Intro to Computer Vision with OpenCV-Python (Day 1)

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Juyong Kim(juyong.kim@vision.snu.ac.kr)

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VISION & LEARNING

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[Day 1]

- OpenCV-Python
  - Introduction / Image Manipulation / Draw Objects
- Edge Detection
  - Image gradient / Canny edge detection

[Day 2]

- Object Classification
  - Object classification / Image feature / Classifier
- Object Tracking
  - Histogram-based Object Tracking / LK optical flow / OpenCV tracking API

OpenCV-Python

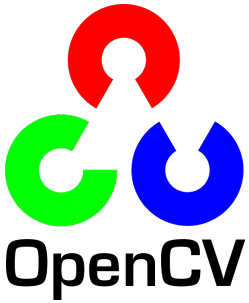
Introduction

Image Manipulation

Draw objects

OpenCV-Python

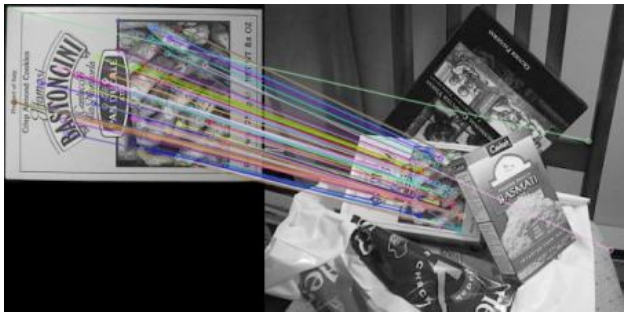
- OpenCV
  - **Computer vision library** started from 1995(Intel)
  - Now supports a multitude of algorithms related to CV and ML(a little of)
- OpenCV-Python
  - OpenCV is basically written in C++
  - OpenCV-Python is a **Python wrapper** of OpenCV
- Prior knowledge of **Python** and **Numpy** is needed
  - A Quick guide to Python - A Byte of Python
  - Basic Numpy Tutorials / Numpy Examples List



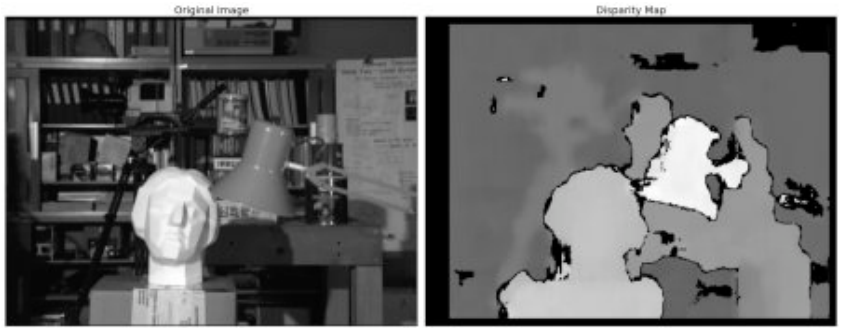
OpenCV-Python

- Examples of algorithms with OpenCV
  - Face detection

  - Feature extraction/matching



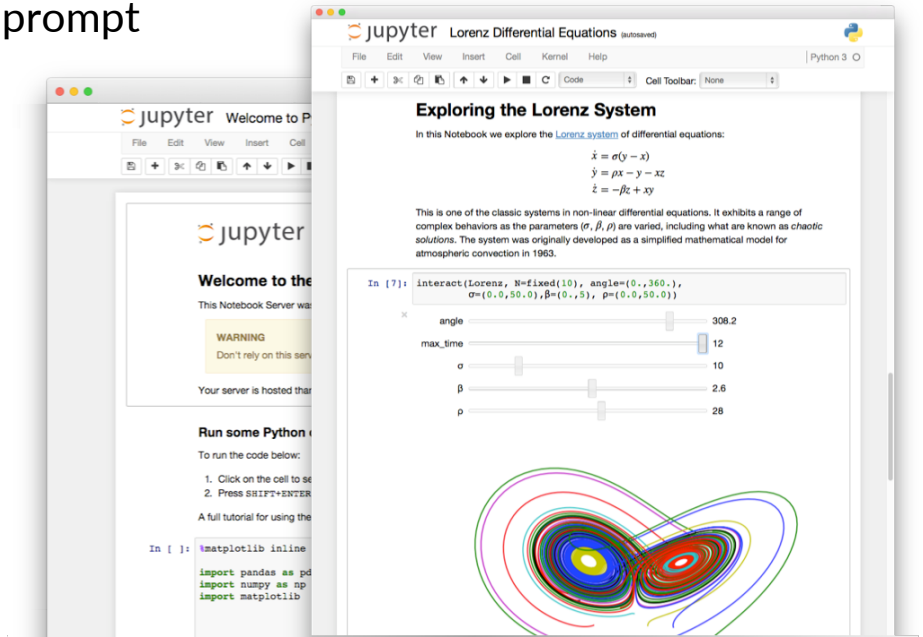
  - Depth map from stereo images



  - Image inpainting

Jupyter Notebook

- Open source web application that
  - compute codes interactively in web browsers
  - share codes and rich text in notebook documents
  - support 40+ programming languages
- Most codes are in Jupyter Notebook formats
  - Except object tracking tutorials
- Running Jupyter Notebook
  1. Open shortcut “cmd – 1705_sk_opencv” on the desktop
  2. Type “`jupyter notebook`” on the prompt
     (Home will be opened automatically)



Using OpenCV-Python

- Import OpenCV-Python package "**cv2**"

```
import numpy as np
import cv2 # OpenCV-Python
%matplotlib inline
import matplotlib.pyplot as plt
```

- **Numpy** arrays are data structure used in cv2
  - Converted from/to CvMat(OpenCV in C++) by OpenCV-Python
  - Also used in many python packages

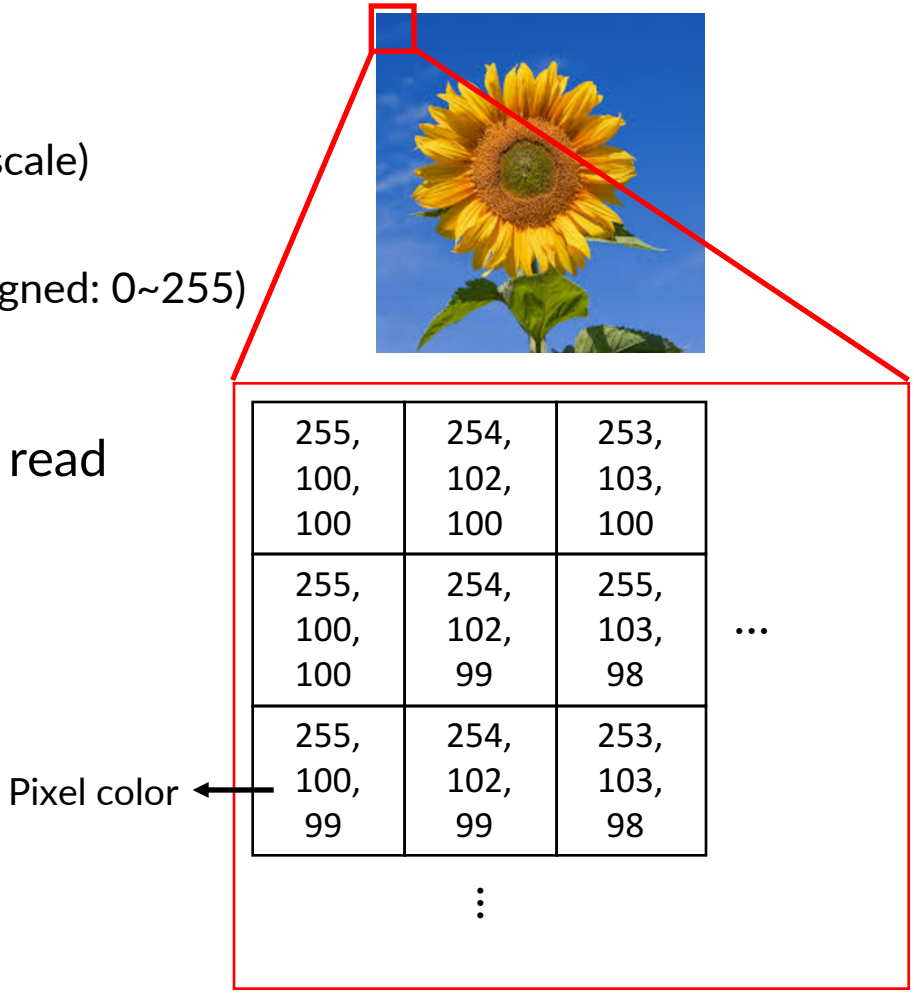
Open/Display an Image

- Open an image

```
img = cv2.imread('image.jpg', cv2.IMREAD_COLOR)
```

- The output is a Numpy array
  - 3D(H×W×C for color)/2D(H×W for grayscale)
  - Top-left to bottom-right
  - Data type(dtype): `np.uint8`(1-byte unsigned: 0~255)

- Flag specifies the way image should be read
  - cv2.IMREAD_COLOR
  - cv2.IMREAD_GRAYSCALE
  - cv2.IMREAD_UNCHANGED

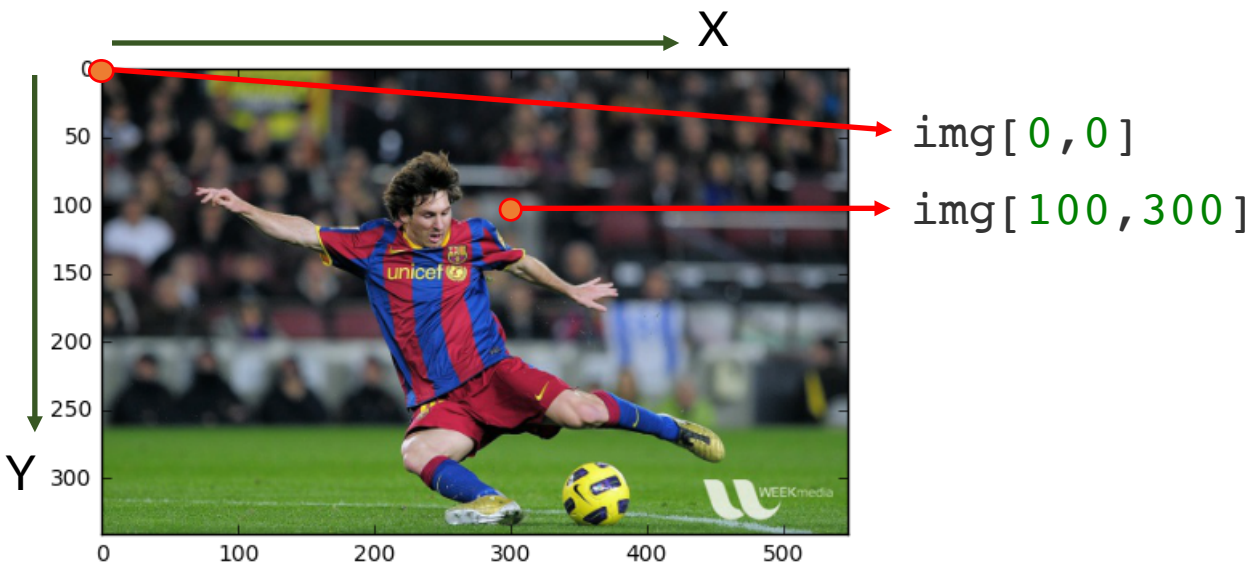


Open/Display an Image

- Display an image using **Matplotlib**

```
# display an image using matplotlib
plt.imshow(img) # => The output in wrong color!!
plt.imshow(cv2.cvtColor(img, cv2.COLOR_BGR2RGB))
```

  - `plt.imshow(img)` displays an (RGB, RGBA, grayscale) image
  - OpenCV represents RGB images as Numpy arrays in **REVERSE** order(**BGR** not RGB)
  - `cv2.cvtColor(img, conversion)` provides conversion among many colortypes



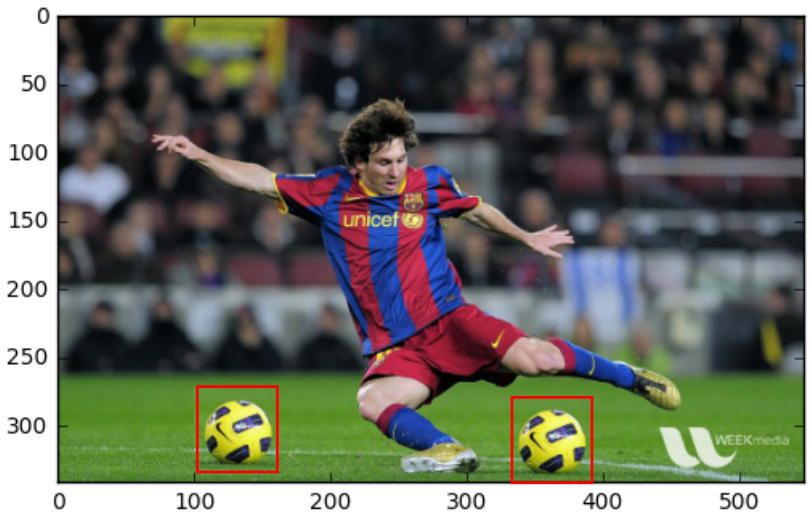
Modify Pixels & ROI

- Pixel and ROI(Region of Interest) can be accessed by Numpy indexing
  - [row, column] ordering – same as matrix indexing

```
# Access a pixel value(BGR order)
img[50, 235]
```

```
=> array([27, 25, 24], dtype=uint8)
```

```
# ROI is obtained using Numpy indexing
ball = img[280:340, 330:390]
img[273:333, 100:160] = ball
```



Draw Objects

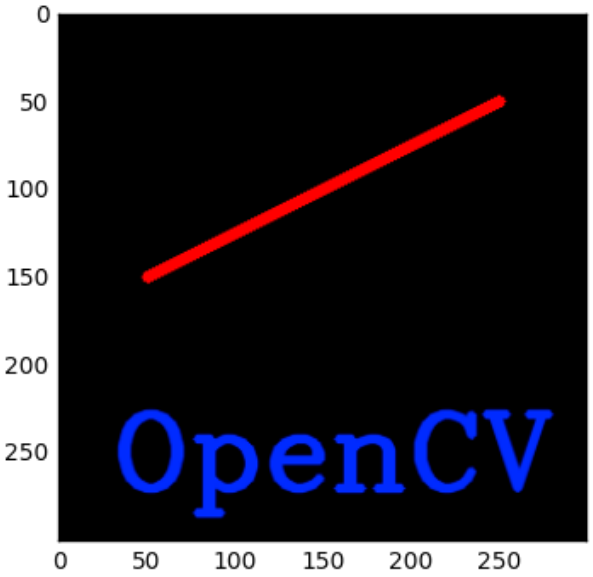
- Draw object(line, rectangle, circle, ellipse, polygon)
  - `cv2.line()`, `cv2.rectangle()`, `cv2.circle()`, `cv2.ellipse()`, `cv2.polyline()`
- Put some text
  - `cv2.putText()`
- Arguments
  - `cv2.function(image, {properties of object})`
  - **RGB** order in color(not BGR)
  - **X, Y** order in position(not row, column)

Draw Objects

- Example

```
# cv2.line(image, startPoint, endPoint, rgb, thinkness)
cv2.line(img, (50,150), (250,50), (255,0,0), 5)

# cv2.putText(image, text, bottomLeft, fontType, fontScale,
rgb, thinkness, lineType)
font = cv2.FONT_HERSHEY_COMPLEX
cv2.putText(img, 'OpenCV', (30,270), font, 2, (0,0,255), 3,
cv2.LINE_AA)
```



Let’s Check the Code

1_getting_started.ipynb

Edge Detection

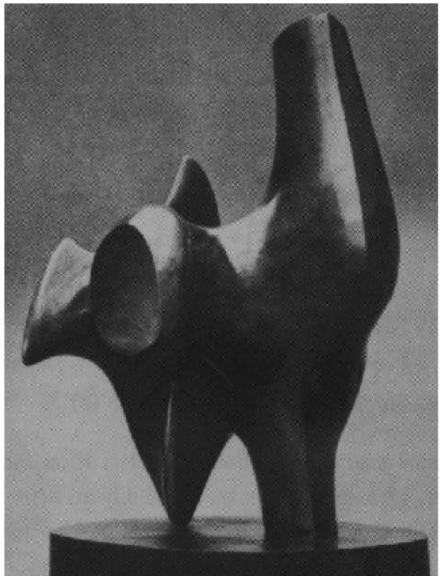
Image gradient

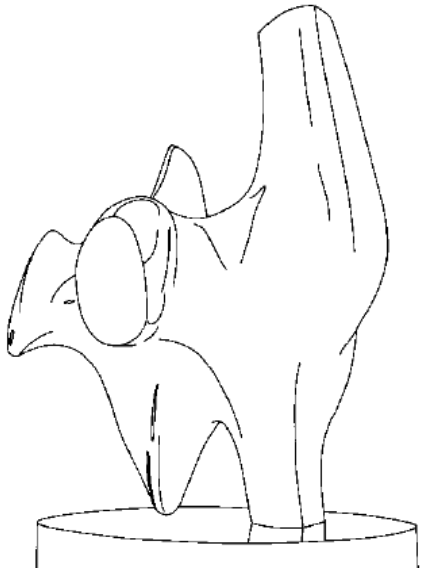
- Sobel operator

Canny edge detection

Edge Detection

- Finding discontinuity of the intensity in images
  - A salient feature of image
  - Much more compact representation than raw pixels
- HOW?
  - Image gradient: DoG, LoG, Sobel operator
  - Dealing with real, noisy images: Canny edge detector





(Image credit: Gunhee Kim CV lecture slides)

Image Gradient

- The image gradient is approximated by filtering

$$\frac{\partial I}{\partial x} \approx \frac{1}{2\varepsilon}\left(\left(I_{i+1,j+1} - I_{i,j+1}\right) + \left(I_{i+1,j} - I_{i,j}\right)\right)$$
$$\frac{\partial I}{\partial y} \approx \frac{1}{2\varepsilon}\left(\left(I_{i+1,j+1} - I_{i+1,j}\right) + \left(I_{i,j+1} - I_{i,j}\right)\right)$$

$$\frac{\partial I}{\partial x} \approx \frac{1}{2\varepsilon}\begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix} \qquad \frac{\partial I}{\partial y} \approx \frac{1}{2\varepsilon}\begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$$

- Sobel operator
  - A better approximation filter of size 3, 5, 7, ···.
  - OpenCV provides Sobel filters of high-dimensional derivatives.

-1	-2	-1
0	0	0
1	2	1

Sobel 3×3 filter

-1	-4	-6	-4	-1
-2	-8	-12	-8	-2
0	0	0	0	0
2	8	12	8	2
1	4	6	4	1

Sobel 5×5 filter

Image Gradient

- Sobel operator in OpenCV

```
dst = cv2.Sobel(src, ddepth, dx, dy, ksize=3, scale=1.0)
```

  - `src`: input image(grayscale, 2-dim array [H×W])
  - `ddepth`: output image depth
  - `dx`: order of the derivative x
  - `dy`: order of the derivative y
  - `ksize`: size of the extended Sobel kernel; it must be 1, 3, 5, or 7
  - `scale`: (optional) scale factor for the computed derivative values

$$\text{dst} \approx \frac{\partial^{\text{dx+dy}}}{\partial^{\text{dx}}x\,\partial^{\text{dy}}y}\,\text{src}$$

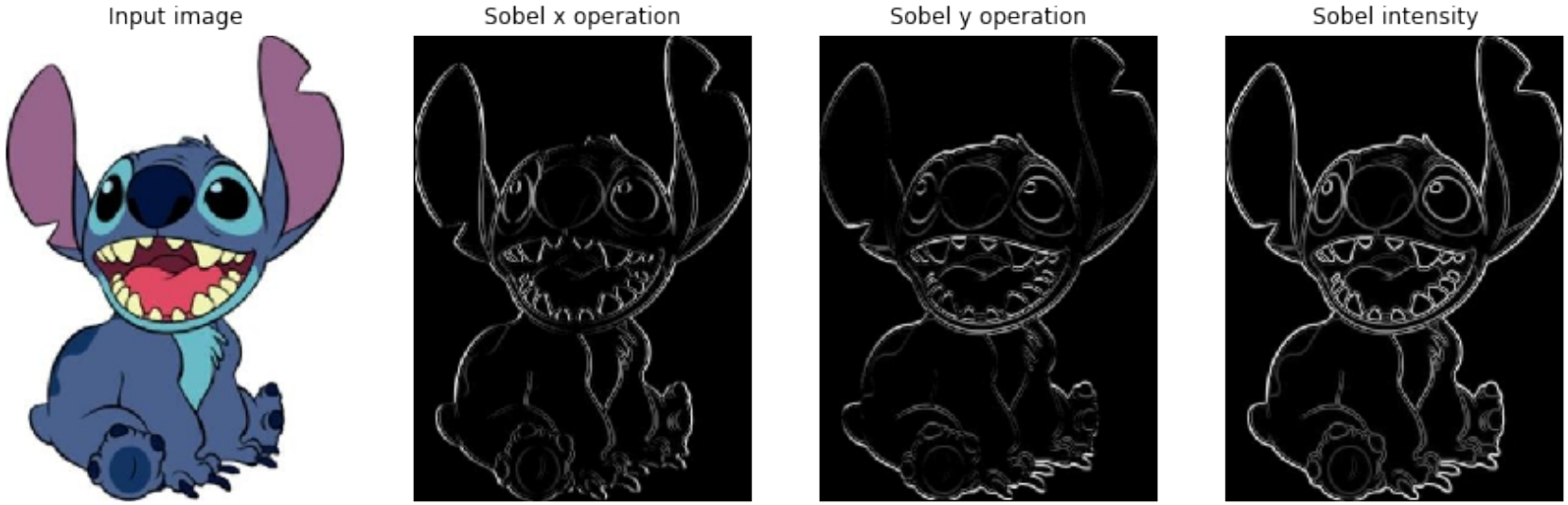


Image Gradient

- Sobel operator in OpenCV(example)

```
img_color = cv2.imread('images/stitch.jpg', cv2.IMREAD_COLOR)
img_gray = cv2.cvtColor(img_color, cv2.COLOR_BGR2GRAY)

sobelx = cv2.Sobel(img_gray, cv2.CV_64F, 1, 0)
```

Grayscale input image

64-bit float output

1st order derivative in x-direction

`cv2.CV_64F`
(Gray when 0)

`cv2.CV_8U`
(Black when 0)

Canny Edge Detector

- A popular edge detection algorithm
- The detection consists of the following procedures(multi-stage algorithm)
  - Noise reduction(5×5 Gaussian filter)
  - Finding image gradient from Sobel-x/y operator
  - Non-maximum suppression(edge-thinning)
  - Hysteresis thresholding

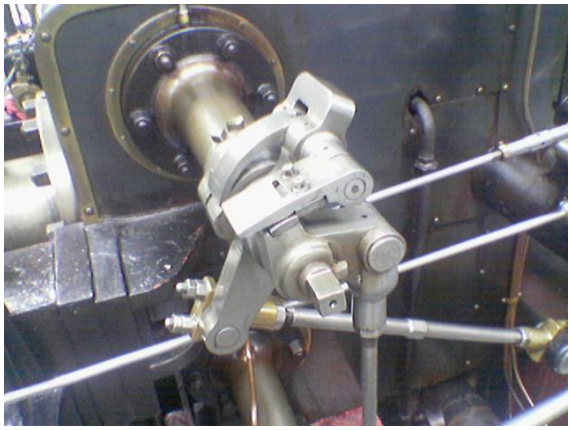
(Image credit: Gunhee Kim CV lecture slides)

Canny Edge Detector

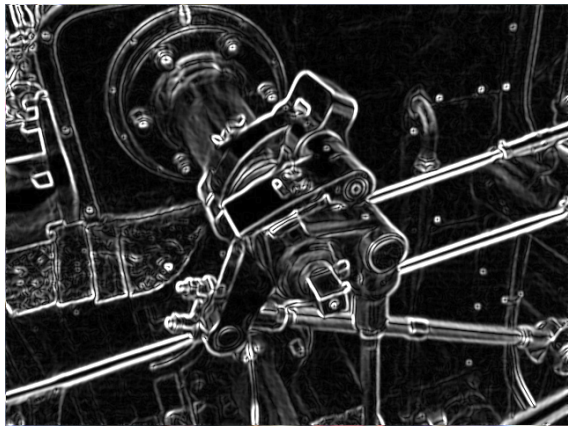
- Sobel operator in OpenCV

```
edges = cv2.Canny(image, threshold1, threshold2,
                  apatureSize=3, L2gradient=False)
```

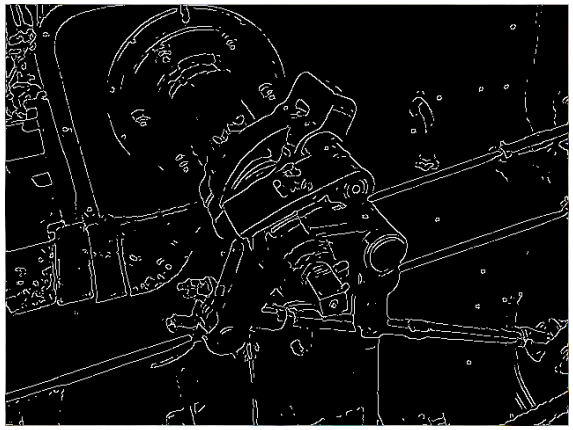
  - `image`: 8-bit grayscale input image
  - `threshold1/threshold2`: thresholds for the hysteresis procedure
  - `apertureSize`: aperture size for the Sobel() operator
  - `L2gradient`: A flag. True to use L_2-norm of gradients. False for L_1-norm



Input image



Sobel operator



Canny edge detector

(Image credit: Wikipedia)

Let’s Check the Code

2_edge_detection.ipynb

Reference

- OpenCV-Python Tutorials
  http://docs.opencv.org/3.0-beta/doc/py_tutorials/py_tutorials.html
- You can download the Jupyter Notebooks of this lecture at
  https://github.com/dalgu90/1705_sk_opencv

Q & A

Thank You!