Homework #1

Deadline: April 14, 2025 23:59

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1. Define the imaging point spread function (PSF) and explain its relation to the resolution of an image. Why is it convenient to assume that PSF is spatially invariant? **(2 pts)**.

2. (a) We saw that a rectangular function

$$\Pi(x) = \begin{cases} A, & -x_0 \leq x \leq x_0 \\ 0, & elsewhere \end{cases}$$

   is one of the key building blocks in imaging systems and image reconstruction. What is the Fourier transform of it? Please show all the steps of your derivation **(2 pts)** and explain the physical meaning of the result **(1 pt)**.

   (b) Show that Fourier Transform preserves all available information (use Perceval's theorem) **(2 pts, *optional for Life Sciences*)**.

3. You are provided with the `jupyter notebook` file and the `.npz` file with the original and distorted images of a sample of MDA231 human breast carcinoma cells [1].

   (a) Can you guess the geometrical shape of the 2D PSF of this aberrated microscope **(1 pt)**?

   (b) Having guessed the PSF, attempt three deconvolution algorithms to restore the clean image from the distorted one: Naive deconvolution **(2 pt)**, Wiener filter **(2 pts)**, and Wiener filter with regularization **(4 pts, *optional for Life Sciences*)**. It is OK to use open-source libraries.

   (c) Which deconvolution algorithm proved to work best visually? **(1 pt)**. Suggest a quantitative image quality metric that would support your visual observations **(1 pt)**.

[1] Cell Tracking Challenge. 3D+Time Datasets (http://celltrackingchallenge.net/3d-datasets/).