Boston University
Department of Electrical and Computer Engineering
EC522 Computational Optical Imaging
Homework No. 6

Issued: Monday, Apr. 1 Due: 11:59 pm Monday, Apr. 17

Depth from defocus: a proof-of-concept demonstration

This problem will provide a simple illustration of "depth from defocus" based on a single measurement. Let us consider a two-layer "3D" scene, consisting of f_1 at depth 1 and f_2 at depth 2. Both objects are transparent so no occlusion effects need to be considered. A single 2D image g is taken, which is modeled as

$$g = f_1 * h_1 + f_2 * h_2, \tag{1}$$

where h_1 and h_2 are the PSFs at the two depths, respectively, and $*$ denotes the 2D convolution.

The following Matlab files are provided.
a) The two-layer object, f_1 and f_2 are in the mat-file `o1.mat` and `o2.mat`, respectively.
b) The two PSFs h_1 and h_2 are provided in `psf1.mat` and `psf2.mat`, respectively.

Write Matlab scripts to complete the following questions. Submit both your scripts as well as the output results.

(1) Simulate the output image, assuming no noise is present.

Although the exact Tikhonov-regularized solution for this problem is difficult to derive in a closed form, one can show that the following approximate solution is effective in estimating the object at each depth:

$$\mathbf{f}_{1,\mu_1} = \mathbf{W}_{2\mathrm{D}}^{*} \mathrm{diag}\left(\frac{\widehat{\mathbf{h}_1}^{*}}{|\widehat{\mathbf{h}_1}|^2 + \mu_1} \right) \mathbf{W}_{2\mathrm{D}} \mathbf{g}, \tag{2}$$

$$\mathbf{f}_{2,\mu_2} = \mathbf{W}_{2\mathrm{D}}^{*} \mathrm{diag}\left(\frac{\widehat{\mathbf{h}_2}^{*}}{|\widehat{\mathbf{h}_2}|^2 + \mu_2} \right) \mathbf{W}_{2\mathrm{D}} \mathbf{g}, \tag{3}$$

where $\mathbf{W}_{2\mathrm{D}}$ is the DFT matrix, $\widehat{\mathbf{h}_1}$ and $\widehat{\mathbf{h}_2}$ are the corresponding transfer functions, and μ_1 and μ_2 are the regularization parameters.

(2) Choose the appropriate regularization parameters μ_1 and μ_2 and show the reconstructions of the two-layer object. Describe your observation.