TEL411 – Digital Image Processing

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Assignment 2

Due date: Tuesday, October 15, 2020

Exercise 1

1. Construct the following 3x3 Gaussian filter:

$$K = \frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

2. Read the "lena_gray_512.tif" grayscale image using the command "imread()".

3. Do the zero padding around the image I. (You can utilize the default "padarray()" function).

4. Construct the 2D convolution function by yourselves. This function should take as an input a kernel K and an input image I. The output if this function should be the convolved image $\tilde{I}$

function convImage = convolution(image,kernel)

5. Measure the distortion between $\tilde{I}$ and I using the Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) metrics.

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

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

6. Repeat the above process from step 3 to 5 while instead of padding zeros you pad/replicate the border pixels of image I.

Exercise 2

1. Use the default function "conv2()" to compute the convolution between the kernel K and the image I.
2. Set the correct input parameters to satisfy the same boundary conditions (1. Zero padding, 2. Replicate the border pixels) and produce a convolved image of the same size as the original one.
3. Compare the results.

Exercise 3

1. Use the default function "imfilter()" to compute the convolution between the kernel K and the image I.
2. Set the correct input parameters to satisfy the same boundary conditions (1. Zero padding, 2. Replicate the border pixels) and produce a convolved image of the same size as the original one.
3. Compare the results.

Theoretical Background

In digital image processing convolutional filtering plays an important role in many algorithms in edge detection, image enhancement, etc. Convolution is the mathematical operation on two functions f, g that produces a third function h. This new function expresses how the

shape of function f is modified by the shape of function g. Convolution is denoted as follows:

$$h = f * g.$$

The mathematical 2D discrete convolution is given by:

$$h(x,y) = \sum_{i=-\infty}^{+\infty} \sum_{j=-\infty}^{+\infty} g(i,j) f(x-i, y-j),$$

where f represents the input image to be convolved with the kernel g resulting in a new output image h. The indices x, y are concerned with the image matrices and the indices i, j deal with that of the kernel. If the size of the kernel involved in convolution is $N \times N$ then the indices i, j will range from $\lfloor -N/2 \rfloor$ to $\lfloor N/2 \rfloor$ where N is usually an odd number.

Hints

- You can find the "lena_gray_512.tif" on eclass (Labs / Input_Data).
- You can always type i.e. 'help function_name' in the command window to learn how to call each function.

What to turn in

You should turn in both your code and a report where you need to illustrate the results of 6 convolutions (2 generated by your own code with zero and replicate padding, 2 generated by conv2() and 2 generated by imfilter()). For each convolved image you should report the MSE and the PSNR values. Last but not least, you should compare the 3 different methods and leave a comment.