Digital Image Processing Homework IV

0550222 葉胤呈

I. Abstraction

In this homework, three images have distorted by different physical phenomena and our goal is to recover these picture from these degradations. Here, modeling on point spread function and Weiner Filter are applied to achieve these goals.

II. Algorithm and Experiment Result

Wiener filter computes the statistical estimation of an unknown signal using a related signal as an input and filtering that known signal to produce the estimate as an output. Thus, in this case, the known signal is the image and the additive unknown signal is the noise. Wiener filter has the form as following:

$$F(u,v) = \frac{H^*(u,v)}{|H(u,v)|^2 + \frac{1}{SNR}} G(u,v) --(1)$$

, where G is the Fourier Transform of the input image and H is the Fourier Transform of the point spread function. I will discuss the approaches by input images because of their different characteristics on degradation models.

- Input Image 1

For this image, I clipped some of the objects (Figure 2) and carefully observed them. We can find that the black windows in (a) and Chinese characters in (c) spread out. Thus, I tried the Gaussian point spread function (figure 2) which can describe the defocus model.
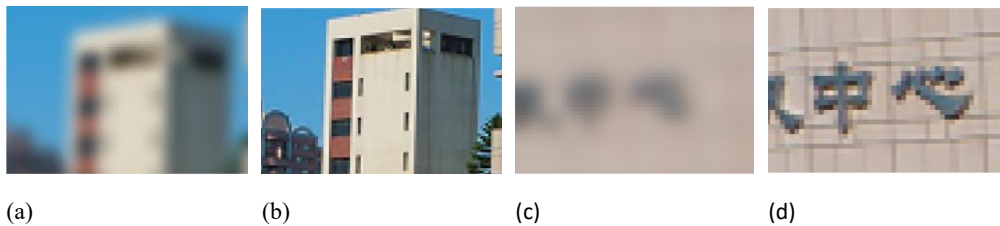

(a)　　　　　　(b)　　　　　　(c)　　　　　　(d)

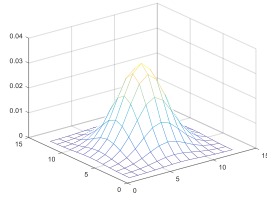**Figure 1. (a), (c) Some details from degradation image; (b), (d) Some details form original image.**

Figure 2. Gaussian point spread function with size 13-by-13 and standard deviation equal 2.2.

After applying the Weiner Filter with SNR = 1000, from equation (1) on the input image 1, we can obtain the results on Figure 3. We can see the details are recovered significantly, Figure (3), (c)-(f). However, I have found that there are some of the unpleasant ringing artifacts are involved. This kind of noise is the nature of Weiner Filter and it is unsolved by Wiener Filter.
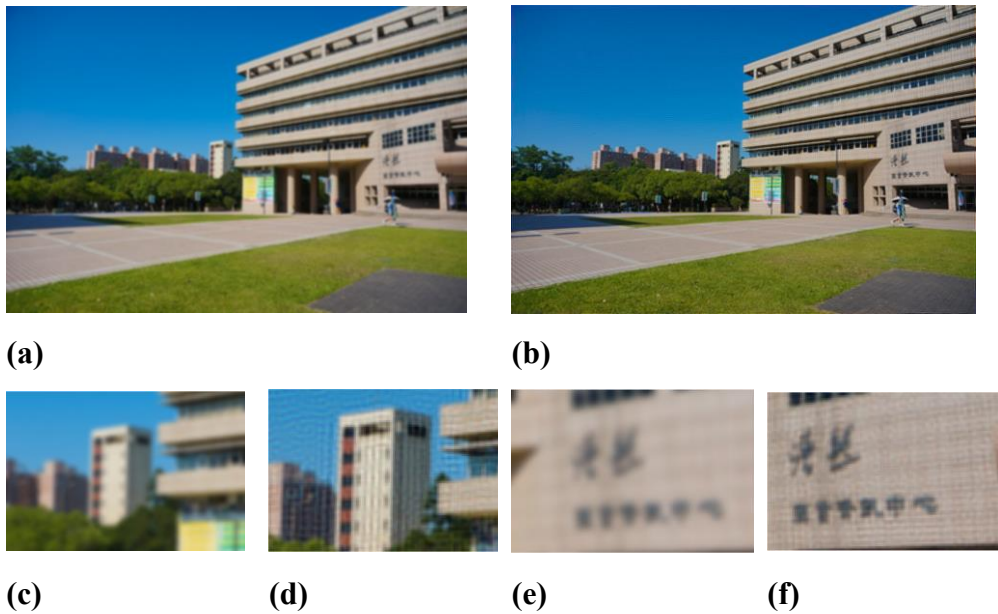

(a)   **(b)**

(c)   **(d)**   **(e)**   **(f)**

Figure 3. (a) Input Blurred Image; (b) Restore image; (c),(e) Some details from blurred image; (d), (f) Some details from resotred image.

● Input Image 2

Follow the same steps, firstly I observe the input image carefully. By measuring the objects in the image, I have concluded that this image is drifted upward by 60 degrees and 16 pixel-length (Figure 4). Therefore, motion point spread function with 60 degrees and 16 pixel-length drift is applied (Figure 5).
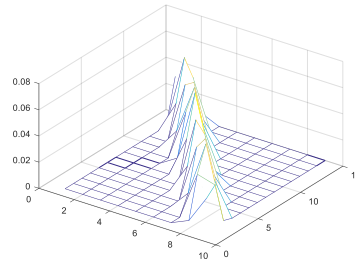
Figure 4. the alphabet 'o' is drift by 60 degrees and 16 pixels

Figure 5, motion point spread function

After applying the Weiner Filter with SNR = 50 from equation (1) on the input image 2, we can obtain the results on Figure 6. We can see the drifted details are recovered significantly, Figure 7, (c)-(f). For the unpleasant noise, the unpleasant ringing artifacts are still involved. Moreover, there exist some of the contour of the objects on the up and down of themselves.
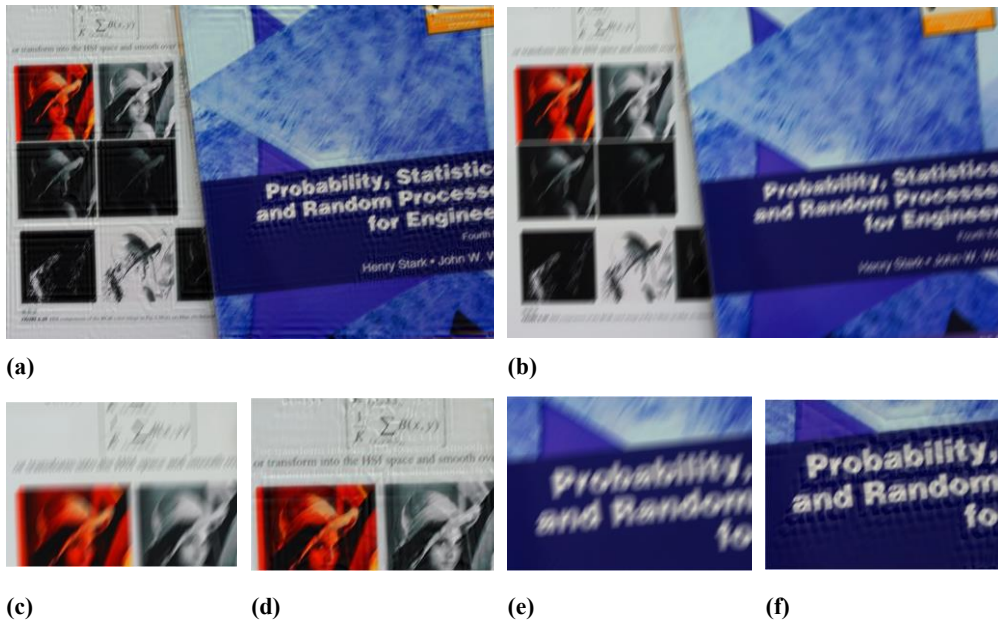

(a)

(b)

(c)

(d)

(e)

(f)

Figure 7. (a) Restored image; (b) Blurred image; (c), (e) Some details in the blurred image; (d), (f) Some details in the restored image

- Input Image 3

    Input Image 3 is also a blurred image but it has some salt-and-pepper noise in it. Thus, I tried to de-noise the image first and then put it though the filter. For the de-noise part, I tried median filter and wavelet de-noising. However, no matter which de-noise methods I tried, they will get the similar results like Figure 8-(c). Both of these methods will smooth the

image, which will make details (high frequency components) lost. Therefore, I directly make the image pass through Wiener Filter.

(a)   (b)   (c)

Figure 8. (a). The input noisy image; (b) recover by Gaussian point spread function; (c) denoise by wavelet and recover by Gaussain point spread function

The result is in Figure 9-(b). There still exist some salt-and-pepper noise in it but the details are clearer than the input image.
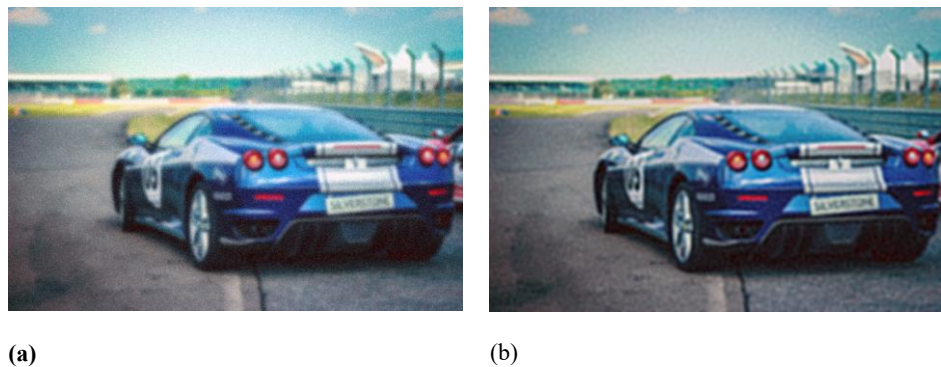

(a)   (b)

Figure 9. (a) The noisy input image; (b) the recovered image by Gaussian point spread function

- Padding Issue

    Image padding is a really important issue in this homework. At very first, I have not padded any image and directly send these inputs into filters. However, there existed some high frequency noise on the boarder. Next, I padded the image with the half size of the point spread function, but this does not work. There is still high frequency noise around the boarder. Then, I increase the padding size until the size of the point spread function and it worked quit well. I think the reason is that the Fast Fourier Transform in Matlab will concatenate image together and there will have some high frequency component around the boarder because it is discontinuous there. Therefore, we have padded the size of the filter to avoid this effect.

Figure 10, High frequency noise on the boarder of the image without padding