Assignment 11

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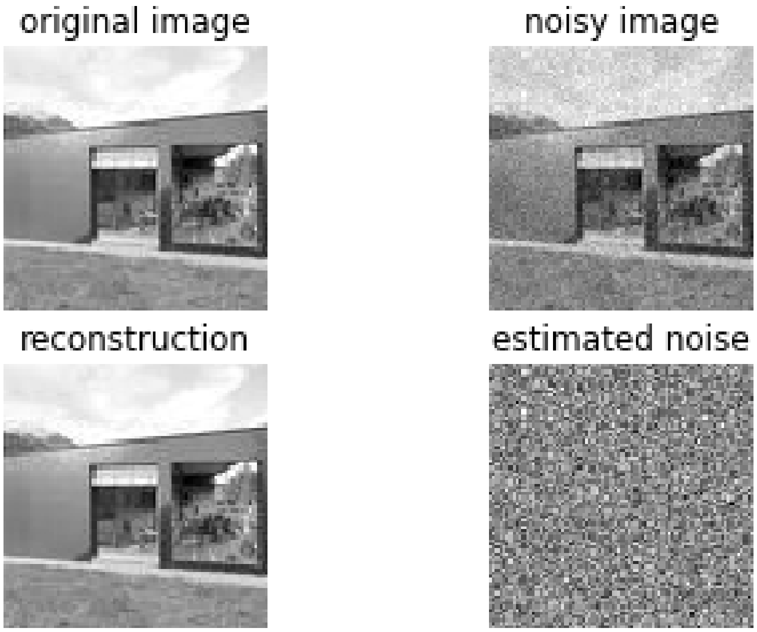
3 Assignment 11

Github Link: https://github.com/farhan-93/assignment11.git ## Image Denoising
Change the given picture due to Memory Error. I used picture of size 80by80
Import Some required libraries

```
In [777]: import matplotlib.pyplot as plt
          import numpy as np
          import scipy as sp
          from scipy import signal
          from skimage import io, color
          from skimage import exposure

          file_image        = 'cau-8.jpg'

          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

          noise_std    = 0.2 # try with varying noise standard deviation
          noise        = np.random.normal(0, noise_std, (row, col))
          im_noise     = im + noise

          # 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)

          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()
```



Function that denoise the image by least squares method. Use the Scipy.sparse for memory management.

```
In [778]: def leastsquare_denoise(im2,Dx,Dy,lamb):
              I=sp.sparse.identity(row*col)
              I=sp.sparse.csr_matrix(I)
              zeroX=sp.sparse.csc_matrix((1,row*col-row))
              zeroy=sp.sparse.csc_matrix((1,row*col-col))

              ############### Creating Block Matrix (The matrix A for |AX-B|^2)
              A=sp.sparse.bmat([[I,np.sqrt(lamb)*Dx.T,np.sqrt(lamb)*Dy]]).toarray()
              ############### Taking dot product of A and transpose of A
              Ai=A.dot(A.T)
              ############### convert above matrix into Sparse Matrix
              Ain=sp.sparse.csc_matrix(Ai)
              ############## Taking inverse of A.A^T
              Ainn=sp.sparse.linalg.inv(Ain)
              ############## Making Block matrix B for |AX-B|^2
              B=sp.sparse.bmat([[im2,zeroX,zeroy]]).toarray()
              ############## reshape the B matrix into (m,)
              B=B.reshape((-1,))
              ############## Taking dot product of A and B
              right=A.dot(B)
              ############## Convert above result in Sparse Matrix
              right=sp.sparse.csc_matrix(right)
              ############## reshape the right matrix into (m,)
              right=right.reshape((-1,))
              ############## Dot product of Ainn and right to calculate the Least square
              lest=Ainn.dot(right.T)
              u=lest.reshape((row, col))
              u=u.toarray()
              u=np.asarray(u)
              ############## return reconstructed image
              return u
```

Generate the Differential operator Matrix for X-axis

```
In [779]: rows=row*col-row
          cols=row*col
          Dx=np.zeros((rows,cols))

          i = 0
          #j=rows+1
          while i < rows:
              j=i+row
              Dx[i][j] = 1
              Dx[i][i] = -1
              i=i+1
          Dx=sp.sparse.csr_matrix(Dx)
```

Generate the Differential operator Matrix for y-axis

```
In [780]: rows=row*col
          cols=row*col-col
          Dy=np.zeros((rows,cols))
          r=0
          for i in range(0,cols-1):
              if (i-1)%col==0 and i==0:
                  Dy[i][i]=-1
                  Dy[i+1][i]=1
              else:
                  Dy[i+r][i]=-1
                  Dy[i+r+1][i]=1

              if (i-1)%col==0 and i!=0:
                  r+=1
          Dy=sp.sparse.csr_matrix(Dy)
```

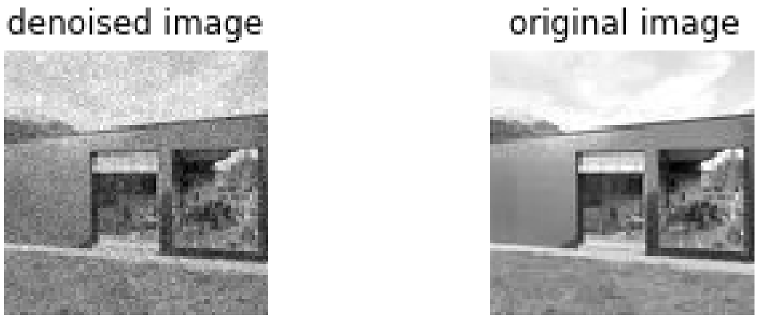
convert Noisy image into sparse matrix

```
In [781]: im2=im_noise.reshape(row*col)
          im2=sp.sparse.csr_matrix(im2)
```

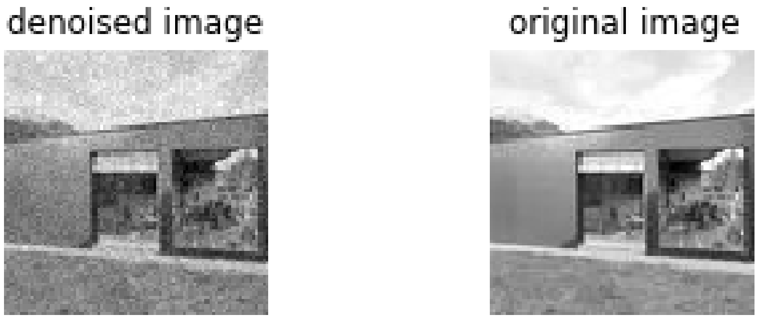
Call the function in loop for trying various lambda values

```
In [782]: error_list=[]
          count=-1 ##### for counting Lambda index
          for i in range(-10,5):
              lamb=(2**i)
              u=leastsquare_denoise(im2,Dx,Dy,lamb)
              error1 = np.linalg.norm(im - u)
              error_list=np.append(error_list,error1)
              print("Index No","lambda Value","=","Calculated Error")
              count=count+1
              print(count,"(2**",i,") =",error1)

              p1 = plt.subplot(2,2,1)
              p1.set_title('denoised image')
              plt.imshow(u, cmap='gray')
              plt.axis('off')
              noise_recon = u - im

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

              plt.show()
```

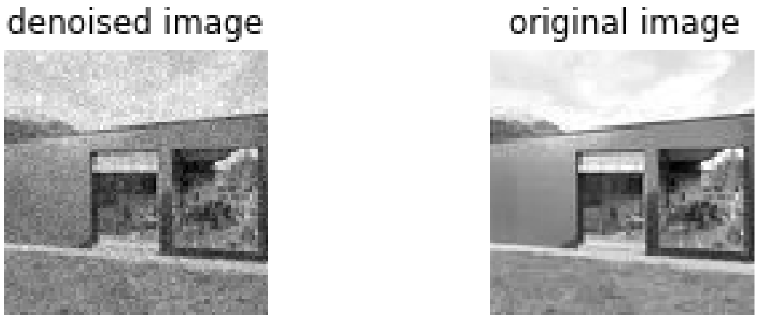
```
Index No lambda Value = Calculated Error
0 (2** -10 ) = 16.008991566261344
```



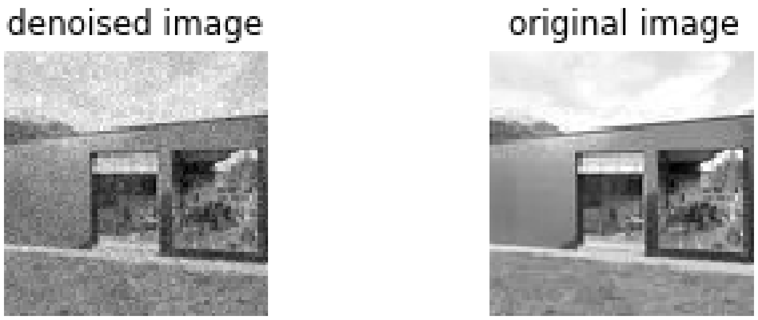
```
Index No lambda Value = Calculated Error
1 (2** -9 ) = 15.948890699266682
```



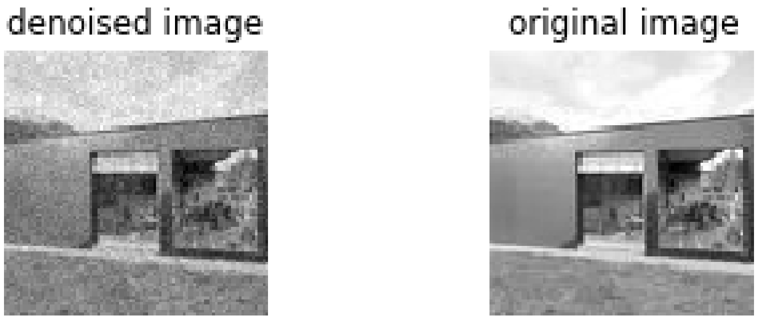
```
Index No lambda Value = Calculated Error
2 (2** -8 ) = 15.831376642886088
```



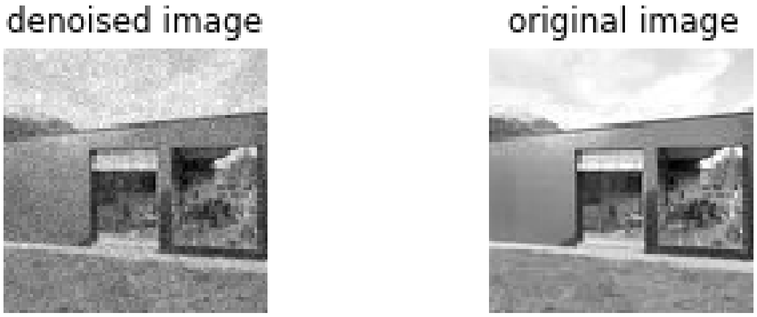
```
Index No lambda Value = Calculated Error
3 (2** -7 ) = 15.606727729429927
```



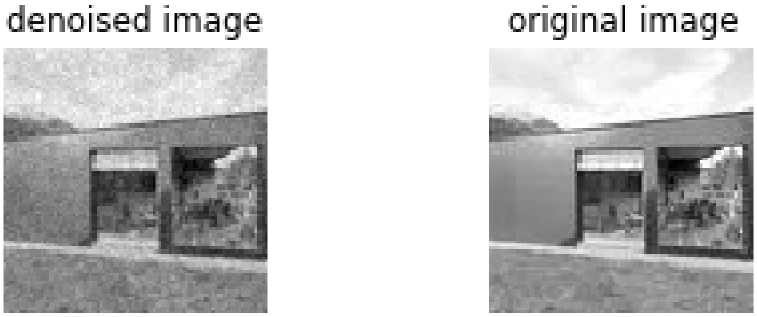
```
Index No lambda Value = Calculated Error
4 (2** -6 ) = 15.196202075370831
```



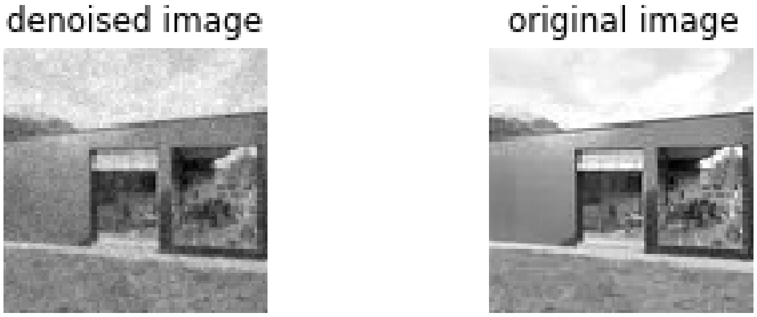
```
Index No lambda Value = Calculated Error
5 (2** -5 ) = 14.511313353059284
```



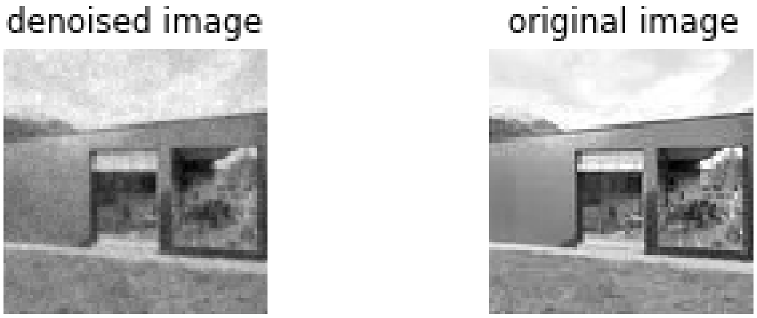
```
Index No lambda Value = Calculated Error
6 (2** -4 ) = 13.569703648856178
```



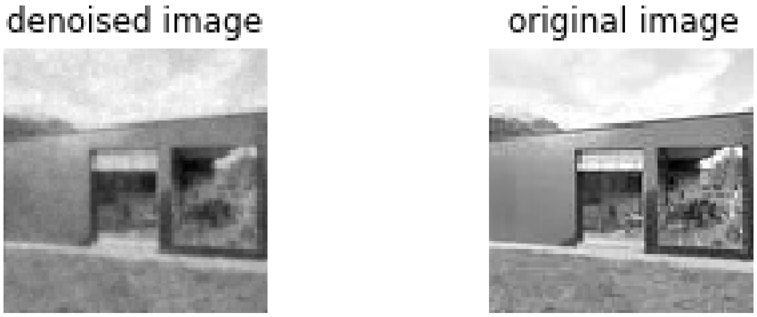
```
Index No lambda Value = Calculated Error
7 (2** -3 ) = 12.79305054289691
```



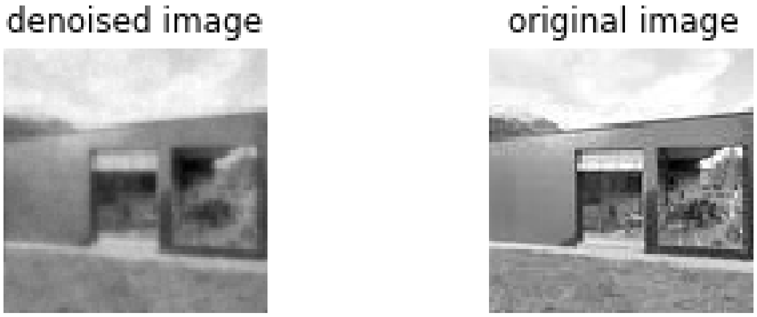
```
Index No lambda Value = Calculated Error
8 (2** -2 ) = 13.209867788201487
```



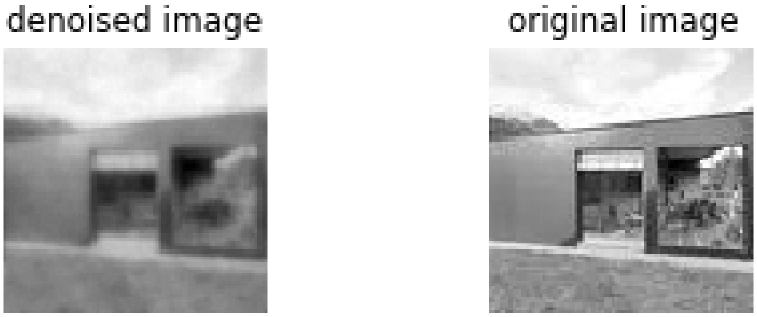
```
Index No lambda Value = Calculated Error
9 (2** -1 ) = 15.615403675099106
```



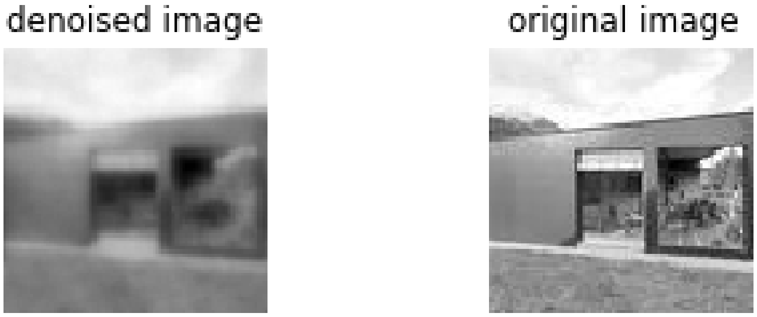
```
Index No lambda Value = Calculated Error
10 (2** 0 ) = 19.596430756136343
```



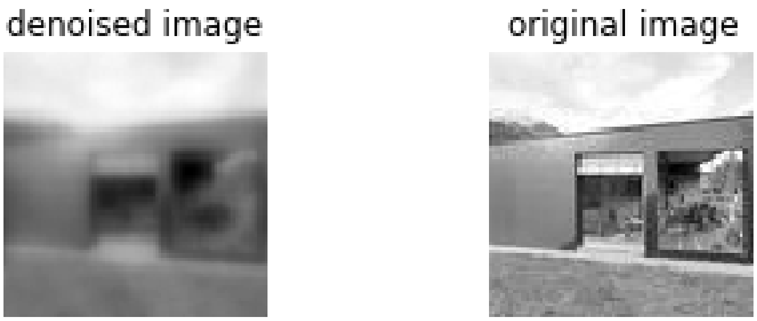
```
Index No lambda Value = Calculated Error
11 (2** 1 ) = 24.295937656428684
```



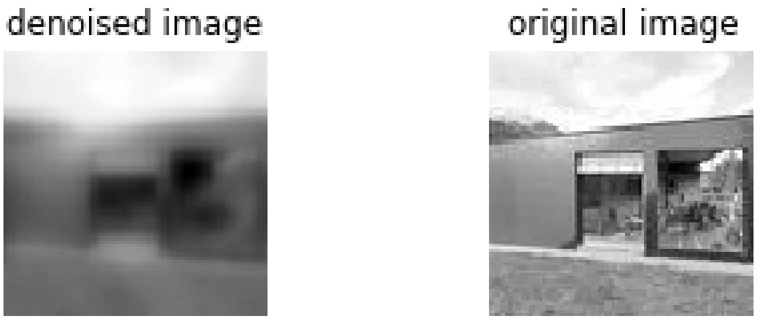
```
Index No lambda Value = Calculated Error
12 (2** 2 ) = 29.13576862424641
```



```
Index No lambda Value = Calculated Error
13 (2** 3 ) = 33.80108531928881
```

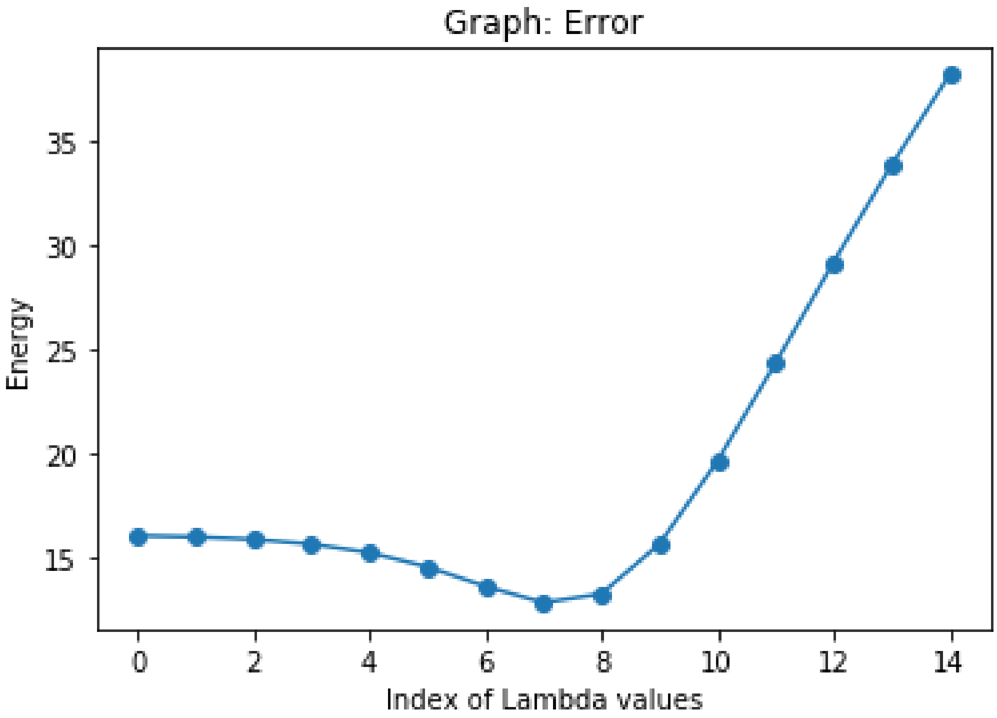


```
Index No lambda Value = Calculated Error
14 (2** 4 ) = 38.1491042980455
```



Generating Gaph for various lambda values against energy

```
In [783]: plt.figure(6)
          plt.plot( error_list,"-o")

          plt.title("Graph: Error");
          plt.xlabel("Index of Lambda values")
          plt.ylabel("Energy");
          plt.show()
```

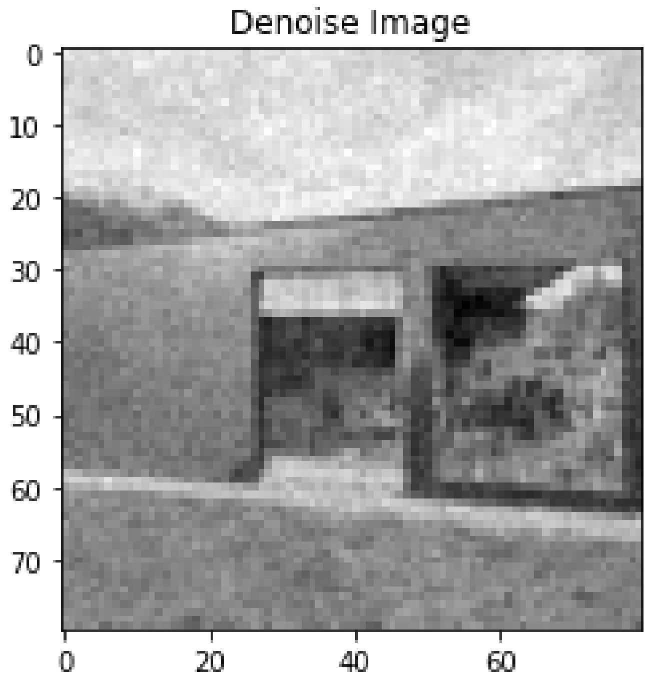


At below we can enter lambda manually and can check the error

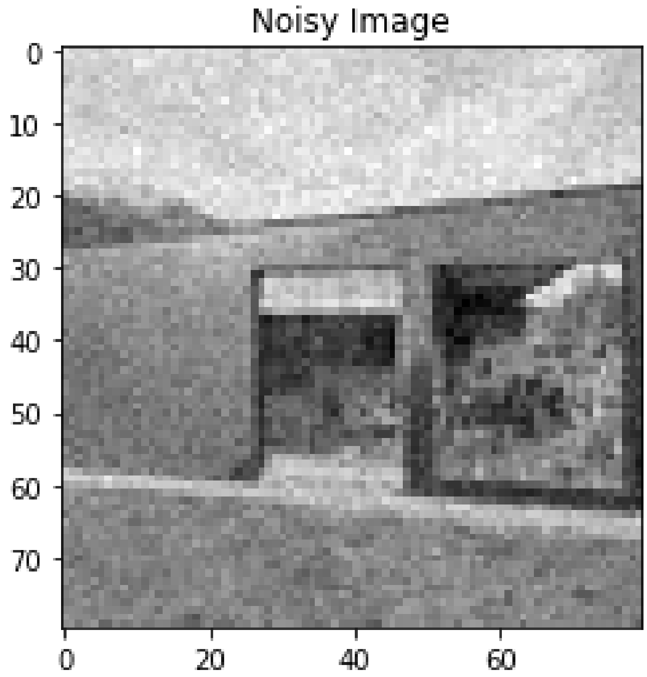
```
In [784]: lamb=0.1
          u=leastsquare_denoise(im2,Dx,Dy,lamb)
```

```
In [785]: plt.title("Denoise Image")
          plt.imshow(u,cmap='gray', interpolation='None')
```

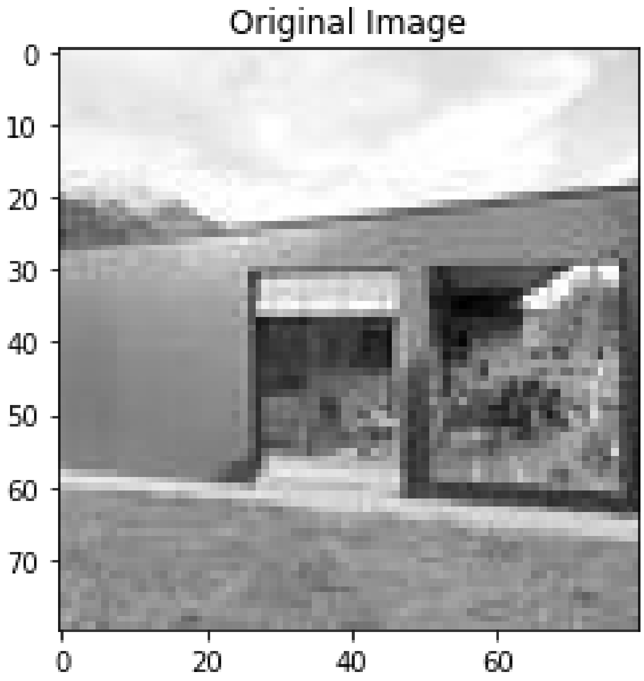
```
Out[785]: <matplotlib.image.AxesImage at 0x1a30e129908>
```



```
In [786]: plt.title("Noisy Image")
          plt.imshow(im_noise,cmap='gray', interpolation='None')

Out[786]: <matplotlib.image.AxesImage at 0x1a30e6c0da0>
```



```
In [787]: plt.title("Original Image")
          plt.imshow(im,cmap='gray', interpolation='None')

Out[787]: <matplotlib.image.AxesImage at 0x1a30dcaefd0>
```



```
In [788]: error        = np.linalg.norm(im - u)

In [789]: error

Out[789]: 12.971766910496417
```