TP3_Image_acquisition_and_sensing

October 26, 2023

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Imagerie Numérique 2023 Automne

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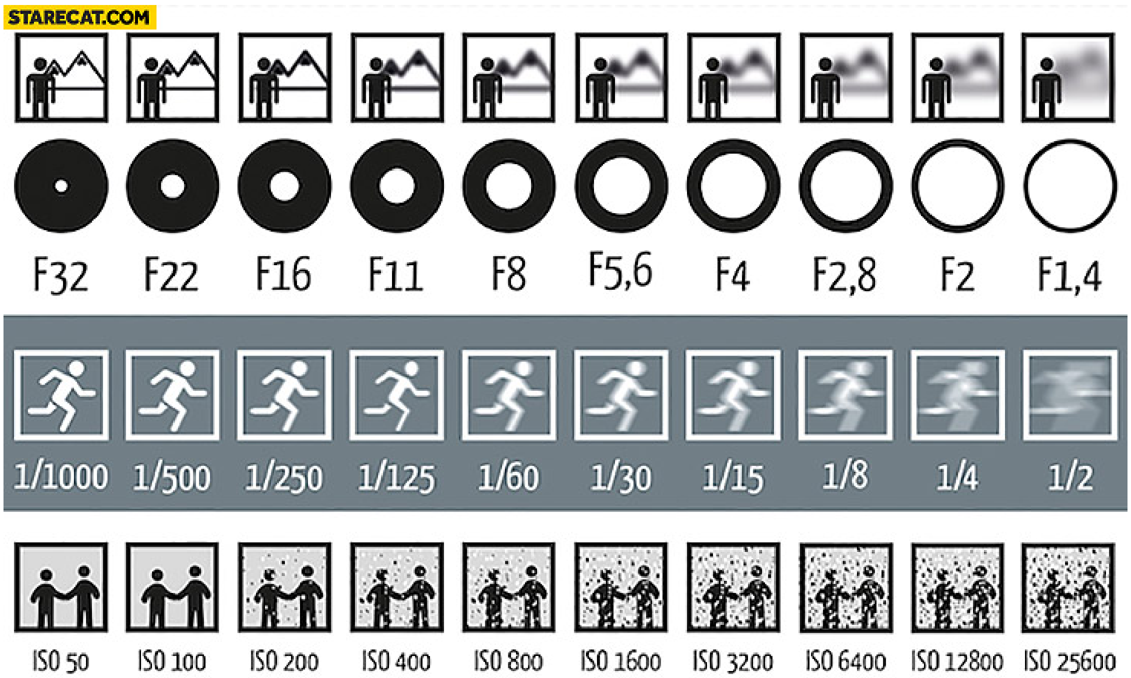
TP Class N°3 - Image acquisition and sensing

Instructions :

- This TP should be completed and uploaded on Moodle before **Thursday 9 November 2023, 23h59**.
- The name of the file you upload should be **TP3_name_surname.ipynb**.
- If you need to include attached files to you TP, please archive them together in a folder named **TP3_name_surname.zip**.

1 Exercise 1

Have a look at the following image :



Using these illustrations, explain the concepts of Aperture, Shutter speed and ISO. How are they built in a modern Digital Single-Lens Reflex ?

2 Exercise 2

(a) In a 100×100 RGB image each pixel is represented by 256 levels of intensity. How many bytes are needed to store these image without any compression?

Answer here

(b) In a 100×100 gray-scale image each pixel is represented by 4 levels of intensity. How many bytes are needed to store these image without any compression?

Answer here

(c) Generate a 100×100 RGB image constituted of uniform random noise (use *numpy.random.uniform()*). Save it as a png file using *plt.imsave()*. Comment on the size of the file.

Hint : In order to understand what is going on, you might want to load the image again in Python using *plt.imread()*

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(d) Generate a 100×100 grayscale gradient image (see TP1 ex 2). Save it again as a png file. Comment.

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3 Exercise 3

(a) Explain the difference between sampling and quantization.

Answer here

(b) You are given a continuous signal $f(x) = sin(x) + \frac{1}{10}cos(10x)$ over the interval $0 \leq x \leq 8\pi$ and $-1.1 \leq y \leq 1.1$.

Using *np.linspace()* and *plt.plot()*, visualize this continuous signal on the given interval with a high number of samples.

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(c) Choose various values of sampling and quantization for this signal and plot the results on a grid of subplots, varying both parameters. Comment on the quality of the approximation.

Hint : Use *np.linspace()* and *np.digitize()* to generate the correct sampling and quantizations, try different values of samples and bins.

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Answer here

4 Exercise 4

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

Figure 1: Gradient image

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Answer here

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

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Answer here

5 Exercise 5

(a) Write the function that measures PSNR value between two images (see Theme 2, Lecture notes).

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(b) Read the image *lena.png* and convert it to grayscale with dynamic range in $[0, 1]$. Create 10 noisy lena images by adding a zero-mean white Gaussian noise with standard deviation $\sigma = 0.1$.

[ ]:

(c) Report the average PSNR value between the original and noisy images. > **Hint** Measure the PSNR between the original and each noisy image, then compute the mean of the results.

[ ]:

(d) 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.

[ ]:

(e) 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.

[ ]:

– your answer –

6 Exercise 6

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

(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 *MSE*.

[ ]:

–your answer –

(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) Convert both images to grayscale and redo part (b). Explain why the PSNR is higher for the denoised grayscale image. > **Hint**: The reason is linked to exercise 4. Explain why.

[ ]:

–your answer –

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

–your answer –