OpenCV with Python

OpenCV is an open source computer vision and machine learning software library. The official library has more than 2500 optimized algorithms, which includes a comprehensive set of classic algorithms as well as state of the art computer vision and machine learning algorithms.

Some popular algorithms in OpenCV can be used :

- To detect and recognize faces.
- To identify objects.
- To track moving objects.
- To stitch images together and lot more.

OpenCV software library is fully supported on Linux, Windows, Android and MacOS. It provides interface in multiple languages including Python, C, C++, Java and MATLAB.

OpenCV-Python is the Python API for OpenCV. It combines the best qualities of OpenCV and power of python scripting. Due to python's full compatibility with machine learning libraries and libraries like Numpy, Scipy, Matplotlib, OpenCV-Python is one of the most popular interface to be used for image processing.

Installation and Setup of OpenCV-Python

On Ubuntu

- Refresh the apt database.
  `# apt-get update`
- Install the package.
  `# apt-get install python3-opencv`
- (Optional) Install related python libraries using PIP.
  `$ pip3 install numpy matplotlib scipy`

OpenCV-Python Programming

1. Getting Started with Images

Things to do :-

- Read an Image from file. (imread)
- Display an Image in an OpenCV Window. (imshow)
- Write an image to a file. (imwrite)

Source Code :

```
import cv2 as cv
import sys

img = cv.imread("samples/starry_night.jpg")
if img is None:
  sys.exit("Could not read the image.")

cv.imshow("Display window", img)
k = cv.waitKey(0)

if k == ord("s"):
  cv.imwrite("processed/starry_night.png", img)
```

Code Analysis :-

```
img = cv.imread("samples/starry_night.jpg")
```

Using `imread(param1, param2)` function, we can read the image file. The First parameter accepts the File path (Absolute or Relative), Second parameter is optional and specifies the format in which we want the image.

RGB 8-bit (Default)

Grayscale

Possible values for Second Parameter :-

- IMREAD_COLOR : loads the image in the BGR 8-bit format. (Default param)
- IMREAD_UNCHANGED : loads the image as it is.
- IMREAD_GRAYSCALE : loads the image as an intensity one.

Above properties can be accessed using cv.* prefix.

```
cv.imshow("Display window", img)
k = cv.waitKey(0)
```

`imshow(param1, param2)` function is used to display the image GUI. The first parameter accepts the title of the window and the second argument is what cv image object to show.

`waitKey(param1)` function is used to tell how long (measured in milliseconds) should it display the image window. A value of 0 means forever.

```
if k == ord("s"):
  cv.imwrite("processed/starry_night.png", img)
```

`imwrite(param1, param2)` function is used to save/write the image file. The first parameter accepts the file name to save with and the second argument is what cv image object to save.

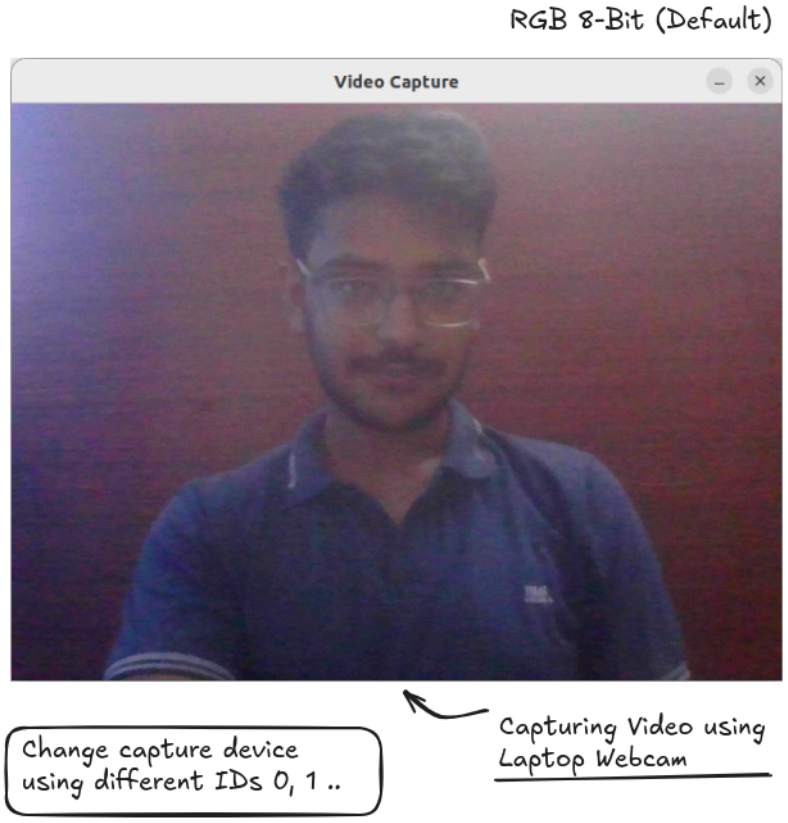
2. Getting started with Videos

Things to do :-

- To read, display and save Video.
- To capture video from a camera.

Capture video from a camera

To capture a video from a camera and convert it to grayscale.



Source Code :-

```
import numpy as np
import cv2 as cv

cap = cv.VideoCapture(0)
if not cap.isOpened() :
  print("Unable to open camera!")
  exit()

while True:
  ret, frame = cap.read()

  if not ret:
      print("Can't receive frame. Exiting ...")
      break

  gray = cv.cvtColor(frame, cv.COLOR_BGR2GRAY)
  cv.imshow('Video Capture', gray)
  if cv.waitKey(1) == ord('q'):
```

```
      break

cap.release()
cv.destroyAllWindows()
```

Code Analysis :-

```
cap = cv.VideoCapture(0)
if not cap.isOpened() :
  print("unable to open camera!")
  exit()
```

`videoCapture(camera_ID)` function is used to select a camera hardware to capture video from. camera_ID can be 0, 1, 2 ... etc.

`cap.isOpened()` returns boolean if the requested camera access is granted or not. If not granted, we can use `cap.open()` to manually invoke it.

```
ret, frame = cap.read()

if not ret:
  print("Can't receive frame. Exiting ....")
  break
```

`ret` boolean shows the status of frame, whether it is received successfully or not.
`frame` contains the actual captured image data.

```
gray = cv.cvtColor(frame, cv.CLOR_BGR2GRAY)
```

`cvtColor(param1, param2)` function to transform color space of the captured frame. In the example above, I am converting it to GrayScale.

```
cap.release()
cv.destroyAllWindows()
```

To release and close all the opened camera hardware and quit the program gracefully.

`cap.get(propID)` method can be used to access some of the features(width, height) of the video, where propID is a number from 0 to 18.

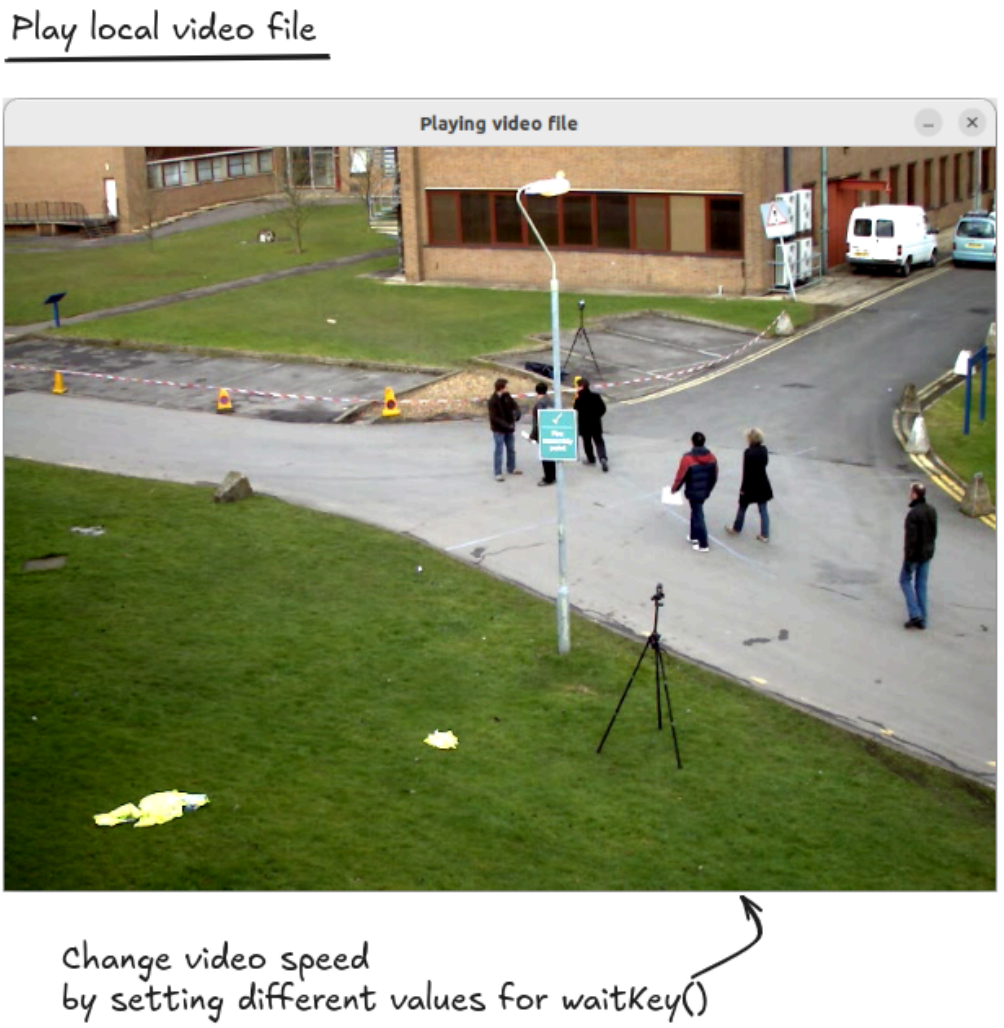
Some of the commonly used propIDs are :-

- CAP_PROP_FRAME_WIDTH
- CAP_PROP_FRAME_HEIGHT

`cap.set(propID, value)` method can be used to modify these capture's propID. For example to set a custom resolution.

Playing Video from file

To play a video file stored locally on the device.



Source Code :-

```
import numpy as np
import cv2 as cv
cap = cv.VideoCapture("samples/vtest.avi")

while cap.isOpened():
  ret, frame = cap.read()

  if not ret:
    print("Can't receive frame! Exiting ....")
        break

  cv.imshow("Playing video file", frame)
```

```
  if cv.waitKey(10) == ord('q'):
        break

cap.release()
cv.destroyAllWindows()
```

Code Analysis :-

```
cv.VideoCapture("samples/vtest.avi")
```

If we want to play a locally stored video file, we can directly pass it the absolute/relative path.

```
if cv.waitKey(25) == ord('q'):
        break
```

renders each frame with a time gap of 25 ms, most closest to real-life scenarios. We can increase the speed of video by reducing it value or increase the value to make it even more slower.

> Make sure that the latest version of either FFMPEG or Gstreamer is installed on your system.

Saving a Video

To save/store a video file captured from camera device.
For images, it is very sample, just use `imwrite()` method.
For videos, we need to use *VideoWriter* object.

Source Code :-

```
import numpy as np
import cv2 as cv

cap = cv.VideoCapture(0)
fourcc = cv.VideoWriter_fourcc(*'x264')
out = cv.VideoWriter('processed/output.mkv', fourcc, 20.0, (640, 480))

while cap.isOpened():
  ret, frame = cap.read()
  if not ret:
    print("Can't receive frame! Exiting ....")
    break
  out.write(frame)
  cv.imshow('Video frame', frame)
  if cv.waitKey(1) == ord('q'):
    break
```

```
cap.release()
out.release()
cv.destroyAllWindows()
```

Code Analysis :-

```
fourcc = cv.VideoWriter_fourcc(*'x264')
```

FourCC code is a 4-byte code used to specify the video codec. There are multiple video codecs available. Some of the most popular ones are DIVX(avi), XVID, MJPG(mp4), X264(mkv), WMV1, WMV2.
Each codec has some advantages or disadvantages over each other, anyway it depends on the context of application.

```
out = cv.VideoWriter('processed/output.avi', fourcc, 20.0, (640, 480))
```

`VideoWriter()` method to create videowriter object, that is used to save the video file. The first parameter is file name, second is fourcc code, third is fps, fourth is resolution.

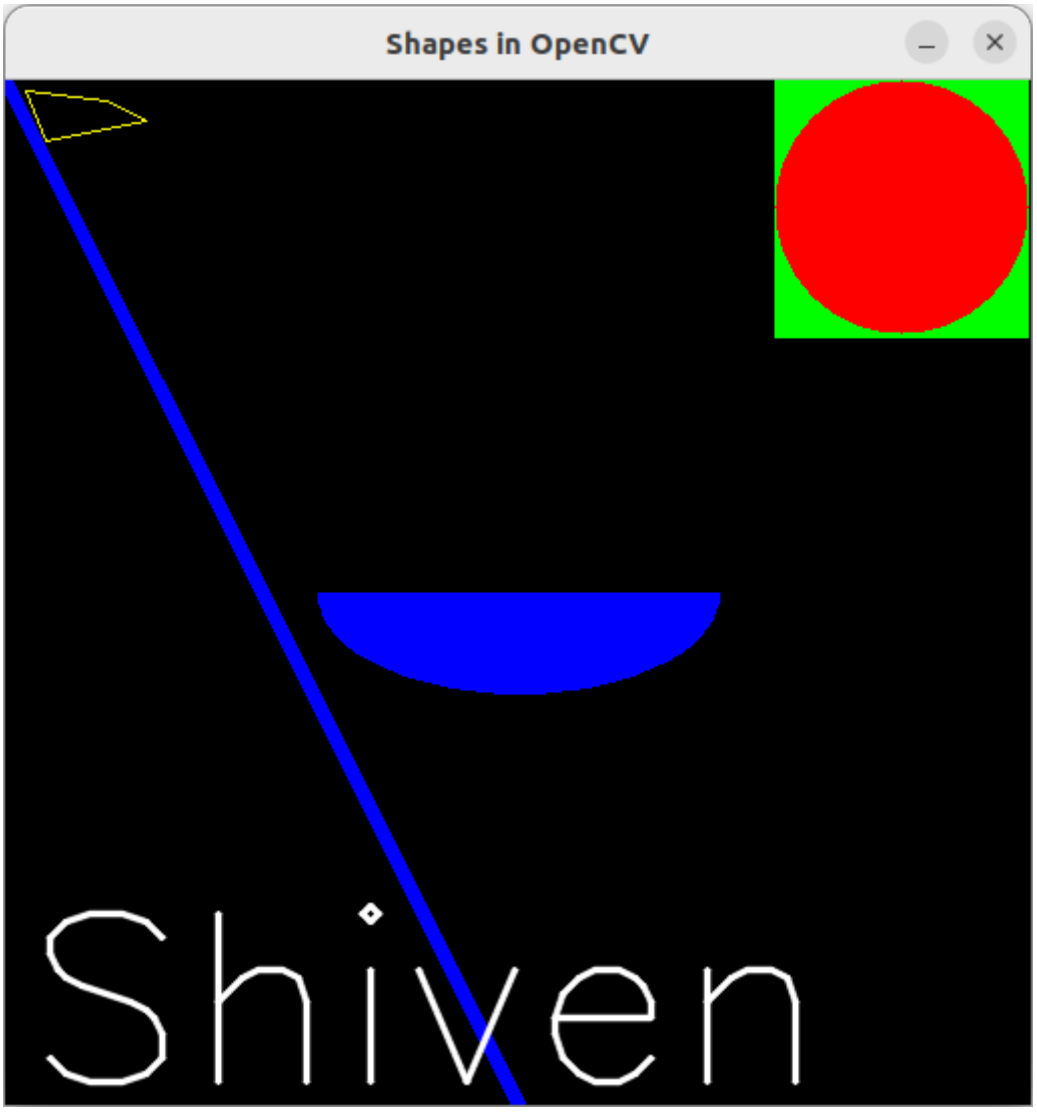
3. Drawing Functions in OpenCV

Things to Learn :-

- Learn to draw different geometrix shapes with OpenCV
- Learn cv.line, cv.circle, cv.rectangle, cv.ellipse, cv.putText

Common arguments to pass in the used functions are

- img : The image where you want to draw the shapes.
- color : Color of the shape, **BGR Format**, pass it as a tuple (255, 0, 0) for blue.
- thickness : Thickness of the line in px. -1 for filled shapes.
- lineType : Type of line to use 8-connected or anti-aliased line.

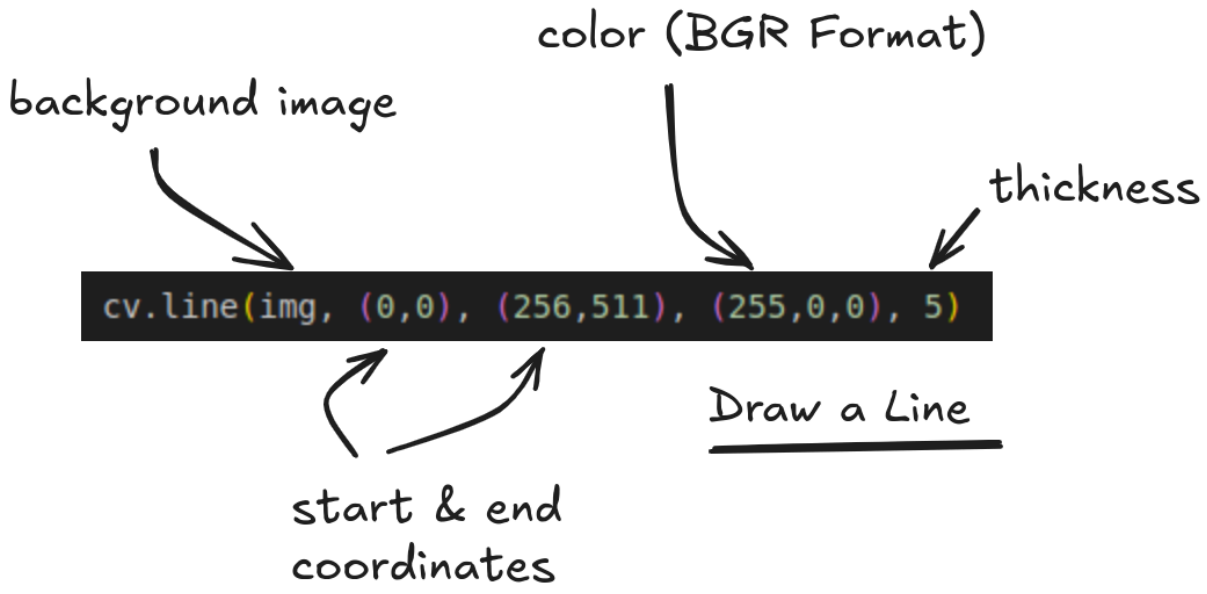


Create a black canvas background

Source Code :-

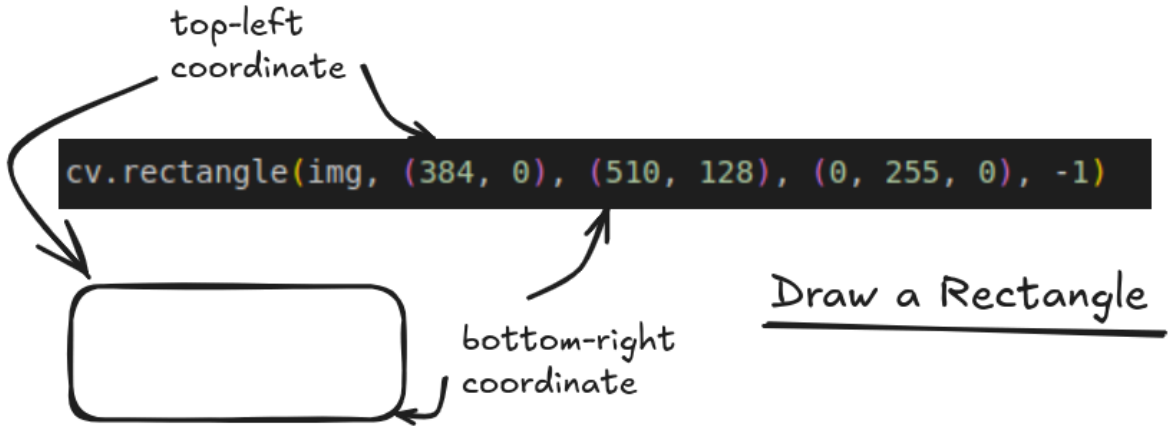
```
import numpy as np
import cv2 as cv

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

Drawing Line



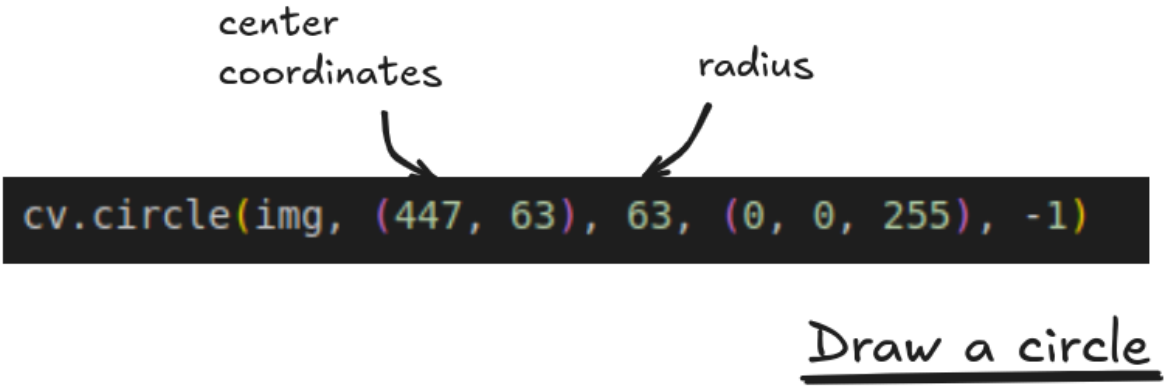
To draw a line, you need to pass *starting* and *ending coordinates* of line.

Drawing Rectangle



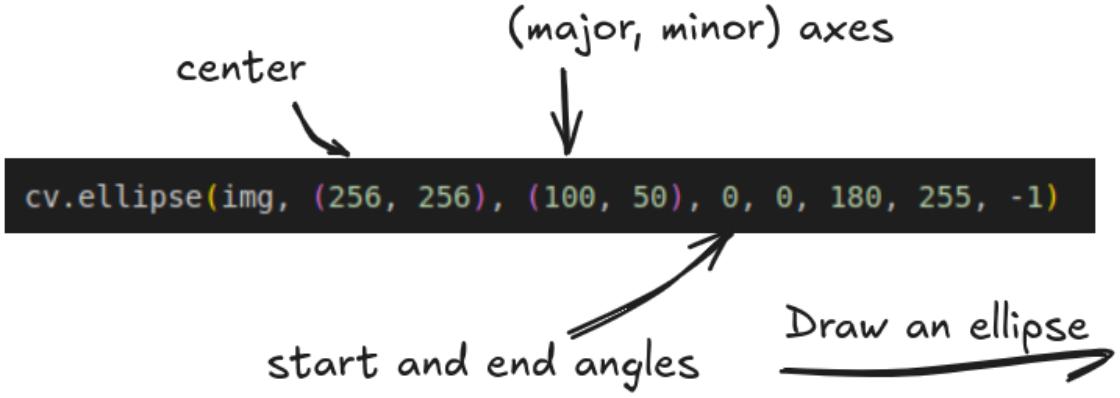
To draw a rectangle, you need to pass top-left and bottom-right corner coordinates.

Drawing Circle



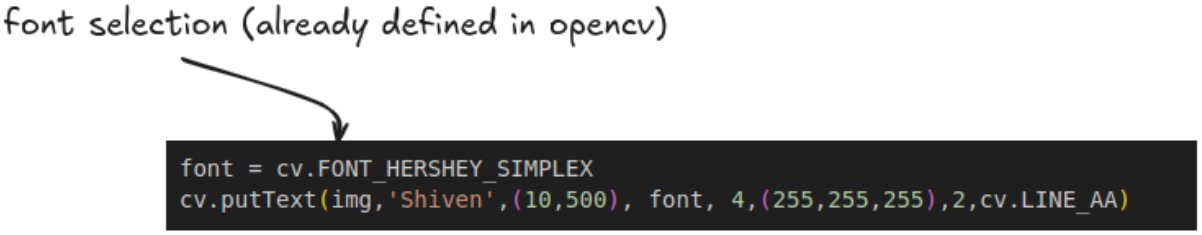
To draw a circle, you need to pass center coordinates and radius.

Drawing ellipse



To draw an ellipse, we need to pass several parameters, center location, axes length, angle measuring starting and ending angle of ellipse arc from major axis.

Adding text to images



4. Mouse as a paint brush

Things to learn :-

- To handle mouse events in OpenCV
- **Mouse event :** anything related to mouse like left-button down, left-button up etc. Returns the coordinates (x, y) with this event and location, we can do whatever we like.
- Learn about cv.setMouseCallback() function

List all available events :

```
import cv2 as cv
events = [i for i in dir(cv) if 'EVENT' in 1]
print(events)
```

```
['EVENT_FLAG_ALTKEY', 'EVENT_FLAG_CTRLKEY', 'EVENT_FLAG_LBUTTON', 'EVENT_FLAG_MBUTTON', 'EVENT_FLAG_RBUTTON', 'EVENT_FLAG_SHIFTKEY', 'EVENT_LBUTTONDBLCLK', 'EVENT_LBUTTONDOWN', 'EVEN
T_LBUTTONUP', 'EVENT_MBUTTONDBLCLK', 'EVENT_MBUTTONDOWN', 'EVENT_MBUTTONUP', 'EVENT_MOUSEHWHEEL', 'EVENT_MOUSEMOVE', 'EVENT_MOUSEWHEEL', 'EVENT_RBUTTONDBLCLK', 'EVENT_RBUTTONDOWN', '
EVENT_RBUTTONUP']
```

Application to draw a circle on an image

To make an application that draws a filled circle when double left clicked.

Source Code :-

```
import cv2 as cv
import numpy as np

# defining mouse callback function
def draw_circle(event, x,y, flags, param):
  if event == cv.EVENT_LBUTTONDBLCLK:
    # draws a blue filled circle, when double clicked.
    cv.circle(img, (x,y), 100, (255, 0, 0), -1)

img = np.zeros((512, 512, 3), np.uint8)
cv.namedWindow('image')
cv.setMouseCallback('image', draw_circle)

while(1):
  cv.imshow('image', img)
  if cv.waitKey(20) & 0xFF == 27:
    break

cv.destroyAllWindows()
```

Code Analysis :-

In the given example above, I have defined a function draw_circle that is ought to render a circle on the canvas, when left-clicked twice. To achieve this effect, I am using

`EVENT_LBUTTONDBLCLK` callback function. That is invoked, when I click on the canvas twice with left button (as the name suggest).

Application to draw a rectangle or circle on an image

To make an application that draws either rectangle or circles (depending on the mode we select) by dragging the mouse.

Source Code :-

```
import numpy as np
import cv2 as cv

drawing = False # variable to store the state of canvas
mode = True # true -> rectangle, false -> circle.
ix, iy = -1, -1

# Callback function
def draw_shape(event, x, y, flags, param):
    global ix, iy, drawing, mode
    if event == cv.EVENT_LBUTTONDOWN:
        drawing = True
        ix, iy = x, y

    elif event == cv.EVENT_MOUSEMOVE:
        if drawing == True:
            if mode == True:
                cv.rectangle(img, (ix, iy), (x, y), (0, 255, 0), -1)
            else:
                cv.circle(img, (x, y), 5, (0, 255, 255), -1)

    elif event == cv.EVENT_LBUTTONUP:
        drawing = False
        if mode == True:
            cv.rectangle(img, (ix, iy), (x, y), (0, 255, 0), -1)
        else:
            cv.circle(img, (x, y), 5, (0, 0, 255), -1)

img = np.zeros((512,512,3), np.uint8)
cv.namedWindow('image')
cv.setMouseCallback('image',draw_shape)

while(1):
    cv.imshow('image',img)
    k = cv.waitKey(1) & 0xFF
    if k == ord('m'):
        mode = not mode
    elif k == 27:
```

```
        break

cv.destroyAllWindows()
```