DIP Assignment 2

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1 Problem 1: Gaussian Noise

1.1 Mean Filter

After reading the image from the file and displaying it, we can see that the original image contains gaussian noise,especially the background is obviously noisy, which is shown in Figure 1.

Figure 1: The original image of Section 1.1

In order to reduce these noises, we can use matlab function 'filter2' or 'conv2' to apply mean filter to the original image.We can apply correlation operation with function 'filter2' and convolution operation with function 'conv2'.Actually,convolution is the same as correlation, except that the filter is first rotated 180 degree.Since the mean filter is symmetric, the convolution and correlation are the same in this problem.

The results of appying mean filter of size 3, 5, 7, 9 to the original image are shown in Figure 2. We can see that as the size increases,the noises are reduced more, but the image becomes more blurred. After comparing these results, I think the filter with a size of 5 works best, the noises in the image are reduced a lot, and the original content of the image is not very blurred.

1.2 Gaussian filter

Mean filter uses surrounding pixels for averaging operation for each pixel. With mean filter,the image can be smoothed, the speed of this operation is fast, and the algorithm is simple. But the noises cannot be

(a) size=3

(b) size=5

(c) size=7

(d) size=9

Figure 2: Mean filter result

removed, it can only be weakly weakened.

Gaussian filter is also a linear smoothing spatial filter, whose coefficients are determined by a Gaussian function.It assigns more weight to the positions near the center, and less weight to the positions far away from the center.While smoothing the image, it can retain more of the overall gray distribution characteristics of the image and effectively reduce noises.

A 2D Gaussian can be formed by convolution of an 1D Gaussian with its transpose.Based on this I wtite a 2D Gaussian filter function **gauss2d(sigma, n)** and write a function **gaussConv(image, sigma, n)** which applies Gaussian convolution to a 2D image for the given value of σ.When the window size is 9 and the σ value is 1.5, the comparison between this function and the matlab function 'imfilter' is shown in the Figure 3.From the comparison of these two images, we can't see the difference, so we can think that the implementation of the function 'gaussConv' is correct.

(a) gaussConv

(b) imfilter

Figure 3: The comparison between function 'gaussConv' and 'imfilter'(n=9,σ=1.5)

Based on this, I want to apply Gaussian filter with masks of different σ value and window size for better results.According to the 3σ-rule of the theory of probability,we can know that it is more appropriate when the filter half-width is about 3σ.So I apply Gaussian filter with a window size of 3,5,7,9,11,13(the corresponding σ values are 0.5,0.8,1.1,1.5,1.8,2.1) to the original image and the results are shown in Figure 4.After comparing these results, I think the filter with the σ value of 1.5 and the window size of 9 works best.

(a) n=3,σ=0.5

(b) n=5,σ=0.8

(c) n=7,σ=1.1

(d) n=9,σ=1.5

(e) n=11,σ=1.8

(f) n=13,σ=2.1

Figure 4: Gaussian filter result

2 Problem 2: Pepper and salt noise

2.1 Minimum filter

After reading the image from the file and displaying it, we can see that the original image contains a lot of white pixel noises,which is shown in Figure 5.

Figure 5: The original image of Section 2.1

We can apply minimum filter to the image to reduce these noises.The minimum value filter compares each pixel with its surrounding pixel value, and replaces the pixel with the smallest pixel value.Since the pixel value of the white pixel noises is relatively large, the minimum filter can reduce the white pixel noises.

The results of appying minimum filter with a window size of 1, 3, 5, 7 to the original image are shown in Figure 6.We can see that when the window size is 3, the noises have been completely reduced. As the window size increases, the picture will become darker, especially the darker area will expand, making the image difficult to distinguish.After comparing these results, I think the filter with the window size of 3 works best.

(a) size=1

(b) size=3

(c) size=5

(d) size=7

Figure 6: Minimum filter result

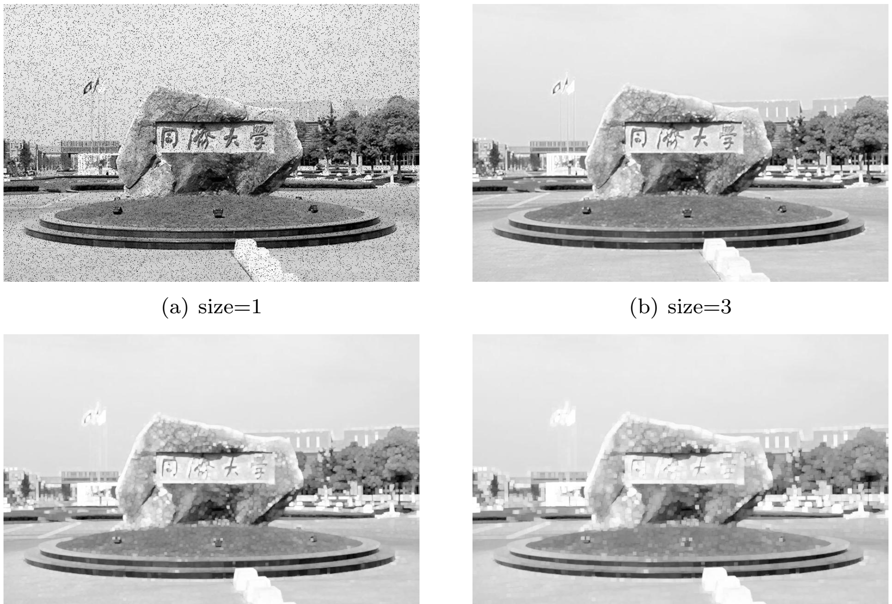
2.2 Maximum filter

After reading the image from the file and displaying it, we can see that the original image contains a lot of black pixel noises,which is shown in Figure 7.

Figure 7: The original image of Section 2.2

We can apply maximum filter to the image to reduce these noises.The maximum value filter compares each pixel with its surrounding pixel value, and replaces the pixel with the smallest pixel value.Since the pixel value of the black pixel noises is relatively small, the maximum filter can reduce the black pixel noises.

The results of appying maximum filter with a window size of 1, 3, 5, 7 to the original image are shown in Figure 8.We can see that when the window size is 3, the noise have been completely reduced. As the window size increases, the picture will become brighter, especially the brighter area will expand, making the image difficult to distinguish.After comparing these results, I think the filter with the window size of 3 works best.



(a) size=1 (b) size=3

(c) size=5 (d) size=7

Figure 8: Maximum filter result

2.3 Median filter

After reading the image from the file and displaying it, we can see that the original image contains a lot of pepper and salt noises,,which is shown in Figure 9.

Figure 9: The original image of Section 2.3

We can apply median filter to the image to reduce these noises.The median value filter compares each pixel with its surrounding pixel value, and replaces the pixel with the median pixel value.Since the pixel value of the black pixel noises is relatively small and the pixel value of the white pixel noises is relatively large, the median filter tend to choose pixel values close to the original content and can reduce the pepper and salt noise.

The results of appying median filter with a window size of 1, 3, 5, 7 to the original image are shown in Figure 10.We can see that when the window size is 3, the noises have been completely reduced. As the window size increases, the picture will become more blurred.After comparing these results, I think the filter with the window size of 3 works best.

(a) size=1

(b) size=3

(c) size=5

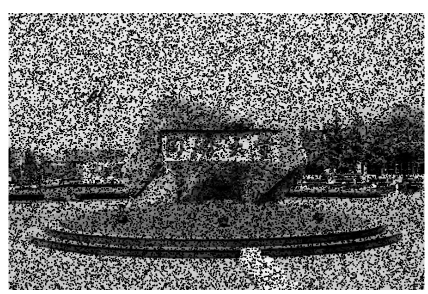
(d) size=7

Figure 10: Median filter result

2.4 Conclusion

The maximum filter can ruduce black pixel noises, but if we use it on an image containing white pixel noises, it will increase the noises. Similarly, the minimum filter will increase the black pixel noises.As shown in Figure 11,the max filter is applied to the original image in Section 2.1 and the min filter is applied to the original image in Section 2.2,which makes the two images full of noises.

(a) Maximum filter



(b) Minimum filter

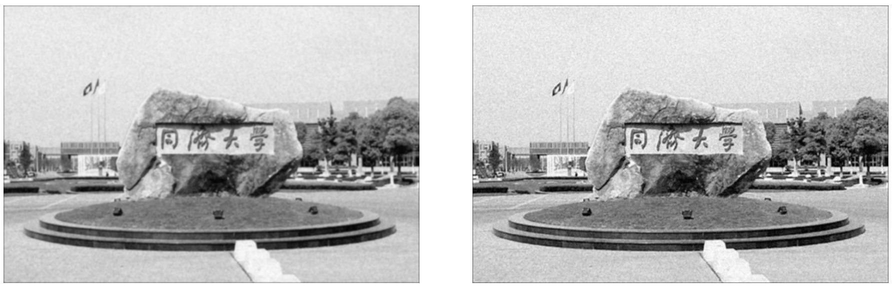
Figure 11: Inappropriate application of maximum filter and minimum filter

Above all, we can know that the minimum filter can be used to reduce white pixel noises, the maximum filter can be used to reduce black pixel noises, and the median filter can be used to reduce pepper and salt noise.

3 Problem 3: Sharpen

3.1 Laplacian Filter

After applying the Laplacian filter to the best result in Section 1.2,the result is shown in Figure 12.We can see that some details of the image is restored,the edges in the image are sharpened,the image becomes clearer, but at the same time the noises in the image are increased.



(a) Original image (b) Sharpened image

Figure 12: Laplacian filter result of the best result in Section 1.2

3.2 Laplacian of Gaussian Filter

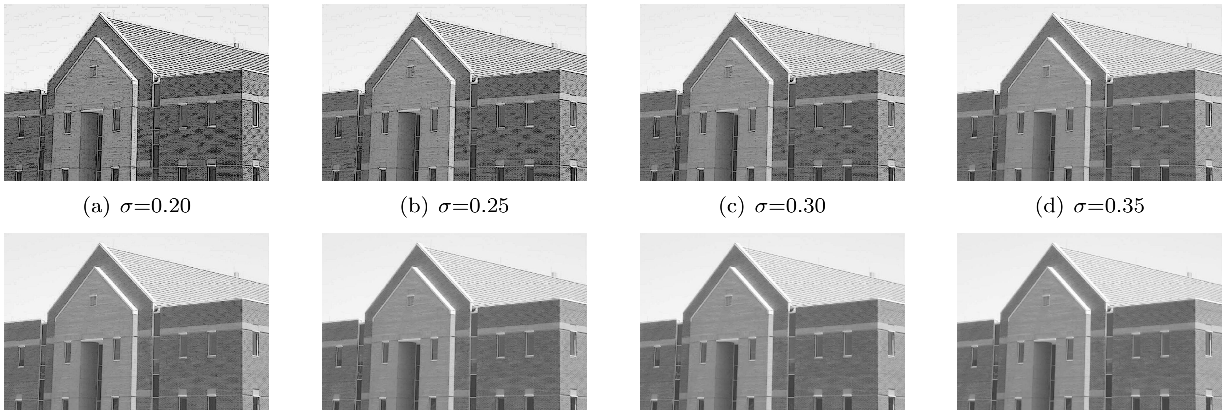
After reading the image from the file and displaying it,we can see that the original image is blurry.After applying the Laplacian filter to the original image,the result is shown in Figure 13.By comparing the two image, we can see that after sharpening, the blur of the original image is reduced and the edges in the image are sharpened,but the sharpened edges appear jagged and at the same time the noise of the image is increased,especially the wall of the house is noisy.

(a) Original image (b) Sharpened image

Figure 13: Laplacian filter result

The Laplacian of Gaussian filter is the convolution of the Gaussian smoothing filter and the Laplacian filter, which is equivalent to first using the Gaussian filter to denoise the image, and then using the Laplacian filter to sharpen the image.Therefore, this filter can reduce the sensitivity of the Laplacian operator to noise, and avoid increasing the noise while sharpening the image.

After applying the Laplacian of Gaussian filter with a window size of 3 and different σ values to the original image,the results are shown in Figure 14.



(a) σ=0.20 (b) σ=0.25 (c) σ=0.30 (d) σ=0.35

(e) σ=0.40 (f) σ=0.45 (g) σ=0.50 (h) σ=0.55

Figure 14: Laplacian of Gaussian filter with a window size of 3 and different σ value

From these results,we can see that when the σ value is small, the sharpening effect of the image is very obvious, but there is more noise. As the σ value increases, the noise of the image is reduced more, but the sharpening effect also become less obvious. Therefore, in actual application, we can adjust the σ value according to the needs to find a balance between noise and sharpening effect.