TEL411 – Digital Image Processing

Doutsi Effrosyni, PhD

Project

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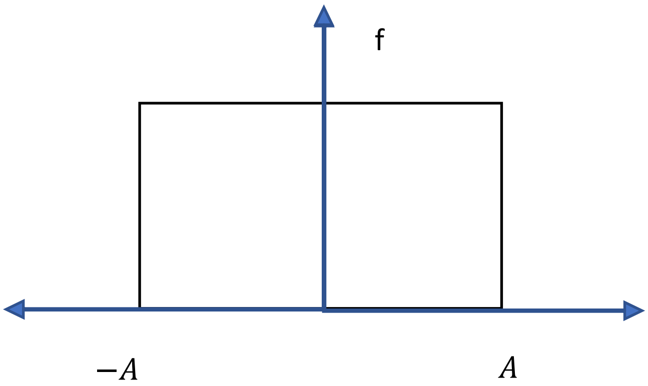
Part A

Quantization is the process of mapping input values from a large set to output values in a smaller set, often with a finite number of elements. Consider a discrete 1D input signal $f(x)$ that consists of values that belong to the interval $[-A\ , A]$ following a uniform



distribution as depicted above. The goal of a *uniform scalar quantizer* (USQ) is to reduce the number of the values that could be assigned to each element of the input signal f. To design a USQ we need to define the number of the quantization levels $L = 2^R$ which must be of the same length $\Delta\ = \frac{A-(-A)}{L} = \frac{2A}{L}$.

1. Assume that your input signal exists in the range $[-255, 255]$. Generate a function called "uni_scalar" that works according to the definition of the uniform scalar quantizer given below:

$$Q(x) = \Delta \times \text{sgn}(x) \left\lfloor \frac{|x|}{\Delta} + \frac{1}{2} \right\rfloor$$

where $\text{sgn}(x)$ stands for the sign, x is the input signal and Δ the quantization step. You may use the sign() function.

2. Plot the characteristic functions of the uniform quantizer for $R = 0, \ldots, 8$.
3. Quantize the ''cameraman.tif" (eclass Labs/Project_Data) for every possible R value and illustrate the quantized images.
4. Measure the distortion D due to the quantization using the Mean Square Error (MSE).
5. Plot the rate-distortion curve $D(R)$ and explain your results.

Part B

The goal of this section is to build a compression system using the Haar transform and the uniform scalar quantizer. You need to decompose an image into 2 Haar levels as follows:

1. Compute the mean and the average difference of each different pair of pixels at each row. Then you follow exactly the same process for each column.
2. You are asked to compute 2 Haar levels thus you need to apply step 1 one more time to the correct Haar subband (see the lectures).

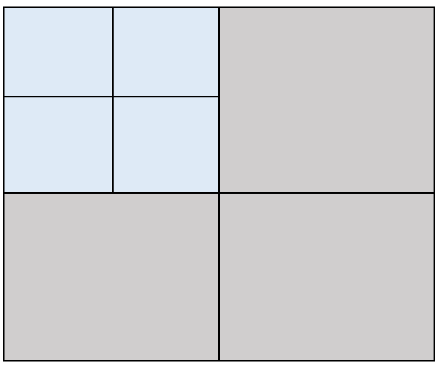
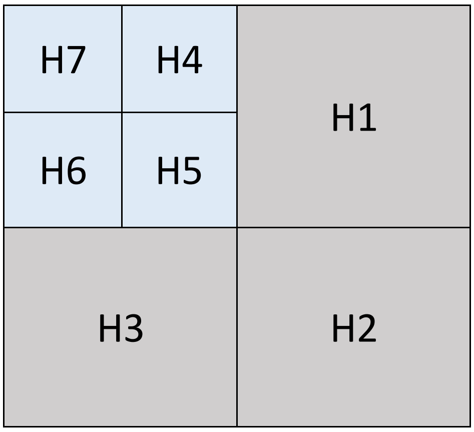


Figure 2. Haar Analysis (2 levels).

3. Then, you will quantize the subbands of these 2 levels using the function “uni_scalar” of Part A. You need to apply different quantization steps at each Haar level (R=2 for the 1^{st} level and R=4 for the 2^{nd} level).
4. Calculate the entropy in each subband, and the total entropy to obtain the compression ratio for each configuration of the quantization step.

$$H = -\sum p \log_2 p.$$



5. To recover your signal, you need to apply the inverse Haar transform meaning that you need to combine the mean and average differences you computed during the Haar analysis (see the lectures).
6. Compute the PSNR between the original and the quantized image and explain your results.

What to turn in

You should turn in both your code and a report. Justify the way you have decided to build your functions. Make sure you illustrate the outcome at each step. Please name your file as “Project_Omada_#” where # the number of your team.

Good Luck!!