Project 1
Echo Cancellation

September 21, 2017

Due: October 5, 2017, 11:59 PM

Instructions

This project will be graded with a letter grade with respect to presentation (25%), methods (35%) and results (40%).

The project requires a report explaining the experimental procedures you followed and you must include data to support your conclusions (for example, figure and tables). Please use the format of an IEEE Transactions paper (limited to 7 double column pages). You can download the format from the IEEE website (https://www.ieee.org/conferences_events/conferences/publishing/templates.html). This means you have to write a brief intro to the theory, explain well the methods and present carefully the results (based on the questions below) and conclusions. 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, **the results should be done by the student alone.**

Your programs must be written in either MATLAB or Python. The relevant code to the project should be included as an attachment to your report.

Please add the following line, along with your signature, at the end of your report: **I confirm that this assignment is my own work, is not copied from any other person's work (published or unpublished), and has not been previously submitted for assessment either at University of Florida or elsewhere.**

Submit your report (including code and statement) as a PDF to the E-Learning at UF (http://elearning.ufl.edu/).

If you have any questions address them to:

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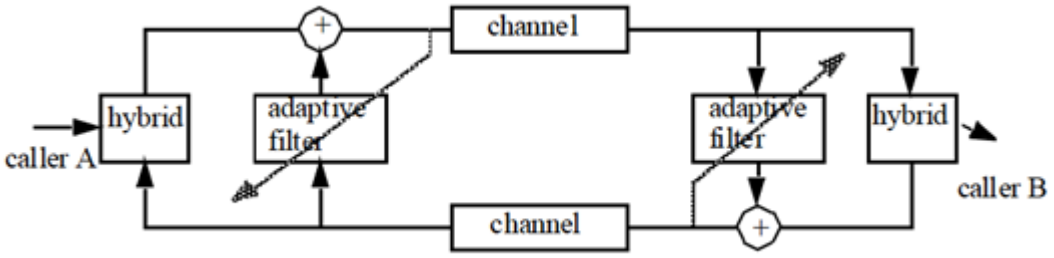
Assignment

Scenario: Middle Earth is being overrun by Sauron and Saruman the White. Gandalf the Gray, while deep in the Mines of Moria, has called the remainder of the fellowship from his cell phone to give them some important information about the ring that Frodo wears around his neck. Unfortunately, the hybrid at the switching station is far from perfect and has allowed a large amount of leakage. Oddly enough, the theme music from the Lord of the Rings can be heard playing quite loudly in Lothlorien, where the fellowship has temporarily congregated. The leakage has allowed the theme music to completely wipe out Gandalf's message. You must repair the hybrid so that Gandalf's message can be recovered, so the quest can continue.

Description: This is an adaptive echo cancellation problem, where the goal is to remove the echo (caller A signal that reaches caller B and comes back with a delay) from the speech of caller A (see figure below).



The data provided for this project represents two voice channels of a long-distance telephone conversation. The signal labeled "music" is the voice channel from caller B end, the signal labeled "corrupted_speech" is the speech of caller A mixed with music, and "fs" is the sample frequency in Hertz. The speech on the near end, as the name suggests, is corrupted as a result of an imperfect two-wire to four-wire hybrid, such as commonly used in most switching stations. The data is in .txt format. After dowloading the files ("music.txt", "corrupted_speech.txt" and "fs.txt"), load them to your preferred coding software (Matlab or Python).

The assumptions for this project are that the far end hybrid is working well, so that the music signal is not corrupted by the speech of caller A, and the near end hybrid has some leakage that causes the mixing. This causes the incoming signal and the outgoing signal to be correlated with each other. The goal is to use a linear adaptive filter as echo canceller to restore the outgoing signal and recover the speech of caller A. The hybrid is not linear, it produces a saturating nonlinearity that complicates the operation, i.e. linear echo cancellation is NOT optimal.

Questions

A. Quantify the performance of a linear FIR filter.

(1) Plot the ERLE of the FIR filter after adaptation as a function of the number of taps to find the best filter order. Scan from 5 to 100 in steps of 5 to evaluate performance .

(2) Show the weight tracks across the training data to select the best step-size.

(3) Compare the intelligibility of the recovered speech versus the original using your ear, and write your impression.

B. Change the FIR to the linear Gamma Filter and compare performance.

(1) Plot the ERLE of the Gamma filter after adaptation as a function of the number of taps, for a fixed feedback parameter in the tap delay line (0.2).

(2) Plot ERLE for the Gamma filter as a function of the feedback parameter, for a fixed number of taps

(3) Compare performance (and listen) with the FIR for the same number of parameters.