Assignment1 Report:

NOISE FILTERING

CSE 691: Image and video processing

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A. Mean filter

a. 25% Apply average smoothing by a mean filter by using two different kernel sizes. Then, compare and evaluate your results.

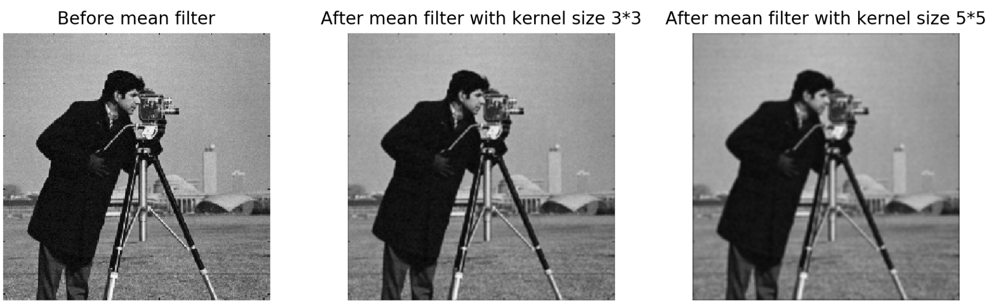
Definition

Mean filter is a kind of linear filter to reduce noise. The idea of mean filtering is simply to replace each pixel value with the mean value of its neighbors.

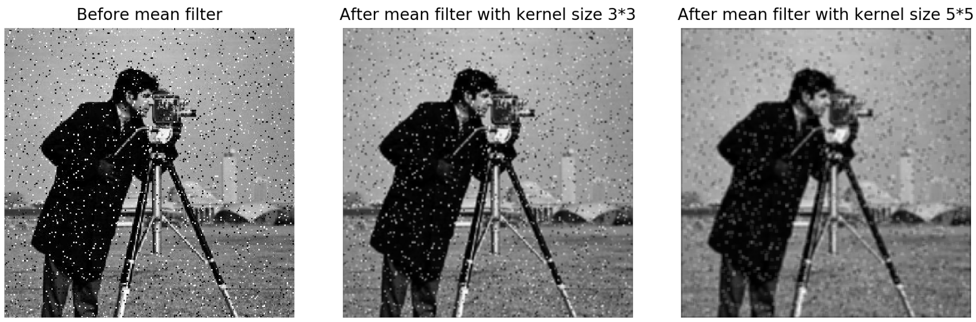
Experiment

We want to reduce the noise by using mean filter. By changing the kernel size, we will illustrate the influence of kernel size in mean filtering. In the following part, we use two kernel size, 3*3 and 5*5 respectively. And the comparison on two size is analyzed.

Output for image1



Output for image2



Observation and Evaluation

In the output1, the three images are listed. The original one and two smoothed images with different kernel size. From the results, the smoothed pictures have less noise and not as sharp as the original one. For the different kernel size, we can see the 3*3 size kernel does a better job because it smooth the image but does not blur it. When the size is 5*5, the whole image is obscure to some degree. So in this case 3*3 size kernel is preferred.

In the output2, when the noise is now pepper noise, same story happens for the two different sizes. Along with the blurring, the noises become blurred too but not removed.

Discussion

We can conclude from the output that the mean smoothing is good for gaussian noise which is in the image1. When the size of kernel gets greater, the picture is more blurred. However, when it comes to pepper noise which is the noise in the image2, the mean smoothing is not as good. The reason I think is because when we calculate the mean we actually include the extreme value from the noise. So the noise is not removed, it is just diffused into the neighborhood.

B. Gaussian filter

b. 40% Apply Gaussian smoothing by using two different σ values. Then, compare and evaluate your results. Comment on your choice of σ values.

Definition

Gaussian filter is a filter where its value is sampled from a Gaussian function. The Gaussian function in frequency domain is an ideal filter.

Experiment

Use two gaussian kernel with different sigmas(standard deviation) to apply the gaussian smoothing. Built the kernels with algorithm INT_GAUSS_KER and use the algorithm SEPAR_FILTER to apply gaussian kernel. In this case we use sigma 0.9 and 2 respectively.

Output for Image1

Output for Image2

Observation and Evaluation

From the output1, both filters worked. But obviously the filter with a sigma 0.9 is much better than that with a sigma 2 because the latter blurs the image. Since we use filter of size 5, we sample 5 pixels from the center of gaussian function. According to the Nyquist–Shannon sampling theorem, we cannot have sigma - standard deviation - less than 0.8 so we pick 0.9 and 2 here. Comparing sigma 0.9 and 2, 0.9 covers most of the gaussian function but sigma 2 not. So the gaussian kernel with sigma 0.9 performances better in this case.

In the output2, the gaussian filters are not doing good on removing pepper noises. Similar to output1, The bigger the sigma is, the more blurred is the image.

Discussion

The gaussian smoothing is good for smoothing gaussian noise as long as the sigma is picked wisely. Due to the chosen pixel sample step, our sigma cannot be less than 0.8. But when it becomes greater, the output gets blurred. For the pepper noise in image2, it does not work properly. From the frequency point of view, the gaussian function in frequency domain is same with itself in time domain. It works like a frequency filter. When the noise is mainly gaussian noise, if the noise is not too extreme, it cannot be reduced by gaussian filter. The noise is still there but since they are relatively similar, it can not be detected by human eyes. For the pepper noise, The extremest noise are eliminated, but the left ones stay. We can see the noise on the man's coat is reduced more than the noise in the background . So the output is not satisfying.

C. Median filter

c. 25% Apply median filtering by using two different kernel sizes. Then, evaluate your results.

Definition

The median filter is a non-linear filter that replaces every pixel with the median in its neighborhood.

Experiment

We apply the median smoothing on the image with two different kernel size. The effect of kernel size of median filter is analyzed. Here we use size 3*3 and size 5*5.

Output for Image1

Output for Image2

Observation and Evaluation

Again, the images from the output1 show that two filters worked. But the filter with smaller size did a better job. The third image is somehow blurred by the filter though it is smoothed.

For the output2, we find that median smoothing is much better than another two other filters. With the filter of size 5*5, almost all noises are removed.

Discussion

Median smoothing works pretty good for gaussian noise and pepper median. For the gaussian median, it can reduce noise as long as the noise is not median. With the kernel size growing, the image will be more and more blurred. And this is easy to understand. Median is a local feature. If we look into the extreme case where the size is equal to that of the image, then all pixel will be replaced by the median of the whole picture, this is, the whole picture is extremely blurred. So we want to make the kernel size small. For the pepper noise, median smoothing is pretty good. A pepper noise is a extreme value in the image. While applying the median filter, the noise itself can never be chosen as a median which means the noise is 'ignored', i.e, reduced. But still, the size shouldn't be too large.

Discussion and Conclusion

10% Which filter is better for each image and why?

The discussions about the internal comparisons like kernel size or sigma are offered in each section above. In this section we focuses on the comparison between filters. For the image2 with pepper noise, it is obviously that median filter with size 3*3 is the best choice. The reason is discussed above. The median filter is the filter that can totally reduce the pepper noise which is difficult for the other two. But for the image1 with gaussian noise, it seems that the three output is similar(mean filter with 3*3, gaussian filter with sigma 0.9, median filter with 3*3). Since the gaussian noise is randomly distributed, these three can do their jobs but can not totally reduce gaussian noise.

After the analysis a question rises very naturally, why don't we use median filter all the time? Since it seems that median filter is the only choice for pepper noise and is fine for the gaussian noise. In my view, the reason I think is because median filter is a non-linear filter which is more expensive in application than linear filters. We can use convolution operation while applying linear filters which is more preferable in practice.

So in conclusion, for pepper noise, use median filter. For gaussian noise, choose either of the three depending on scenario.