I suggest that you use the signal n(n) as the input to the LMS algorithm and use d(n) as the desired response, but you can reverse them and evaluate the differences.

The simplest algorithm of the APA family is the normalized LMS, and please start with it.

You will find the data set project1.mat in the course website. This file contains a .mat file with two channel data labeled desired (d) and input (n). The sampling frequency is 21 KHz.

The project requires a report explaining the experimental procedures you followed and you must include data to support your conclusions. Please use the format of an IEEE Transactions paper (limited to 7 double column pages). This means you have to write a brief intro to the theory, explain well the methods and present carefully the results (see below) and conclude. Remember that any scientific paper should, by definition, contain sufficient information such others can replicate your results. A scientific paper must also contain ORIGINAL material only. If you happen to use text or equations from other source you have to reference what you cut and paste (this is not allowed in a normal publication, but here it is OK provide you reference). Of course, I expect the results to be done by the student group without outside help. I would like to see in the report (at least) the following:

Start with a 2-tap filter

1- Plots of the performance surface contours for the two weights filter case.
2- Plot the weight tracks
3- Plot the learning curve and interpret it.
4- Estimate the frequency response from the desired signal to the error when the filter is adapted.
5- Estimate the SNR improvement in dB by the ERLE=$10\log(E\{d^2\}/(E[e^2])$.

Increase the filter order based on an analysis of performance. Explain your choice for the filter order.

1- Estimate again the frequency response from the desired signal to the error.
2- Compute the SNR improvement in dB
3- Evaluate the filter performance as a function of the stepsize.
4- Estimate the misadjustment.
5- Comment on the results obtained and address issues related to the convergence of the algorithm in non-stationary environments.

Repeat the procedure with another APA algorithm using the LMS selected filter order. Explain why you decided to use this specific APA member, and what was your goal when you made the selection. Then compare the performance/computation tradeoff against the LMS and see if your goal was fulfilled.