Assignment11

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- Description: Image denoising using least square regularization
- github: https://github.com/mydream757/Computer_Vision

1. Import libraries

- import needed libraries.

```
In [1]: import matplotlib.pyplot as plt
        import numpy as np
        from scipy.sparse import coo_matrix
        from scipy import signal
        from skimage import io, color
        from skimage import exposure
```

2. Set the image

- bring an image. I resized the given image to smaller one

```
In [2]: file_image        = 'cau-1.jpg'
        #read and set the image
        im_color         = io.imread(file_image)
        im_gray          = color.rgb2gray(im_color)
        im          = (im_gray - np.mean(im_gray)) / np.std(im_gray)
        (row, col)  = im.shape
```

- generate a noise image

```
In [3]: #generate noise
        noise_std   = 0.2 # try with varying noise standard deviation
        noise       = np.random.normal(0, noise_std, (row, col))
        im_noise    = im + noise
```

- image vectorization

```
In [4]: #this is vectorization of the image
        im_vector = im_noise.reshape(row*col)
        n = im_vector.size
```

3. Define functions

- create_A makes least square, 'A'

```
In [5]: #the function returns 'A'
        def create_A(t):
            eigen  = np.eye(n-1,n)
            dX  = np.roll(eigen,1)
            minus = -np.eye(n-1,n)
            dX = dX + minus
            dY = minus
            for i in range(n-2):
                for k in range(n-1):
                    if k+col<n-1 and dY[i][k]==-1:
                        dY[i][k+col] = 1
            a_first = np.eye(row*col)

            A = np.vstack((a_first,np.sqrt(t)*dX))
            A = np.vstack((A,np.sqrt(t)*dY))

            return A;
```

- create_B makes least square, 'b'

```
In [6]: #the function returns 'b'
        def create_B(t):

            b_first = im_vector.reshape((n,1))
            b_second = np.zeros((n-1,1))
            b = np.vstack((b_first,b_second))
            b = np.vstack((b,b_second))
            return b;
```

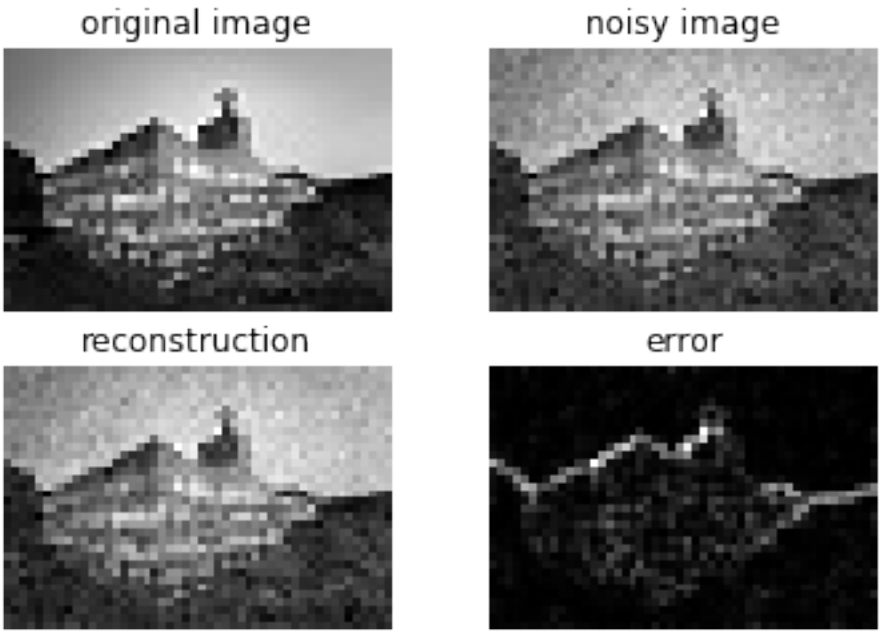
4. Result of varing lamda

- iterate and show the results

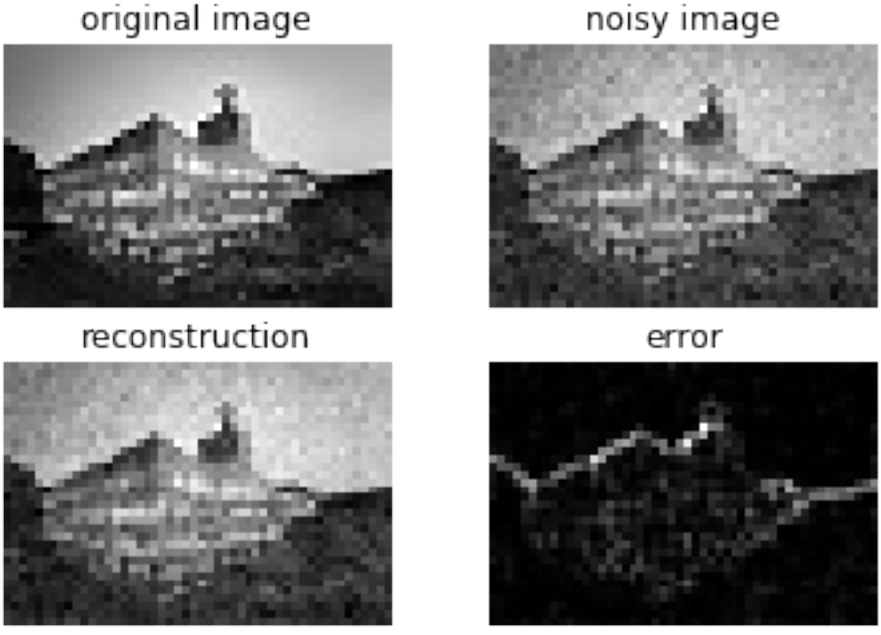
```
In [7]: #iteration 11 times
        for i in range(11):

            l = pow(2,i-5)
            #solve the least square problem.
            ans = np.dot(np.linalg.pinv(create_A(l)),create_B(l))

            #reshape to show image
            im_recon = ans.reshape((row,col))
            #gradient for computing error
            dX,dY = np.gradient(im_recon)
            #use sparse matrix because of matrix overflow
```

```
            dX  = coo_matrix(dX)
            dY  = coo_matrix(dY)

            dX2 = dX.multiply(dX).todense()
            dY2 = dY.multiply(dY).todense()

            #compute error
            error = (im_recon-im_noise)**2 + l*(dX2+dY2)
            #show the result
            print('lamda: ', l)
            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('error')
            plt.imshow(error, cmap='gray')
            plt.axis('off')

            plt.show()
```

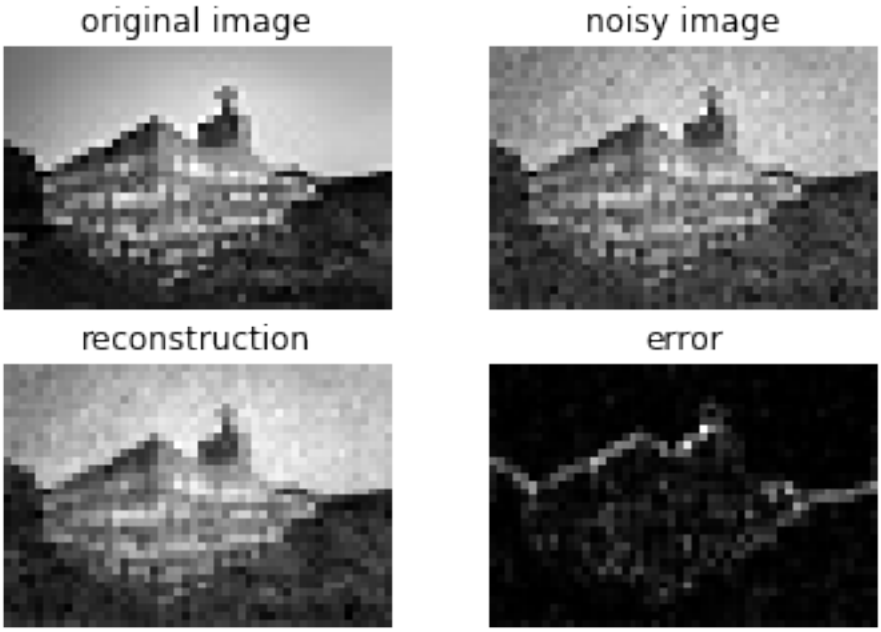
```
lamda:  0.03125
```


original image
noisy image
reconstruction
error

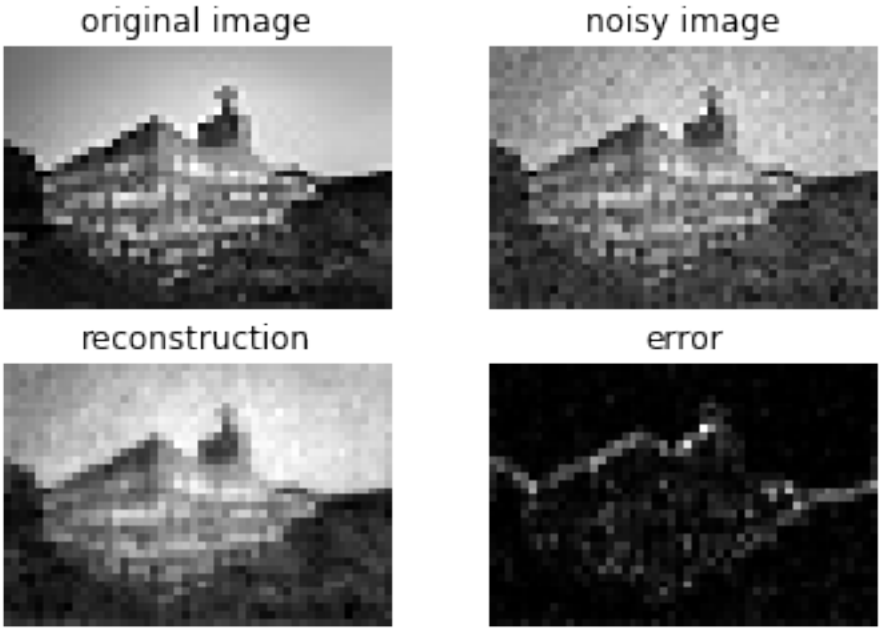
```
lamda:  0.0625
```


original image
noisy image
reconstruction
error

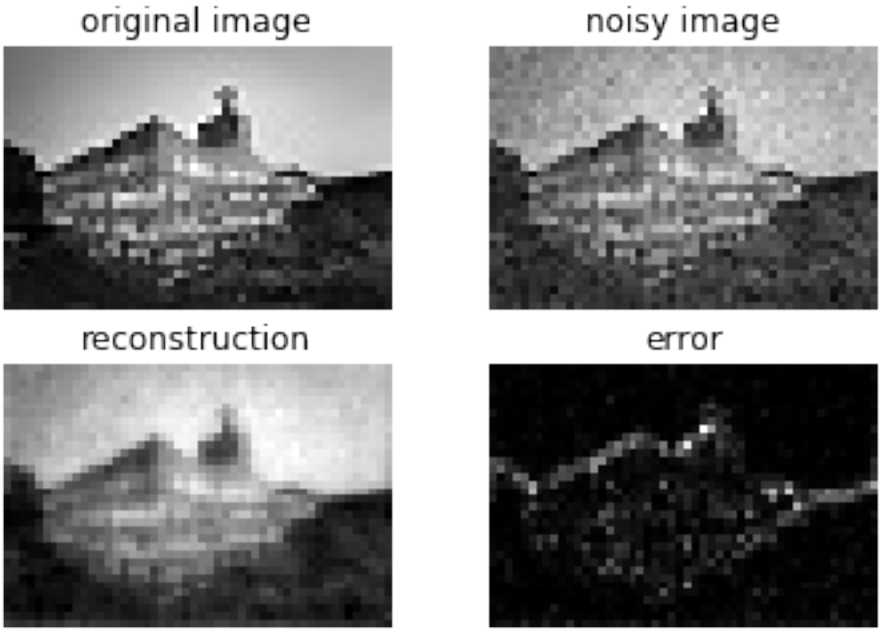
lamda: 0.125



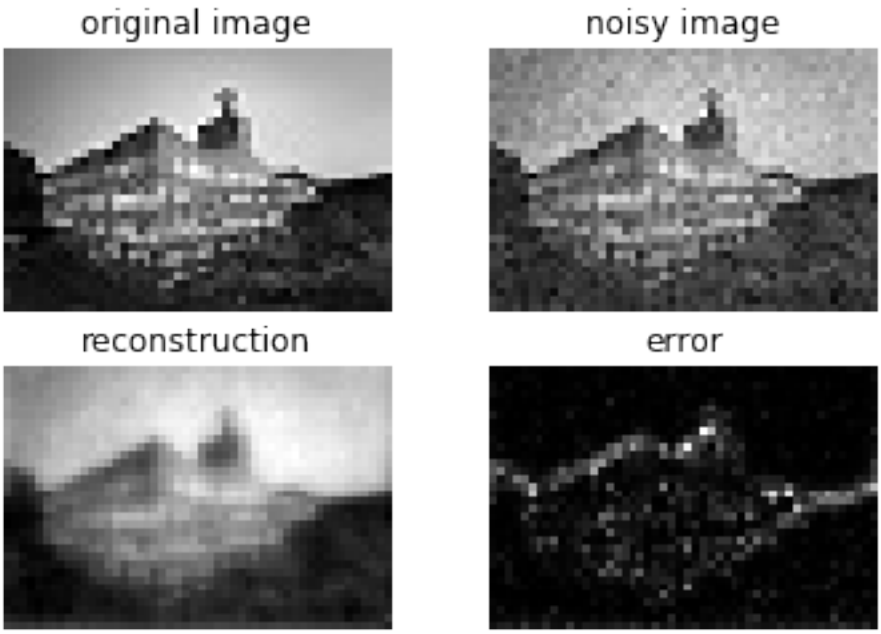
lamda: 0.25



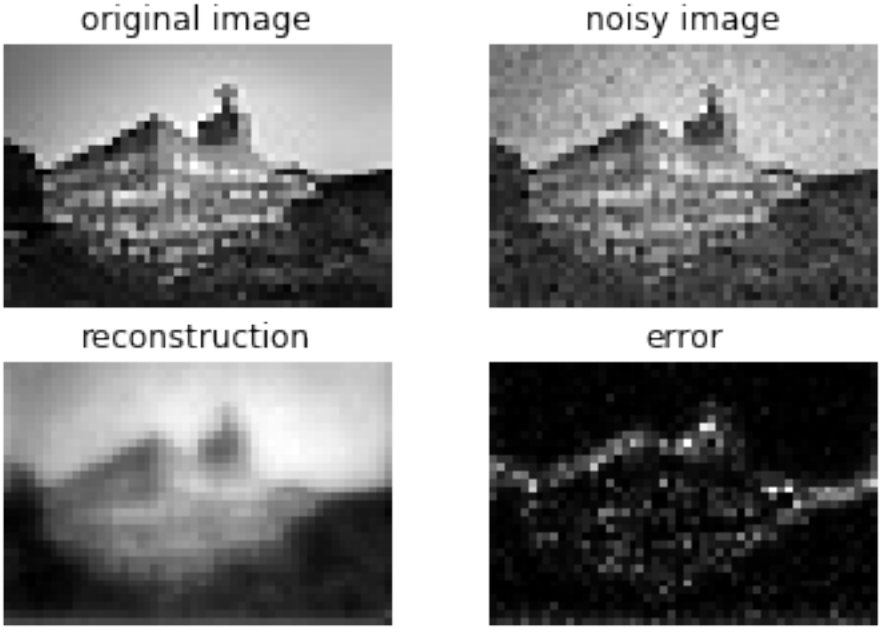
```
lamda:  0.5
```



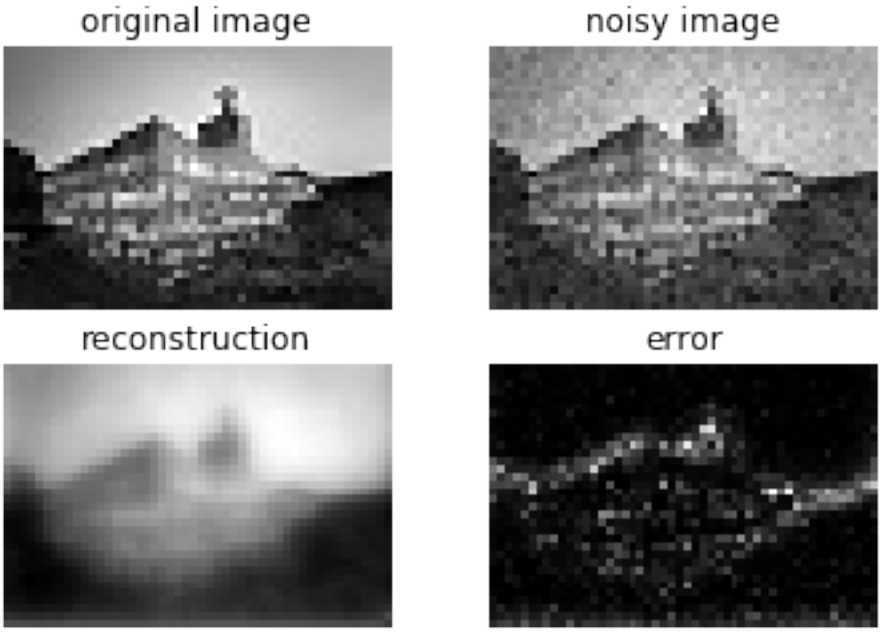

```
lamda:  1
```


original image
noisy image
reconstruction
error

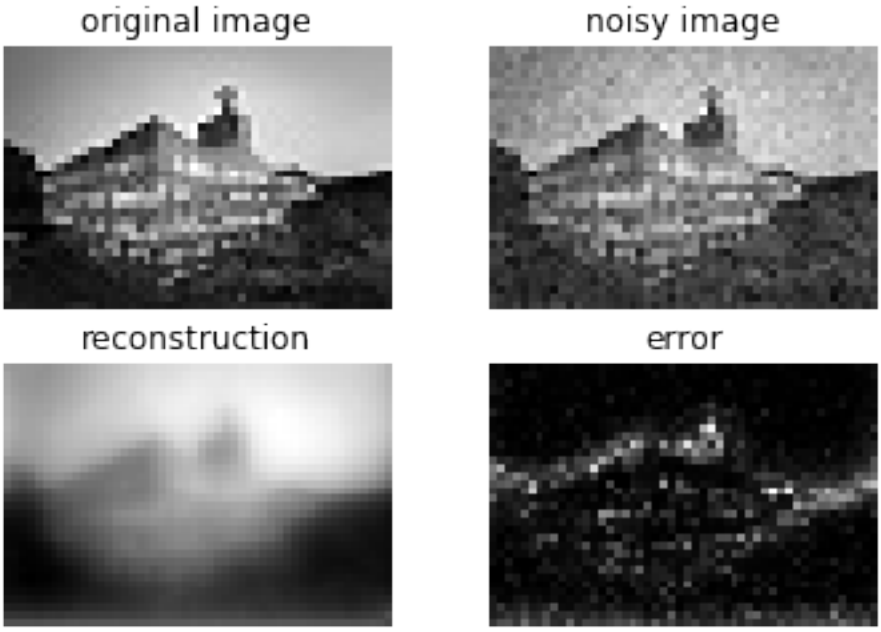
```
lamda:  2
```


original image
noisy image
reconstruction
error

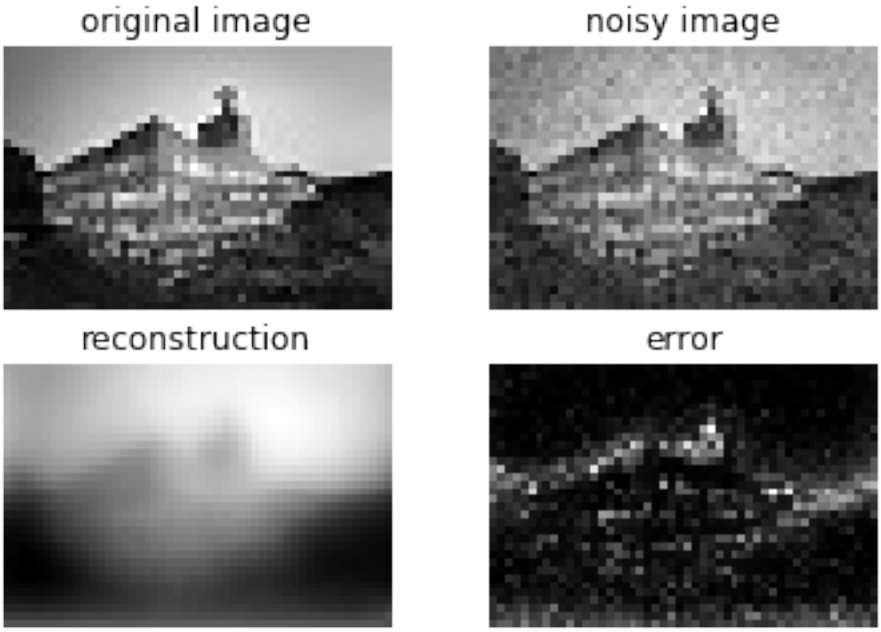
lamda: 4



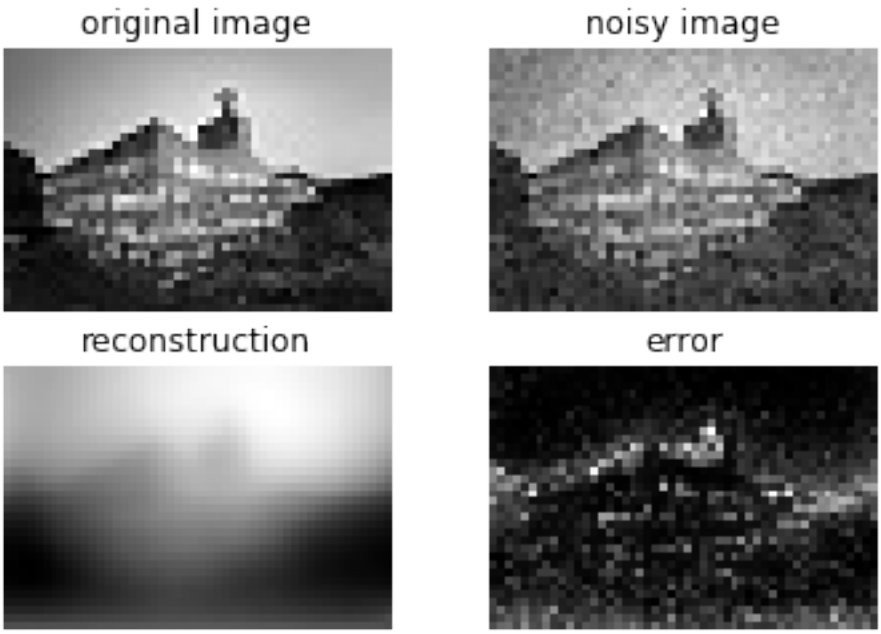
lamda: 8



```
lamda:  16
```




```
lamda:  32
```


original image
noisy image
reconstruction
error