assignment3_1

March 26, 2021

1 Derivative of Matrix

1.1 import library

[8]:
```
import numpy as np
import matplotlib.image as img
import matplotlib.pyplot as plt
import matplotlib.colors as colors
```

1.2 load image

[37]:
```
I = img.imread('./doggo.jpg', format = None)
```

1.3 check the size of image

[39]:
```
n_row = 383
n_col = 512

print(I.shape)
```

```
(383, 512, 3)
```

1.4 convert the input image into gray scale if it is color

[40]:
```
if I.shape[2] == 3:
    I = 1/3 * (I[:,:,0] + I[:,:,1] + I[:,:,2])
#     0.2989 * I[:, :, 0] + 0.5870 * I[:, :, 1] + 0.1140 * I[:, :, 2]
```

1.5 normalize input image so that the range of image is $[0, 1]$

[41]:
```
I = (I - I.min()) / (I.max() - I.min())
```

```
git commit -a -m "load image"
git push origin master
```

1.6 generate a matrix to compute the derivative in x-direction

[42]:
```
Dx = np.diag(np.ones(n_col) * -1)
Dx_1 = np.ones(n_col - 1)
Dx_1 = np.diag(Dx_1, k = -1)
Dx = Dx + Dx_1
print(Dx)
Dx.shape
```

```
[[-1.  0.  0. …  0.  0.  0.]
 [ 1. -1.  0. …  0.  0.  0.]
 [ 0.  1. -1. …  0.  0.  0.]
 …
 [ 0.  0.  0. … -1.  0.  0.]
 [ 0.  0.  0. …  1. -1.  0.]
 [ 0.  0.  0. …  0.  1. -1.]]
```

[42]: (512, 512)

1.7 compute the derivative of I with respect to x-direction

[43]:
```
Ix = I @ Dx
print(Ix)
Ix.shape
```

```
[[ 0.          0.          0.01176471 …  0.         -0.01176471
  -0.71764706]
 [ 0.          0.          0.01176471 …  0.          0.
  -0.72941176]
 [ 0.          0.01176471  0.         …  0.          0.
  -0.72941176]
 …
 [ 0.01960784  0.05490196  0.0627451  …  0.          0.
  -0.20392157]
 [ 0.02352941  0.03529412  0.04313725 … -0.01176471 -0.00784314
  -0.20784314]
 [ 0.01176471  0.02352941  0.00784314 … -0.01568627 -0.01176471
  -0.21960784]]
```

[43]: (383, 512)

```
git commit -a -m "compute the derivative in x-direction"
git push origin master
```

1.8 generate a matrix to compute the derivative in y-direction

[44]:
```
Dy = np.diag(np.ones(n_row) * -1)
Dy_1 = np.ones(n_row - 1)
Dy_1 = np.diag(Dy_1, k = 1)
Dy = Dy + Dy_1
print(Dy)
Dy.shape
```

```
[[-1.  1.  0. …  0.  0.  0.]
 [ 0. -1.  1. …  0.  0.  0.]
 [ 0.  0. -1. …  0.  0.  0.]
 …
 [ 0.  0.  0. … -1.  1.  0.]
 [ 0.  0.  0. …  0. -1.  1.]
 [ 0.  0.  0. …  0.  0. -1.]]
```

[44]:
```
(383, 383)
```

1.9 compute the derivative of I with respect to y-direction

[45]:
```
Iy = Dy @ I
print(Iy)
Iy.shape
```

```
[[ 0.          0.          0.         …  0.          0.
   0.01176471]
 [ 0.          0.          0.01176471 …  0.          0.
   0.        ]
 [ 0.          0.01176471  0.         …  0.          0.
   0.        ]
 …
 [ 0.02352941  0.02745098  0.00784314 …  0.02352941  0.01176471
   0.00392157]
 [ 0.05098039  0.03921569  0.02745098 …  0.01960784  0.01568627
   0.01176471]
 [-0.21568627 -0.22745098 -0.25098039 … -0.24705882 -0.23137255
  -0.21960784]]
```

[45]:
```
(383, 512)
```

```
git commit -a -m "compute the derivative in y-direction"
git push origin master
```

1.10 compute L_2^2 of the gradient of I

[46]:
```
norm_gradient = (Ix * Ix) + (Iy * Iy)
print(norm_gradient)
```

```
[[0.00000000e+00 0.00000000e+00 1.38408304e-04 … 0.00000000e+00
  1.38408304e-04 5.15155709e-01]
 [0.00000000e+00 0.00000000e+00 2.76816609e-04 … 0.00000000e+00
  0.00000000e+00 5.32041522e-01]
 [0.00000000e+00 2.76816609e-04 0.00000000e+00 … 0.00000000e+00
  0.00000000e+00 5.32041522e-01]
 …
 [9.38100730e-04 3.76778162e-03 3.99846213e-03 … 5.53633218e-04
  1.38408304e-04 4.15993849e-02]
 [3.15263360e-03 2.78354479e-03 2.61437908e-03 … 5.22875817e-04
  3.07574010e-04 4.33371780e-02]
 [4.66589773e-02 5.22875817e-02 6.30526720e-02 … 6.12841215e-02
  5.36716647e-02 9.64552095e-02]]
```

1.11 define functions for the visualization

[47]:
```
def plot_image(I):

    plt.figure(figsize=(10,10))
    plt.imshow(I, cmap = 'gray', )
    plt.title('input image')
    plt.axis('off')

def plot_image_derivative_x(Ix):

    plt.figure(figsize=(10,10))
    plt.imshow(Ix, norm = colors.LogNorm(), cmap = 'gray')
    plt.title('image derivative of x')
    plt.axis('off')


def plot_image_derivative_y(Iy):

    plt.figure(figsize=(10,10))
    plt.imshow(Iy, norm = colors.LogNorm(), cmap = 'gray')
    plt.title('image derivative of y')
    plt.axis('off')


def plot_norm_gradient(norm_gradient):

    plt.figure(figsize=(10,10))
    plt.imshow(norm_gradient, norm = colors.LogNorm(), cmap = 'gray')
```

```
    plt.title('norm gradient')
    plt.axis('off')
```

```
git commit -a -m "define functions for the visualization"
git push origin master
```

2

3 # results

4

5 # 01. plot the input image in gray scale

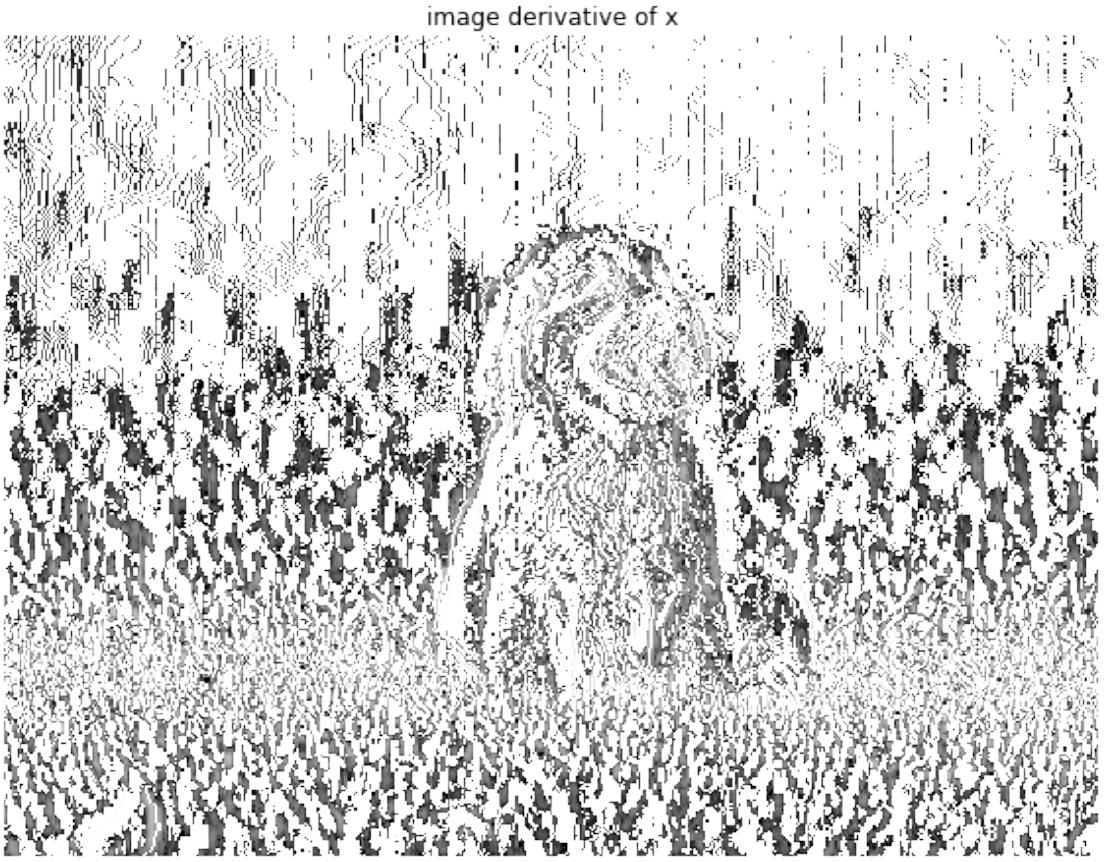
[48]:
```
plot_image(I)
```

[ ]:
```

```

6 # 02. plot the derivative I_x of input image in x-direction

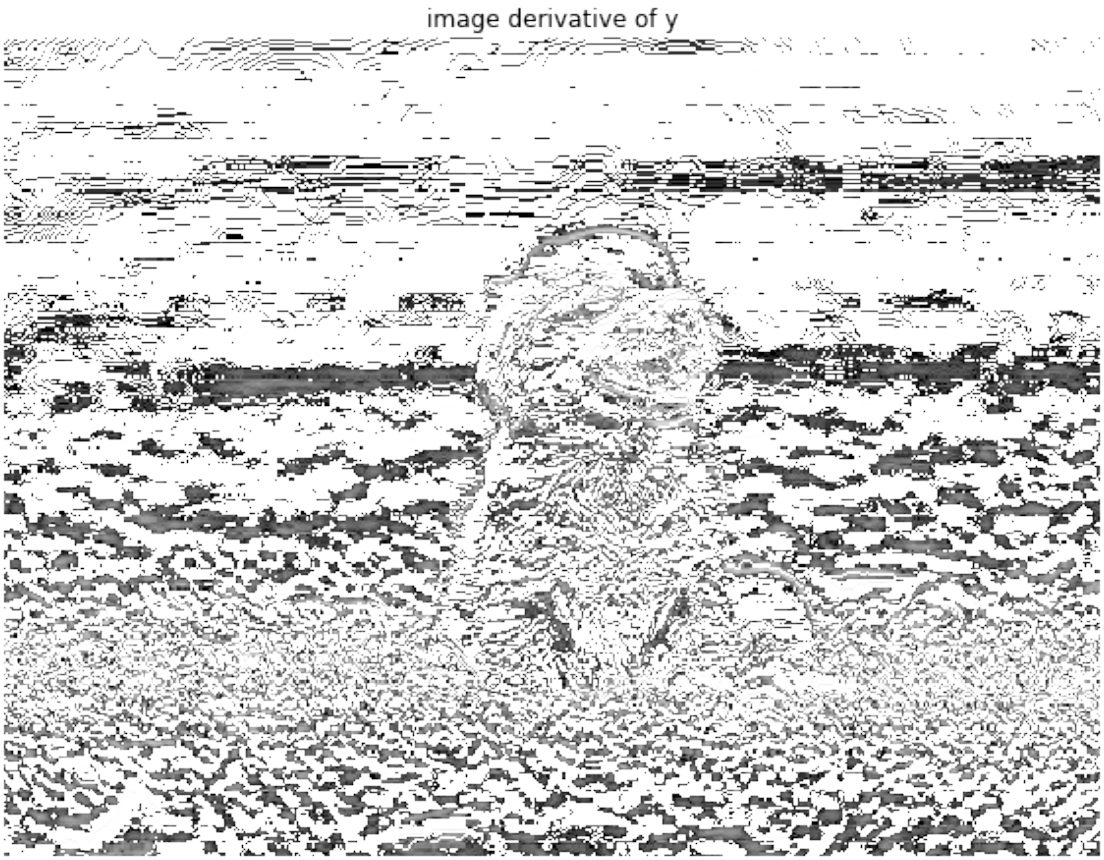
[49]:
```
plot_image_derivative_x(Ix)
```



[ ]:

7 # 03. plot the derivative I_y of input image in y-direction

[50]:
```
plot_image_derivative_y(Iy)
```



[ ]:

8 # 04. plot L_2^2 norm $I_x^2 + I_y^2$ of the gradient of input image

[51]:
```
plot_norm_gradient(norm_gradient)
```


norm gradient

[ ]:

[ ]:

[ ]: