Homework 1

ELEN0071 University of Liège, Spring 2021

Due: Wednesday 17/03/2021 11:59 pm

Instructions: make a group of two students and perform the following steps.

1. Name your homework report `LastName1_LastName2_homework1.pdf` (in alphabetical order).

2. Compress your M-files (and possible related files, except the .wav files) into a single ZIP file, and name it as `LastName1_LastName2_homework1.zip`.

3. Submit both files on the Gradescope platform (`www.gradescope.com`; Entry Code: 74GYRD):

   (a) Submit your report (the PDF file) to Homework 1 (report).

   (b) Submit your codes (the ZIP file) to Homework 1 (code).

4. Ensure that all group members are correctly added to the submissions.

If you are not familiar with the Gradescope platform, please click on each step of the following guideline: (1) Joining a course using a course code, (2) Submitting a PDF, (3) Code submission, (4) Adding group members.

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1. Magnitude and phase spectrum graphs. The following equation generates the samples of a DT signal that is known as a Hann (Hanning) window:

$$w[n] = 0.5\,(1 - \cos(2\pi \frac{n}{N}))\,, \quad 0 \leqslant n \leqslant N.$$

For $N = 63$,

(a) Plot the Hann window.

(b) Plot its magnitude spectrum.

(c) Plot its phase spectrum.

In your plots, the magnitude response should be expressed in decibels (dB) and the normalized angular frequency should be scaled by π and expressed in ($\times\pi$ rad/sample).

Hint: the MATLAB function db(x,'power') converts the elements of x to dB.

2. Magnitude response. A system with two complex conjugate zeros is defined by

$$H(z) = b_0[1 - 2r\cos(\phi)z^{-1} + r^2 z^{-2}]\,.$$

For $b_0 = 1$, $r = 0.9$, and $\phi = 0.4\pi$,

(a) Plot the magnitude response of $H(z)$ in dB.

(b) Change the parameter ϕ and try to interpret its effect on the magnitude response.

(c) What could be a possible application of $H(z)$.

3. Echo cancelation. The file `hw1_echo_2021.wav` contains a single echo. The echo is generated using the filter $H(z) = 1 + \alpha z^{-D}$

(a) Play the sound, plot its corresponding autocorrelation function, find the delay D expressed in number of sampling intervals and the equivalent delay τ expressed in seconds.

(b) Assume the amplitude of the reflected sound is fifty-five percent of the emitted one ($\alpha = 0.55$). Design a filter to remove the echo from the signal, then test your filter. Explain clearly the design procedure.

Your answer should include the filter coefficients (numerator and denominator), e.g., a or b = [1, zeros(1,d-1), +alpha].