Computer Vision *Ajinkya Tejankar, KA32810*

HW1: Filters and edge detection

Section 2: Written Assignment

1. Run GaussianBlurImage and SeparableGaussianBlurImage with sigma = 2, 4, 8 on Seattle.jpg. How many seconds does it take to run each function? How long do you think it would take to run each with sigma = 32?

   The plot below summarizes the times for various values of sigma. If we only look at the curve until the sigma value 8, then both curves are linear with some delta on y axis. This might lead us to conclude that the time for GaussianBlurImage at sigma = 32 can be calculated by extrapolating this line, but, the shape of the curve becomes exponential later. The exact amount of time taken for each filter is shown in the table below. Times for sigma = 32 are 78s and 288s for GaussianBlurImage and SeparableGaussianBlurImage respectively.

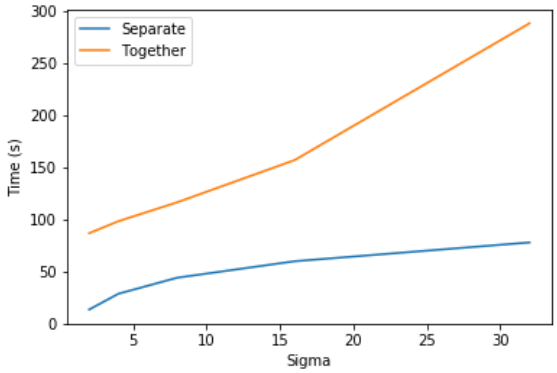

Figure 1: Sigma vs Time

Filter Type	Sigma	Time (s)
Separable	2.0	14.36
Separable	4.0	29.51
Separable	8.0	44.82
Separable	16.0	60.57
Separable	32.0	78.55
Together	2.0	87.40
Together	4.0	98.90
Together	8.0	116.95
Together	16.0	157.33
Together	32.0	288.16

Table 1: Execution Times

2. What is the best amount of blur to apply when down-sampling Moire.jpg by 8x (pressing Half Size 3 times)? Does down-sampling Seattle.jpg require the same amount of blur?

A grid search was conducted to find the best blur value and a blur of sigma = 16 is needed to avoid any sort of moire effect, but it becomes so black that it no longer resembles the original image. Thus, sigma = 8 value is best if the image is not zoomed in. The naked eye can't really see the moire effect in it. Similarly, sigma = 4 gives the best result for Seattle.jpg even after zooming in without losing resemblence to the original image.

Figure 2: sigma = 8

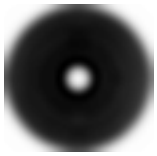

Figure 3: sigma = 16

Figure 4: sigma = 4

3. Can you find an edge in TightRope.png that is visible to the human eye, but does not have a strong response from the Sobel edge detector?

The edges colored with red in the original image, the image on the right side, are not detected with as strong a response as compared to the human eye.

Figure 5: Tight Rope

Figure 6: Tight Rope (Edge Magnitudes)

4. If you rotate the image 20 times by 2 degrees, does it produce the same result as rotating the image by 40 degrees? If not, why? Please use "imrotate" command in Matlab.

No. Because, each time an image is rotated a part of it must be trimmed for it to fit in its own box. Thus the image is trimmed a little bit 20 times in comparison to it being only trimmed once when it's rotated by 40 degrees.

5. If you apply blur before applying FindPeaksImage you can remove many noisy edges. What is the best amount of blur to apply to Gogh.png to find the cleanest edges? In addition to answering these questions, please turn in your best peak edge image called GoghEdge.png.

> Values of sigma ranging from 1 to 16 with a step of 1 were tried to find best peak edge responses after applying a gaussian filter. Applying sigma = 4 gives the best results. The output of this experiment can be found in the folder answers/movies/gaussian-peak-images. It is assumed that this question asks for Gaussian blur not bilateral blur (which is the subject of next question).

6. **Extra:** What is the best bilateral input values (sigmaS and sigmaI) for removing the jpg artifacts in Seattle.jpg without blurring the images details? Following Q6, does using BilateralImage to blur the image before applying FindPeaksImage produce better edges?

> The best values of sigmaS and sigmaI were found to be 1 and 0.1 respectively. Also, applying BilateralImage to blur the image before applying FindPeaksImage does indeed produce better results. This can be verified by comparing the two images below. A grid search was conducted to find the best parameter values. It can also be seen that the image thus produced is even better than the image produced with Gaussian blur. Note that the BilateralImage only works for grayscale images to keep the implementation fast and simple. A fast implementation allows for more experimentation with parameters.

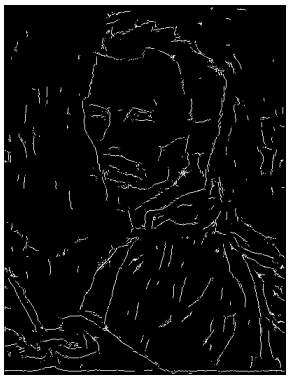

Figure 7: Bilateral filter (sigmaS=5, sigmaI=2.1)

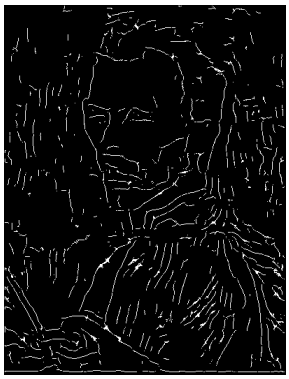

Figure 8: Gaussian filter (sigma=4)

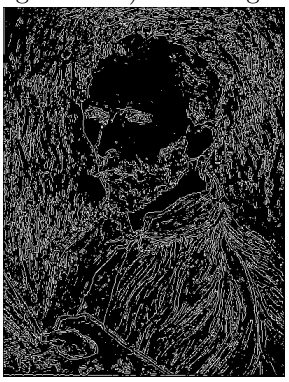

Figure 9: Without Any Filtering