16.36 Communication Systems Engineering
Spring 2009

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Aeronautics and Astronautics

16.36: Comm. Systems Engineering
Problem Set No. 2

Problem 1: Text problem 6.6

Problem 2: Text problem 6.11

Part 3) What is the mean squared-error distortion for the quantization rule in part 2?

Part 4) Now consider the quantization rule in part 2 of the question. Can a different three-level quantization rule have been chosen to yield a higher entropy? If so, describe the rule and the resulting entropy and mean squared-error distortion. Did the distortion increase or decrease?

Problem 3: Text problem 6.41, solve using Table 6.3 (Optimal Non-Uniform Quantizer for a Guassian Source).

Problem 4: Text problem 6.46* (not part 4)

*Note that the tables give the distortion (D) and Δ values for a Gaussian source with 0 mean and $\sigma^2 = 1$. To adjust your results for a source with Power σ^2=Px, you must multiply the distortion values by σ^2 and the Δ values by $\sigma = (Px)^{1/2}$

Problem 5: Matlab Exercise
In this exercise, you will implement a quantizer for a sampled audio stream and see the effects of reducing the number of quantization levels on sound quality.

a) Download the audio file `clip.wav` from the materials section on the course website. Use the Matlab function `wavread` to read the audio clip into Matlab. Be sure to capture all the outputs, as you will need these to properly play back the quantized version you will produce. You can play back a vector using the `sound` function.
b) Create a function called `quantize` that will take as input the sound vector produced from `wavread` and the number of quantization levels, N, as a power of two (an input of 4 would be 2^4 quantization levels). For simplicity, implement a uniform quantizer with the region size, Δ, being evenly spaced across the range of the input sound and x_i being assigned the middle of the region.
c) The `quantizer` function should return the following:
    a. Quantized waveform ready for playback
    b. Entropy of the quantized waveform
    c. Mean squared-error distortion between the quantized waveform and the original input
d) Run your function for N = 1, 2,…, 8. Play back the result using `sound` to hear the distortion (remember to use the values returned from `wavread`). Note: As the number of quantization levels increases, the running time will take longer.

Turn in your commented code with resulting entropy and distortion for the different quantization levels.