Intro

I try to implement wiener filter variant given here, in this repository.

Usage

Run `main.m` matlab code. The rusults are stored in `./result/`.
`main.m` uses `wiener_filter.m` and `Sxx_train.m` that contain the main filter and the PSD estimator (uses multiple images to train first).
To look at some of the saved results from previous runs, look at `./saved_results/`.

Theory

In Wiener filter, we try to reconstruct an image that has been convolved with a known error function `h(t)`. The convolved image also contains an additive white noise (Gaussian). The filter minimizes the root mean squared error between the reconstructed denoised image and the original image. The error metric that Weiner filter reduces is MSE is directly proportional to the L2 distance between reconstructed and the original image.

While calculating the "deblurring filter" that needs to be convolved with the distorted image the filter needs S_xx, i.e. the PSD of the original image. But this can't be possible as we are to generate this original image itself. The filter gets around this by multiple ways, the way that I have used in my implementation is to use the empirical fact that the PSD of all the natural images is nearly similar, therefore a PSD of another uncorrupted image can be used to estimate the PSD of the original image.

We calculate the PSD of 10 images with similar dimensions, average out this PSD and use this value for the value of S_xx in the Weiner filter Equations to be used as an estimate for the image that we need to reconstruct.

Equation

$$W(f_1, f_2) = \frac{H^*(f_1, f_2) S_{xx}(f_1, f_2)}{|H(f_1, f_2)|^2 S_{xx}(f_1, f_2) + S_{\eta\eta}(f_1, f_2)},$$

This equation is what I have implemented. This equation's LHS is the deblurring filter that would need to be convolved with the original image.

Here:

```
H           : DTFT of the blur function
S_xx        : PSD of the original image (estimated using 10 other images)
S_nn        : PSD of the additive noise
W           : DTFT of the deblur function
f1, f2      : coordinates in the frequency domain
```

Requirements

```
MATLAB                                  Version 9.5         (R2018b)
```

```
toolboxes installed:
  Simulink                                    Version 9.2         (R2018b)
  Control System Toolbox                      Version 10.5        (R2018b)
  DSP System Toolbox                          Version 9.7         (R2018b)
  Data Acquisition Toolbox                    Version 3.14        (R2018b)
  Deep Learning Toolbox                       Version 12.0        (R2018b)
  Image Processing Toolbox                    Version 10.3        (R2018b)
  Instrument Control Toolbox                  Version 3.14        (R2018b)
  Optimization Toolbox                        Version 8.2         (R2018b)
  Signal Processing Toolbox                   Version 8.1         (R2018b)
  Simulink Control Design                     Version 5.2         (R2018b)
  Statistics and Machine Learning Toolbox     Version 11.4        (R2018b)
  Symbolic Math Toolbox                       Version 8.2         (R2018b)
```

Sample Results

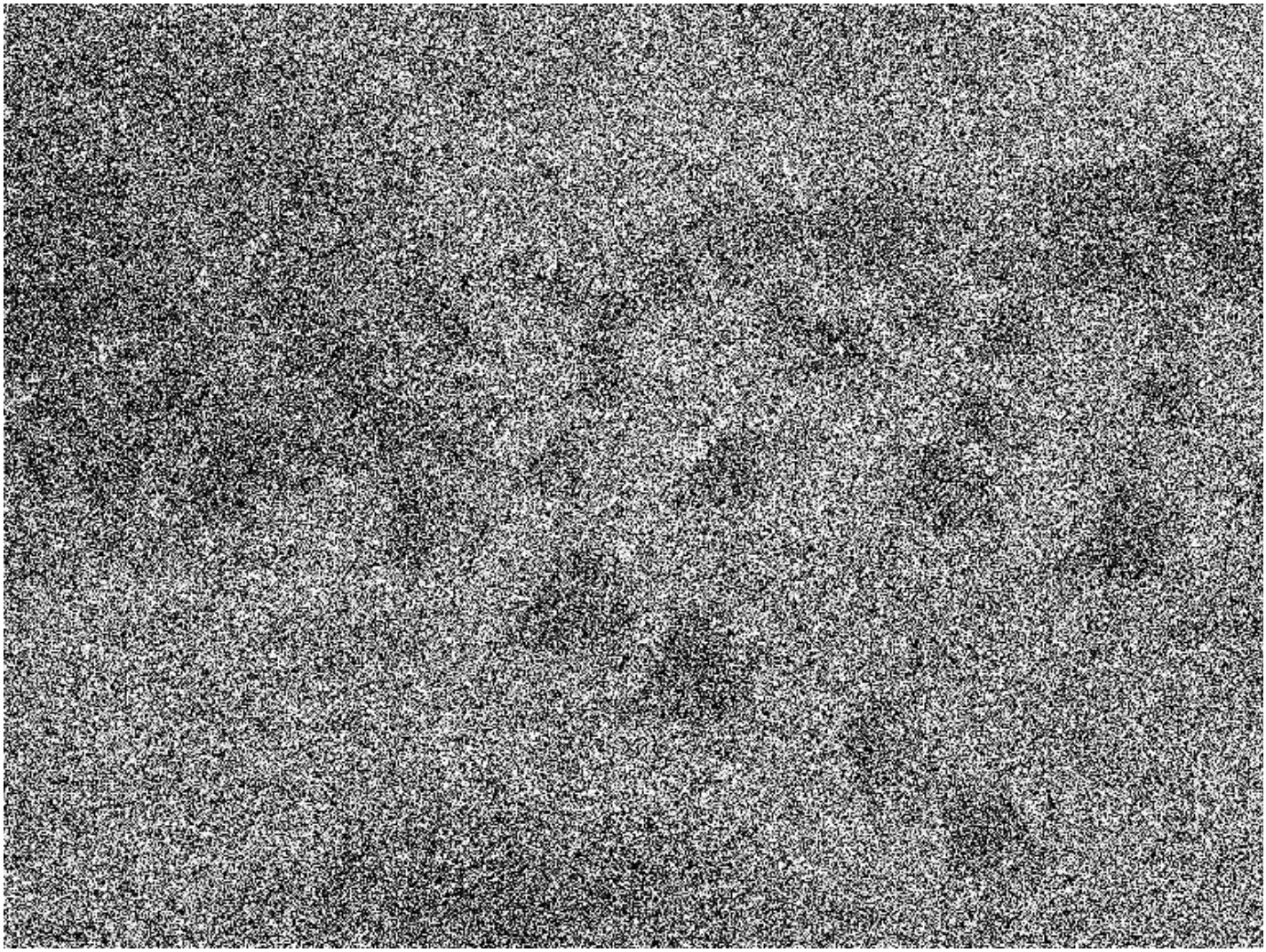
Image 1:
Original Image:

Blurred + Noise Added Image:

Recontructed Image:

Image 2:
Original Image:

Blurred + Noise Added Image:



Recontructed Image:

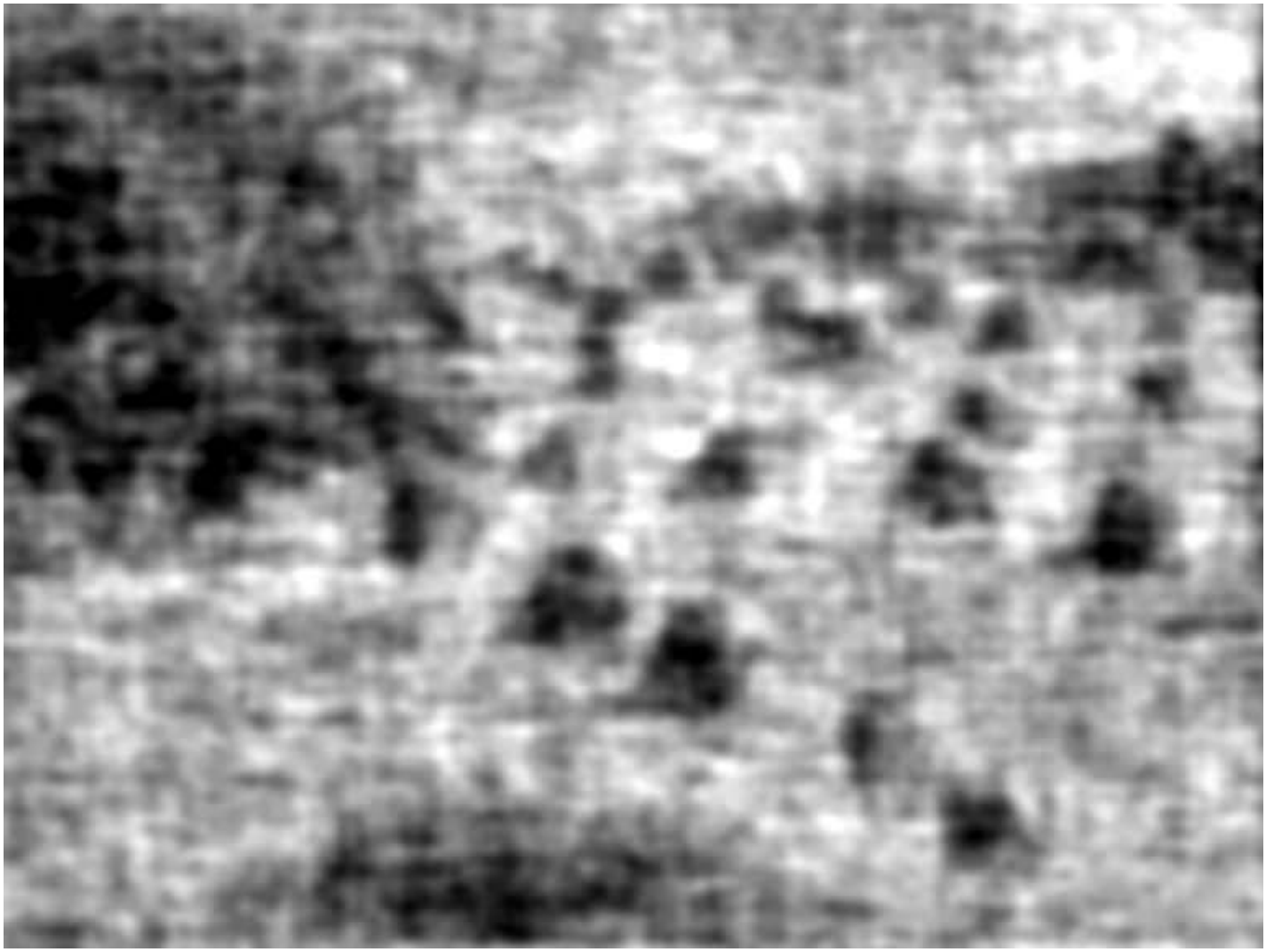
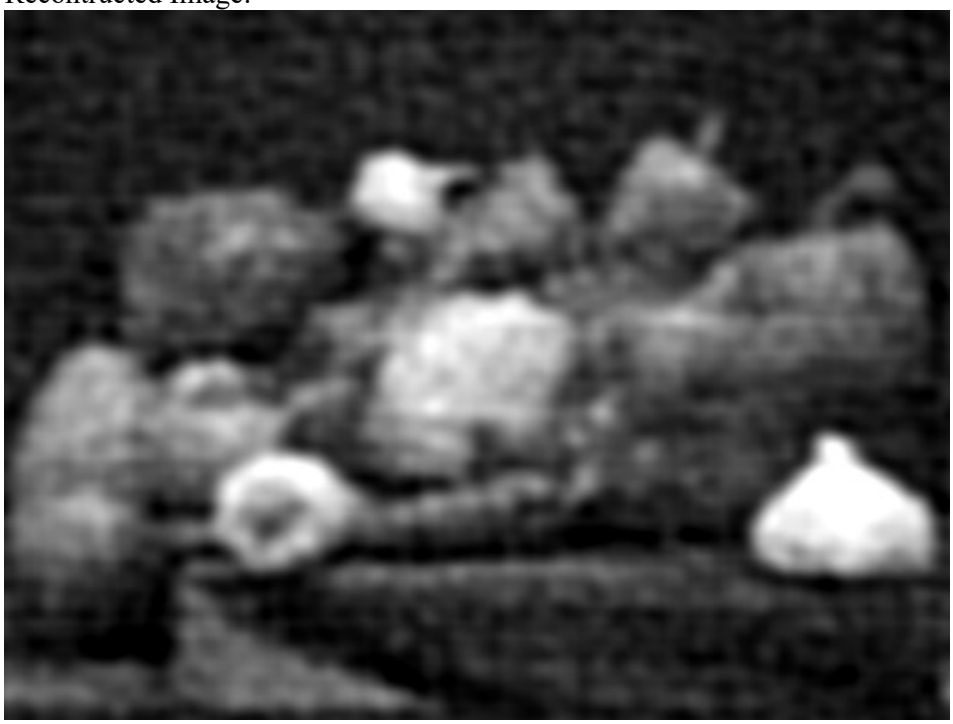


Image 3:
Original Image:

Blurred + Noise Added Image:

Recontructed Image:



Metrics

Sr	dim	σ_blurr	σ_noise	PSNR_original	MSE_original	MSE_restored	PSNR_restored
1	12	5	0.2	13.2 dB	92.33	58.55	16.7 dB
2	12	10	0.2	13.2 dB	92.52	58.97	16.8 dB
3	12	10	0.4	9.38 dB	102.1	57.80	17.0 dB
4	12	10	1.0	6.46 dB	108.4	47.60	16.5 dB
5	7	9	0.8	6.97 dB	107.4	49.70	18.0 dB
