TEL411 – Digital Image Processing

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Assignment 1

Due date: Sunday, October 31, 2021

Exercise 1

Let $I(i,j)$, where $i = 1, \dots, N$ and $j = 1, \dots, M$, be a digital 2D grayscale image. The goal of this exercise is to **downsample** the initial image using the following scaling parameters

- row sampling scale $\frac{1}{2}$, column sampling scale $\frac{1}{4}$
- row sampling scale $\frac{1}{4}$, column sampling scale $\frac{1}{2}$
- row sampling scale $\frac{1}{8}$, column sampling scale $\frac{1}{8}$

and upsample again using the appropriate scaling parameters in order to create a new image $\tilde{I}(i,j)$ of the same original size $N \times M$.

You should also verify the impact of using or not an **anti-aliasing filter** as well as what is the best **kernel** function among the nearest-neighbor interpolation, the bilinear interpolation and the cubic interpolation.

To compare the original and the reconstructed image it should be utilized the Mean Square Error (MSE) function

$$MSE(I, \tilde{I}) = \frac{1}{MN} \sum_{i}^{N} \sum_{j}^{M} (I(i,j) - \tilde{I}(i,j))^2$$

and the Peak Signal-to-Noise Ratio (PSNR) metric

$$PSNR(I, \tilde{I}) = 10\log_{10}\left(\frac{\max_I^2}{MSE(I, I)}\right)$$

Theoretical Background

Aliasing is an effect that causes different signals to become indistinguishable when sampled. It also often refers to the distortion or artifact that results when a signal reconstructed from samples is different from the original continuous signal. When an anti-aliasing filter is applied before sampling it satisfies that the a signal sampler to restrict the bandwidth of a signal to satisfy the Nyquist–Shannon sampling theorem over the band of interest.

When an image is scaled down to a lower size, there is a question of what will be the color of the remaining pixels. When an image is scaled up to a larger size, the inverse question is what will be the color of the new pixels in between the original pixels. Constructing new data points within the range of a discrete set of known data points is called **interpolation**. There exist several answers to these questions and different kernel function that address the aforementioned issues.

Hints

You can find some original grayscale images on eclass Labs/Input_Data.
Maybe it would be useful to use the “imresize” function.

What to turn in

You should turn in both your code and a report. Please provide all the necessary information in your report such that one should be able to understand either your code or your results. In addition, your report should present all the different recovery case (18 in total). Please illustrate both the downsampled and the upsampled images. Last but not least, you should also report all the MSE and PSNR values and discuss the numerical results.