Cairo University
Faculty of Engineering
Electronics & Communication Department.

ELC325B
3rd year 2022 – 2023

Assignment 1

The objective of this assignment is to experiment with uniform and non-uniform quantization using Matlab

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1- Implement a uniform scalar quantizer function with the header

`q_ind = UniformQuantizer(in_val, n_bits, xmax, m),`

where **`in_val`** is a vector with the original samples, **`n bits`** is the number of bits available to quantize one sample in the quantizer, **`xmax`** and **`m`** define the range of the quantizer from **mΔ /2-xmax** to **mΔ /2+xmax**, so that the width of each quantization interval is **Δ = 2 × xmax/L**, where L is the number of quantization intervals. **`m`** defines the mean (or offset) of the quantizer reconstruction levels. Setting `m` = 0 defines a "midrise" quantizer, and **`m`** = **1** gives a "midtread" quantizer. The function should return the index of the chosen quantization level in **`q_ind`**

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2- **Implement a uniform scaler de-quantizer function with the header**

`deq_val=UniformDequantizer(q_ind,n_bits,xmax,m)`

where **`deq_val`** is the corresponding dequantized value for **`q_ind`**. The rest of the function parameters (i.e., **`n_bits,xmax,m`**) are the same as in part 1.

Hint: *The uniform scalar quantizer/dequantizer is a highly structured quantizer. They can be implemented essentially by only a scalar division (no multiplications, comparisons or loops are needed), making the computational complexity independent of the bitrate. Make sure your encoder has a computational complexity independent of the bitrate!*

3- **Test the quantizer/dequantizer functions on a deterministic input** as follows: Generate an input ramp signal **`x=-6:0.01:6 and pass it through the`** quantizer-dequantizer assuming that n_bits= 3 and x_{max} = 6. Plot the input/output signal (on the same graph) for m=0. Repeat (on another graph) for m=1.

4- Now test your input on a random input signal as follows:

a. Generate a sequence of 10,000 independent and identically distributed (i.i.d) continuous uniform random variables between -5 and 5.
b. Pass each sample through the two implemented functions, and calculate the quantization error using x_{max} = 5 and m=0
c. Calculate the SNR defined as E(input^2)/E(quantization error^2).
d. Repeat b-c for n_bits=2:1:8,
e. On the same plot. sketch the simulation and the theoretical SNR (in dB) on the vertical axis vs n_bits on the horizontal axis.

5- **Now test the uniform quantizer on a non-uniform random input as follows:**
   - **a.** repeat part 4 assuming the input samples are i.i.d. The polarity of each sample is random and it takes the value +/- with probability 0.5. The magnitude of each sample follows an exponential distribution with PDF f(x)= e^(-x).

6- **Now quantize the the non-uniform signal using a non-uniform μ law quantizer as follows**
   - a. Repeat part 5 using non-uniform μ quantization. Compare the results for $\mu = 0$ (uniform quantization in part 5), 5, 100, 200 (on the same graph).

Hint: *You do not need to alter the uniform quantizer/dequantizer functions, just add a block for expanding the signal before the quantizer and for compressing the signal after the dequantizer*