CENG 391 Introduction to Image Understanding

03 November, 2017

Homework 2

Due Date: 16 November 2017, 23:55

Programming Assignment — Bilateral Filter

Bilateral filter was introduced to smooth images while preserving edges. Like Gaussian smoothing filters, each pixel is replaced by a weighted average of its neighbours. But unlike them, image content is taken into account. In Gaussian smoothing filters, the effect of a pixel on the other one only depends on the spatial distance between them. In addition to this, also the difference between intensity values determines the effect on a pixel in bilateral filter.

In Figure 1, filter that is represented by blue color is the filter for spatial differences and it is actually Gaussian smoothing filter. The other filter which is represented by green color, is the filter for intensity differences.

The bilateral filter is defined by the following formula: (taken from https://en.wikipedia.org/wiki/Bilateral_filter)

$I^{filtered}(x) = \frac{1}{W_p} \sum_{x_i \in \Omega} I(x_i) g_i(||I(x_i) - I(x))||) g_s(||x_i - x||)$

where W_p is the normalization term and defined as follows:

$W_p = g_i(||I(x_i) - I(x))||) g_s(||x_i - x||)$.

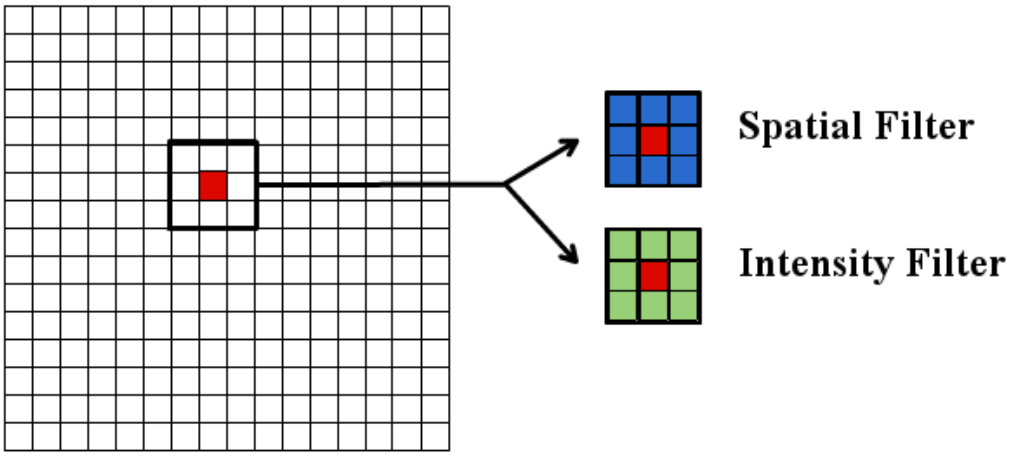

Figure 1: Bilateral filter representation.

Here;

- $I^{filtered}$ is the filtered image that is bilateral filter applied,
- I is the input image,
- x are the spatial coordinates of the pixel to be filtered,
- Ω is the window centered in x,
- g_i is the intensity kernel for smoothing differences in intensities.
- g_s is the spatial kernel for smoothing differences in coordinates.

Both g_i and g_s are Gaussian function which is shown in the below:

$G_\sigma(x)) = \frac{1}{2\pi\sigma^2} \exp -(\frac{x^2}{2\sigma^2}))$

You should define window with a size of **7x7** and there are two different sigma values for intensity kernel(σ_i) and spatial kernel(σ_s) correspondingly. To determine the best sigma values for each filter you should try different values for both sigmas and observe the effect of them on the image.

In this assignment, you are expected to comment on the effect of different sigma values on the image and you should also indicate the reason behind the selection of sigma values that you take.

You should implement bilateral filter on your own. For the given input image, you should have two outputs. One is the filtered image obtained by your own bilateral filter implementation and the other one is the filtered image after you apply OpenCV implementation(**"bilateralFilter()"**).

HINT: Take window size 7x7, $\sigma_i = [2, 20]$, and $\sigma_s = [2, 20]$.

Besides, other required files, you should send two output images named as **"filtered_image_own.png"** and **"filtered_image_OpenCV.png"**.

IMPORTANT NOTE:

You can write your comments at the end of the source code as comment block.