Gradient of Image

import library

In [ ]:

```
import numpy as np
import matplotlib.image as img
import matplotlib.pyplot as plt
from matplotlib import cm
import matplotlib.colors as colors
```

load input image ('test.jpeg')

In [ ]:

```
I0 = img.imread('test.jpeg')
```

check the size of the input image

In [ ]:

```
# ++++++++++++++++++++++++++++++++++++++++++++++++++
# complete the blanks
#
num_row     = I0.shape[0]
num_column  = I0.shape[1]
num_channel = I0.shape[2]
#
# ++++++++++++++++++++++++++++++++++++++++++++++++++

print('number of rows of I0 = ', num_row)
print('number of columns of I0 = ', num_column)
print('number of channels of I0 = ', num_channel)
```

```
number of rows of I0 =  510
number of columns of I0 =  512
number of channels of I0 =  3
```

convert the color image into a grey image

- take the average of the input image with 3 channels with respect to the channels into an image with 1 channel

In [ ]:

```
# ++++++++++++++++++++++++++++++++++++++++++++++++++
# complete the blanks
#

I = np.mean(I0, axis=2)


num_row     = I.shape[0]
num_column  = I.shape[1]
#
# ++++++++++++++++++++++++++++++++++++++++++++++++++

print('number of rows of I = ', num_row)
print('number of columns of I = ', num_column)
```

```
number of rows of I =  510
number of columns of I =  512
```

normalize the converted image

- normalize the converted grey scale image so that its maximum value is 1 and its minimum value is 0

In [ ]:

```
# ++++++++++++++++++++++++++++++++++++++++++++++++++
# complete the blanks
#

I = (I - np.min(I))/np.ptp(I)

#
# ++++++++++++++++++++++++++++++++++++++++++++++++++

print('maximum value of I = ', np.max(I))
print('minimum value of I = ', np.min(I))
```

```
maximum value of I =  1.0
minimum value of I =  0.0
```

define a function to compute the derivative of input matrix in x(row)-direction

- forward difference : $I[x+1,y] - I[x,y]$

In [ ]:

```
def compute_derivative_x_forward(I):

    D = np.zeros(I.shape)

    # ++++++++++++++++++++++++++++++++++++++++++++++++++
    # complete the blanks
    #

    D = np.pad(I, (1,1), mode = 'edge')
    D = np.roll(D, shift = -1, axis=0) - D
    D = D[1:I.shape[0]+1, 1:I.shape[1]+1]

    #
    # ++++++++++++++++++++++++++++++++++++++++++++++++++

    return D
```

- backward difference : $I[x,y] - I[x-1,y]$

In [ ]:

```
def compute_derivative_x_backward(I):

    D = np.zeros(I.shape)

    # ++++++++++++++++++++++++++++++++++++++++++++++++++
    # complete the blanks
    #

    D = np.pad(I, (1,1), mode = 'edge')
    D = D - np.roll(D, shift=1, axis=0)
```

```
    D = D[1:I.shape[0]+1, 1:I.shape[1]+1]

    #
    # ++++++++++++++++++++++++++++++++++++++++++++++++++

    return D
```

- central difference : $\frac{1}{2}(I[x+1,y] - I[x-1,y])$

In [ ]:
```
def compute_derivative_x_central(I):

    D = np.zeros(I.shape)

    # ++++++++++++++++++++++++++++++++++++++++++++++++++
    # complete the blanks
    #

    D = np.pad(I, (1,1), mode = 'edge')
    D = (np.roll(D, shift=-1, axis=0) - np.roll(D, shift=1, axis=0))/2
    D = D[1:I.shape[0]+1, 1:I.shape[1]+1]

    #
    # ++++++++++++++++++++++++++++++++++++++++++++++++++

    return D
```

define a function to compute the derivative of input matrix in y(column)-direction

- forward difference : $I[x,y+1] - I[x,y]$

In [ ]:
```
def compute_derivative_y_forward(I):

    D = np.zeros(I.shape)

    # ++++++++++++++++++++++++++++++++++++++++++++++++++
    # complete the blanks
    #

    D = np.pad(I, (1,1), mode = 'edge')
    D = np.roll(D, shift=-1, axis =1) -D
    D = D[1:I.shape[0]+1, 1:I.shape[1]+1]

    #
    # ++++++++++++++++++++++++++++++++++++++++++++++++++
    return D
```

- backward difference : $I[x,y] - I[x,y-1]$

In [ ]:
```
def compute_derivative_y_backward(I):

    D = np.zeros(I.shape)

    # ++++++++++++++++++++++++++++++++++++++++++++++++++
    # complete the blanks
    #
```

```
    D = np.pad(I, (1,1), mode = 'edge')
    D = D - np.roll(D, shift=1, axis=1)
    D = D[1:I.shape[0]+1, 1:I.shape[1]+1]

    #
    # ++++++++++++++++++++++++++++++++++++++++++++++++++

    return D
```

- central difference : $\frac{1}{2}(I[x, y+1] - I[x, y-1])$

In [ ]:

```
def compute_derivative_y_central(I):

    D = np.zeros(I.shape)

    # ++++++++++++++++++++++++++++++++++++++++++++++++++
    # complete the blanks
    #

    D = np.pad(I, (1,1), mode = 'edge')
    D = (np.roll(D, shift=-1, axis=1) - np.roll(D, shift=1, axis=1))/2
    D = D[1:I.shape[0]+1, 1:I.shape[1]+1]

    #
    # ++++++++++++++++++++++++++++++++++++++++++++++++++

    return D
```

compute the norm of the gradient of the input image

- L_2^2-norm of the gradient $\left(\frac{\partial I}{\partial x}, \frac{\partial I}{\partial y}\right)$ is defined by $\left(\frac{\partial I}{\partial x}\right)^2 + \left(\frac{\partial I}{\partial y}\right)^2$

In [ ]:

```
def compute_norm_gradient_central(I):

    norm_gradient = np.zeros(I.shape)

    # ++++++++++++++++++++++++++++++++++++++++++++++++++
    # complete the blanks
    #

    norm_gradient = np.square(compute_derivative_x_central(I)) + np.square(compute_de

    #
    # ++++++++++++++++++++++++++++++++++++++++++++++++++

    return norm_gradient
```

---

functions for presenting the results

In [ ]:
```
def function_result_01():

    plt.figure(figsize=(8,6))
    plt.imshow(I0)
    plt.show()
```

In [ ]:
```
def function_result_02():

    plt.figure(figsize=(8,6))
    plt.imshow(I, cmap='gray', vmin=0, vmax=1, interpolation='none')
    plt.show()
```

In [ ]:
```
def function_result_03():

    D = compute_derivative_x_forward(I)

    plt.figure(figsize=(8,6))
    plt.imshow(D, cmap='gray')
    plt.show()
```

In [ ]:
```
def function_result_04():

    D = compute_derivative_x_backward(I)

    plt.figure(figsize=(8,6))
    plt.imshow(D, cmap='gray')
    plt.show()
```

In [ ]:
```
def function_result_05():

    D = compute_derivative_x_central(I)

    plt.figure(figsize=(8,6))
    plt.imshow(D, cmap='gray')
    plt.show()
```

In [ ]:
```
def function_result_06():

    D = compute_derivative_y_forward(I)

    plt.figure(figsize=(8,6))
    plt.imshow(D, cmap='gray')
    plt.show()
```

In [ ]:
```
def function_result_07():

    D = compute_derivative_y_backward(I)

    plt.figure(figsize=(8,6))
    plt.imshow(D, cmap='gray')
    plt.show()
```

In [ ]:
```
def function_result_08():

    D = compute_derivative_y_central(I)
```

```
    plt.figure(figsize=(8,6))
    plt.imshow(D, cmap='gray')
    plt.show()
```

In [ ]:

```
def function_result_09():

    D = compute_norm_gradient_central(I)

    plt.figure(figsize=(8,6))
    plt.imshow(D, cmap='gray')
    plt.show()
```

In [ ]:

```
def function_result_10():

    D = compute_norm_gradient_central(I)

    plt.figure(figsize=(8,6))
    im = plt.imshow(D, cmap=cm.jet, norm=colors.LogNorm())
    plt.colorbar(im)
    plt.show()
```

In [ ]:

```
def function_result_11():

    D = compute_derivative_x_forward(I)

    value1 = D[0, 0]
    value2 = D[-1, -1]
    value3 = D[100, 100]
    value4 = D[200, 200]

    print('value1 = ', value1)
    print('value2 = ', value2)
    print('value3 = ', value3)
    print('value4 = ', value4)
```

In [ ]:

```
def function_result_12():

    D = compute_derivative_x_backward(I)

    value1 = D[0, 0]
    value2 = D[-1, -1]
    value3 = D[100, 100]
    value4 = D[200, 200]

    print('value1 = ', value1)
    print('value2 = ', value2)
    print('value3 = ', value3)
    print('value4 = ', value4)
```

In [ ]:

```
def function_result_13():

    D = compute_derivative_x_central(I)

    value1 = D[0, 0]
    value2 = D[-1, -1]
    value3 = D[100, 100]
```

```
    value4 = D[200, 200]

    print('value1 = ', value1)
    print('value2 = ', value2)
    print('value3 = ', value3)
    print('value4 = ', value4)
```

In [ ]:

```
def function_result_14():

    D = compute_derivative_y_forward(I)

    value1 = D[0, 0]
    value2 = D[-1, -1]
    value3 = D[100, 100]
    value4 = D[200, 200]

    print('value1 = ', value1)
    print('value2 = ', value2)
    print('value3 = ', value3)
    print('value4 = ', value4)
```

In [ ]:

```
def function_result_15():

    D = compute_derivative_y_backward(I)

    value1 = D[0, 0]
    value2 = D[-1, -1]
    value3 = D[100, 100]
    value4 = D[200, 200]

    print('value1 = ', value1)
    print('value2 = ', value2)
    print('value3 = ', value3)
    print('value4 = ', value4)
```

In [ ]:

```
def function_result_16():

    D = compute_derivative_y_central(I)

    value1 = D[0, 0]
    value2 = D[-1, -1]
    value3 = D[100, 100]
    value4 = D[200, 200]

    print('value1 = ', value1)
    print('value2 = ', value2)
    print('value3 = ', value3)
    print('value4 = ', value4)
```

In [ ]:

```
def function_result_17():

    D = compute_norm_gradient_central(I)

    value1 = D[0, 0]
    value2 = D[-1, -1]
    value3 = D[100, 100]
    value4 = D[200, 200]

    print('value1 = ', value1)
```

```
    print('value2 = ', value2)
    print('value3 = ', value3)
    print('value4 = ', value4)
```

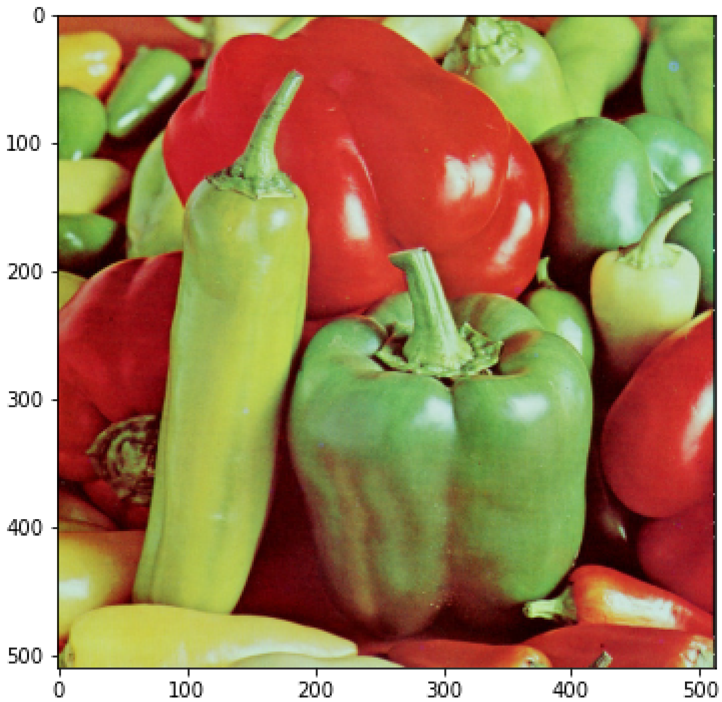
---

results

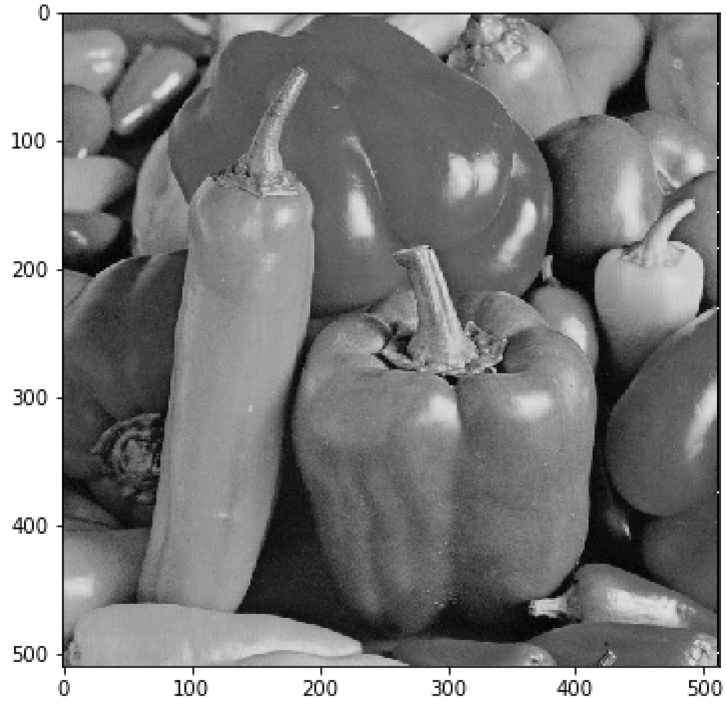
In [ ]:

```
number_result = 17

for i in range(number_result):
    title = '## [RESULT {:02d}]'.format(i+1)
    name_function = 'function_result_{:02d}()'.format(i+1)

    print('**************************************************')
    print(title)
    print('**************************************************')
    eval(name_function)
```

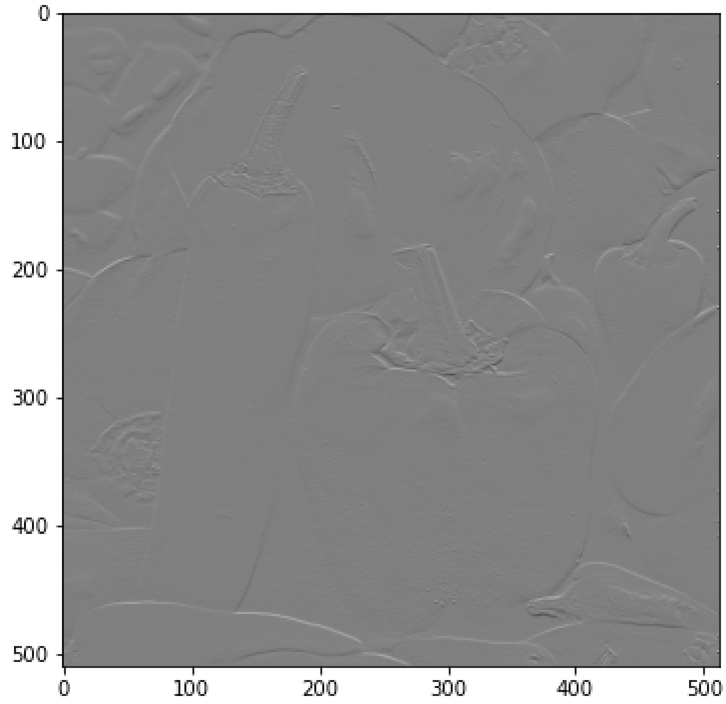
```
**************************************************
## [RESULT 01]
**************************************************
```



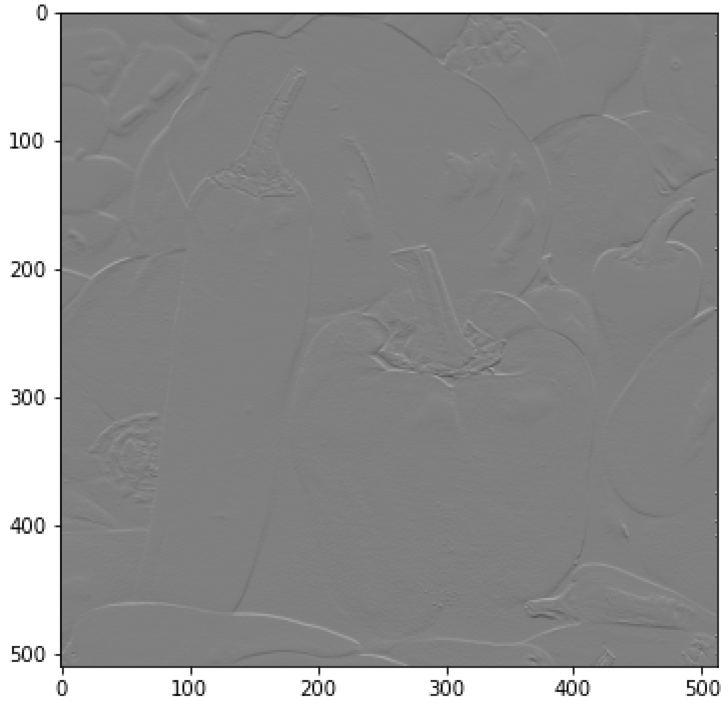

```
**************************************************
## [RESULT 02]
**************************************************
```



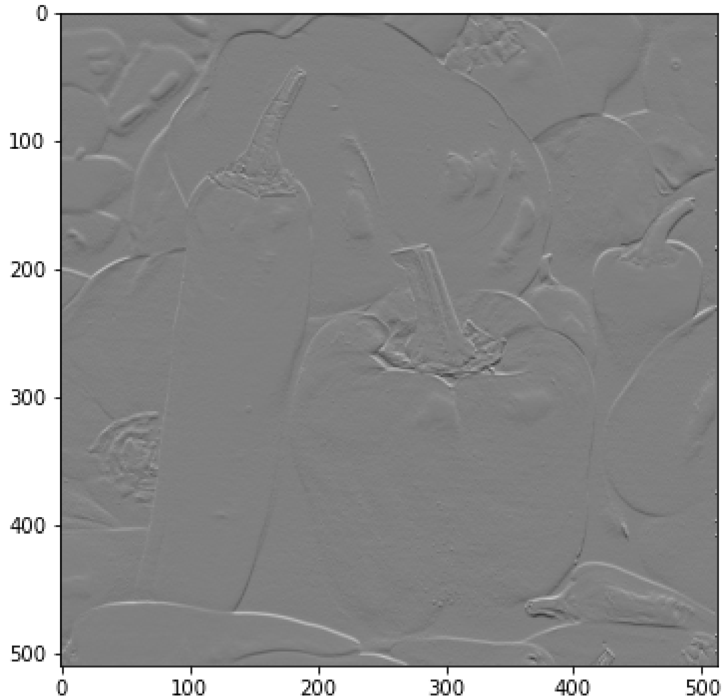
```
**************************************************
## [RESULT 03]
**************************************************
```



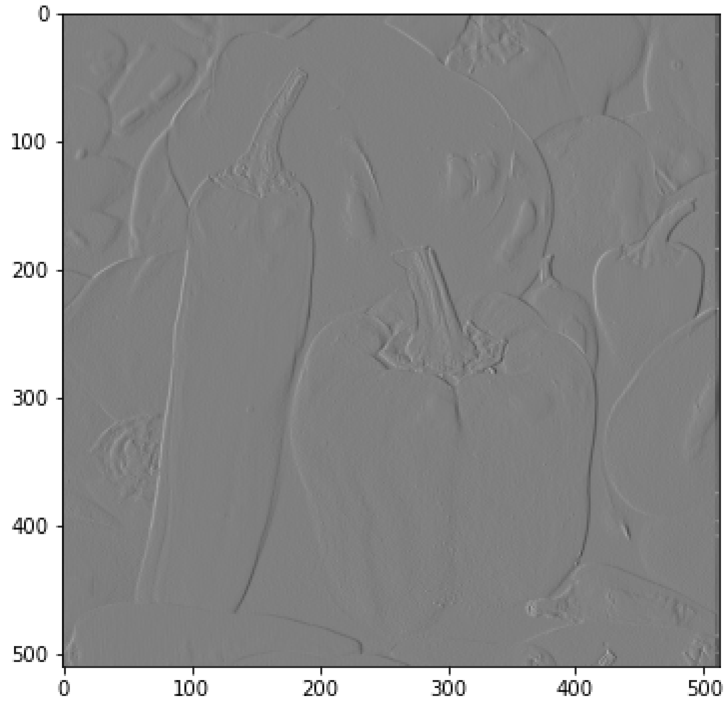
```
**************************************************
## [RESULT 04]
**************************************************
```



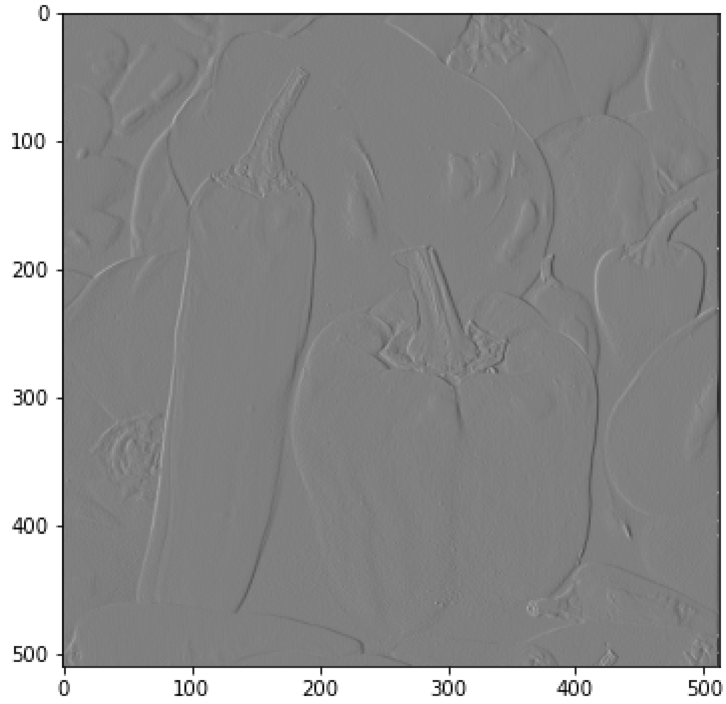
****
[RESULT 05]
****



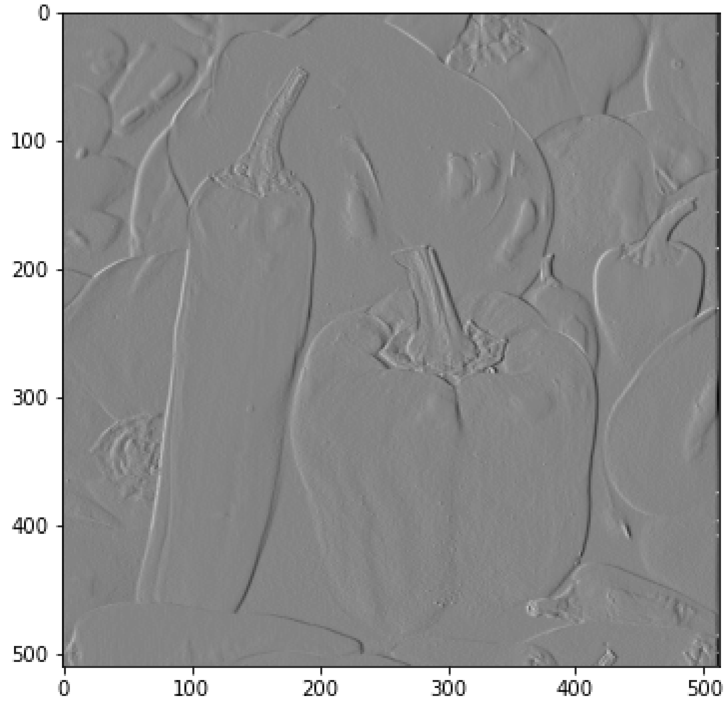
****
[RESULT 06]
****



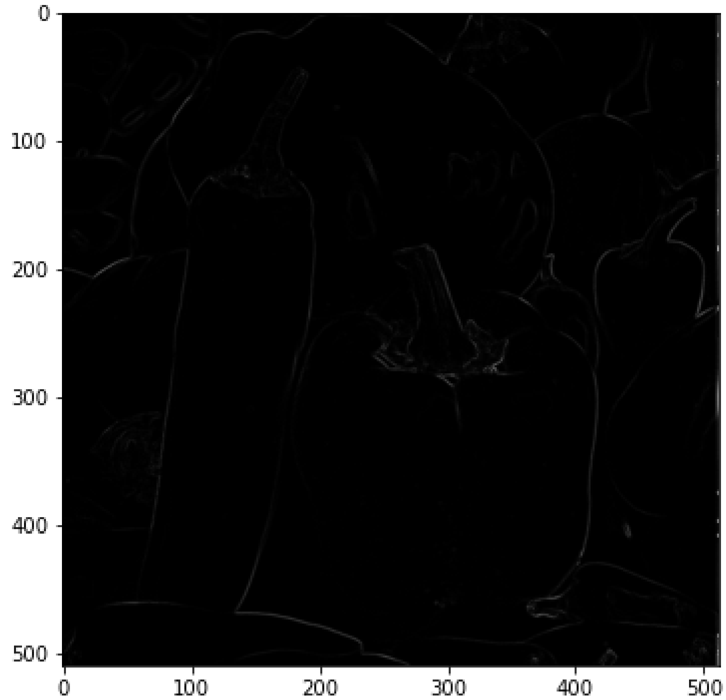

```
*************************************************
## [RESULT 07]
*************************************************
```



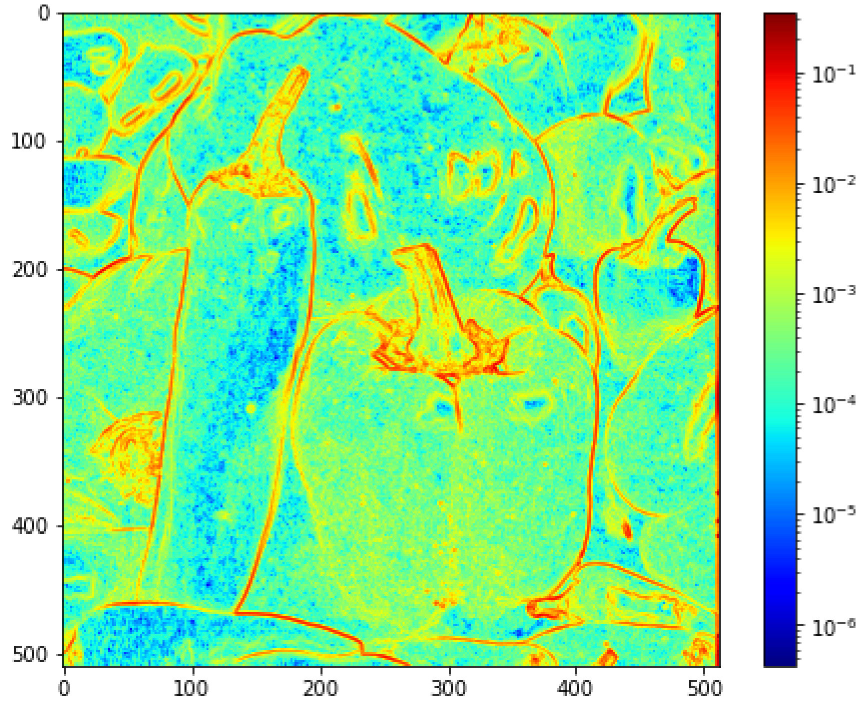

```
*************************************************
## [RESULT 08]
*************************************************
```




```
**************************************************
## [RESULT 09]
**************************************************
```




```
**************************************************
## [RESULT 10]
**************************************************
```




```
**************************************************
## [RESULT 11]
**************************************************
value1 =  -0.007853403141361237
value2 =  0.0
value3 =  -0.005235602094240843
value4 =  0.011780104712041883
**************************************************
## [RESULT 12]
**************************************************
value1 =  0.0
value2 =  0.0026178010471204186
value3 =  0.015706806282722253
value4 =  -0.013089005235602025
**************************************************
## [RESULT 13]
**************************************************
value1 =  -0.0039267015706806185
value2 =  0.0013089005235602093
value3 =  0.005235602094240843
value4 =  -0.0006544502617800707
**************************************************
## [RESULT 14]
**************************************************
value1 =  -0.03534031413612565
value2 =  0.0
value3 =  -0.017015706806282727
value4 =  0.0
**************************************************
## [RESULT 15]
**************************************************
value1 =  0.0
value2 =  -0.6426701570680627
value3 =  0.00916230366492149
value4 =  0.007853403141361293
**************************************************
## [RESULT 16]
**************************************************
value1 =  -0.017670157068062825
value2 =  -0.32133507853403137
value3 =  -0.0039267015706806185
```

```
value4 =  0.003926701570680646
**************************************************
## [RESULT 17]
**************************************************
value1 =  0.00032765343603519625
value2 =  0.10325794591705269
value3 =  4.2830514514404736e-05
value4 =  1.5847290370329858e-05
```

In [ ]: