CSE 691: Image and Video Processing

Spring 2020 Assignment 1

Noise Filtering

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Objectives

- Understand the three types of filters: average, gaussian, and median.
- Apply the different filters to different images, understand how each works, and evaluate their effect on the image.

Method

To run the code, run ***main.m*** and make sure all function files are in same folder.

The output image is labeled as :

Out [Original Image Number][Type of filter][Parameters]

For example, out2gaus31 represents it used image2, gaussian filter size 3, and sigma value 1.

1. In averaging filter, I created two matrices of ones with size 3x3 and 5x5. Both matrix are divided by the number of entries in the matrix. That is, 3x3 matrix divide by 9 and 5x5 matrix divide by 25. Masking this filter over the image using convolution will output an image that will have much less noise. I used MATLAB *conv2()* function in this part.

2. For Gaussian filtering, the *main.m* calls the function *gaus()* in *gaus.m* with input parameters image, filter size, and sigma value. I directly used the 2D Gaussian formula $G = \frac{e^{-\frac{x^2+y^2}{2\sigma^2}}}{2\pi\sigma^2}$ where x and y are vectors defined by the *meshgrid()* with size from -filter size to +filter size. Similar to part 1, convolve this filter with the image using *conv2().*

3. For median filtering, the *main.m* calls the function *med()* in *med.m* with input parameters image and size of the filter. It first calculates the offset to determine the starting and ending coordinate for the loop. The borders are padded to zero. For a coordinate, it takes its neighboring pixels and form a matrix of size specified by the input. Calculate the median and replace that coordinate pixel with this median. After looping through the whole image, the new output will be the filtered image.

Results and Discussion

Figure 1. a) Original Image, *NoisyImage1.jpg* (left),
b) Original image with salt pepper noise, *NoisyImage2.jpg* (right)

In part 1, the 3x3 and 5x5 averaging filtered are applied to both images.

Figure 2. a) Image1 with 3x3 mean filter(top left), b) Image1 with 5x5 mean filter(top right), c) Image 2 with 3x3 mean filter(bottom left), d) Image2 with 5x5 mean filter(bottom right)

From figure 2, we can see that the averaging filter smooths the image. This is especially noticeable at the edges. For example, the elbow of the camera man and the poles of the tripod. Comparing a and b, the larger the filter, the more blurry the image gets. This is because more neighboring pixels are averaged so details of the image become less visible. When looking at c and d, the images are only blurred but the salt and pepper noise are not reduced. This means averaging filter is unfit for removing this kind of noise despite the size of the filter.

In part 2, gaussian filter are applied to the two images, the filter size and sigma value combos are: (3,1), (3,3), (5,3), and (3,8). This way we can evaluate the effects of different values of sigma and different filter sizes. I chose the sigma values to be 1, 3 and 8. Considering 1 and 8 are the two extremes while 3 acts as a non-changing factor for comparing the two different filter sizes.

Figure 3. a) Image1 with gaussian filter size 3 and sigma = 1(top left),
b) with filter size 3 and sigma = 3(top right),
c) with filter size 5 and sigma = 3(bottom left),
d) with filter size 3 and sigma = 8(bottom right)

The gaussian filter does a similar job as averaging filter. However, we know that averaging filter does not remove the impulsive noise or the secondary lobe. It is not visible by comparing figure 2 and figure 3, but the gaussian filter will let low frequency to pass and averaging filter will not. Comparing figure 3 a, b, and d, we can see that the higher the sigma value, the blurry the image. This is expected result as the sigma decides how much an image is filtered. Now comparing b and c which both have same sigma value and different filter size. From the buildings behind, it is slightly visible that c is more blurry. Similar to averaging filter, a larger filter will produce a more blurred image.

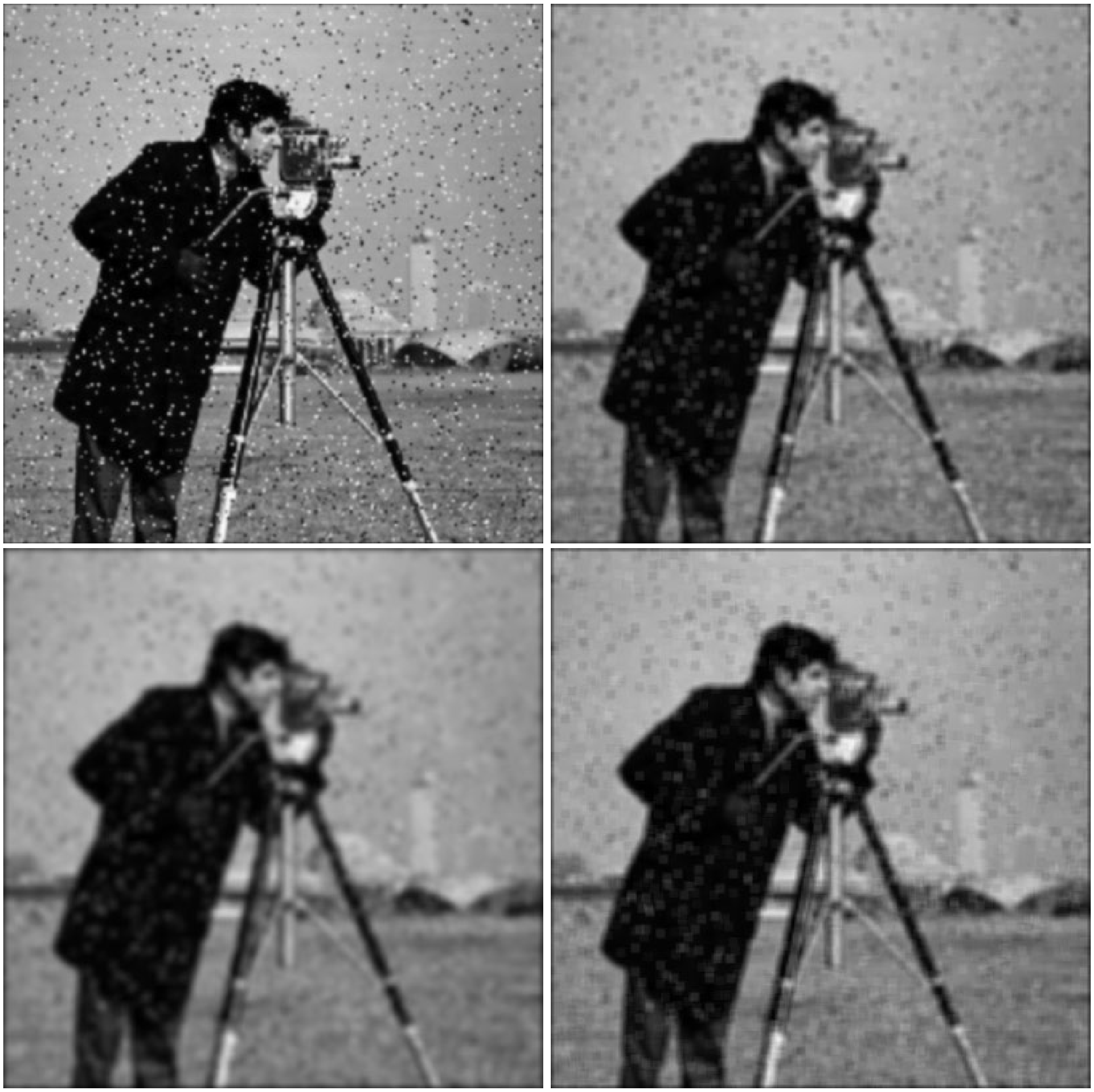

Figure 4. a) Image2 with gaussian filter size 3 and sigma = 1(top left),
b) with filter size 3 and sigma = 3(top right),
c) with filter size 5 and sigma = 3(bottom left),
d) with filter size 3 and sigma = 8(bottom right)

Gaussian filter with image2 has similar results as with image1. Although the image is filtered and blurred, the salt and pepper noise are not reduced. This is not an effective method for removing this kind of noise as well.

Overall, the gaussian filter is slightly better than averaging filter, but its uses are limited to certain type of images only. I also did some comparison to the built in function *imgaussfilt(),* with a smaller sigma value, the outputs are very close. However, with a larger sigma, matlab automatically adjusts to a larger filter size, so the output from matlab function is more blurry than the one in this assignment.

In part 3, I used two filter sized 3x3 and 5x5. For a pixel, it extracts the neighboring pixels and replace that pixel coordinate with the median value from the extracted matrix. The borders of the output are zero-padded.

Figure 5. a) Image1 with 3x3 median filter(top left), b) Image1 with 5x5 median filter(top right), c) Image 2 with 3x3 median filter(bottom left), d) Image2 with 5x5 median filter(bottom right)

The effects of median filter on image1 (figure 5. a and b) are not very obvious when compared to mean and gaussian filter. We can still see that the edges are smoothed if we look closely. However, the border effect are extremely visible. When looking at figure 5. c and d, the salt and pepper noise are being filtered out. The 3x3 filter did not completely filter out all the noise, rather reduced it. The 5x5 worked better than 3x3 for this image, but the output seemed very rough.

Future Improvement

The gaussian filter can be improved by improving the sigma-filter size relation. Right now it is hard for a user to decide which combination with produce the best result of all.

The function for the median filter can be shortened when getting the median value of a matrix. This reduces the possibility of making an error in the algorithm. I am currently using matlab 2018a which does not support the functions *median(matrix,'all').*

Conclusion

Overall, the gaussian filter works best for filtering an image with regular noise. In general it is better than average filter because it has no secondary lobes which makes it a better low pass filter. Median filters works best for salt and pepper noise, but not other noises.