

EEL 6502
Project #2

Due April 24, 2012

Description: This is an adaptive echo cancellation problem, where the goal is to remove the echo from one signal (the input to an adaptive filter) that corrupts the second signal (desired signal for the adaptive filter). 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 the far end, the signal labeled "corrupted_speech" is the speech signal of the speaker on the near end, 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 offices. The data is in a Matlab format. After downloading the file, "proj2.mat", simply type "load proj2" in Matlab.

The reason the hybrid is used is because the performance of long-distance communications using four wires is significantly better than the performance using the two-wire system found in most homes. Therefore, a hybrid is located at a switching office at each end of the conversation to facilitate conversion to and from four wires. However, hybrids commonly allow leakage of the signal being received into the signal that is being sent. The result is that a person's own speech is returned to them with some delay. When the delay is large enough, such as occurs with long-distance calls, the effect is very annoying.

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

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 office 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.

A. Compare the performance of two different linear filters, the tapped delay line and the Gamma filter.

- (1) Plot the ERLE of the tapped delay line filter as a function of the number of taps.
- (2) Plot the ERLE of the Gamma filter as a function of the number of taps, for a fixed feedback parameter.
- (3) Plot ERLE for the Gamma filter as a function of the feedback parameter, for a fixed number of taps.
- (4) Recover the outgoing speech signal and compare the intelligibility of the recovered speech using each structure.
- (5) Show one set of weight tracks for each structure.

B. Implement the KLMS algorithm using quantization (QKLMS). Compare the performance with the best of the linear filters in terms of ERLE and also by listening to the output. Can you plot weight tracks for the QKLMS?