Boston University
Department of Electrical and Computer Engineering
EC522 Computational Optical Imaging
Homework No. 5

Issued: Monday, Mar. 18 Due: 11:59 pm Monday, Apr. 1

Deblurring from multiple defocused measurements

This problem will continue our discussions on solving the inverse problem from defocused measurement. In HW 4, we consider the case where we are only given a single measurement. In HW 5, we will consider the recovery of a single object by taking *multiple* defocused measurements.

As an illustration, let us consider two defocused measurement, as described by

$$g_1 = f * h_1; \tag{1}$$
$$g_2 = f * h_2; \tag{2}$$

The following Matlab files are provided.
a) The object, f, is in the mat-file `I1.mat`.
b) We will consider two defocus distances, including $z_1 = 0.1$mm and $z_2 = -0.2$mm. The corresponding PSFs, h_1 and h_2 are provided in `psf1.mat` and `psf2.mat`, respectively.

First, derive your results for the following problems.
(1) Rewrite the two measurements into a single linear model in the $\mathbf{y} = \mathbf{Ax}$ form.
(2) following the derivation procedure demonstrated in the lectures, derive the least-squares (LS) solution of this problem.
(3) Derive the Tikhonov regularization solution of this problem.

Next, write Matlab scripts to complete the following questions. Submit both your scripts as well as the output results.
(4) Simulate the output images for the two cases, assuming no noise is present.
(5) Consider both measurements suffer from the same level of white Gaussian noise (WGN) for all pixels. For $n_{\text{std}} = 1, 10$. Simulate the corresponding noisy images.
(6) At each noise level, find the "best" deblurred images in each case.
(7) How does the noise level affect the reconstruction quality? Qualitatively explain the artifacts you see in the reconstruction. How does the noise level affect the optimal value of Tikhonov regularization parameter?