SciComp with Py

CVIP

Basic Image Processing with OpenCV

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Outline

- OpenCV Background
- Basic Image Processing w/ OpenCV

OpenCV Background

OpenCV

- OpenCV (opencv.org) is a open source CV library
- Free for both commercial and academic use under a BSD license
- OpenCV has C++, Java, & Python interfaces
- Available on Linux, Mac OS, Android, iOS, Windows

Image Formats

- Image formats are different standards of storing digital images
- Broadly speaking, there are three kinds of data storage: compressed, uncompressed, and vector
- There are two types of compression: lossless and lossy
- Common formats: JPEG (compressed, lossy), BMP (uncompressed, lossless), PNG (compressed, lossless), SVG (scalable vector graphics)
- OpenCV supports all common formats

Pixels

- Pixel is the smallest addressable element in a raster image, i.e., a matrix of pixels
- Each pixel is a sample of an original image
- Pixels are typically represented as 3-tuples (red, green, blue) or (blue, green red)
- Number of representable colors is denoted by bits per pixel:

  1 bpp = 2^1 = 2; 2 bpp = 2^2 = 4; 2^3 = 8 , etc.

Switching to CV Workspace

If you want to use OpenCV on your pi within the cv workspace, do:

```
$ source ~/.profile
$ workon cv
```

Working with CV2.SO

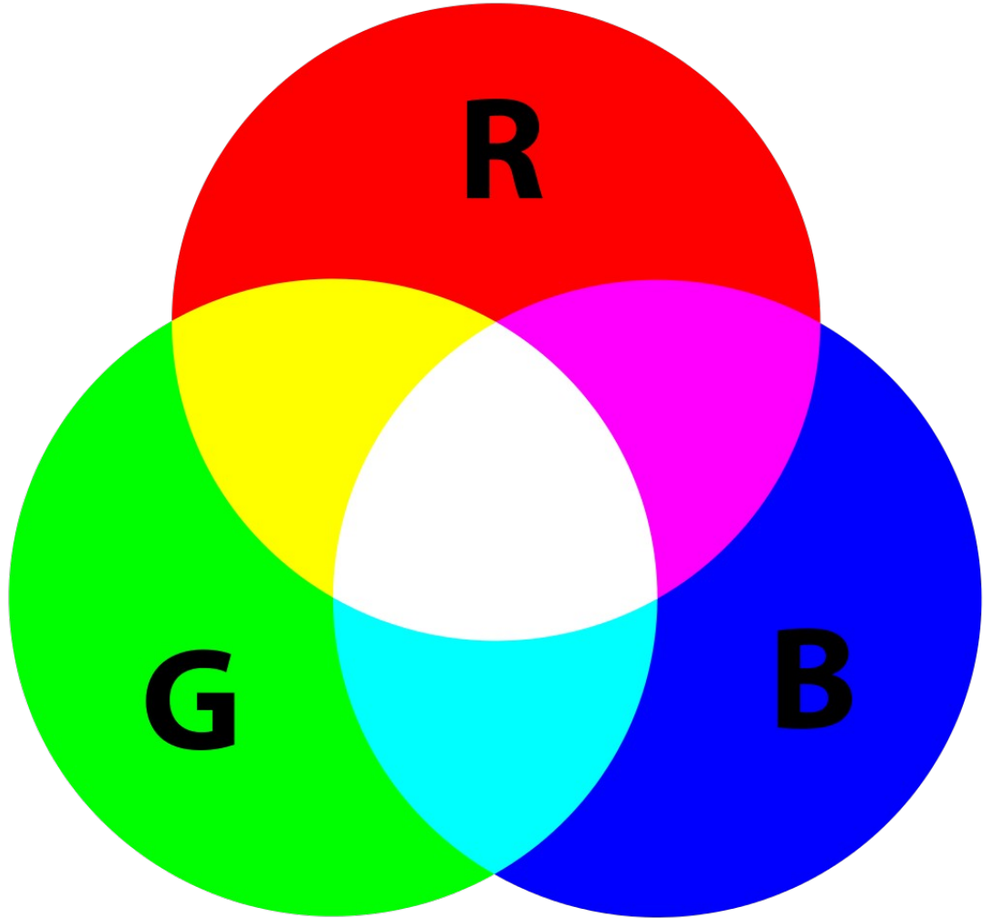
- Another way to ensure that your Python programs run with OpenCV is to place cv2.so into your current working directory
- cv2.so is the share object file installed on your machine when you install OpenCV from scratch

Checking OpenCV Installation

```
$ python
Python 2.7.6 (default, Jun 22 2015, 17:58:13)
[GCC 4.8.2] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import cv2
>>> cv2.__version__
'3.0.0'
>>>
```

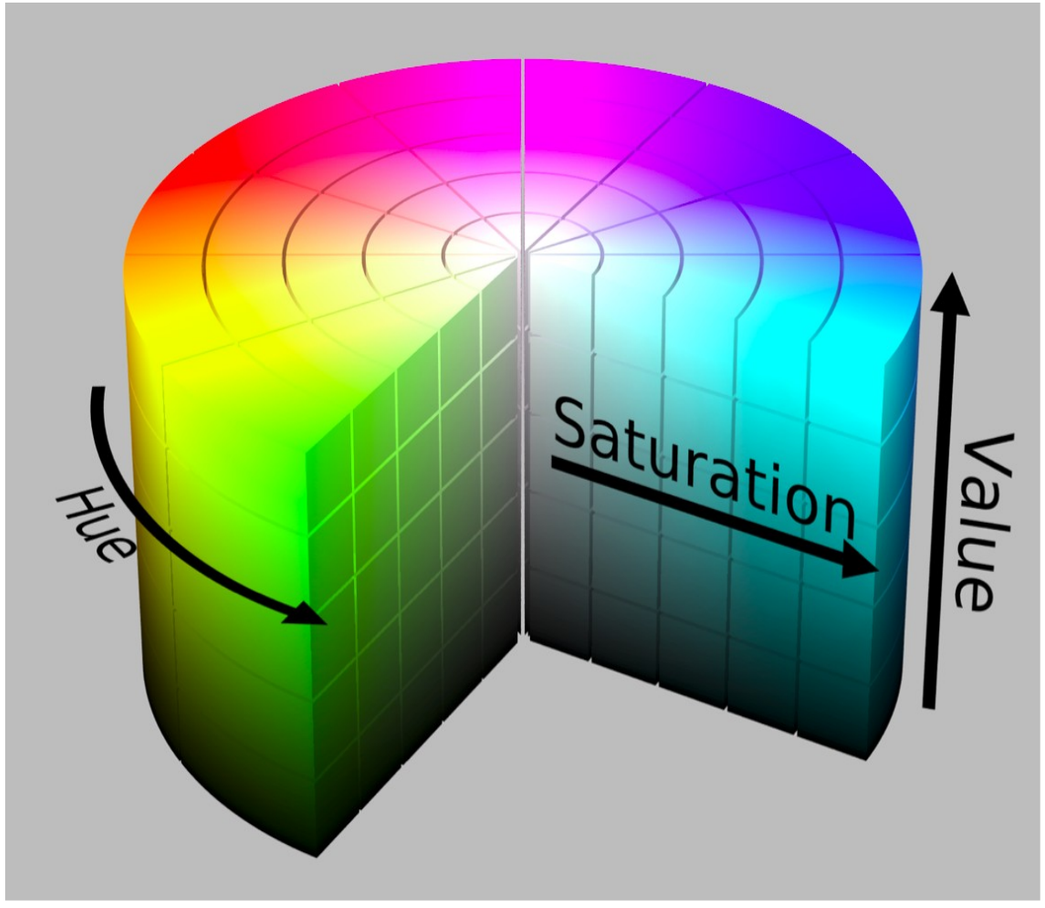
Basic IP

RGB Color Space



In OpenCV, the standard pixel representation is B, G, R, e.g., [10, 234, 50]. The values of B, G, R are in [0, 255]. [0, 0, 0] is black; [255, 255, 255] is white.

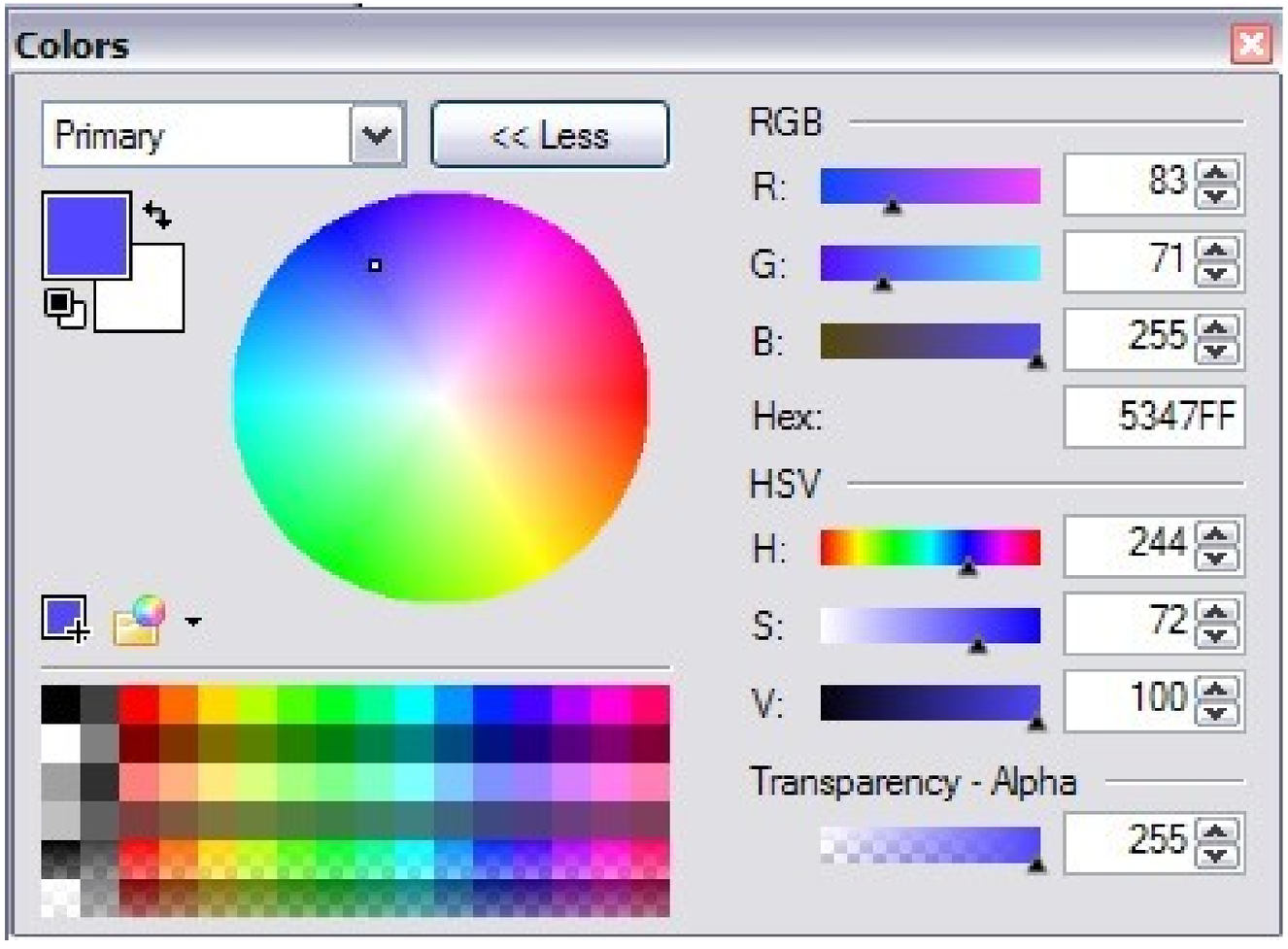
HSV Color Space



- Hue is color value [0, 179]
- Saturation is color vibrancy [0, 255]; at lower saturation in the center everything is white
- Value is brightness/intensity of color [0, 255]; it goes from dark (below) to bright (above)

RGB & HSV Spaces

It is possible to map an RGB point to a HSV point and vice versa; most image processing applications have this option



Problem

Write a program that loads a user specified image, converts it into grayscale, displays it in a window, and waits for the user to press a key before closing the window.

Sample Call

```
$ python   load_image.py  -i truck.jpg
```

Loading Images

load_image.py

```
import argparse
import cv2

ap = argparse.ArgumentParser()
ap.add_argument('-i', '--image', required = True, help = 'Path to image')
args = vars(ap.parse_args())

image = cv2.imread(args['image'])

cv2.imshow('Image', image)
cv2.waitKey(0)
```

Parse user args

Load image from user-specified file

Show Image

Wait for user to press a key

Problem

Write a program that loads a user specified image, prints out the shape of the image (height, width, number of channels), displays the image in a window, and waits for the user to press a key before closing the window.

Sample Call

```
$ python   image_shape.py  -i truck.jpg
```

Getting Image's Shape (Height, Width, Num of Channels)

image_shape.py

```
import argparse
import cv2

ap = argparse.ArgumentParser()
ap.add_argument('-i', '--image', required = True, help = 'Path to image')
args = vars(ap.parse_args())

image = cv2.imread(args['image'])
(h, w, num_channels) = image.shape
print 'h=' + str(h) + '; ' + 'w=' + str(w) + '; ' + 'c=' + str(num_channels)

cv2.imshow('Loaded Image', image)
cv2.waitKey(0)
```

Load image from user-specified file

Get & print image's shape

Show image

Problem

Write a program that loads a user specified image, converts it into grayscale, displays the original image and the grayscale image in two windows, and waits for the user to press any key before closing the windows.

Sample Call

```
$ python   grayscale_image.py  -i truck.jpg
```

Grayscaling

Grayscaling is an operation of converting RGB pixels to grayscale intensity pixels. Here is a commonly used conversion formula:

```
def luminosity(rgb, rcoeff=0.2126, gcoeff=0.7152, bcoeff=0.0722):
    return rcoeff*rgb[0]+gcoeff*rgb[1]+bcoeff*rgb[2]
```

Grayscaling

grayscale_image.py

```
import cv2
import argparse

ap = argparse.ArgumentParser()
ap.add_argument('-i', '--image', required = True, help = 'Path to image')
args = vars(ap.parse_args())

image = cv2.imread(args['image'])

cv2.imshow('Original', image)
cv2.waitKey()

gray_image = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
cv2.imshow('Grayscaled', gray_image)
cv2.waitKey()

cv2.destroyAllWindows()
```

Grayscale image

Grayscaling

grayscale_image2.py

```
import cv2
import argparse

ap = argparse.ArgumentParser()
ap.add_argument('-i', '--image', required = True, help = 'Path to image')
args = vars(ap.parse_args())

image = cv2.imread(args['image'], 0)
cv2.imshow('Grayscaled', image)
cv2.waitKey()

cv2.destroyAllWindows()
```

Grayscale image: the image is grayscaled, because the 2nd parameter is 0.

Problem

Write a program that loads a user specified image, splits it into R, G, B channels, displays each channel in a separate window, and then merges the three channels back and displays the merged image and the original images, displays images where R, G, and B are amplified.

Sample Call

```
$ python   bgr_channels.py  -i truck.jpg
```

Splitting Image into B, G, R Channels

bgr_channels.py

```
image = cv2.imread(args['image'])
## split the image into 3 channels
B, G, R = cv2.split(image)
## show each channel
print "B's shape:", B.shape
print "G's shape:", G.shape
print "R's shape:", R.shape

cv2.imshow('Red', R)
cv2.imshow('Green', G)
cv2.imshow('Blue', B)
cv2.waitKey(0)
cv2.destroyAllWindows()

## merge B, G, R channels back to get the original image
merged = cv2.merge([B, G, R])
cv2.imshow('Merged', merged)

## amplifying blue by adding 100 to it
amplified_blue = cv2.merge([B+100, G, R])
cv2.imshow('Amplified Blue', amplified_blue)
```

A Better Way of Splitting Image into B, G, R Channels

Get the height and width of the image

split_merge.py

```
image = cv2.imread(args['image'])

B, G, R = cv2.split(image)

zeros = np.zeros(image.shape[:2], dtype='uint8')

cv2.imshow('Red', cv2.merge([zeros, zeros, R]))
cv2.imshow('Green', cv2.merge([zeros, G, zeros]))
cv2.imshow('Blue', cv2.merge([B, zeros, zeros]))

cv2.waitKey(0)
cv2.destroyAllWindows()
```

Splitting Image into B, G, R, Channels

```
$ python   split_merge.py  -i truck.jpg
```

3 Big M's

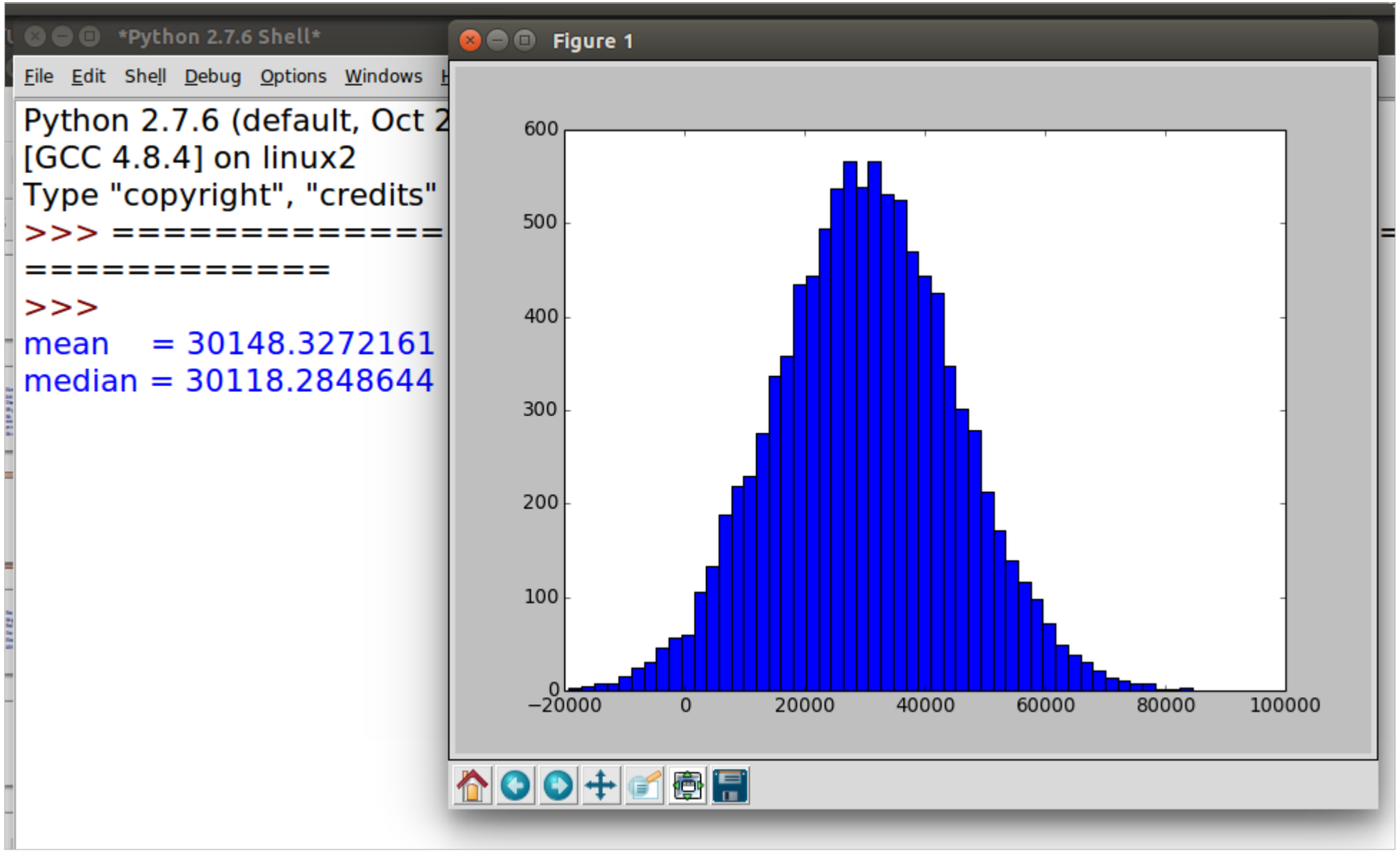
- Mean – is the average of a set of values
- Median – a numerical value **v** right in the middle of the sorted sequence of values so that exactly half of the values in the set are less than v and half are greater than **v**
- Mode – the most frequent value in a set of values

Plotting Mean & Median

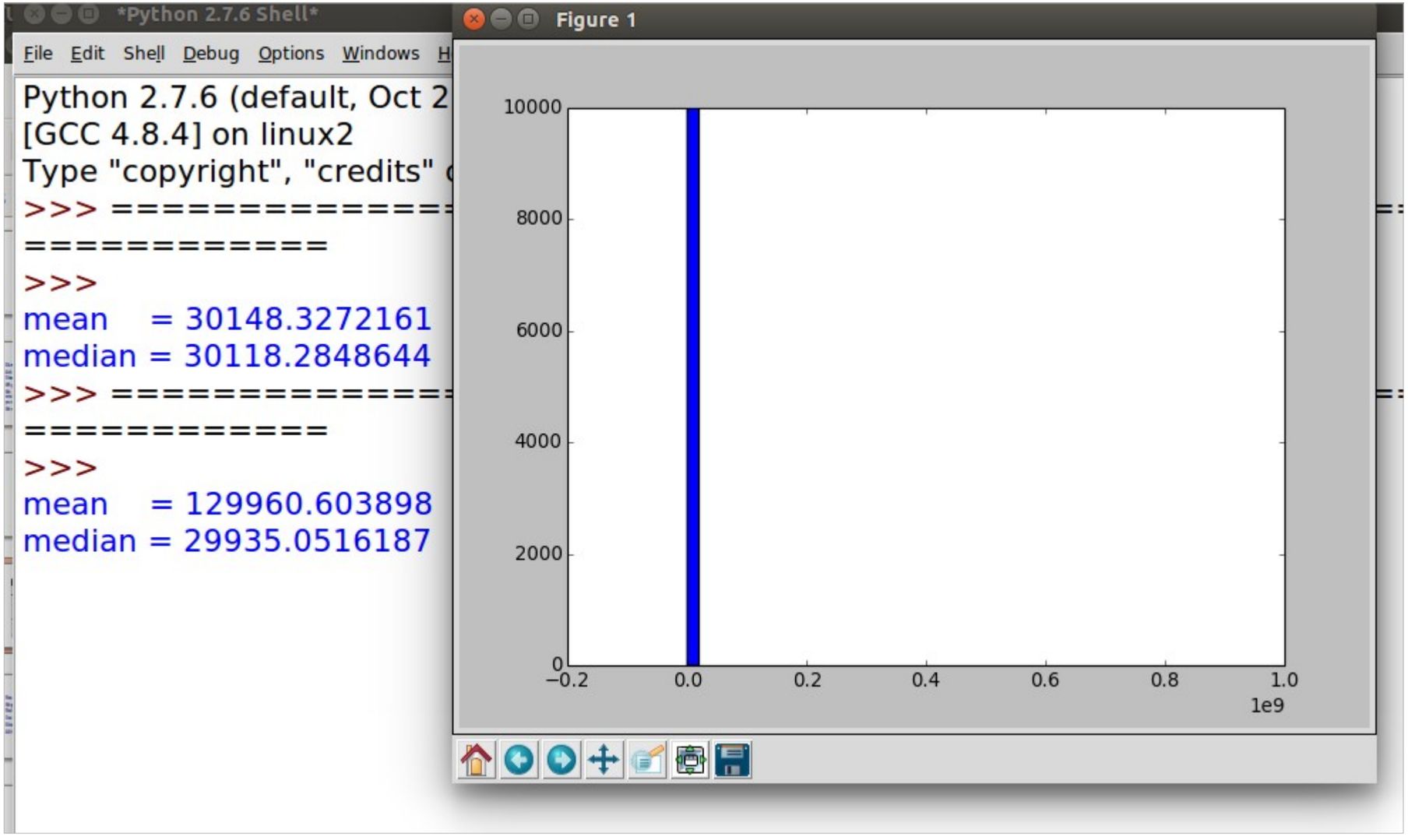
source in mean_median_mode.py

```
import numpy as np
import matplotlib.pyplot as plt
from scipy import stats
## use normal distribution to generate 10,000 points
## centered on 30,000 with an STD = 15,000
incomes = np.random.normal(30000, 15000, 10000)
## if you want to see an outlier, add this
## billionaire's income to the list of incomes
#incomes = np.append(incomes, [1000000000])
mn = np.mean(incomes)
print('mean   = ' + str(mn))
md = np.median(incomes)
print('median = ' + str(md))
## if you want to see a plot of incomes
plt.hist(incomes, 50)
plt.show()
```

Incomes w/o Billionaire's Salary



Incomes w/ Billionaire's Salary



Computing Mode

source in mean_median_mode.py

```
import numpy as np
import matplotlib.pyplot as plt
from scipy import stats
## create a random array of 500 ages from 10 up to 90.
ages = np.random.randint(10, high=90, size=500)
print(ages)
mo = stats.mode(ages)
## the result will print like (array([ 22.]), array([ 18.])),
## where the first number, 22, is the most frequent age
## and the second number, 18, is the number of times
##that age occurs in ages.
print(mo)
```

Mode Test Run

[26 45 69 33 68 66 22 66 65 34 48 46 88 53 84 87 85 68 11 54 12 81 38 84 49 16 81 66 22 47 19 69 89 33 80 79 62 63 46 59 88 51 63 83 60 59 61 19 17 60
52 40 49 56 56 69 43 33 56 68 21 39 31 41 75 35 79 50 25 80 43 16 38 72 32 22 86 41 10 89 19 27 72 39 29 77 88 36 84 26 14 38 16 64 73 20 25 29 26 53
28 54 45 45 62 85 51 74 39 30 25 17 59 32 58 49 70 52 37 13 72 12 82 86 88 72 12 31 35 31 13 74 30 89 85 17 22 78 53 67 52 47 86 77 40 15 62 30 41 52
40 27 76 26 65 86 81 36 76 32 41 24 24 24 83 72 61 60 51 80 47 33 47 32 82 22 18 61 79 34 36 28 54 41 80 58 38 56 46 12 64 84 65 59 55 66 72 50 54 60
65 45 32 64 55 85 56 11 20 67 56 85 15 46 84 48 70 72 23 60 89 73 71 55 23 27 87 85 70 77 42 27 87 22 12 35 33 13 53 37 11 62 78 75 20 11 41 51 11 33
29 83 29 70 33 33 75 65 10 14 89 19 33 76 85 63 80 57 76 22 84 88 42 53 34 33 74 69 41 14 13 26 51 58 89 86 48 64 21 31 41 10 76 73 65 30 83 61 40 35
76 58 81 73 36 46 71 61 53 37 18 78 29 48 60 14 10 55 77 69 35 76 82 21 35 66 61 20 59 18 26 40 36 77 42 22 57 86 40 86 65 16 41 70 19 71 85 60 68 52
52 51 84 28 27 82 34 84 59 73 58 65 35 37 40 67 36 56 39 11 17 71 75 48 12 30 17 24 53 27 35 40 60 17 69 37 83 85 28 16 61 40 67 44 73 21 70 71 47 69
69 56 86 44 44 67 41 76 49 24 46 11 13 56 15 55 56 10 55 63 40 28 87 53 32 62 82 79 66 40 26 80 30 65 34 49 47 78 17 23 65 62 62 52 66 29 64 15 58 78
41 40 71 71 48 73 41 75 73 66 51 60 23 31 31 79 23 16 31 23 67 78 34 59 13 74 26 16 37 75 14 58 55 82 74 29 30 25 37 63 41 15 17 66 64 84 11 49 52 18]

(array([41.]), array([13.]))

References

- https://en.wikipedia.org/wiki/Gaussian_blur
- https://en.wikipedia.org/wiki/Erosion_(morphology)
- https://en.wikipedia.org/wiki/Dilation_(morphology)
- www.opencv.org