Assignment11

December 13, 2018

1 Assignment11

1.1 Name : ChoiBowon

1.2 StudentID : 20155212

1.3 GitHub : https://github.com/ChoiBowon/Assignment

```
In [ ]: import matplotlib.pyplot as plt
        import numpy as np
        from scipy import signal
        from scipy import sparse
        from skimage import io, color
        from skimage import exposure
```

1.4 File input

```
In [ ]: file_image        = 'cau.png'

        # im :
        # im_noise :
        # im_recon : im , reconstruction (denoised image) !!!!!
        # noise_recon : im_noise - im_recon(im)
        # error  im - im_recon.

        im_color         = io.imread(file_image)
        im_gray          = color.rgb2gray(im_color)
        im          = (im_gray - np.mean(im_gray)) / np.std(im_gray)
        im = im[0:im.shape[0], 0:im.shape[1]]
        (row, col)  = im.shape



        # obtain the reconstructed (denoised) images with varying degrees of regularization

        #im_recon     = im # this must be replaced with the reconstructed (denoised) image
        #noise_recon = im_noise - im_recon
        #error       = np.linalg.norm(im - im_recon)
```

1.5 Transfer image to vector

```
In [ ]: def transfer(im_noise):
            (height, width) = im_noise.shape
            im_noise_vec = np.empty(height*width)
            for i in range(width):
                im_noise_vec[i*height:(i+1)*height] = im_noise[:,i]

            return im_noise_vec
```

1.6 Define Deviation_X function

```
In [93]: def deviation_x(shape):
             deviation_x = np.zeros(((shape[0]-1) * shape[1], shape[0] * shape[1]))

             for i in range(shape[1]):
                 for j in range(shape[0]-1):
                     deviation_x[i*(shape[0]-1)+j, i*shape[0]+j] = -1
                     deviation_x[i*(shape[0]-1)+j, i*shape[0]+j+1] = 1

             return sparse.csr_matrix(deviation_x)
```

1.7 Define Deviation_Y function

```
In [94]: def deviation_y(shape):
             deviation_y = np.zeros((shape[0] * (shape[1]-1), shape[0] * shape[1]))

             for i in range(shape[1] - 1):
                 for j in range(shape[0]):
                     deviation_y[i*shape[0]+j, i*shape[0]+j] = -1
                     deviation_y[i*shape[0]+j, (i+1)*shape[0]+j] = 1

             return sparse.csr_matrix(deviation_y)
```

1.8 Define least_square_problem function

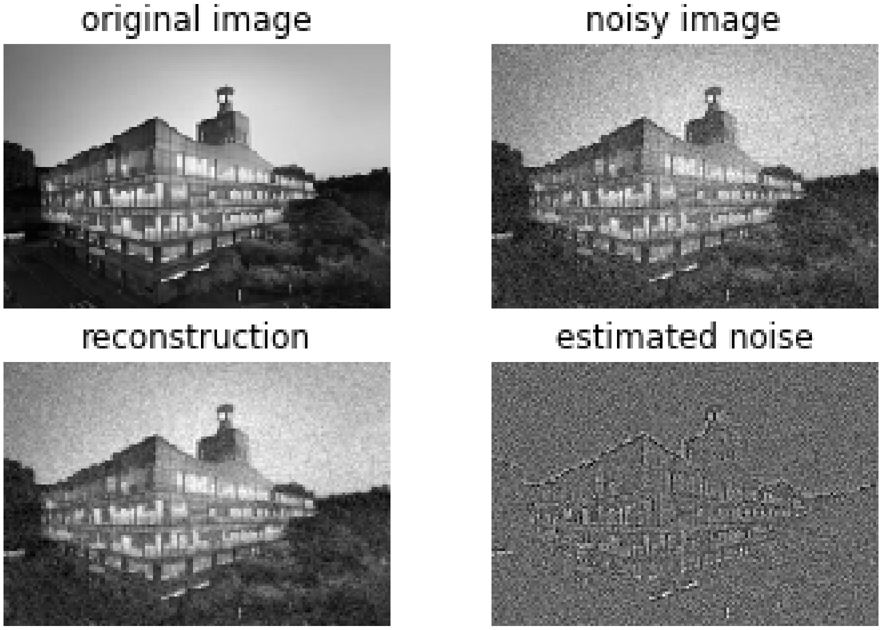
```
In [95]: def least_square_problem(lamb, im_noise):
             im_noise_vec = transfer(im_noise)
             dx, dy = deviation_x(im_noise.shape), deviation_y(im_noise.shape)

             A = sparse.eye(len(im_noise_vec))
             A = sparse.vstack([A, np.sqrt(lamb)*dx, np.sqrt(lamb)*dy])

             b = np.zeros(len(im_noise_vec) + dx.shape[0] + dy.shape[0])
             b[:len(im_noise_vec)] = im_noise_vec

             return A,b
```

1.9 Define function for reconstruction image

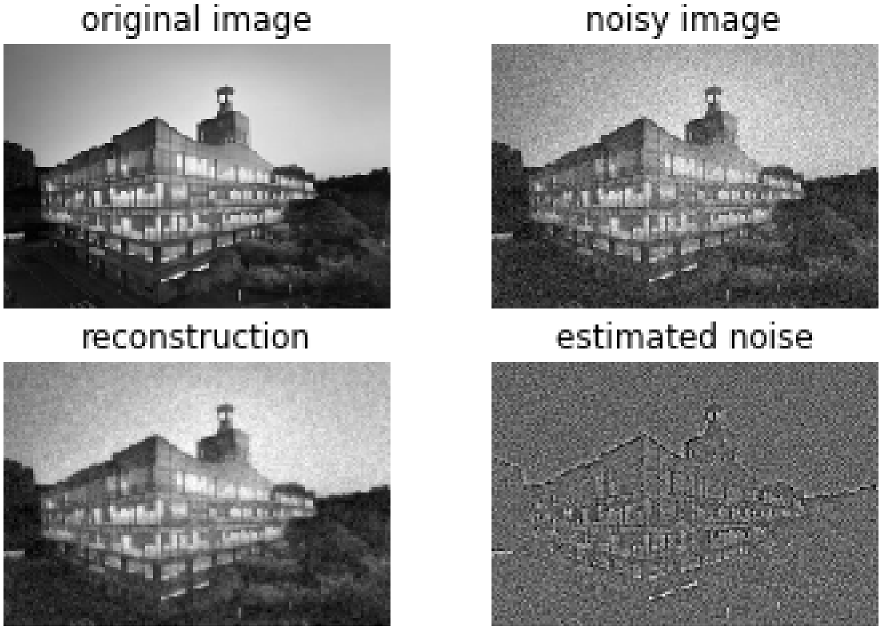
```
In [96]: def reconstruction(lamb, im_noise):
             A, b = least_square_problem(l, im_noise)
             sol, _, _, _, _, _, _, _, _, _ = sparse.linalg.lsqr(A, b)
             im_recon = np.empty(im.shape)
             for i in range(im.shape[1]):
                 im_recon[:, i] = sol[im.shape[0]*i:im.shape[0]*(i+1)]

             return im_recon
```

```
In [97]: for s in [0.2, 0.4, 0.8, 1]:
             for l in [2**(-3), 2**(-2), 2**(-1), 2**0, 2**1, 2**2, 2**3]:
                 print("noise_std =",s, "lambda =", l)

                 noise_std   = s # try with varying noise standard deviation
                 noise       = np.random.normal(0, noise_std, (row, col))
                 im_noise    = im + noise

                 im_recon = reconstruction(l, im_noise)
                 noise_recon = im_noise - im_recon
                 error = np.linalg.norm(im - im_recon)
                 print("error = ", error)

                 #plot_img(im, im_noise, im_recon, noise_recon)
                 p1 = plt.subplot(2,2,1)
                 p1.set_title('original image')
                 plt.imshow(im, cmap='gray')
                 plt.axis('off')

                 p2 = plt.subplot(2,2,2)
                 p2.set_title('noisy image')
                 plt.imshow(im_noise, cmap='gray')
                 plt.axis('off')

                 p3 = plt.subplot(2,2,3)
                 p3.set_title('reconstruction')
                 plt.imshow(im_recon, cmap='gray')
                 plt.axis('off')

                 p4 = plt.subplot(2,2,4)
                 p4.set_title('estimated noise')
                 plt.imshow(noise_recon, cmap='gray')
                 plt.axis('off')

                 plt.show()
```

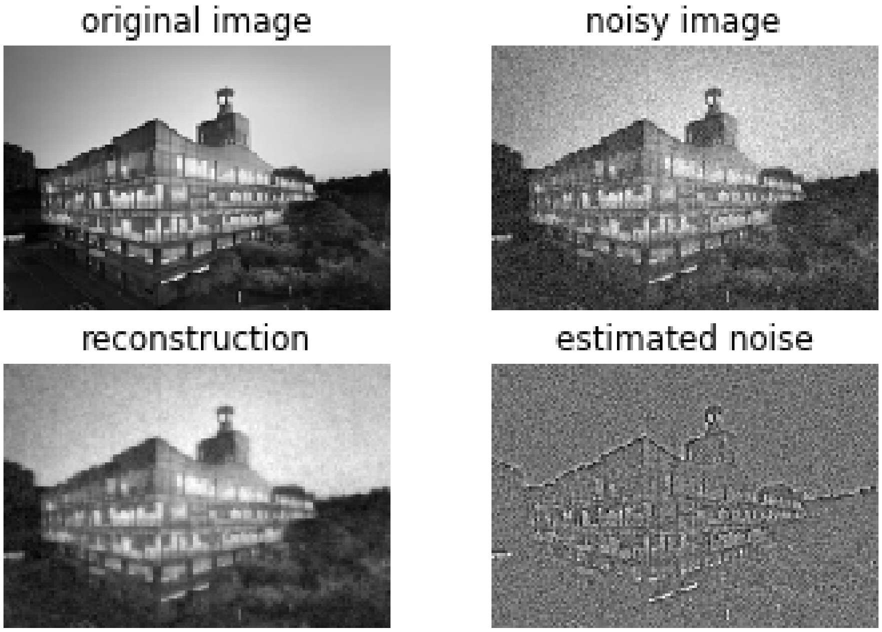
```
noise_std = 0.2 lambda = 0.125
error =  23.776364804245528
```



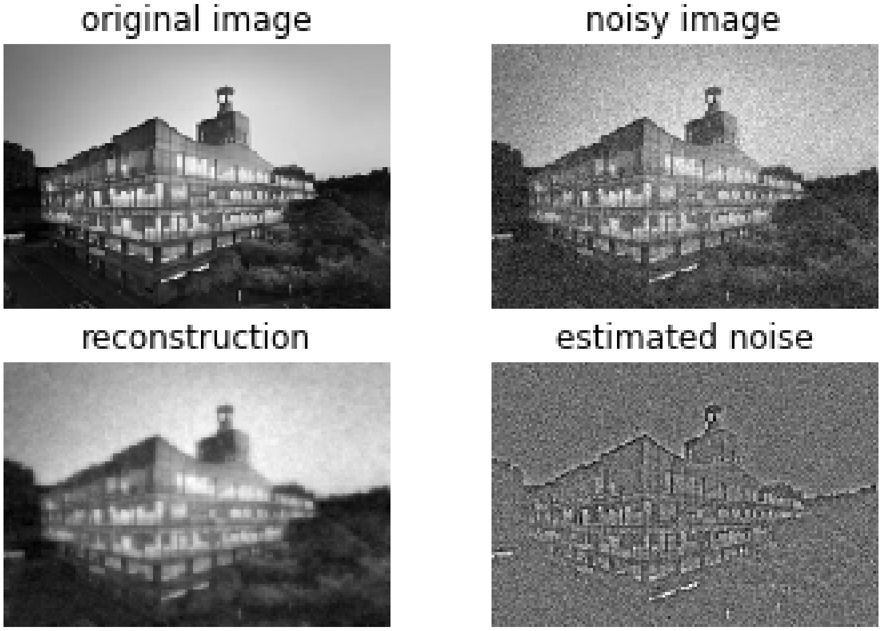
```
noise_std = 0.2 lambda = 0.25
error =  22.387907209814898
```



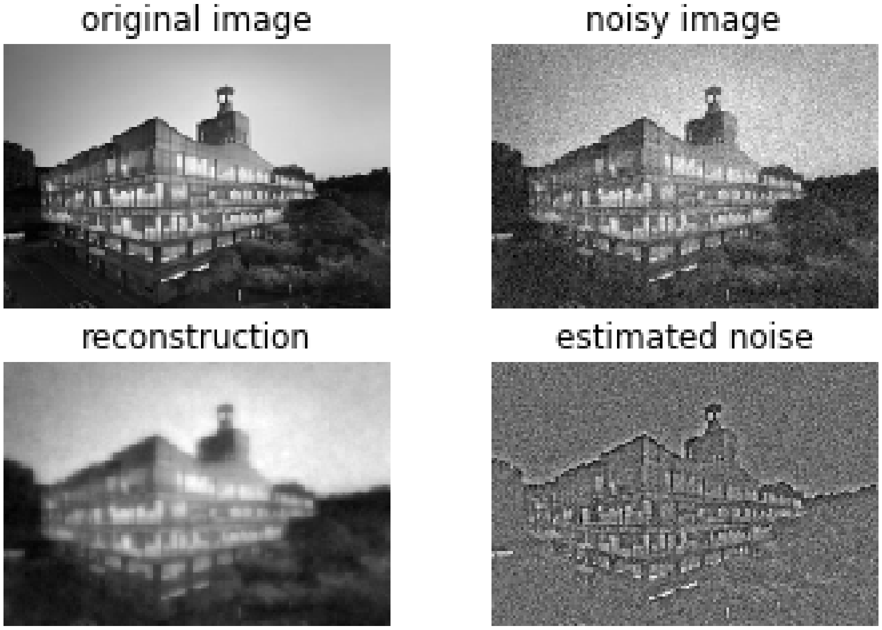
```
noise_std = 0.2 lambda = 0.5
error =  23.730695015021016
```



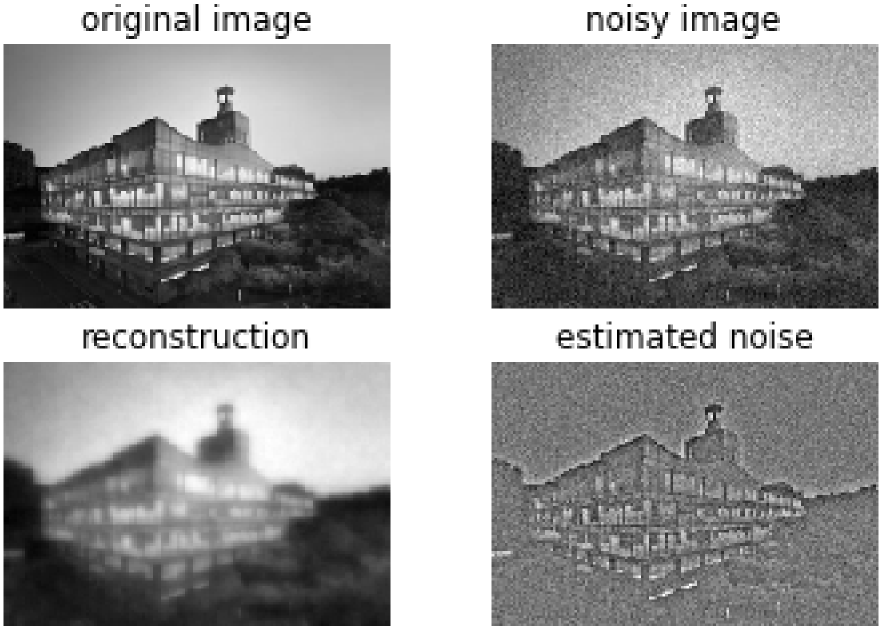
```
noise_std = 0.2 lambda = 1
error =  28.024521848525843
```



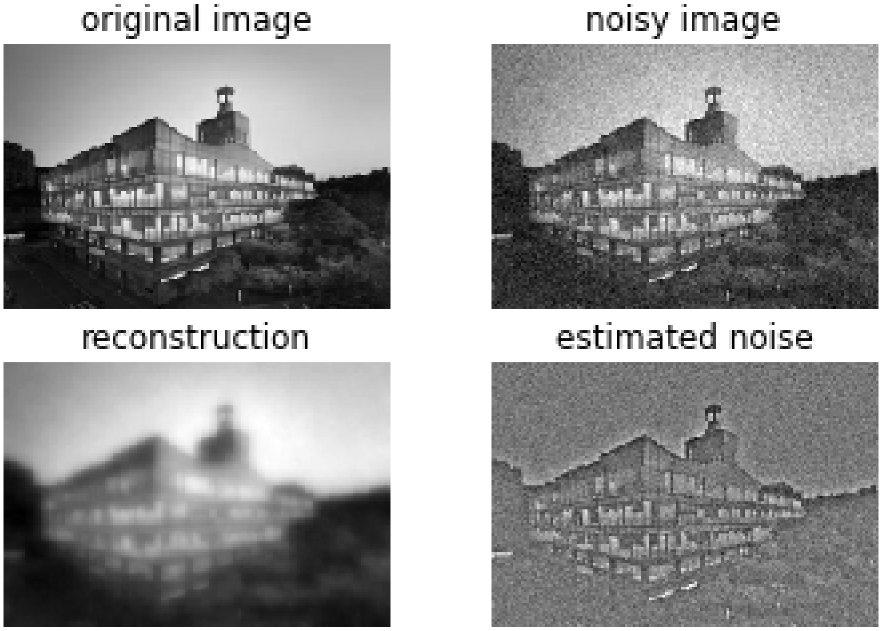
```
noise_std = 0.2 lambda = 2
error =  33.99260895691776
```



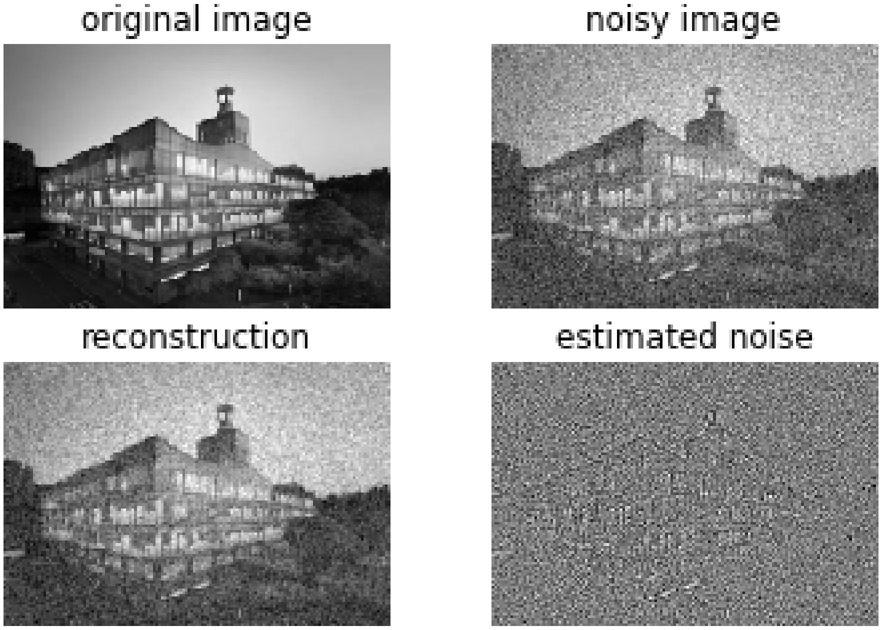
```
noise_std = 0.2 lambda = 4
error =  40.44506125869757
```



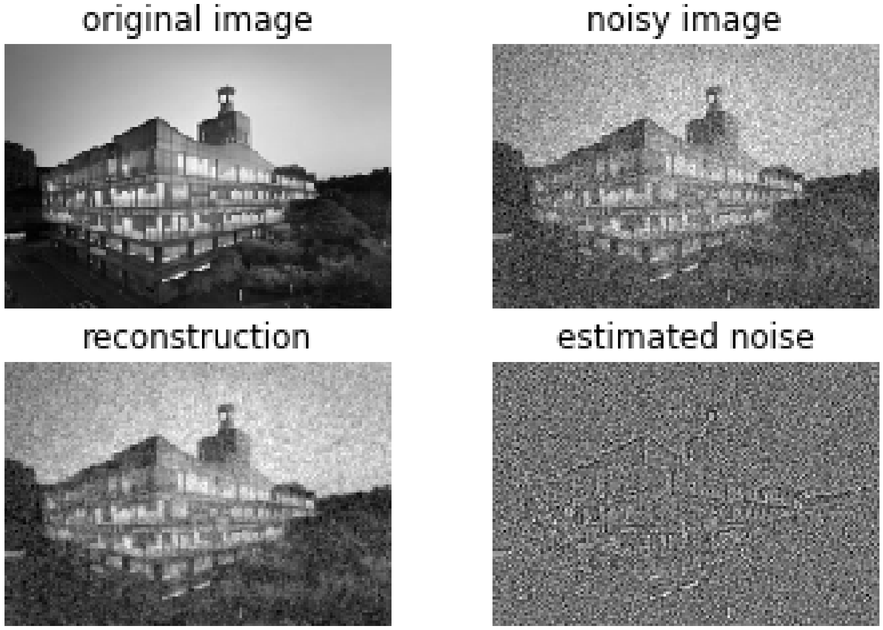
```
noise_std = 0.2 lambda = 8
error =  46.957993038541844
```



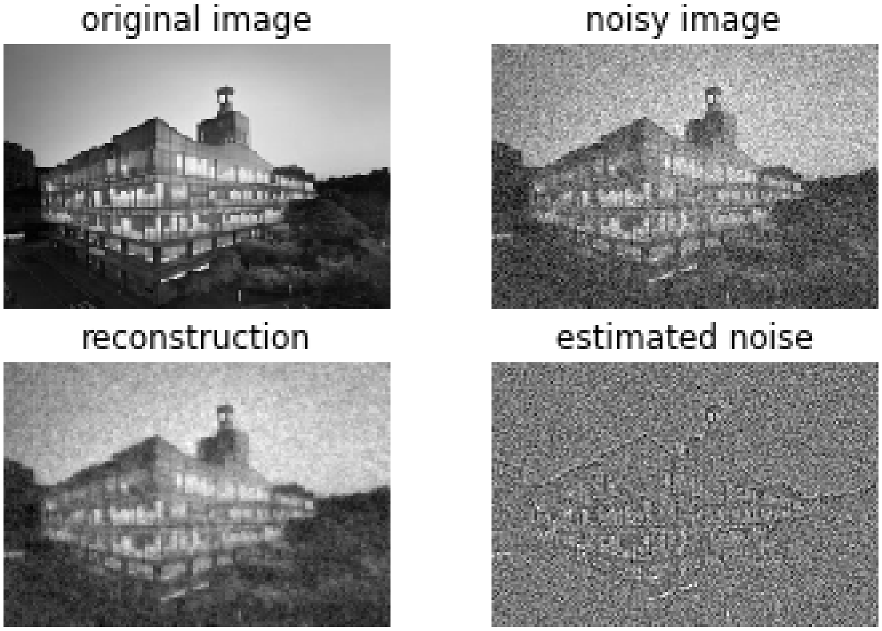
```
noise_std = 0.4 lambda = 0.125
error =  45.01729798577633
```



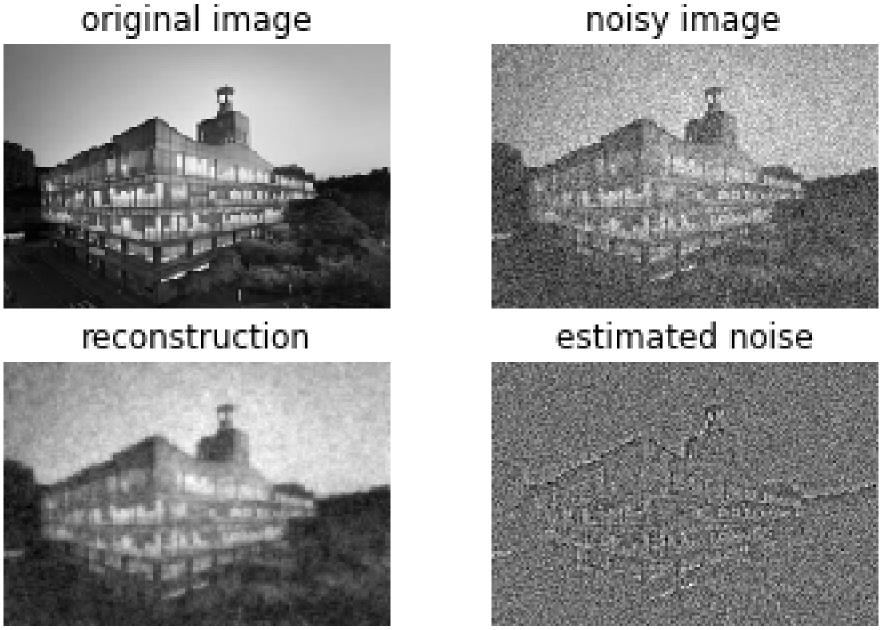
```
noise_std = 0.4 lambda = 0.25
error =  38.17923209966897
```



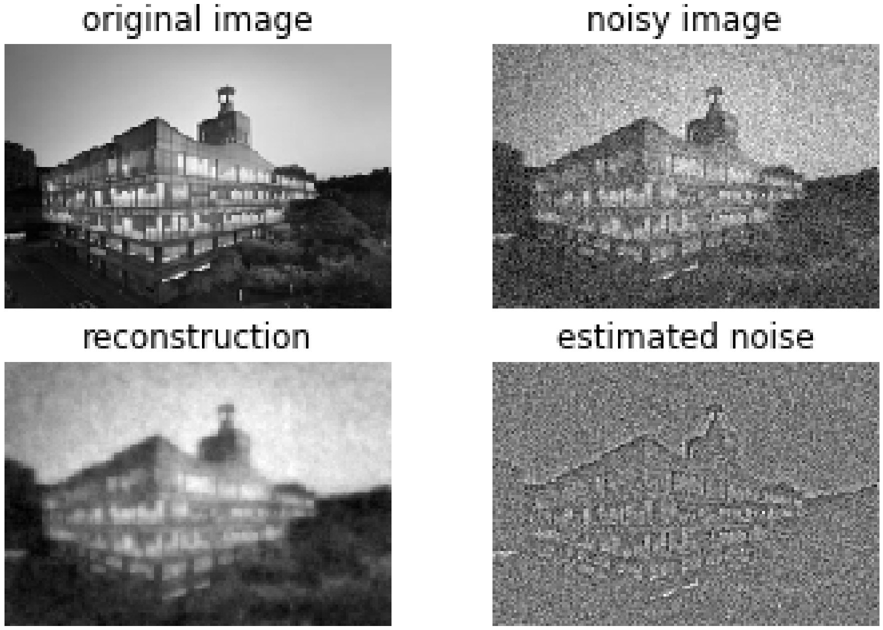
```
noise_std = 0.4 lambda = 0.5
error =  33.16822565885946
```



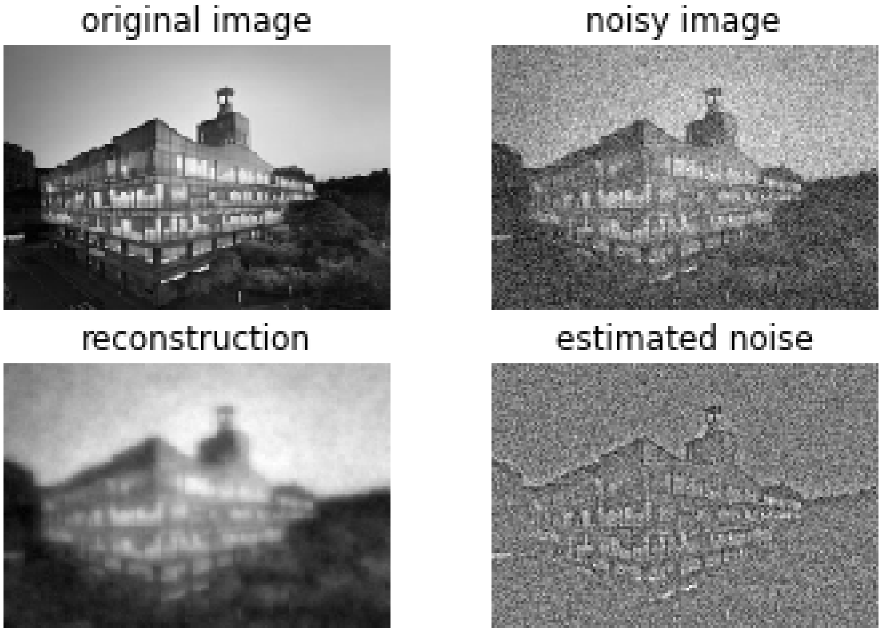
```
noise_std = 0.4 lambda = 1
error =  32.84136948498753
```



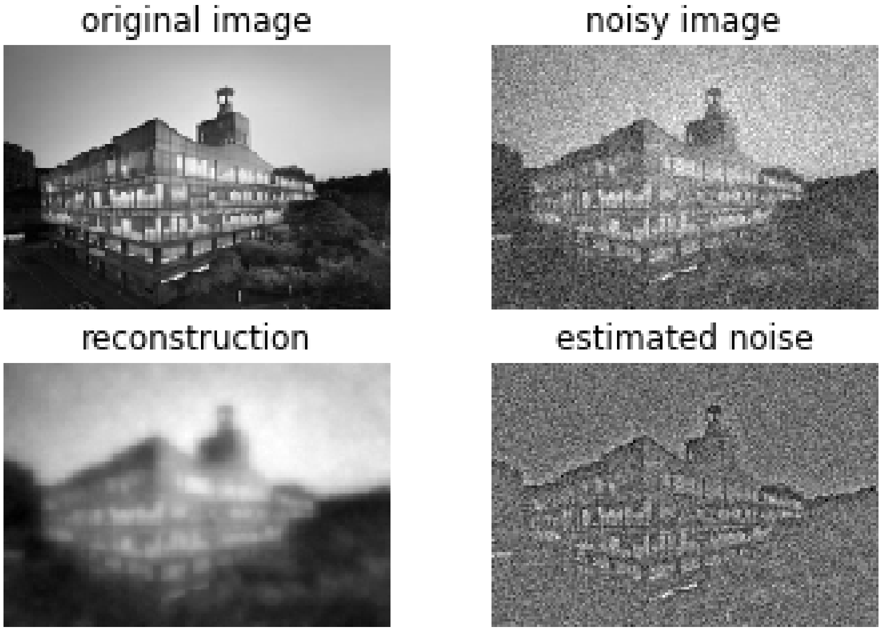
```
noise_std = 0.4 lambda = 2
error =  36.17210724444731
```



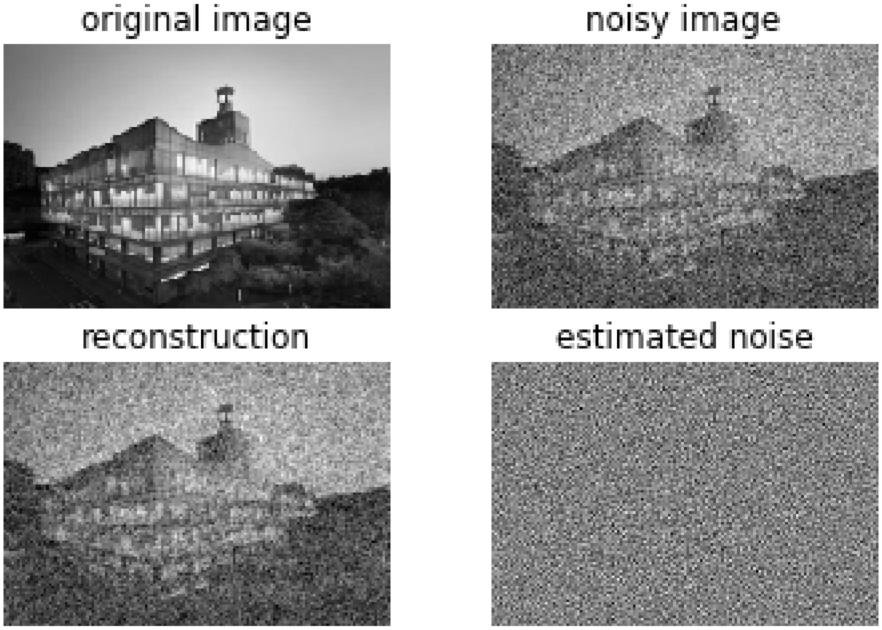
```
noise_std = 0.4 lambda = 4
error =  41.591131287740424
```



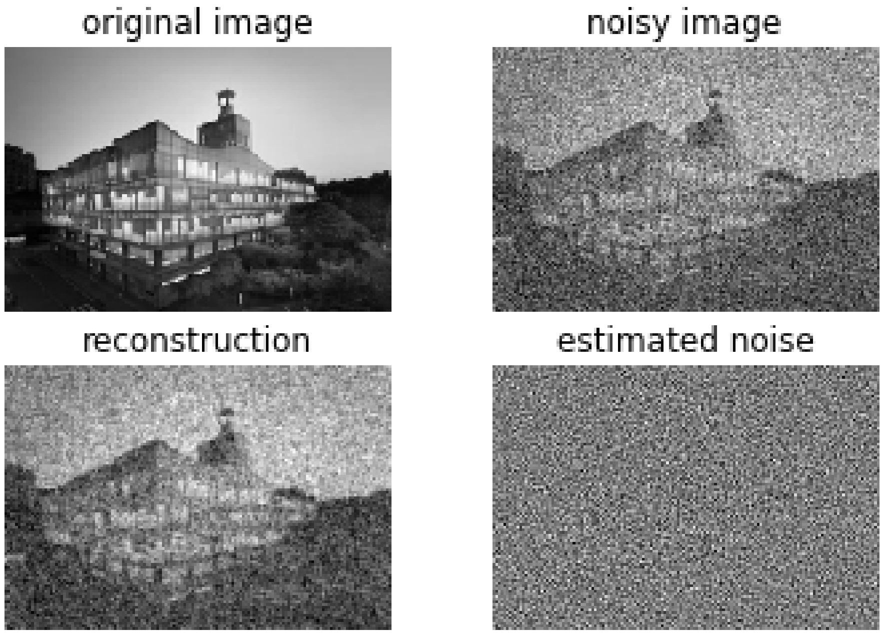
```
noise_std = 0.4 lambda = 8
error =  47.24124051068839
```



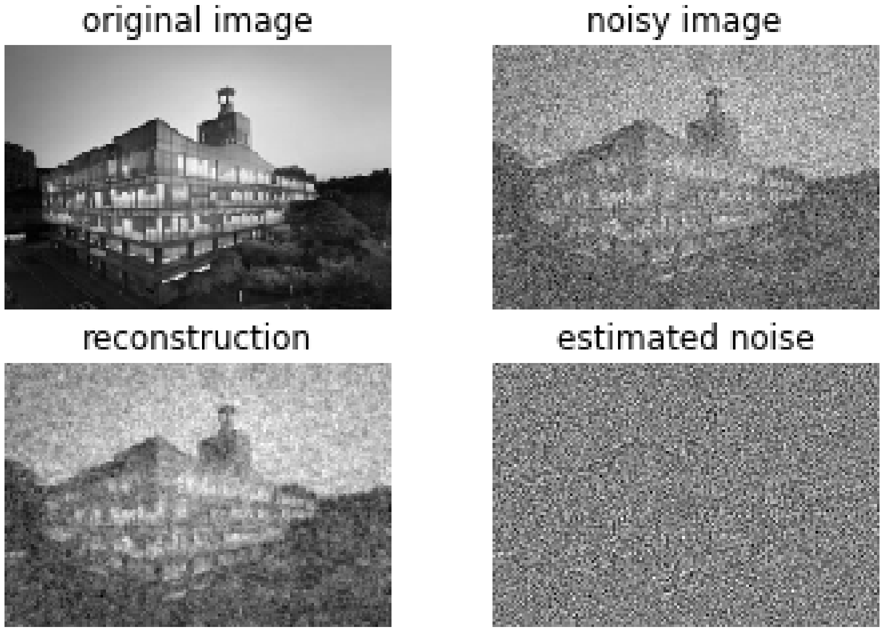
```
noise_std = 0.8 lambda = 0.125
error =  89.40093450122532
```



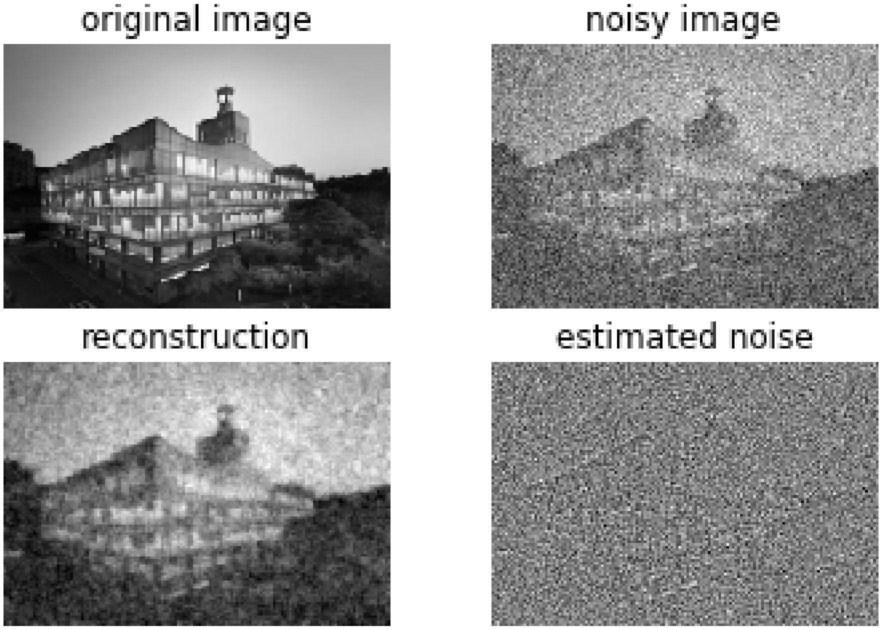
```
noise_std = 0.8 lambda = 0.25
error =  72.7915767347094
```



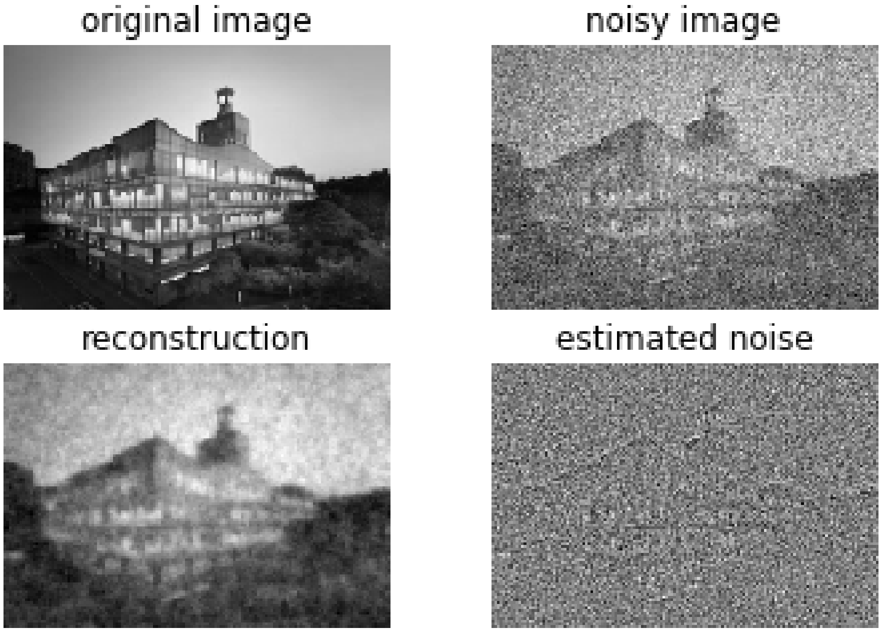
```
noise_std = 0.8 lambda = 0.5
error =  57.23191391725615
```



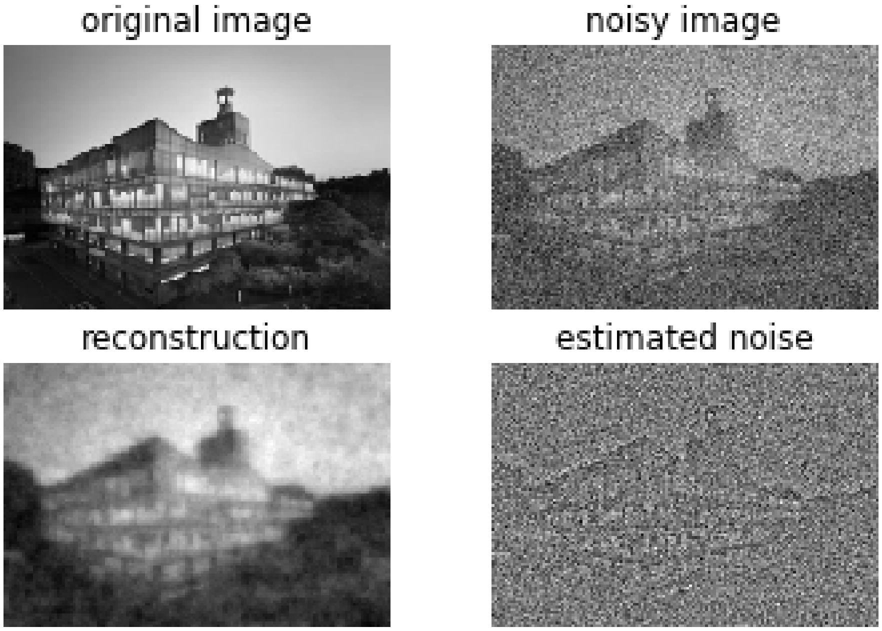
```
noise_std = 0.8 lambda = 1
error =  46.81163124728616
```



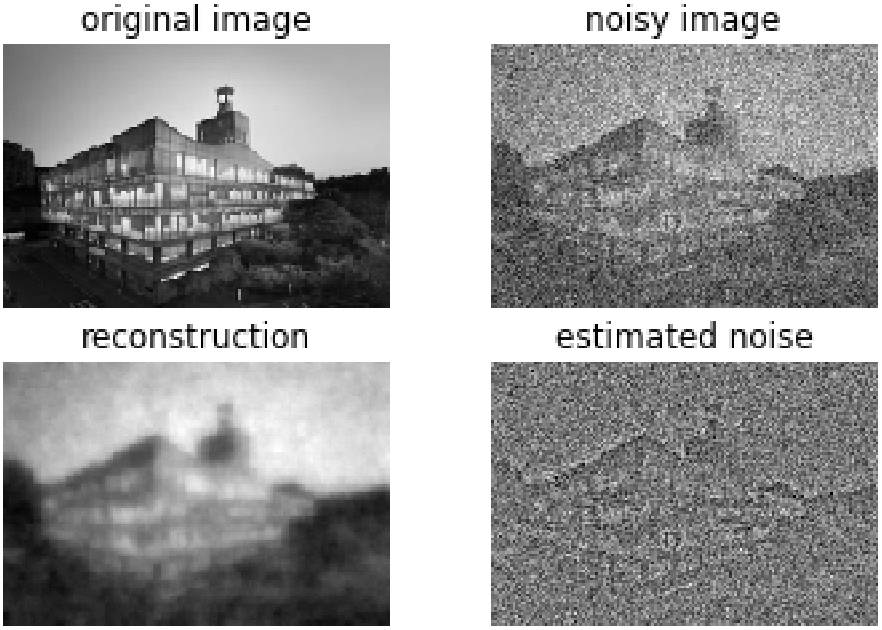
```
noise_std = 0.8 lambda = 2
error =  42.90560179646062
```



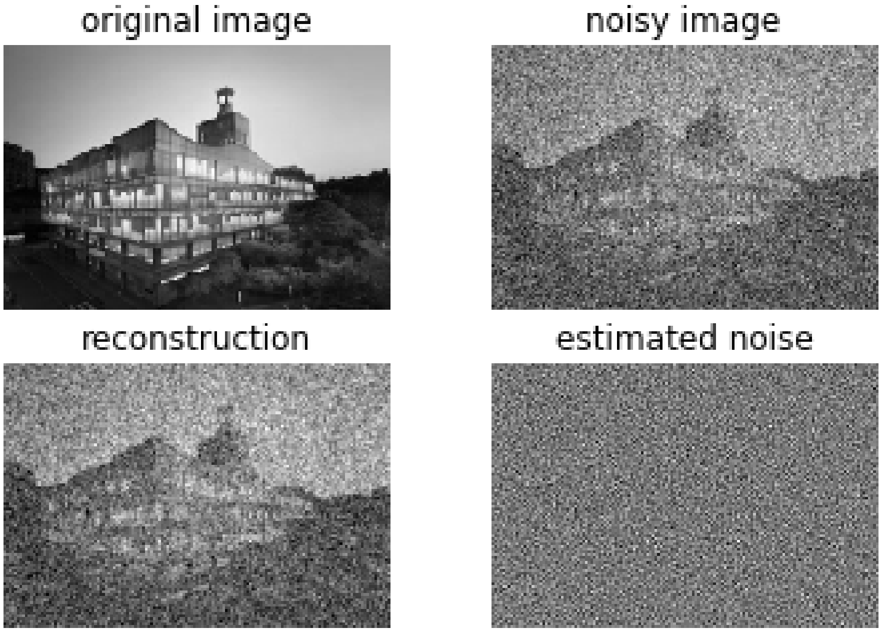
```
noise_std = 0.8 lambda = 4
error =  44.758754123847986
```



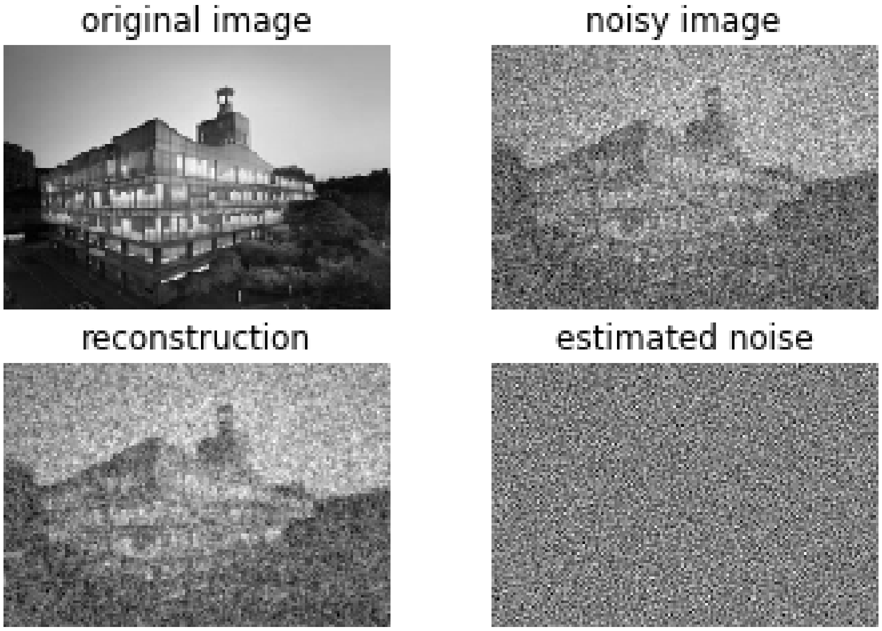
```
noise_std = 0.8 lambda = 8
error =  48.71116464635873
```



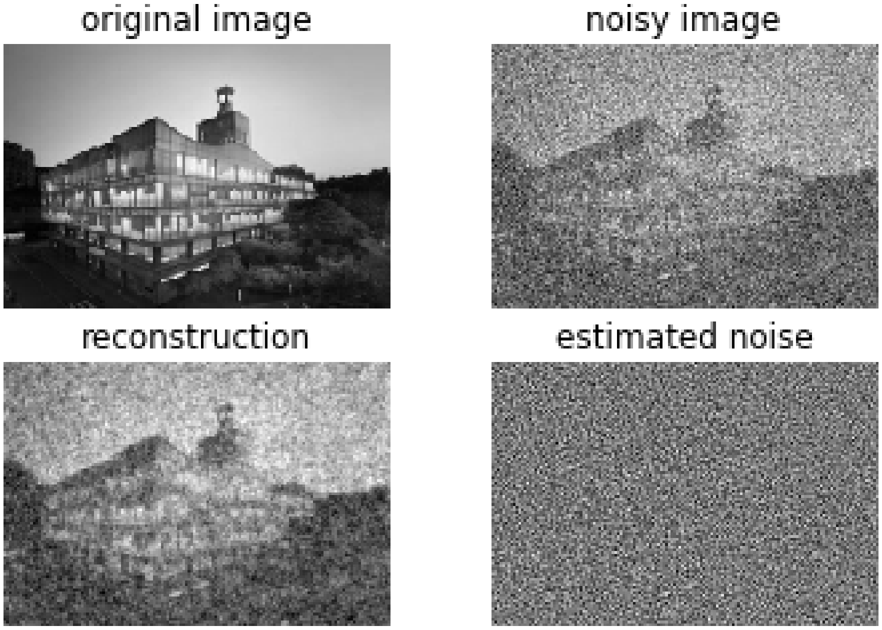
```
noise_std = 1 lambda = 0.125
error =  111.78870796158022
```



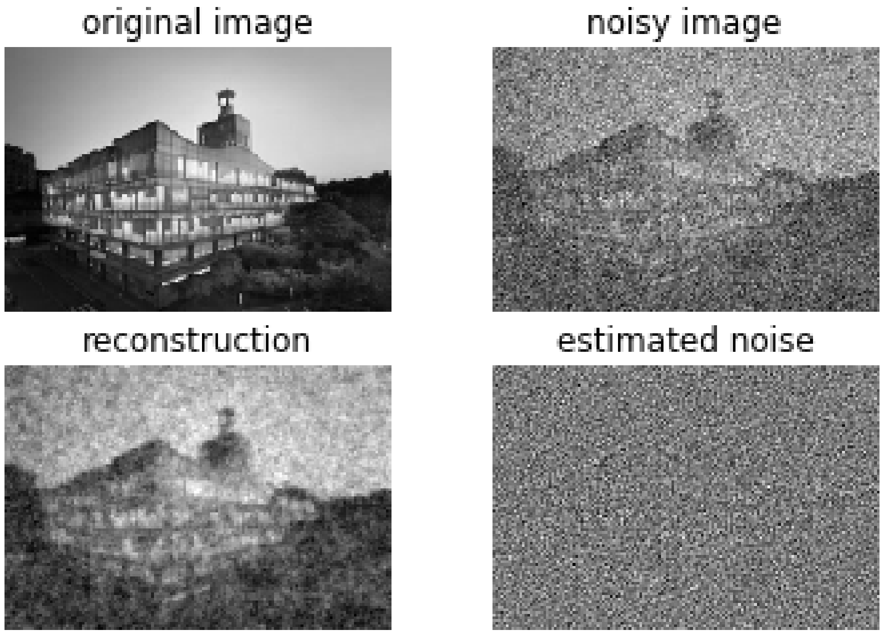
```
noise_std = 1 lambda = 0.25
error =  90.2615350942122
```



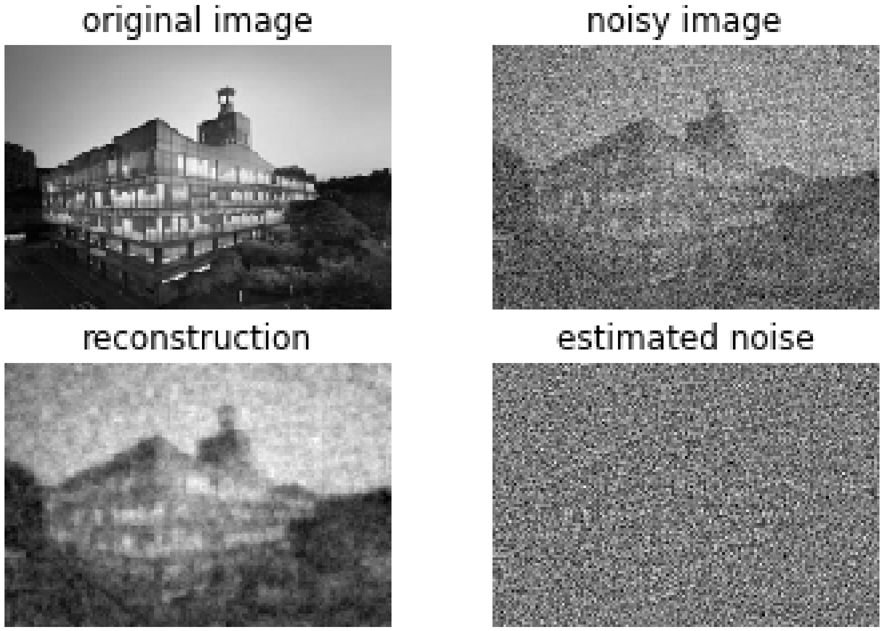
```
noise_std = 1 lambda = 0.5
error =  70.75239902482079
```



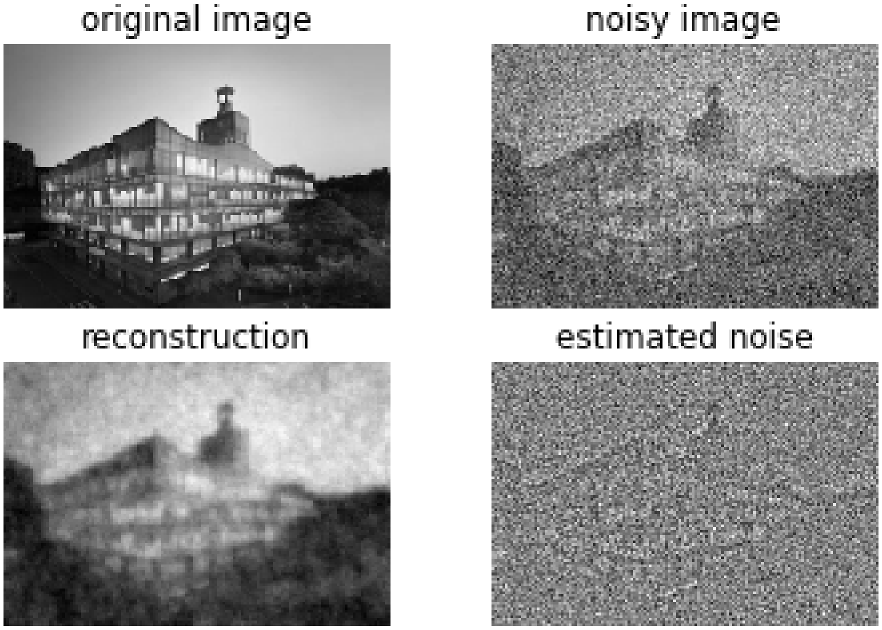
```
noise_std = 1 lambda = 1
error =  55.47425995446462
```



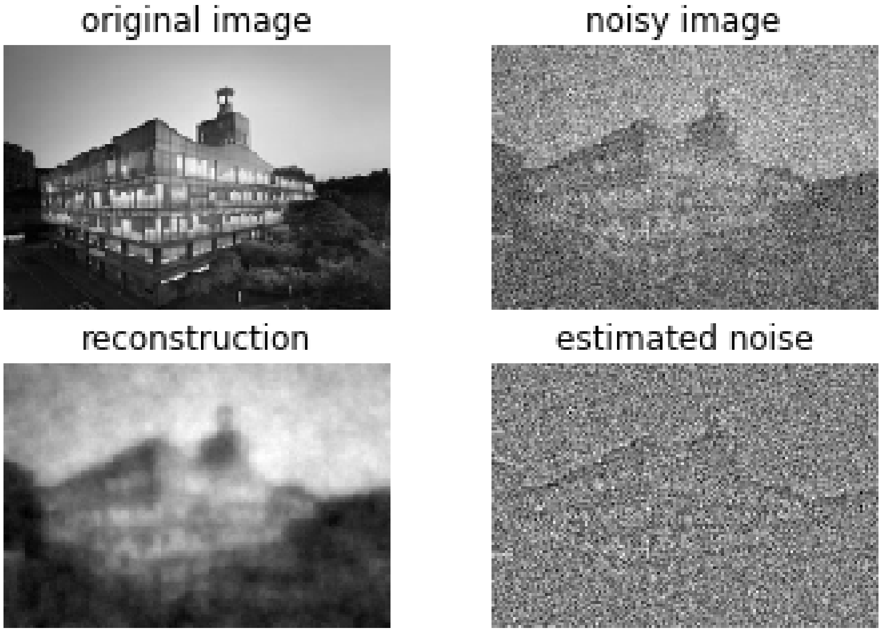
```
noise_std = 1 lambda = 2
error =  47.89673748691033
```



```
noise_std = 1 lambda = 4
error =  46.70265503075038
```



```
noise_std = 1 lambda = 8
error =  49.928402331457825
```


original image
noisy image
reconstruction
estimated noise