Mini Project 2: Adaptive Tone Canceller

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ECE 201

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Problem Statement

The FlyingCarpet airline company has bought a fleet of new aircraft with brand new jet engines that save fuel and shorten travel times. The only problem: the engines produce a very annoying, loud whining sound that can be heard throughout the aircraft. Preliminary analysis shows that the sound consists of a tone of exactly 1200Hz.

Your group has been retained as consultants to FlyingCarpet to help develop a system to cancel out the annoying sound for passengers in their seats. The solution entails an adaptive canceller that works as follows:

- All passengers' head rests will be equipped with two small microphones and four small speakers. The microphones will be located near where the passenger's ears are and the speakers surround the passenger's head. The exact location of these devices varies from seat to seat and is not available.
- The speakers and microphones are connected to a signal processing system. The signals from the microphones are sampled (rate $f_s = 10$ KHz); from these samples, an existing algorithm estimates the amplitude and phase of the signal at each microphone every 25 ms.
- Your responsibility is to determine the amplitude and phase of sinusoids to be played through each of the four speakers so that the signal picked up by the microphones is as small as possible. Specifically, every 25 ms you should take the measured amplitudes and phases from the microphones and determine amplitudes and phases for the sinusoids to be played through each speaker over the next 25 ms. Your objective is to minimize the power of the sinusoids picked up by the microphones.
- Note that the amplitude and phase of the sinusoid played through a speaker changes on its way to the microphones. The signal gets weaker and the phase changes as a result of the propagation delay. The changes are deterministic but they are not known to you. Therefore, a solution that adapts to the unknown propagation effects is needed.

Deliverables

This is a group project; groups are assigned by the instructor. Each group must deliver the following two work products:

1. A MATLAB function (must be named `adaptCanceller.m`) that accepts a pair of phasors (one for each microphone) and a structure that captures the state of your algorithm (essentially memory that is carried between invocations of your algorithm). The outputs are a set of four phasors that indicate the amplitudes and phases of the signals played through the speakers and an updated state structure; this state structure will be the input state on the next invocation. An example function is provided (see below).

2. A report in the form of a Powerpoint presentation. The report must not exceed six slides and should document how you solved the problem. An example report is provided (see below).

Material

To help you get started with this project, I am providing you with the following material:

- A sample report that documents the example solution that I provide (see below).

- A MATLAB script (testCanceller.m) for testing your adaptive canceller. This script simulates the propagation of signals to the microphone and generates phasors for the signals seen by the microphones. It invokes the `adaptCanceller.m` function every (simulated) 25 ms and uses the phasors produced by this function to update the phasor at the microphone for the next iteration.

- An example MATLAB solution: the file adaptCanceller.m provides an example solution. This is a reasonable, but not very good solution that is intended to help you with the "mechanics" of this project.

  It is critical that you do not modify the first line of this example in your own solution and that your solution is stored under the same file name (`adaptCanceller.m`). In other words, you will have to overwrite this example function.

- The scoring function will be similar to the test function. The scoring will measure how small the cancelled signal is at the end of the test period.

Assuming that you the two MATLAB files in your MATLAB working directory, you can simply run `testCanceller`, which in turn invokes `adaptCanceller.m`. If successful, you will see a plot that shows the power at the microphones over time and you will hear a 60-second sinusoid with decreasing power over time. As you develop your own solution, simply replace the example `adaptCanceller.m` file with your own.

Schedule

The mini project will proceed according to the following schedule:

1. Wednesday, March 18: Project assigned and groups announced.
2. Wednesday, March 25: Draft project report to be presented to another group.

   You must prepare a Powerpoint report that describes how you plan to solve this problem. Schedule a meeting with the other group before class on March 25.
3. Monday, March 30: Written (typed), constructive feedback must be provided to the group that presented to your group.

   Send a copy to the instructor by e-mail; make sure it is obvious which group you're commenting on.
4. Monday, March 30: MATLAB submissions accepted online.
5. Sunday, April 12 (at 11:59pm): Deadline to submit M-files.
6. Sunday, March2April 12 (at 11:59pm): Final versions of your report must be submitted through Blackboard - one submission per group.

Grading

Your group's score will depend on the following criteria:

1. Report: the quality of your group's report will count 40% towards your grade. I will evaluate accuracy, correctness, presentation of the report, as well as the originality of your solution.
2. MATLAB code: The grade for your MATLAB code will depend on the quality of your canceller as measured by the power of the signal observed by the microphones. This component counts 40% towards your grade.
3. Feedback to other group: the quality of the feedback you provide to the group that presented to you counts 20% towards your grade.