OpenCV: Getting Started

COMPUTER VISION (COURSE-HY23992)

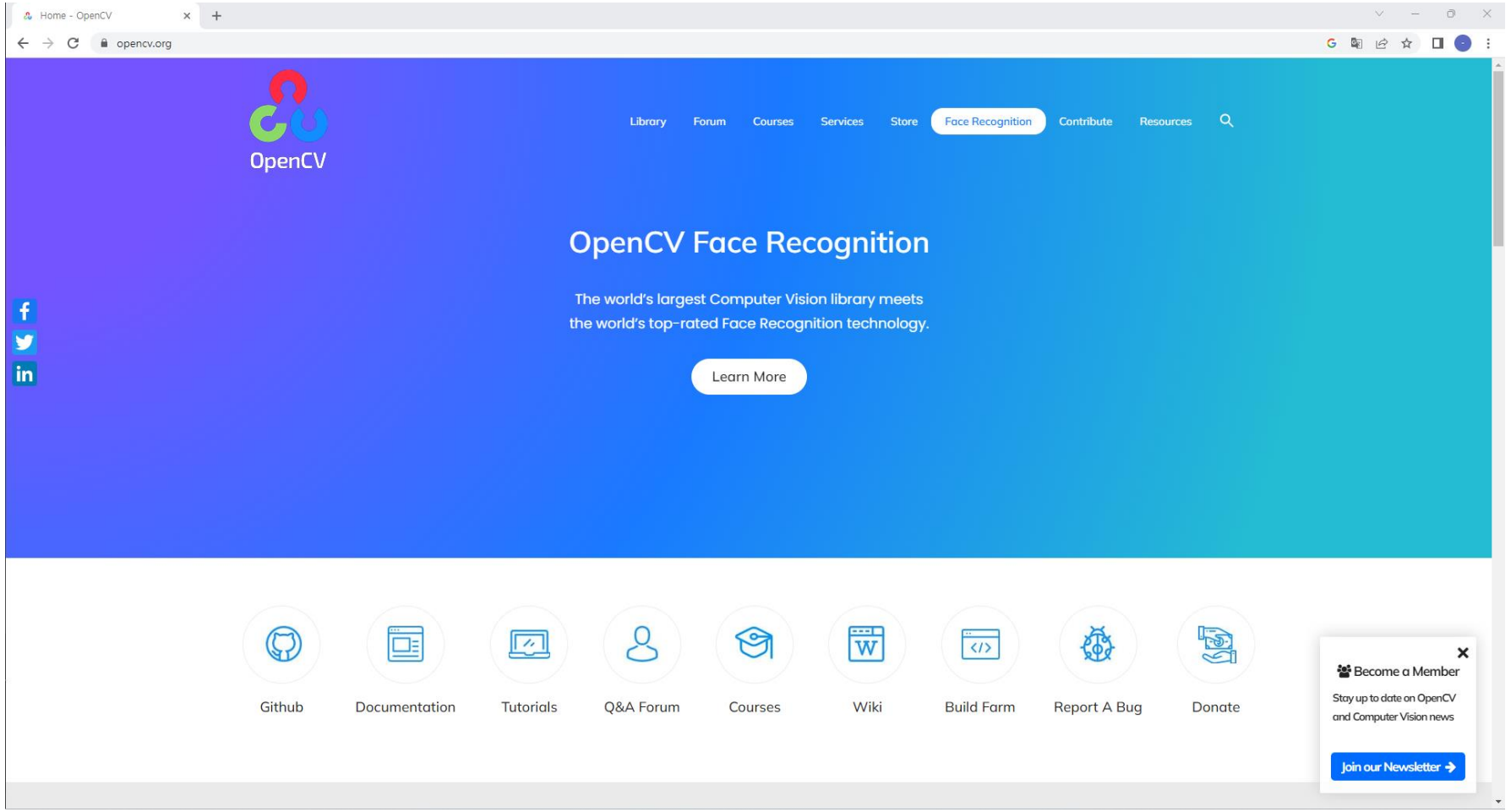
Q YOUN HONG

OpenCV Overview

- OpenCV (Open Source Computer Vision Library)
  - A library including several hundreds of computer vision algorithms
  - Originally developed by Intel (June, 2000)
  - Current stable version: 4.9.0 (Dec. 2023)
  - Cross-platform, free and open-source software (Apache License 2)
    - Developed in C/C++
    - C, C++, Java, JavaScript, **Python** interfaces
    - Support Windows, macOS, Linux

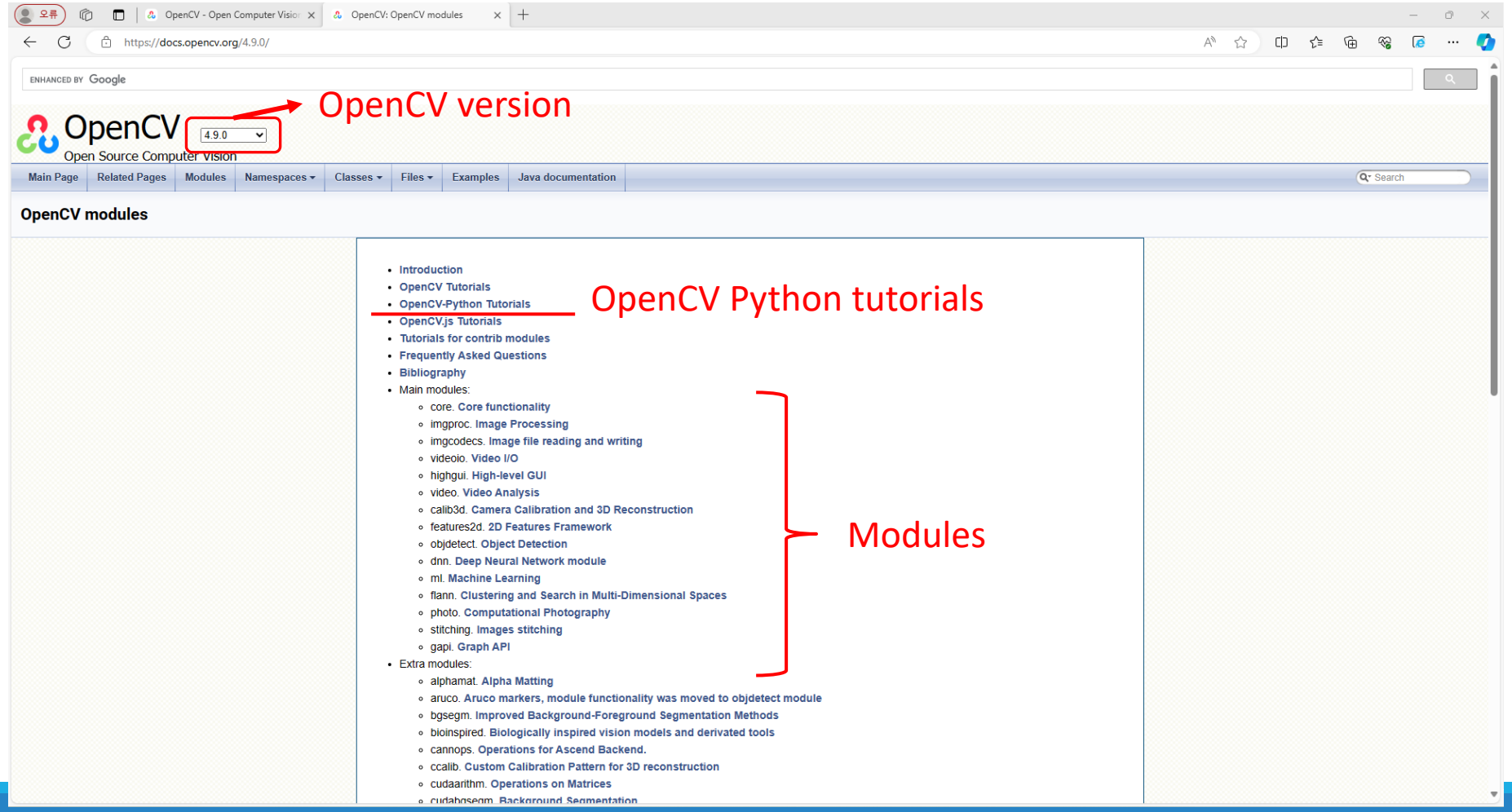
OpenCV Online Resources

- Official website: https://opencv.org



OpenCV Online Resources

- OpenCV manuals: https://docs.opencv.org



OpenCV Online Resources

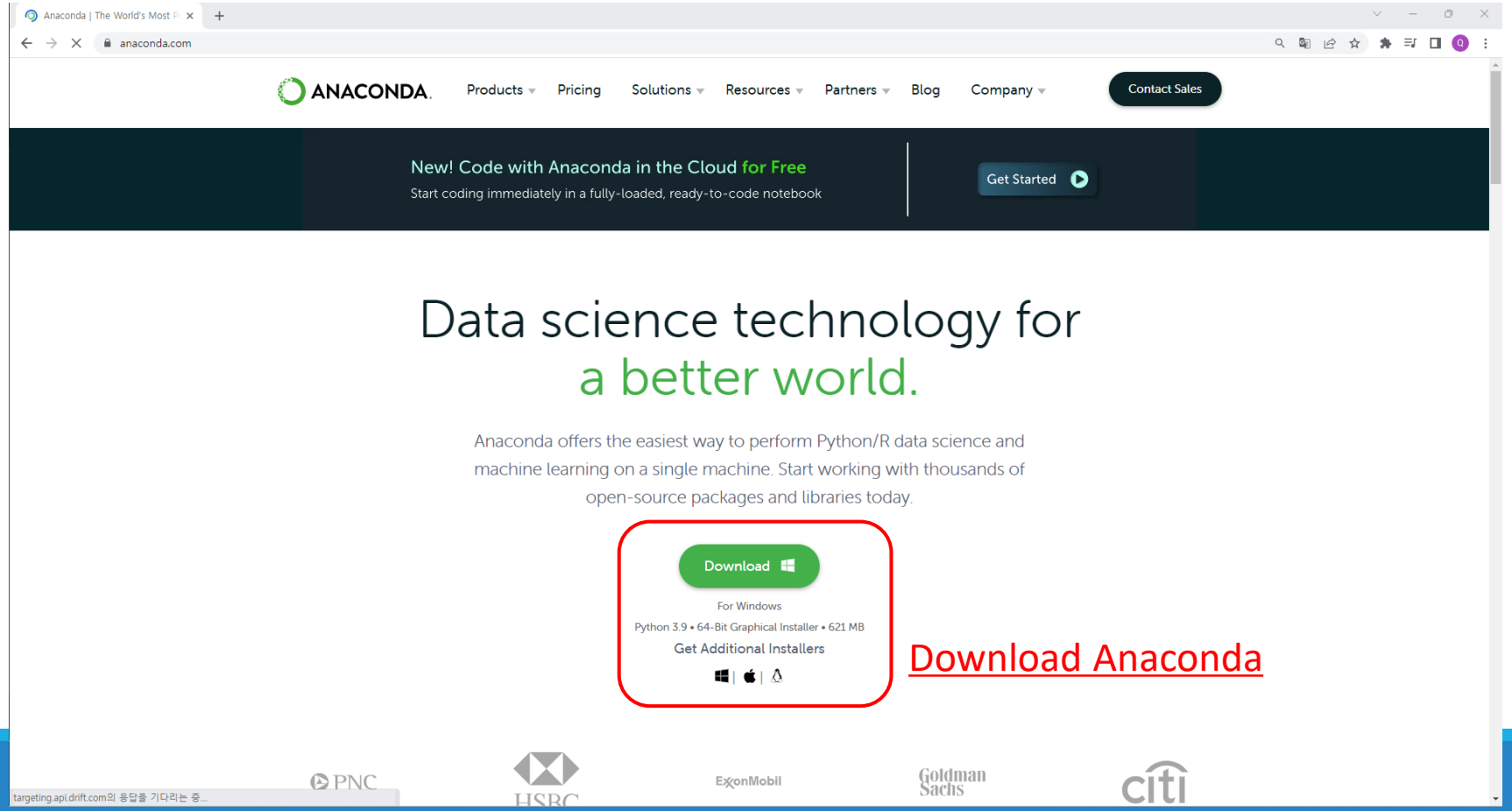
- GitHub: https://github.com/opencv/opencv
- Other resources
  - https://opencv.org/resources/
  - https://cafe.naver.com/opencv (in Korean)

Setting Up Development Environment

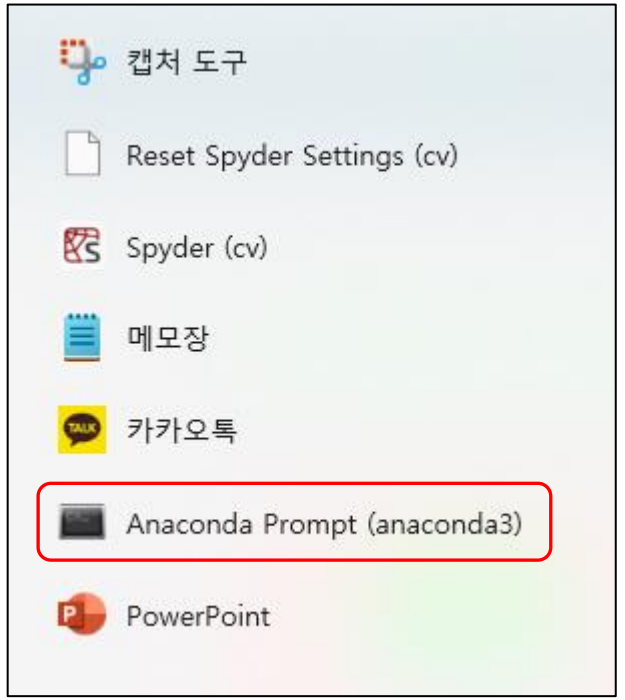
- Install Python Compiler
- Install IDE (Integrated Development Environment)
  - PyCharm, Jupyter, **Spyder**
- Libraries
  - OpenCV (+ NumPy, Matplotlib, PyQt)
  - (Optional) TensorFlow….

Installing Anaconda

- Anaconda (https://anaconda.com)
  - Create an integrated environment to manage Python and packages
  - Provide a virtual environment to use packages of different version



Download Anaconda

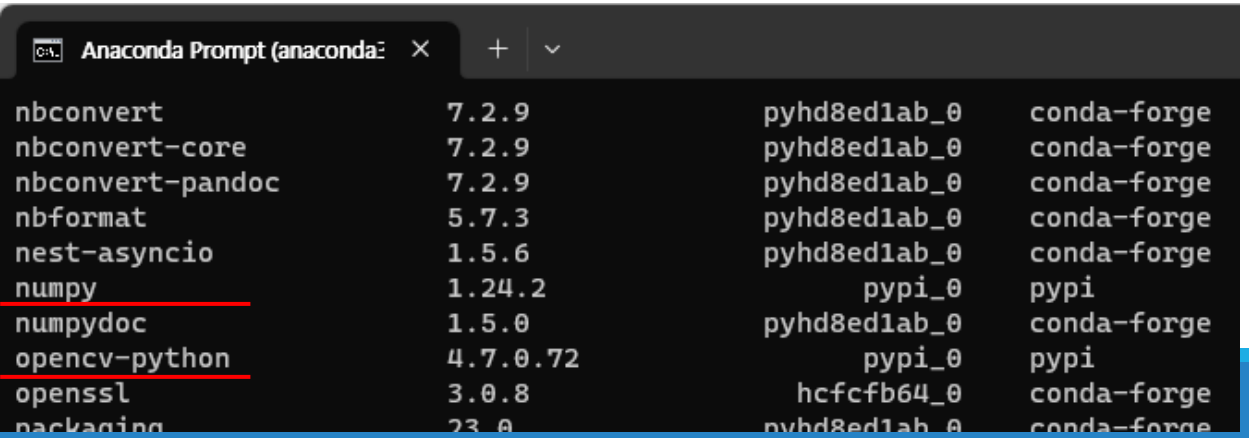


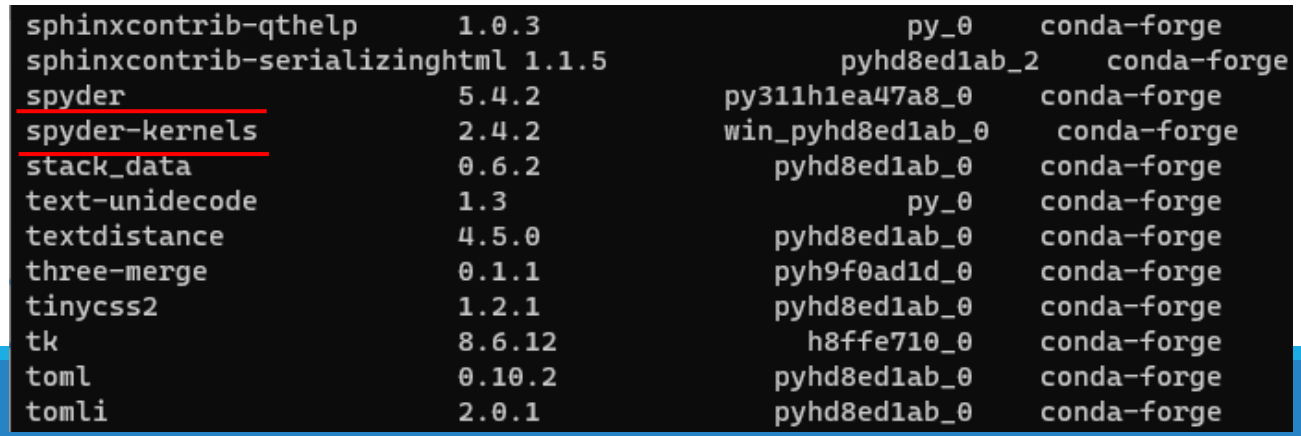
Setting Up Development Environment

- Step 1: install anaconda
- Step 2: create a virtual environment
- Step 3: install IDE (Spyder) and OpenCV

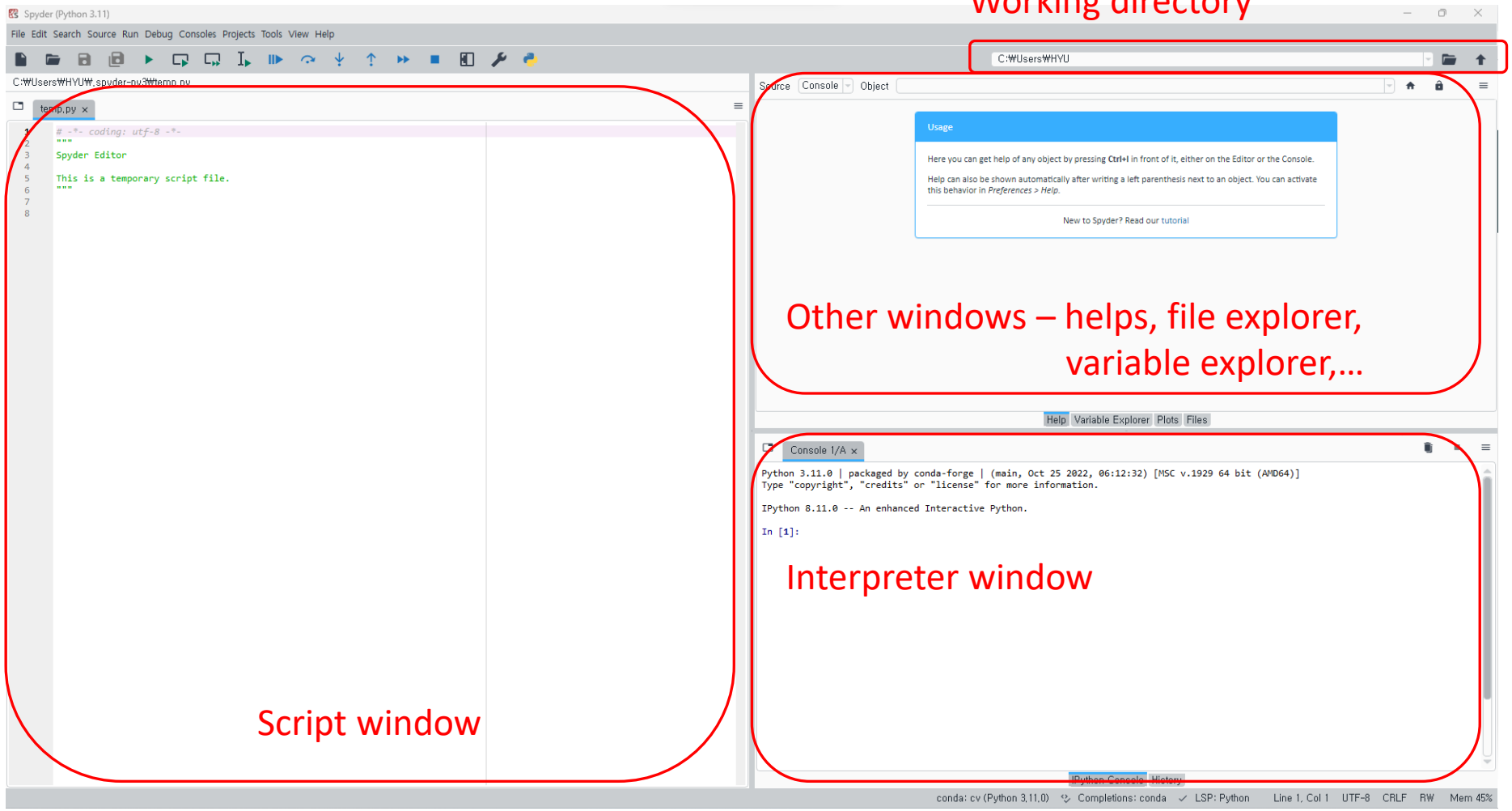
```
(base) C:\Users\HYU> conda create –c conda-forge
-n cv spyder
(base) C:\Users\HYU> conda activate cv
(cv) C:\Users\HYU> pip install opencv-python
(cv) C:\Users\HYU> conda list
(cv) C:\Users\HYU> spyder
```

1. Create a new virtual environment ‘cv’ and install Spyder (IDE) in ‘cv’
2. Switch the base environment to ‘cv’
3. Install OpenCV
4. List the packages in ‘cv’
5. Launch Spyder in ‘cv’





Let's Launch Spyder!



OpenCV: Getting Started!

- Example 1: read an image file and display the image

example1.py

```
1   import cv2 as cv
2   import sys
3
4   img = cv.imread('Erica.jpg')
5
6   if img is None:
7       sys.exit('No file found')
8
9   cv.imshow('HY24011', img)
10
11  cv.waitKey()
12  cv.destroyAllWindows()
```

Console 1/A

```
Python 3.11.0 | packaged by conda-forge | (main, Oct 25 2022, 06:12:32) [MSC v.1929 64 bit (AMD64)]
Type "copyright", "credits" or "license" for more information.

IPython 8.11.0 -- An enhanced Interactive Python.

In [1]: runfile('D:/CV2024-Spring/practice1/src/example1.py', wdir='D:/CV2024-Spring/practice1/src')
```

OpenCV: Getting Started!

- Example 1: read an image file and display the image

example1.py

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2   import sys
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7       sys.exit('No file found')
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9   cv.imshow('HY24011', img)
10
11  cv.waitKey()
12  cv.destroyAllWindows()
```

(L1) import opencv module and bind it to ‘cv’
(L2) to use system calls (i.e. exit())
(L4) read an image from an image file and store to ‘img’
(L9) display ‘img’ on the screen

Image in OpenCV

- An image in OpenCV: a numpy.ndarray object
  - Numpy: a package including mathematical functions, random number generators, linear algebra routines, etc. (https://numpy.org)
  - Numpy.ndarray: N-dimensional array object
  - Can use member functions of numpy.ndarray

    - ‘dir(img)’ to list all member functions

```
In [2]: type(img)
Out[2]: numpy.ndarray

In [3]: img.shape
Out[3]: (600, 800, 3)
```

```
In [7]: help(img.trace)
Help on built-in function trace:

trace(...) method of numpy.ndarray instance
    a.trace(offset=0, axis1=0, axis2=1, dtype=None, out=None)

    Return the sum along diagonals of the array.

    Refer to `numpy.trace` for full documentation.

    See Also
    --------
    numpy.trace : equivalent function
```

Image in OpenCV

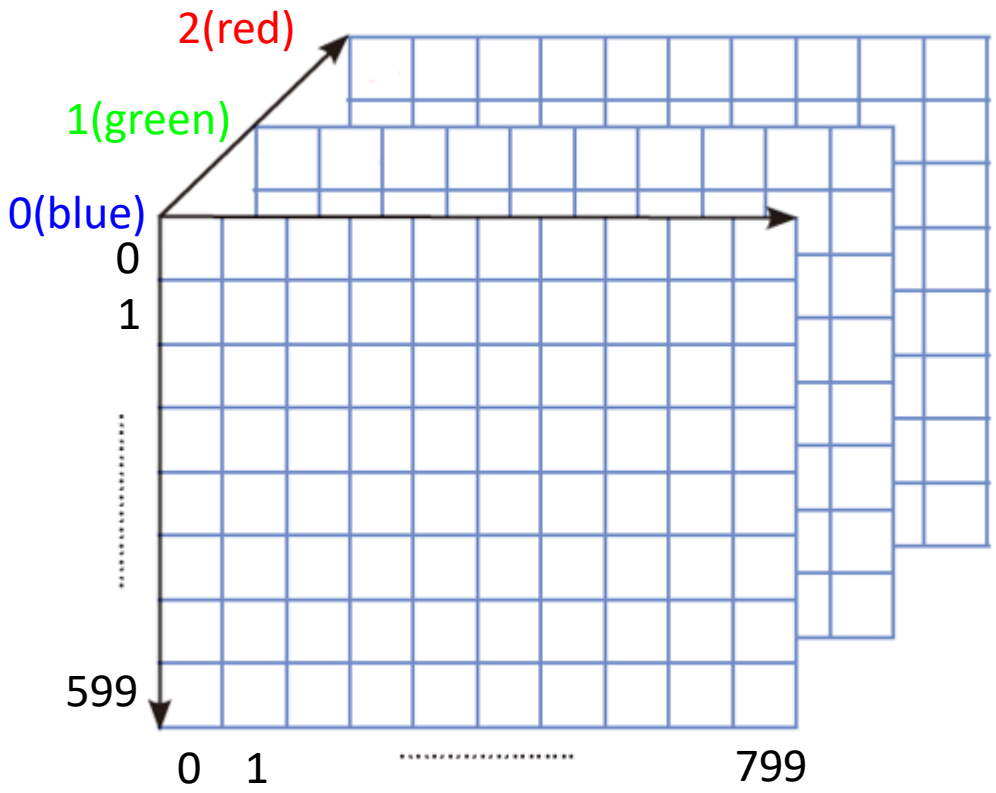
- An image in OpenCV: a 3-dimensional array object
  - (Number of rows) x (Number of columns) x (Number of color channels)
  - An image has #(rows) x #(columns) pixels
  - A pixel is represented as (r, c) = (y, x)
  - A pixel has blue, green, red values

```
In [10]: print(img[0,0])
[248 251 255]

In [11]: print(img[599,0])
[ 84  95 127]

In [12]: print(img[599,799])
[ 87  99 133]

In [13]: print(img[0,799])
[226 226 226]
```



Simple Image Processing

Example 2: convert a color image to a grayscale image and resize the grayscale image

example2.py

```
1  import cv2 as cv
2  import sys
3
4  img = cv.imread('Erica.jpg')
5
6  if img is None:
7      print('No file found')
8
9  gray = cv.cvtColor(img, cv.COLOR_BGR2GRAY)
10 gray_small = cv.resize(gray, dsize=(0,0), fx=0.5, fy=0.5)
11
12 cv.imwrite('Erica_gray.jpg', gray)
13 cv.imwrite('Erica_graysmall.jpg', gray_small)
14
15 cv.imshow('Color Image', img)
16 cv.imshow('Gray Image', gray)
17 cv.imshow('Gray Small Image', gray_small)
18
19 cv.waitKey()
20 cv.destroyAllWindows()
```

Simple Image Processing

example2.py

```
1  import cv2 as cv
2  import sys
3
4  img = cv.imread('Erica.jpg')
5
6  if img is None:
7      print('No file found')
8
9  gray = cv.cvtColor(img, cv.COLOR_BGR2GRAY)
10 gray_small = cv.resize(gray, dsize=(0,0), fx=0.5, fy=0.5)
11
12 cv.imwrite('Erica_gray.jpg', gray)
13 cv.imwrite('Erica_graysmall.jpg', gray_small)
14
15 cv.imshow('Color Image', img)
16 cv.imshow('Gray Image', gray)
17 cv.imshow('Gray Small Image', gray_small)
18
19 cv.waitKey()
20 cv.destroyAllWindows()
```

(L9) change color-space of the image:

- cvtColor(): a function to covert color space of an image
- COLOR_BRG2GRAY: convert the color space of img from BGR model to Grayscale model

❖ Color space: will be covered later in the class

❖ Color spaces covered in OpenCV

https://docs.opencv.org/4.x/d8/d01/group__imgproc__color__conversions.html

(L12~L13) save the processed images to the image files

- Imwrite()

Simple Image Processing

example2.py

```
1  import cv2 as cv
2  import sys
3
4  img = cv.imread('Erica.jpg')
5
6  if img is None:
7      print('No file found')
8
9  gray = cv.cvtColor(img, cv.COLOR_BGR2GRAY)
10 gray_small = cv.resize(gray, dsize=(0,0), fx=0.5, fy=0.5)
11
12 cv.imwrite('Erica_gray.jpg', gray)
13 cv.imwrite('Erica_graysmall.jpg', gray_small)
14
15 cv.imshow('Color Image', img)
16 cv.imshow('Gray Image', gray)
17 cv.imshow('Gray Small Image', gray_small)
18
19 cv.waitKey()
20 cv.destroyAllWindows()
```

(L10) resize a source image (down/up) to the specified size

- dsize: output image size. (0,0) if fx, fy are used instead
- fx, fy: scale factor along horizontal/vertical axes

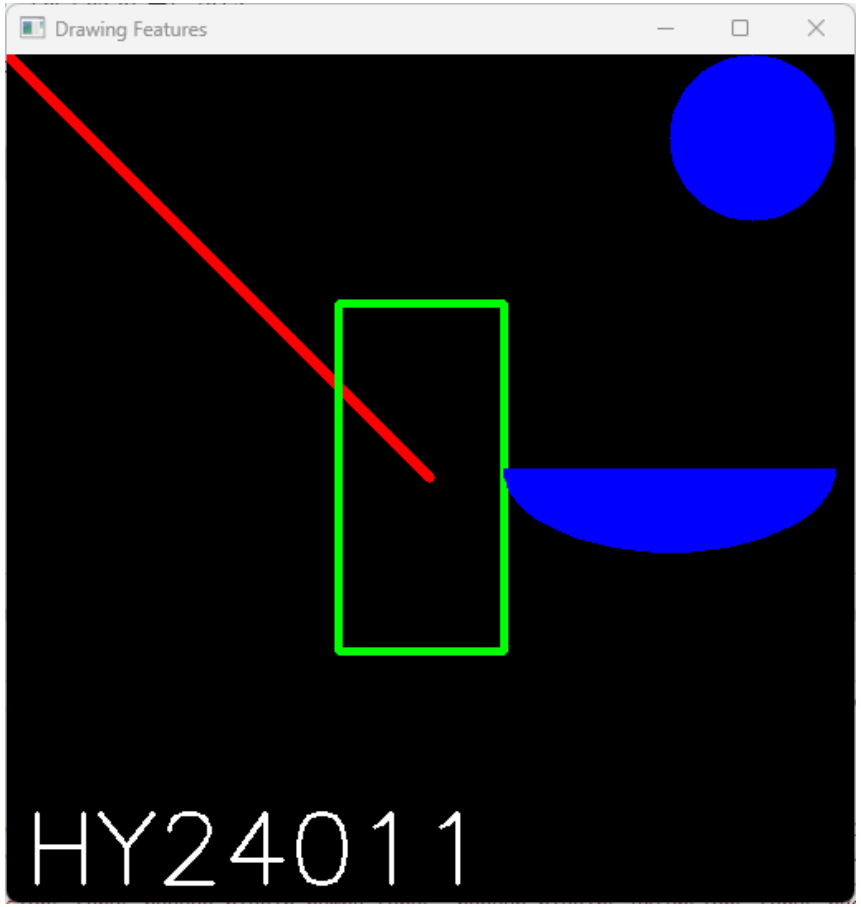
(Question)
How does the image look like if fx and fy are not the same?

Example3: Drawing Functions

- Draw geometric primitives on an image

example3.py

```python
import numpy as np
import cv2 as cv

img = np.zeros((512, 512, 3), np.uint8)

cv.line(img, (0, 0), (255, 255), (0, 0, 255), 5)
cv.rectangle(img, (200, 150), (300, 360), (0, 255, 0), 3)
cv.circle(img, (450, 50), 50, (255, 0, 0), -1)
cv.ellipse(img, (400, 250), (100, 50), 0, 0, 180, 255, -1)

cv.putText(img, 'HY24011', (10, 500), cv.FONT_HERSHEY_SIMPLEX,
           2, (255, 255, 255), 2)

cv.imshow('Drawing Features', img)

cv.waitKey()
cv.destroyAllWindows()
```



Drawing Functions

example3.py

```python
import numpy as np
import cv2 as cv

img = np.zeros((512, 512, 3), np.uint8)

cv.line(img, (0, 0), (255, 255), (0, 0, 255), 5)
cv.rectangle(img, (200, 150), (300, 360), (0, 255, 0), 3)
cv.circle(img, (450, 50), 50, (255, 0, 0), -1)
cv.ellipse(img, (400, 250), (100, 50), 0, 0, 180, 255, -1)

cv.putText(img, 'HY24011', (10, 500), cv.FONT_HERSHEY_SIMPLEX,
           2, (255, 255, 255), 2)

cv.imshow('Drawing Features', img)

cv.waitKey()
cv.destroyAllWindows()
```

(L4) Create an new image in black (0, 0, 0)

(L6) cv.line(): Draw a line on the image

- From (x,y) = (0, 0) to (255, 255) in red (0, 0, 255) with thickness = 5

(L7) cv.rectangle(): Draw a box on the image

- (200, 150): upper left corner vertex of a box
- (300, 360): lower right corner vertex of a box
- Draw a box in green (0,255,0) with thickness = 3

(L8) cv. circle(): Draw a circle on the image

- (450, 50): the center point of a circle
- Radius = 50
- Fill the interior of a circle (-1)

(L9) cv.ellipse(): Draw an ellipse on the image

- (400, 250): the center point of an ellipse
- (100, 50): half of the sizes of the main axes of an ellipse
- 0: rotate an ellipse in 0 degrees
- 0, 180: draw an ellipse from 0 to 180 degrees
- Fill the interior of an ellipse (-1)

Drawing Functions

example3.py

```python
import numpy as np
import cv2 as cv

img = np.zeros((512, 512, 3), np.uint8)

cv.line(img, (0, 0), (255, 255), (0, 0, 255), 5)
cv.rectangle(img, (200, 150), (300, 360), (0, 255, 0), 3)
cv.circle(img, (450, 50), 50, (255, 0, 0), -1)
cv.ellipse(img, (400, 250), (100, 50), 0, 0, 180, 255, -1)

cv.putText(img, 'HY24011', (10, 500), cv.FONT_HERSHEY_SIMPLEX,
           2, (255, 255, 255), 2)

cv.imshow('Drawing Features', img)

cv.waitKey()
cv.destroyAllWindows()
```

(L11) cv.putText(): write ‘HY24011’ on the image

- (10, 500): the bottom left corner point of the text string
- cv.FONT_HERSHEY_SIMPLEX: font type
- 2: Scale(size) of the text
- Write the text in white (255, 255, 255)
- 2: Thickness of the text

❖ All points in drawing functions are given in ‘Rect’ type: (x,y)
❖ For more details:
https://docs.opencv.org/4.x/d6/d6e/group__imgproc__draw.html

Example 4: GUI Features

- GUI (Graphical User Interface) enables users to interact with opencv applications using input/output devices
- Ex4-1: Draw boxes on an image when clicking mouse buttons

example4.py

```python
import cv2 as cv
import sys

img = cv.imread('Erica.jpg')

if img is None:
    print('No file found')


# mouse callback function
def draw(event,x,y,flags,param):
    if event == cv.EVENT_LBUTTONDOWN:
        cv.rectangle(img,(x,y),(x+100,y+100),(0,0,255),2)
    elif event == cv.EVENT_RBUTTONDOWN:
        cv.rectangle(img,(x,y),(x+100,y+100),(0,255,0),2)
    cv.imshow('Drawing a rectangle', img)

cv.namedWindow('Drawing a rectangle')
cv.setMouseCallback('Drawing a rectangle',draw)

while(True):
    if cv.waitKey(1)==ord('q'):
        break
cv.destroyAllWindows()
```

Handling Mouse Events

example4.py

```
1  import cv2 as cv
2  import sys
3
4  img = cv.imread('Erica.jpg')
5
6  if img is None:
7      print('No file found')
8
9
10 # mouse callback function
11 def draw(event,x,y,flags,param):
12     if event == cv.EVENT_LBUTTONDOWN:
13         cv.rectangle(img,(x,y),(x+100,y+100),(0,0,255),2)
14     elif event == cv.EVENT_RBUTTONDOWN:
15         cv.rectangle(img,(x,y),(x+100,y+100),(0,255,0),2)
16     cv.imshow('Drawing a rectangle', img)
17
18 cv.namedWindow('Drawing a rectangle')
19 cv.setMouseCallback('Drawing a rectangle',draw)
20
21 while(True):
22     if cv.waitKey(1)==ord('q'):
23         break
24 cv.destroyAllWindows()
```

- Handle events in OpenCV: via callback functions
- Identify a window with the title of the window (cv.namedWindow())

(L10-L16) Define a callback function :

- The function handles left and right click events
- Draw a red square when clicking left mouse button
- Draw a blue square when clicking right mouse button

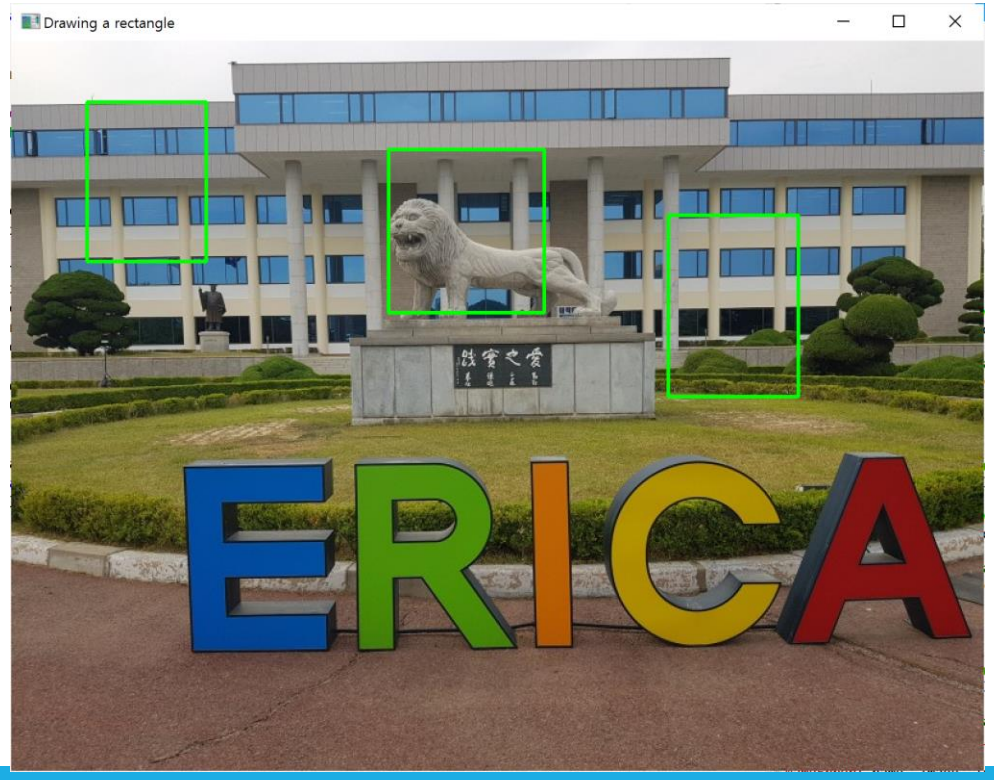
(L19) Register a callback function to handle mouse events

(L21-23) Execute an infinite while loop:
Whenever mouse events happen, call draw()

Ex4-2. Handling Mouse Dragging Events

```python
import cv2 as cv
import sys

img = cv.imread('Erica.jpg')

if img is None:
    print('No file found')


# mouse callback function
def draw(event,x,y,flags,param):
    global ix, iy;

    if event == cv.EVENT_LBUTTONDOWN:
        ix,iy=x,y
    elif event == cv.EVENT_LBUTTONUP:
        cv.rectangle(img,(ix,iy),(x,y),(0,255,0),2)
    cv.imshow('Drawing a rectangle', img)

cv.namedWindow('Drawing a rectangle')
cv.setMouseCallback('Drawing a rectangle',draw)

while(True):
    if cv.waitKey(1)==ord('q'):
        break
cv.destroyAllWindows()
```

- Change the size of boxes while pressing a left mouse button
- Save the initial position of a box when clicking down a mouse, but do not draw anything
- Draw a box with the saved position and the current position when clicking up a mouse



Ex4-3: Paint Brush

```python
import cv2 as cv

img = cv.imread('Erica.jpg')

if img is None:
    print('No file found')

BrushSize=5
LColor,RColor=(255,0,0),(0,0,255)

def painting(event,x,y,flags,param):
    if event==cv.EVENT_LBUTTONDOWN:
        cv.circle(img,(x,y),BrushSize,LColor,-1)
    elif event==cv.EVENT_RBUTTONDOWN:
        cv.circle(img,(x,y),BrushSize,RColor,-1)
    elif event==cv.EVENT_MOUSEMOVE:
        if flags==cv.EVENT_FLAG_LBUTTON:
            cv.circle(img,(x,y),BrushSize,LColor,-1)
        elif flags==cv.EVENT_FLAG_RBUTTON:
            cv.circle(img,(x,y),BrushSize,RColor,-1)
    cv.imshow('Painting', img)

cv.namedWindow('Painting')
cv.imshow('Painting', img)
cv.setMouseCallback('Painting', painting)

while(True):
    if cv.waitKey(1)==ord('q'):
        break
cv.destroyAllWindows()
```

❖ Draw circles not only in pressing mouse buttons, but in moving mouse (L16-L20) When a mousemove event is detected, the event also saves which button is pressed in the ‘flags’ parameter

(Example_optional) Video Capture

```
1  import cv2 as cv
2  import sys
3
4  cap = cv.VideoCapture(0, cv.CAP_DSHOW)
5  if not cap.isOpened():
6      sys.exit('Cannot open camera')
7
8  while True:
9      # Capture frame-by-frame
10     ret,frame = cap.read()
11
12     if not ret:
13         print('Cannot receive frame')
14         break
15     cv.imshow('Video Display', frame)
16
17     key=cv.waitKey(1)
18     if key==ord('q'):
19         break
20
21 # release the capture
22 cap.release()
23 cv.destroyAllWindows()
```

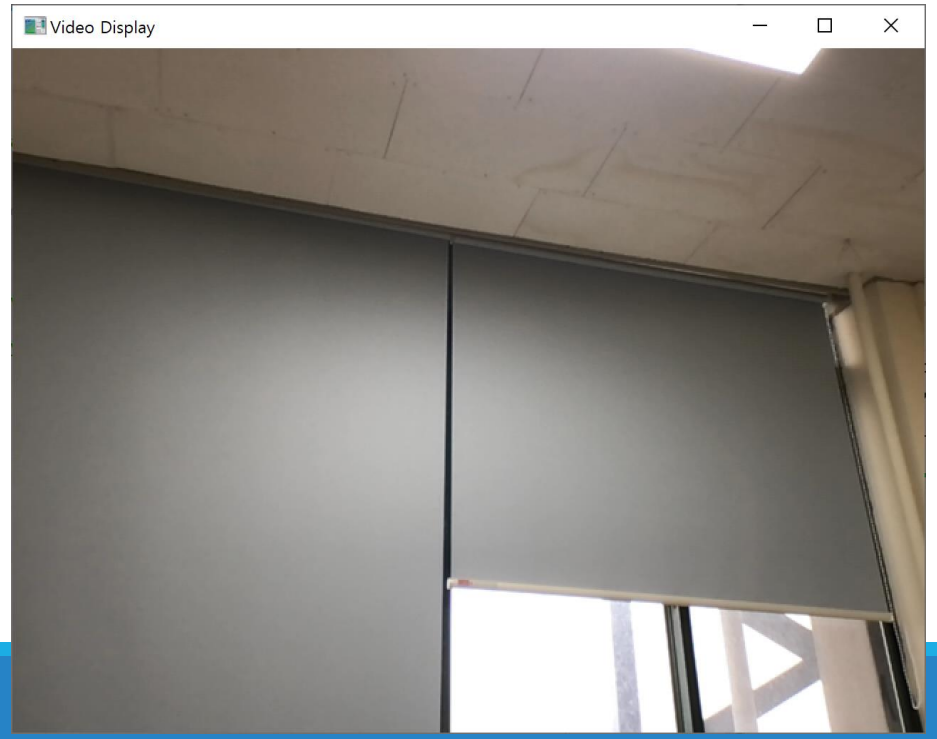
❖ Capture live stream with a camera and display on the screen

(L4) cv.VideoCapture(): create a 'VideoCapture' object

(L22) cap.release(): release(disconnect) the camera after use

(L8-L20) Capture frame-by-frame images

- (L10) Capture the current frame to 'frame'
- (L12~L14) If failed to capture, halt
- (L15) Display the captured frame



Review Task!

- Create an image as follows:

Write your student ID here

[Instruction]
- Grayscale image
- Draw a rectangle around ‘ERICA’ in magenta
- Write your own student ID below in green
- Save the new image to ‘jpg’ file

[Submission]
Submit your python file and jpg file to LMS

[Hint]
https://docs.opencv.org/4.x/de/d25/imgproc_color_conversions.html
You might need 2 color conversions