Lab Instructions - session 4

Noise and Filtering

Adding Gaussian noise to an image

File: ‘**add_gaussian_noise.py**’

```
import numpy as np
import cv2

I = cv2.imread('isfahan.jpg', cv2.IMREAD_GRAYSCALE);

# convert I to floating point from unsigned integer
# Note: For displaying floating point images the maximum
# intensity has to be 1 instead of 255
I = I.astype(np.float) / 255

# create the noise image
sigma = 0.04 # notice maximum intensity is 1
N = np.random.randn(*I.shape) * sigma

# add noise to the original image
J = I+N; # or use cv2.add(I,N);

cv2.imshow('original',I)
cv2.waitKey(0) # press any key to exit

cv2.imshow('noisy image',J)
cv2.waitKey(0) # press any key to exit

cv2.destroyAllWindows()
```

- What does the line `I = I.astype(np.float) / 255` do?
- An asterisk `"*"` before an argument in a python function call, gives elements of the argument (which is typically a tuple) as separate arguments to the function. In the above, if `I.shape = (200,300)`, then `np.random.randn(*I.shape)` is the same thing as `np.random.randn(I.shape[0],I.shape[1])`. Similarly, if `I.shape = (200,300,3)` for a color image, then `np.random.randn(*I.shape)` is equivalent to `np.random.randn(I.shape[0],I.shape[1],I.shape[2])`.
- Try different values of **sigma** and see the result. What is the effect of small/large sigma on the added noise?
- Change `cv2.IMREAD_GRAYSCALE` to `cv2.IMREAD_COLOR` in imread (or remove this argument) and see the result.

Task 1:

We want to simulate white noise (**snow noise** or **Barfak** in Persian!) in the old analog TVs. We read an image, and then, in every iteration of a loop, we add a **different** randomly generated Gaussian noise to it. We show the image at around **30 frames per second (**Hence the command `cv2.waitKey(33)`**)**. Notice that you need to create a new noise image at every new frame. Your program must increase or decrease the intensity of noise when the user presses the keys **'u'** or **'d'** respectively. Read the file **snow_noise.py** and change it to create this demo. **Notice that sigma should never get negative.**

File: '`snow_noise.py`'

```python
import numpy as np
import cv2

I = cv2.imread('isfahan.jpg', cv2.IMREAD_GRAYSCALE);
I = I.astype(np.float) / 255

sigma = 0.04 # initial standard deviation of noise

while True:

    J = I; # change this line so J is the noisy image

    cv2.imshow('snow noise',J)

    # press any key to exit
    key = cv2.waitKey(33)
    if key & 0xFF == ord('u'): # if 'u' is pressed
        pass # increase noise
    elif key & 0xFF == ord('d'):  # if 'd' is pressed
        pass # decrease noise
    elif key & 0xFF == ord('q'):  # if 'q' is pressed then
        break # quit

cv2.destroyAllWindows()
```

Image Smoothing/Blurring

Smoothing an image with a box kernel
File: '**blur_box.py**'

```
import numpy as np
import cv2

I = cv2.imread('isfahan.jpg').astype(np.float64) / 255;

# display the original image
cv2.imshow('original',I)
cv2.waitKey()

# creating a box filter
m = 7 # choose filter size

# create an m by m box filter
F = np.ones((m,m), np.float64)/(m*m)
print(F)

# Now, filter the image
J = cv2.filter2D(I,-1, F)
cv2.imshow('blurred',J)
cv2.waitKey()

cv2.destroyAllWindows()
```

-1: This parameter specifies the depth of the output image. When set to -1, the output image will have the same depth as the input image (I). This is the most common usage.

"depth" = the number of bits used to represent each pixel value in the image.

- Alter the value of **m** and see what happens.
- Why the division by `(m*m)` in `F = np.ones((m,m), np.float64)/(m*m)`?
  the division by (m*m) is performed to normalize the filter kernel F.

Task 2:

You can also apply a box filter to an image using the cv2.blur (or cv2.boxFilter) functions. An m by n box filter can be applied using

```
J = cv2.blur(I,(m,n))
```

Rewrite the above using cv2.blur or cv2.boxFilter. Read the OpenCV documentation for details.

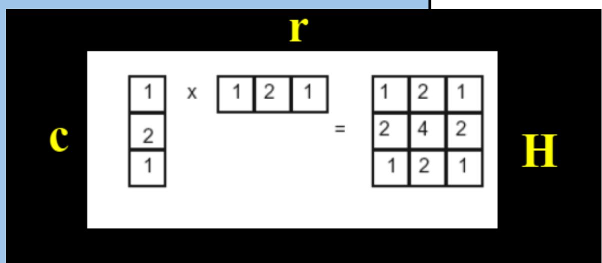
cv2.blur = Blurs an image using the normalized box filter.

cv2.boxFilter = Blurs an image using the box filter. Have (normalize) flag

Smoothing with a Gaussian Kernel

Here, we first create a one-dimensional Gaussian kernel. Then make a two-dimensional Gaussian kernel out of the 1D kernel, and apply the 2D kernel to the image.
File: '**blur_gaussian.py**'

```
import numpy as np
import cv2

I = cv2.imread('isfahan.jpg').astype(np.float64) / 255;

m = 13; # we will create an m by m filter

# create a 1D Gaussian filter
Fg = cv2.getGaussianKernel(m, sigma=-1);
# by setting sigma=-1, the value of sigma is computed
# automatically as: sigma = 0.3*((ksize-1)*0.5 - 1) + 0.8

print(Fg)
print(Fg.shape) # Fg is 1-dimensional (m by 1)

exit() # delete this to continue

# Now we create a 2D filter
# We use matrix multiplication to create an m by m 2D filter
# out of "m by 1" and "1 by m" 1D filters, which in this case happens
# to be the same thing as the correlation between 1D filters
Fg =  Fg.dot(Fg.T) # an "m by 1" matrix multiplied by a "1 by m" matrix

print(Fg)
print(Fg.shape)

exit() # delete this to continue

# filter the image with the Gaussian filter
Jg = cv2.filter2D(I,-1, Fg)

cv2.imshow('original',I)
cv2.waitKey()

cv2.imshow('blurred_Gaussian',Jg)
cv2.waitKey()

cv2.destroyAllWindows()
```



- Alter the value of m and see what happens. Notice that altering m will alter filter sigma = 0.3*((m-1)*0.5 - 1) + 0.8. You can also give sigma explicitly.

Task 3:

You can simply use the [cv2.gaussianBlur]() function to perform Gaussian smoothing. Read the [OpenCV documentation]() and change the above so it uses the [cv2.gaussianBlur]() function. An m by n Gaussian filter can be applied using

Blurs an image using a Gaussian filter.

```
Jg = cv2.GaussianBlur(I,(m,n),0)
```

Gaussian kernel size

automatically calculate the standard deviation based on the kernel size

Smoothing with a Bilateral Filter

file: '**blur_bilateral.py**'

```
import numpy as np
import cv2

I = cv2.imread('isfahan.jpg').astype(np.float32) / 255

size = 9  # bilateral filter size (diameter)
sigma_color = 0.3
sigma_space = 25

J1 = cv2.bilateralFilter(I,size, sigma_color, sigma_space)

cv2.imshow('original',I)
cv2.waitKey()

cv2.imshow('blurred_Gaussian',J1)
cv2.waitKey()

cv2.destroyAllWindows()
```

A lower value means that colors must be very similar to each other to be considered neighbors

- Alter the parameter **sigma_color** and see the effect.
- Alter the parameter **sigma_space** and see the effect.

controls the coordinate space sigma. It defines the neighborhood size in the spatial domain.
A higher value means that pixels farther away from the central pixel will have a greater influence on the filtering process.

Bilateral Filter = make sure only those pixels with similar intensity to central pixel is considered for blurring. So it preserves the edges since pixels at edges will have large intensity variation.

Task 4:

This is an extension to **Task 1**. This time we also filter the noisy image using the box and Gaussian filters. You need to complete the file **noise_filter_demo.py**. Your program must have the following functionalities:

- **press the 'b' key:** use a box filter
- **press the 'g' key:** use Gaussian filter
- **press the 'l' key:** use bilateral filter
- **press the '+' key:** increase filter size **m**
- **press the '-' key:** decrease filter size **m**
- **press the 'u' key:** increase noise intensity
- **press the 'd' key:** decrease noise intensity
- **press the 'p' key:** increase sigma_color
- **press the 'n' key:** decrease sigma_color
- **press the 'q' key:** quit the program

File: '`noise_filter_demo.py`'

```
import numpy as np
import cv2

I = cv2.imread('isfahan.jpg').astype(np.float32) / 255

noise_sigma = 0.04 # initial standard deviation of noise

m = 1 # initial filter size,
# with m = 1 the input image will not change

gm = 3  # gaussian filter size

size = 9  # bilateral filter size
sigmaColor = 0.3
sigmaSpace = 75

filter = 'b' # box filter

while True:
    # add noise to image
    N = np.random.rand(*I.shape) * noise_sigma
    J = I + N

    if filter == 'b':
        # filter with a box filter
        F = np.ones((m,m), np.float64)/(m*m)
    elif filter == 'g':
```

```
        # filter with a Gaussian filter
        pass
    elif filter == 'l':
        # filter with a bilateral filter
     pass


    cv2.imshow('img', K)
    key = cv2.waitKey(30) & 0xFF


    if key == ord('b'):
        filter = 'b' # box filter
        print('Box filter')

    elif key == ord('g'):
        filter = 'g' # filter with a Gaussian filter
        print('Gaussian filter')

    elif key == ord('l'):
        filter = 'l'  # filter with a bilateral filter
        print('Bilateral filter')

    elif key == ord('+'):
        # increase m
        m = m + 2
        print('m=',m)

    elif key == ord('-'):
        # increase m
        if m >= 3:
            m = m - 2
        print('m=', m)

    elif key == ord('u'):
        # increase noise
        pass

    elif key == ord('d'):
        # decrease noise
        pass

    elif key == ord('p'):
        # increase gm
        pass

    elif key == ord('n'):
        # decrease gm
```

```
        pass

    elif key == ord('>'):
        # increase size
        pass

    elif key == ord('<'):
        # decrease size
        pass

    elif key == ord('q'):
        break # quit

cv2.destroyAllWindows()
```

- Change the noise intensity. In each case try to find the optimal filter size **m**.
- Compare the Gaussian filter with the box filter. Which one performs better?

References

1. OpenCV: Smoothing Images

Smoothing an image with a box kernel

Smoothing with a Gaussian Kernel