DIP Assignment 5: Question 2

October 22, 2015

1 Question

Suppose you are standing in a well-illuminated room with a large window, and you take a picture of the scene outside. The window undesirably acts as a semi-reflecting surface, and hence the picture will contain a reflection of the scene inside the room, besides the scene outside. While solutions exist for separating the two components from a single picture, here you will look at a simpler-to-solve version of this problem where you would take two pictures. The first picture g_1 is taken by adjusting your camera lens so that the scene outside (f_1) is in focus (we will assume that the scene outside has negligible depth variation when compared to the distance from the camera, and so it makes sense to say that the entire scene outside is in focus), and the reflection off the window surface (f_2) will now be defocussed or blurred. This can be written as $g_1 = f_1 + h_2 * f_2$ where h_2 stands for the blur kernel that acted on f_2. The second picture g_2 is taken by focusing the camera onto the surface of the window, with the scene outside being defocussed. This can be written as $g_2 = h_1 * f_1 + f_2$. Given g_1 and g_2, and assuming h_1 and h_2 are known, your task is to derive a formula to determine f_1 and f_2. Note that we are making the simplifying assumption that there was no relative motion between the camera and the scene outside while the two pictures were being acquired, and that there were no changes whatsoever to the scene outside or inside. Even with all these assumptions, you will notice something inherently problematic about the formula you will derive. What is it? [10 + 10 = 20 points]

2 Solution

We have the following two equations:

$$g_1 = f_1 + f_2 * h_2$$
$$g_2 = f_1 * h_1 + f_2$$

Now, it can be seen that these equations will convert to a set of linear equations in two variables if we take Fourier transform throughout.

$$G_1 = F_1 + F_2 H_2$$

$$G_2 = F_1 H_1 + F_2$$

On solving this set of equations for F_1 and F_2, we get:

$$F_1 = \frac{H_2 G_2 - G_1}{H_1 H_2 - 1}$$

$$F_2 = \frac{H_1 G_1 - G_2}{H_1 H_2 - 1}$$

And then f_1 and f_2 can be found out by taking the Fourier inverse.

Possible problems with this method are:

1. The terms F_1 and F_2 will blow up at those frequencies where $H_1 H_2$ is 1.

2. In presence of noise the original equations change to

$$g_1 = f_1 + f_2 * h_2 + n_1$$

$$g_2 = f_1 * h_1 + f_2 + n_2$$

   And thus,

$$G_1 = F_1 + F_2 H_2 + N_1$$

$$G_2 = F_1 H_1 + F_2 + N_2$$

   And on solving this we get,

$$F_1 = \frac{H_2 G_2 - G_1}{H_1 H_2 - 1} + \frac{N_1 - N_2 H_2}{H_1 H_2 - 1}$$

$$F_2 = \frac{H_1 G_1 - G_2}{H_1 H_2 - 1} + \frac{N_2 - N_1 H_1}{H_1 H_2 - 1}$$

   - We cannot use this procedure if Fourier transform of noise is unknown.
   - Even if the Fourier transform for noise is known, for smaller values of $H_1 H_2 - 1$, the magnitude of second term in both of the above equations increases, and thus the contribution of noise to F_1 and F_2 increases by a significant amount, thus leading to bad results. So, this method will not always work as expected in presence of noise and worst, it will even deteriorate the results.