Lab 4 – Image Filtering

Goal: Introduction to image filtering in spatial and in frequency domains.

Introduction

In the early days of image processing the use of Discrete Fourier Transform (DFT) was very restricted because of its high computational complexity. With the introduction of the FFT algorithm the complexity of DFT was reduced and DFT became an extremely important practical tool of image processing.

In this lab we'll study the properties of DFT and two practical applications:

- Computation of convolution by two methods – direct method (in spatial domain) and indirect method (in frequency domain).
- Computation of edge enhancement by unsharp masking.

Preliminary report

1. Prove the following properties of the Continuous 2-D Fourier Transform:
   - Linearity property,
   - Scaling property,
   - Rotation property,
2. Explain the purpose of python's function **fft.fftshift** from **numpy** library.
3. The magnitude of spectrum usually has a large dynamic range. How do you usually display the magnitude of spectrum?
4. Which values are returned by the function **cv2.getOptimalDFTSize**? Explain why it's useful?
5. Study the pythons module **scipy.ndimage**. Give a short explanation about the following filters: uniform_filter, median_filter, gaussian_filter, laplace, prewitt and sobel. Explain the main input argument for this functions.
6. Explain the purpose of unsharp masking (**skimage.filters.unsharp_mask**). Give a short explanation of this process.
7. Explain the Periodicity property of DFT. What difficulties it imposes on image processing? Explain your answer.

8. Explain the Conjugate Symmetry property of DFT. How it can be utilized in algorithms in order to reduce the number of computational operations?

Description of the experiment

Open the Jupyter notebook supplied for Lab4 and follow the instructions in the 3 sections:

Part 1 - DFT Properties

Part 2 – Convolution

Part 3 – Unsharp masking

Final report

Submit the results of testing and demonstrations from the 3 parts of the experiment, with the image of your choice. Explain your results in each step.

Answer all the questions appeared in the final report in your Jupyter notebook - in the end of each section as Raw NBConvert cell, save the files as PDF format.
Use: File -> Download as -> PDF. Make sure to submit all your plots and results.

References

- R. C. Gonzalez, R. E. Woods and S. L. Eddins, *Digital Image Processing using MATLAB*. Pearson Education, Inc., 2004 (Library Dewey number 621.368 GON).
- A. K. Jain, *Fundamentals of Digital Image Processing*. Prentice-Hall, Inc., 1989 (Library Dewey number 621.368 JAI).
- https://opencv-python-tutroals.readthedocs.io/en/latest/py_tutorials/py_imgproc/py_transforms/py_fourier_transform/py_fourier_transform.html
- *Image Operators: Image Processing in Python, Jason M.Kinser*
- https://homepages.inf.ed.ac.uk/rbf/HIPR2/fourier.htm