

Assignment 1

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

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 $m\Delta/2 - \text{xmax}$ to $m\Delta/2 + \text{xmax}$, so that the width of each quantization interval is $\Delta = 2 \times \text{xmax}/L$, 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**

2- Implement a uniform scalar 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:

- Generate a sequence of 10,000 independent and identically distributed (i.i.d) continuous uniform random variables between -5 and 5.
- Pass each sample through the two implemented functions, and calculate the quantization error using $x_{\max} = 5$ and $m=0$
- Calculate the SNR defined as $E(\text{input}^2)/E(\text{quantization error}^2)$.
- Repeat b-c for $n_bits=2:1:8$,
- 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 ± 1 with probability 0.5. The magnitude of each sample follows an exponential distribution with PDF $f(x) = e^{-x}$.

6- Now quantize 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*