UNIVERSITÉ DE GENÈVE
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Département d'informatique

Imagerie Numérique

Image acquisition and sensing

TP Class N° 3

October 23, 2020

Exercise 1. *(0.5 point)*

(a) In a 100×100 gray-scale image each pixel is represented by 256 gray levels.

(b) In another 100×100 gray-scale image each pixel is represented by 4 gray levels.

How many bytes are needed to store each of these images without any compression?

Exercise 2. *(0.5 point)*

Explain the difference between sampling and quantization.

Exercise 3. *(0.5 point)*

You are given a continuous signal $f(x, y) = \sin(x) + \cos(y)$. Choose a sampling and a quantization of this signal and plot the result as a 3D surface $\big(x,\ y,\ f(x, y)\big)$ over the interval $-5 < x < 5$ and $-5 < y < 5$. Display the obtained result.

Exercise 4. *(1.5 point)*

(a) Generate a gradient image like the one represented in Figure 1. Encode this image with $k = 7,\ 5,\ 3,\ 2,\ 1$ bits per pixel (Theme 3, page 109). Display and explain the results.

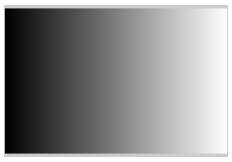

Figure 1: Gradient image

(b) Do the same with the grayscale image *lena.png*. Display the obtained results.

Exercise 5. *(1.5 point)*

Write a function that measures the PSNR value between two images (Theme 2, page 118).

(a) Read the image *lena.png* and convert it to grayscale. Create 10 noisy *lena* images by adding a zero-mean white Gaussian noise with standard deviation $\sigma = 25$.

(b) Report the average PSNR value between the original and the noisy images.

> **Hint:** Measure the PSNR between the original and each noisy image, then compute the mean of the results.

(c) Perform image denoising by using the so named *frame averaging* approach.

> **Hint:** Perform a pixel-wise summation of all noisy images. Divide the obtained sum image by the number of images in the summation.

(d) Measure the PSNR between the original and the denoised image. Comment the obtained result in the light of the previous computations. Explain when (under which condition) *frame averaging* is successful and when it does not work.

Exercise 6. *(1.5 point)*

You are given a pair of two images (reference and noisy) from the RENOIR dataset[1].

(a) Visualize each color channels for both images (a grayscale display of each channel). Are all channels equally affected by the noise? Justify your answer based on the *PSNR* or the *MSE*.

(b) Try to decrease the noise by downsampling the image 2 times and then upsampling it back to its original size. Apply this method to the RGB noisy image. Measure the PSNR between the reference and the obtained denoised images.

> **Hint:** To measure the PSNR between RGB images, compute the PSNR for each color channel and then take the average value.

(c) Do the sub-exercise 6.b for the grayscale image. Explain why the PSNR is higher for the denoised grayscale image.

> **Hint:** Justify your answer based on exercise 5.

(d) What other methods could you suggest to improve the noisy image quality?

Submission

Please archive your report and codes in "Name_Surname.zip" (replace "Name" and "Surname" with your real name), and upload to "`Assignments/TP3: Image acquisition and sensing`" on `https://moodle.unige.ch` before Thursday, November 5 2020, 23:59 PM. Note, **the assessment is based not only on your code, but also on your report, which should include your answers to all questions and the experimental results**.

[1] `http://ani.stat.fsu.edu/~abarbu/Renoir.html`