Homework 1

ELEN0071 University of Lige, Spring 2019

Due: Wednesday 04/03/2019 11:59pm

Instructions: Name your homework report `LastName1_LastName2_LastName3_homework1.pdf` (in alphabetical order). Submit your homework report on the Montefiore submission platform (`http://submit.montefiore.ulg.ac.be`).

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1. **Magnitude response of a filter.** Consider a filter with the transfer function

$$H(z) = \frac{b_0}{[1 - 2r\cos(\omega_0)z^{-1} + r^2 z^{-2}]^K}$$

with $K = 8$, $r = 0.9$, $b_0 = 5.3936 \times 10^{-7}$.

   (a) Plot the magnitude response $|H(e^{j\omega})|$ for $\omega_0 = \frac{\pi}{3}$.

   (b) Plot the magnitude response $|H(e^{j\omega})|$ for $\omega_0 = \frac{2\pi}{3}$.

   (c) Explain clearly the main effect of the variation of ω_0 to the magnitude response.

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

   Hint: $H(z)$ could be treated as a cascade of K second-order filters.

2. **Autocorrelation of a single echo.** A single echo $y[n]$ is generated using the FIR filter

$$y[n] = x[n] + ax[n - D], \qquad -1 < a < 1,$$

   where $x[n]$ is the original sound, D is the round-trip delay, and a is the attenuation factor due to propagation and reflection.

   Develop an expression for the autocorrelation $r_y[l]$ in terms of the autocorrelation $r_x[l]$, D and a.

3. **Echo cancelation.** The file `hw1_echo.wav` contains a single echo (see exercice 2).

   (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 seventy percent of the emitted one ($a = 0.7$). 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].