Critical Thinking 4 - Laplacian Filters for Different Kernel Windows

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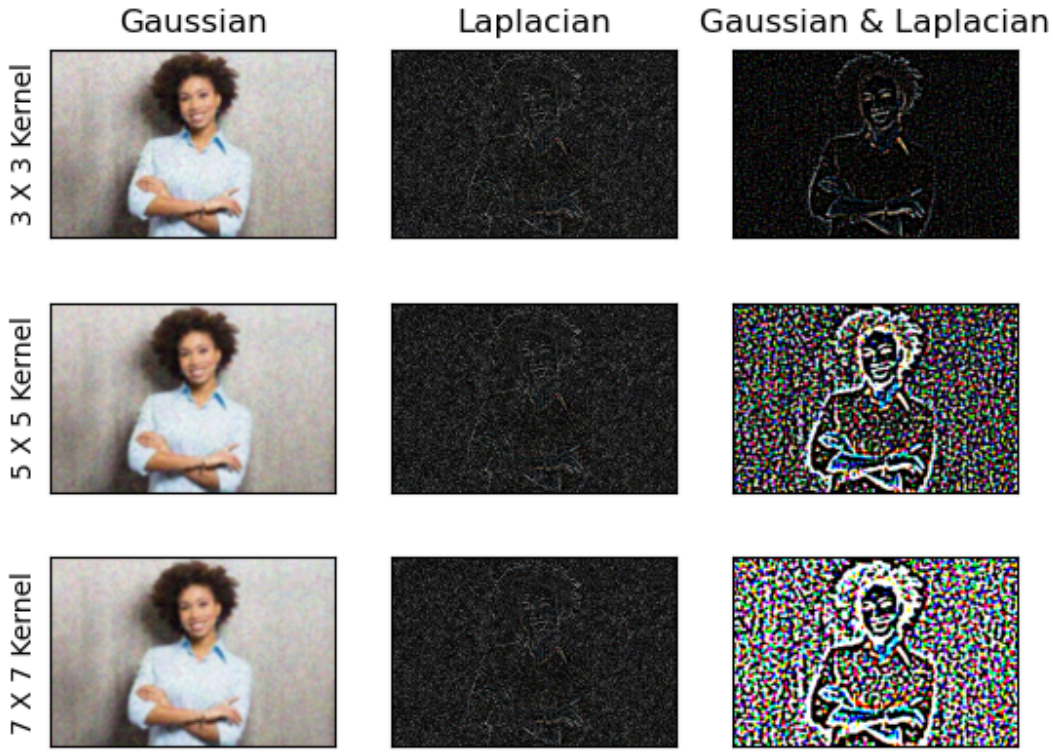
Introduction

The parameters of this assignment required an exploration of Gaussian filtering, Laplacian filtering, and a combination (Laplacian of Gaussian) of the two. Figure 1 shows the original image to which each set of filters was applied. As denoted in the assignment instructions, the provided image contains Gaussian noise. For each of the three filter types, the 3 X 3, 5 X 5, and 7 X 7 kernel were applied, and the resulting images were arranged in Figure 2. Across all kernel sizes, a sigma (σ) value of 1 was used. A σ value that is too small could cause the LoG filter to become too compact to be accurately described (Gunn, 1999), and larger σ values require larger kernels to represent accurately (Bhuyan, 2019). A few different values were

Figure 1 Image with Gaussian Noise

Note. Image was provided as part of assignment parameters. The image is permeated with Gaussian noise. Retrieved from https://frostlor-cdn-prod.courses.csuglobal.edu/frost/assets/images/ic348fc4-a862-3fd6-8cd5-b5f260e022fc/Mod4CT2.jpg

Figure 2 Gaussian and Laplacian Filters (Sigma = 1)



Note. This figure shows 9 images corresponding to 3 different processing filters (Gaussian, Laplacian, and LoG (Gaussian & Laplacian)) and 3 different kernel sizes (3 X 3, 5 X 5, and 7 X 7). Each column corresponds to one filter type and each row corresponds to one kernel size.

tested, but σ=1 provided cleaner results than others on the larger kernels, so it was used to create the images in Figure 2.

Filter Discussion

When it comes to edge detection, the LoG filter is a very common approach (Kennedy & Basu, 1997). As previously mentioned, the LoG filter is comprised of both a Gaussian and a Laplacian processing step. The Gaussian filter is applied first to smooth the image and reduce the prevalence of Gaussian noise. Gaussian noise is an idealized form of white noise, and a Gaussian mask is a type of convolution that can bring the values of a pixel into closer harmony with its neighbors (Hambel et al., 2015). In this way, a Gaussian filter smooths the image, but it does

have the consequence of amplifying impulse noise that may be present. Both the 5 X 5 and 7 X 7 kernel LoG images show an increasing amount of impulse noise present in Figure 2. The Gaussian filter results in the noise being averaged over a larger neighborhood, so there are more pixels with distorted intensity values (Davies, 2018).

While the Gaussian filter helps remove noise and smooth an image, the Laplacian filter is a type of sharpening filter used to highlight fine details in an image (Bhuyan, 2019). As evident from Figure 2, the Laplacian filter alone has difficulty distinguishing the edge of an object (in this case, a person) from the noise present in the image. The application of the Gaussian filter helps bring values of neighboring pixels in line with the edges and non-edges, allowing the Laplacian filter to calculate the resultant locations of the edges better.

Edge Detection Results

It is the combination of these two filters, the LoG approach, that ultimately results in better edge detection. Figure 2 clearly shows that the LoG images better represent the subject's outline than the Laplacian approach. The 3 X 3 kernel provided an adequate outline of the subject while minimizing noise. The two primary convolution masks that are used with Gaussian filters operate in the 3 X 3 space, and ". . . it will not normally be appropriate to smooth [an image] using convolution masks larger than 3 X 3 or at most 5 X 5 pixels." (Davies, 2018, p. 44). The results from figure 2 seem to agree with that sentiment.

However, an LoG approach can suffer from poor localization around edges with high curvature (Ulupinar & Medioni, 1990). One area of curvature that lacks definition in both the 3 X 3 and 5 X 5 LoG images is the subject's right shoulder. While the 7 X 7 LoG image is plagued by increased impulse noise, the subject's outline is thicker, and the area around the right shoulder

is much more defined. In cases where high curvature is present, it may be helpful to utilize larger LoG kernels and explore other processing methods to remove the presence of impulse noise.

References

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