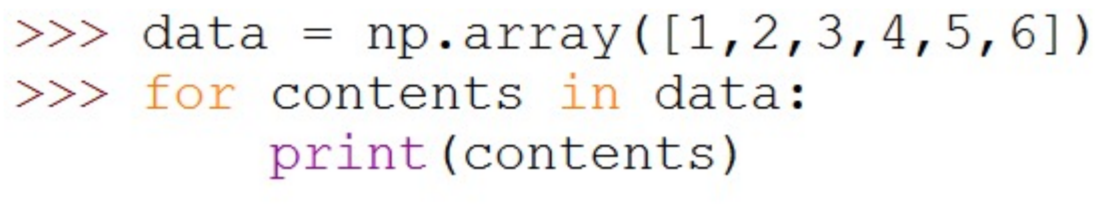
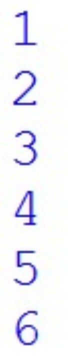
# 2D Looping

# Looping Through a 1D Array

- For a 1D array



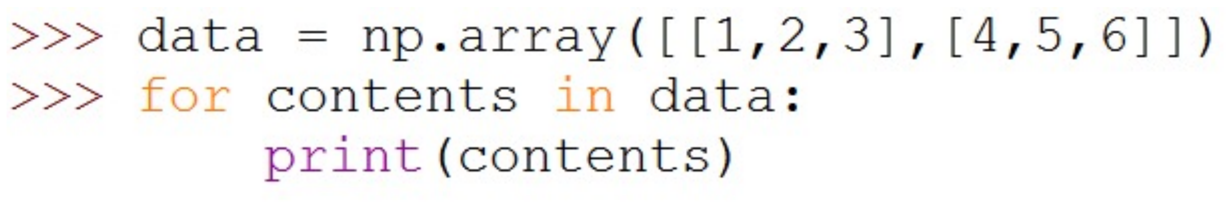
```
>>> data = np.array([1,2,3,4,5,6])
>>> for contents in data:
        print(contents)
```



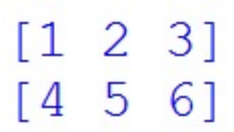
```
1
2
3
4
5
6
```

# Looping Through a 2D Array

- But for a 2D array



```
>>> data = np.array([[1,2,3],[4,5,6]])
>>> for contents in data:
        print(contents)
```

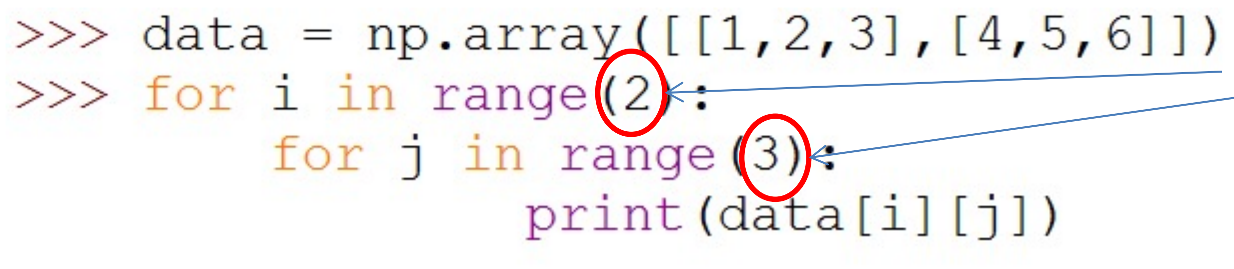


```
[1 2 3]
[4 5 6]
```

- Not every single “item” but the two rows

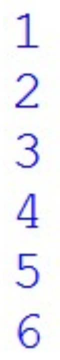
# Looping Through a 2D Array

- To investigate every single item



```
>>> data = np.array([[1,2,3],[4,5,6]])
>>> for i in range(2):
        for j in range(3):
            print(data[i][j])
```

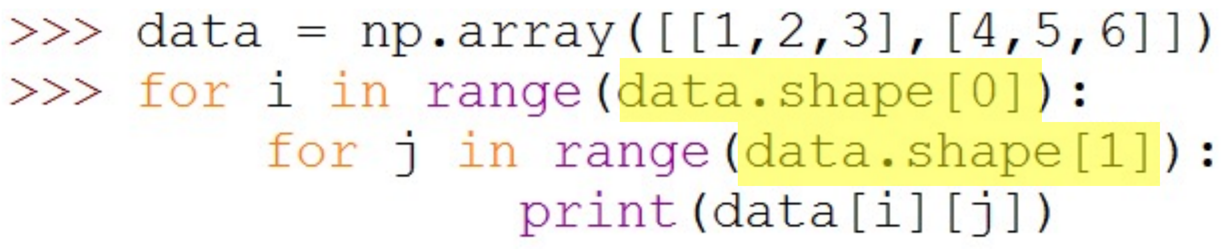
What if I don’t know how many rows and columns in the array?



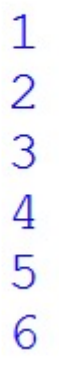
```
1
2
3
4
5
6
```

# Looping Through a 2D Array

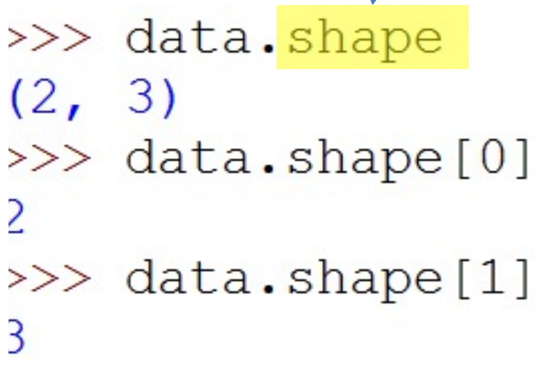
The member “shape” tells you the dimensions of the array



```
>>> data = np.array([[1,2,3],[4,5,6]])
>>> for i in range(data.shape[0]):
        for j in range(data.shape[1]):
            print(data[i][j])
```



```
1
2
3
4
5
6
```

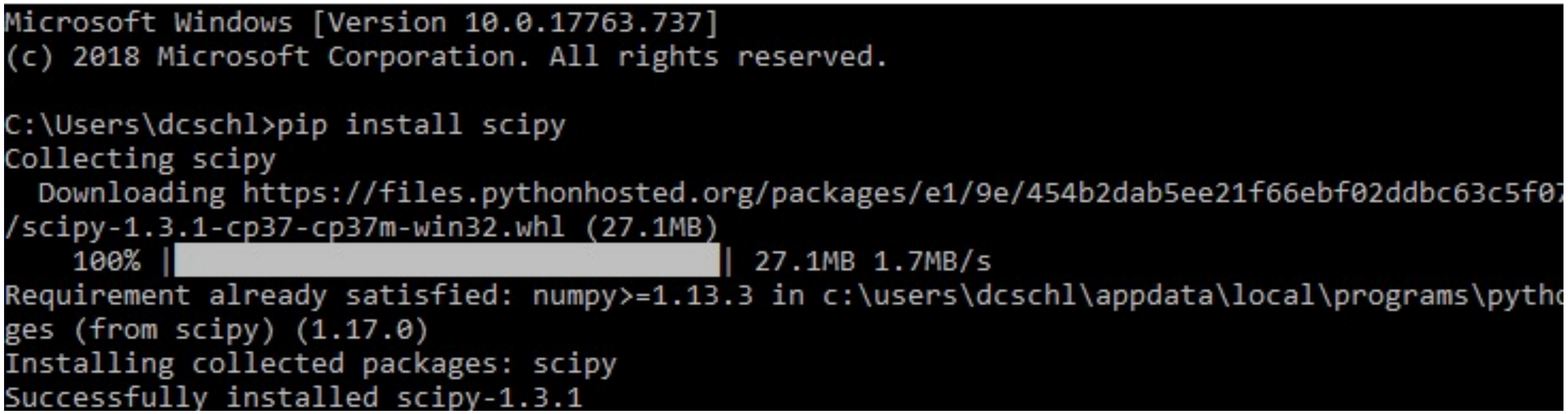


```
>>> data.shape
(2, 3)
>>> data.shape[0]
2
>>> data.shape[1]
3
```

## Installing Python Packages

- Python comes with built-in functions
- However, you need to manually installed additional packages
  - In Assignment 0, the instructions asked you to install, imageio, numpy, etc
- In this lecture we will need “imageio”
  - To install “imageio”  (or any other packages), go to cmd.exe
    - Type “`pip install imageio`”

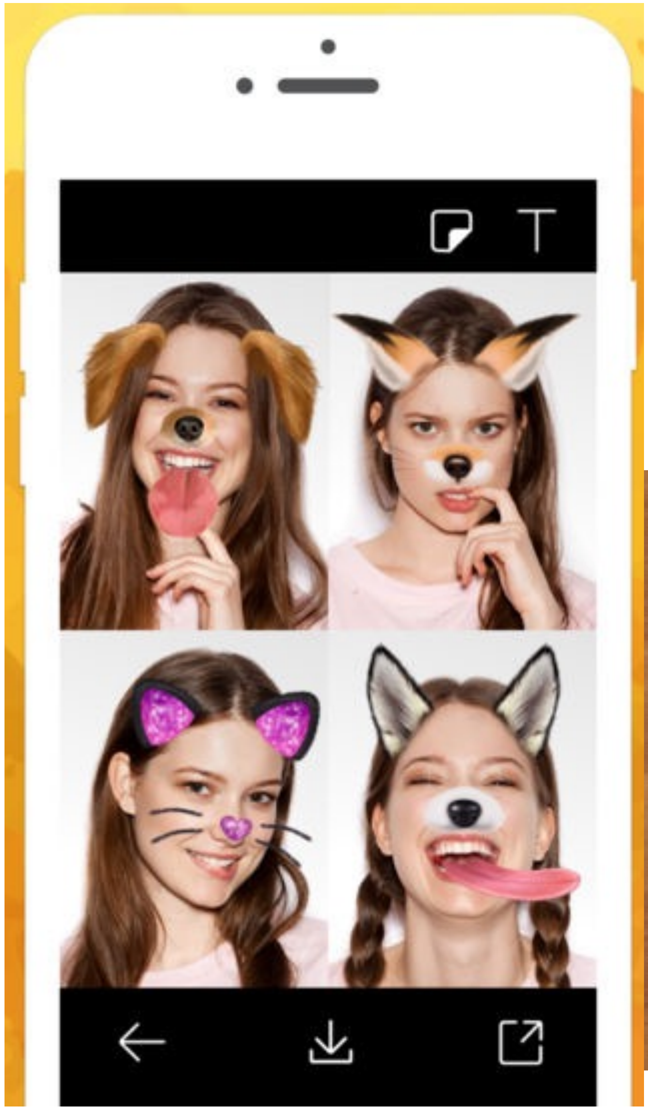
- Provided you have your internet connected
- **`pip`** will download the package and install it for you

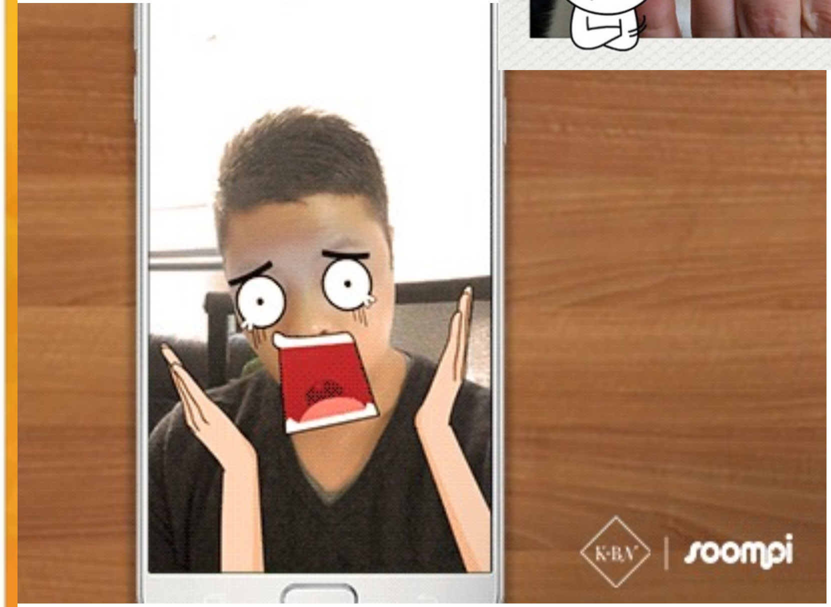


```
Microsoft Windows [Version 10.0.17763.737]
(c) 2018 Microsoft Corporation. All rights reserved.

C:\Users\dcschl>pip install scipy
Collecting scipy
  Downloading https://files.pythonhosted.org/packages/e1/9e/454b2dab5ee21f66ebf02ddbc63c5f07
/scipy-1.3.1-cp37-cp37m-win32.whl (27.1MB)
    100% |████████████████████████████████| 27.1MB 1.7MB/s
Requirement already satisfied: numpy>=1.13.3 in c:\users\dcschl\appdata\local\programs\pytho
ges (from scipy) (1.17.0)
Installing collected packages: scipy
Successfully installed scipy-1.3.1
```

## Image Processing

# We have all these photo apps



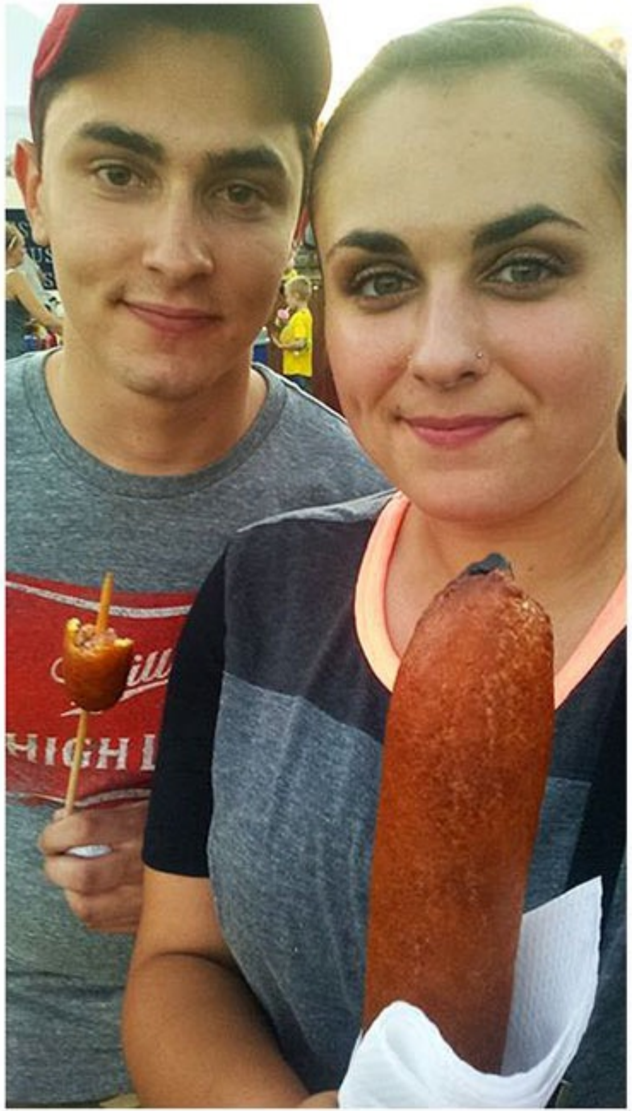


https://www.everydayfamily.com/slideshow/10-hilariously-awful-photoshop-fails/

M[redacted]il.com>

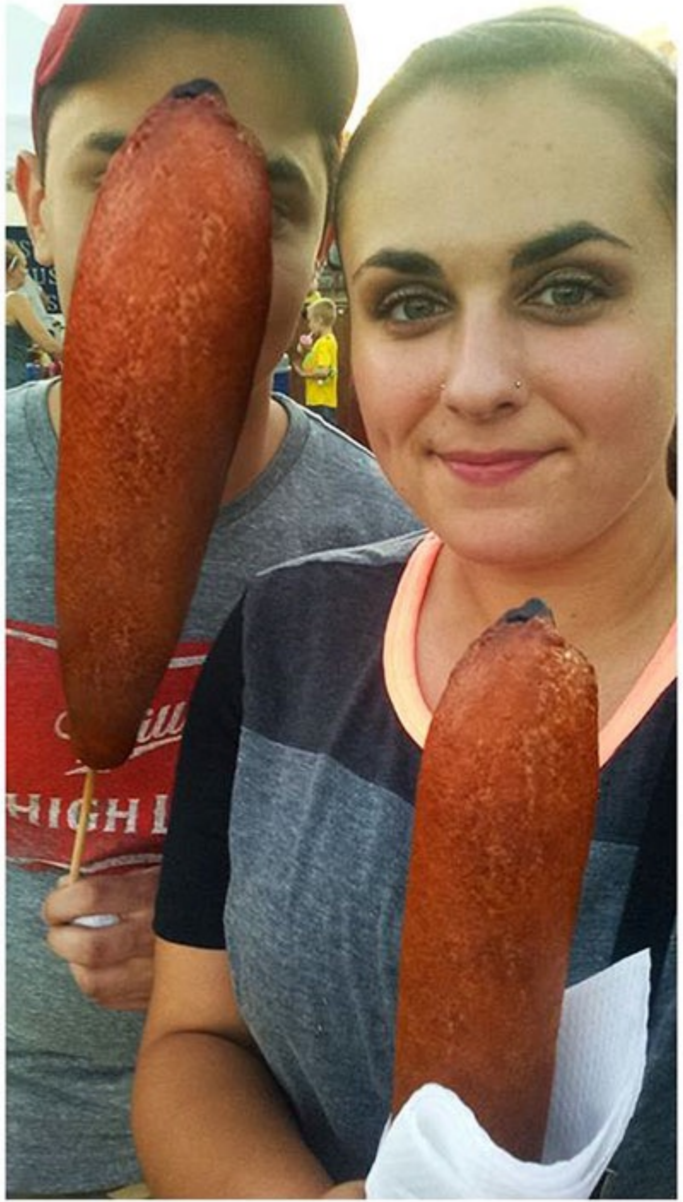
to me

Hey, just wondering if you could edit this photo of me and my boyfriend. I was hoping you could make his corn dog whole again... with no bites taken out... thanks!



James Fridman <fjamie013@gmail.com>

Done.

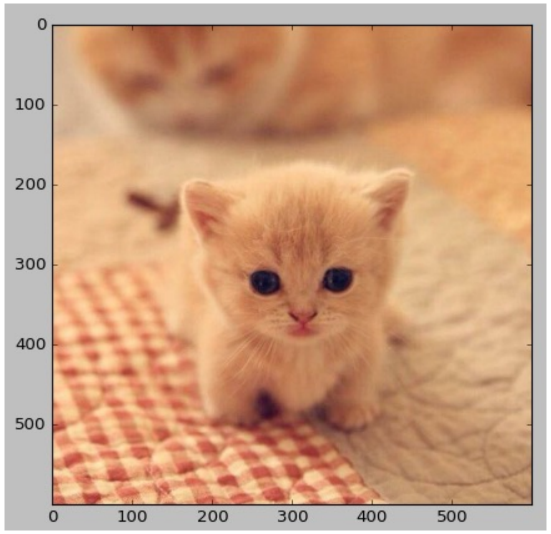


# Image Processing

- To load an image, you can use the package "imageio"

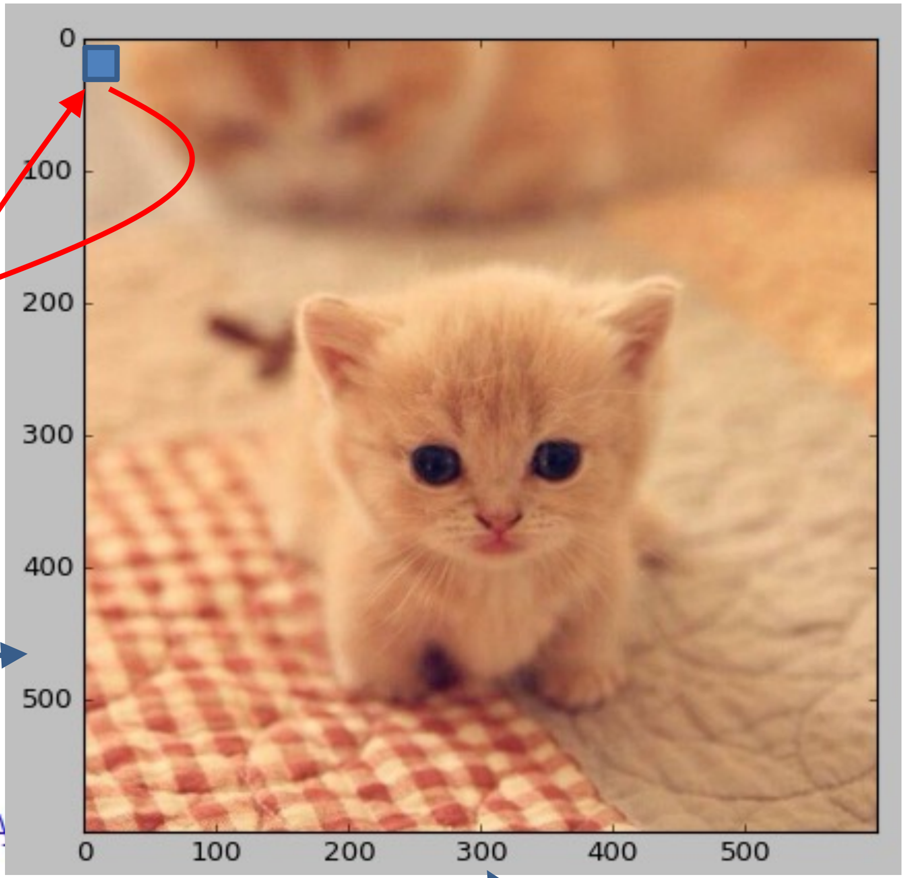
```
import imageio
import matplotlib.pyplot as plt

cat_pic = imageio.imread('cute cat.jpg')

plt.imshow(cat_pic)
plt.show()
```

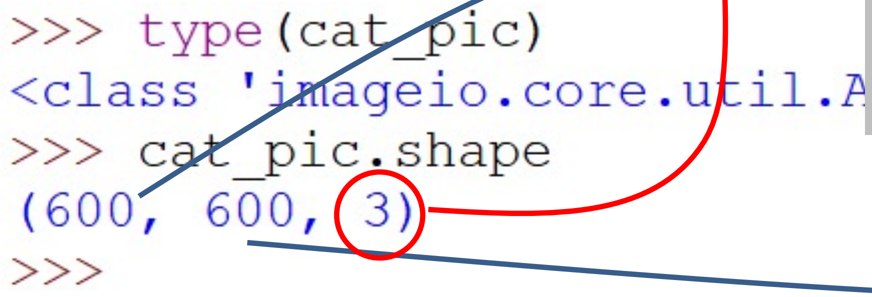
```
>>> type(cat_pic)
<class 'imageio.core.util.Array'>
>>> cat_pic.shape
(600, 600, 3)
>>>
```



# Image Processing

- 600 x 600 pixel
  - And each pixel has three values of R, G and B
  - [R, G, B]

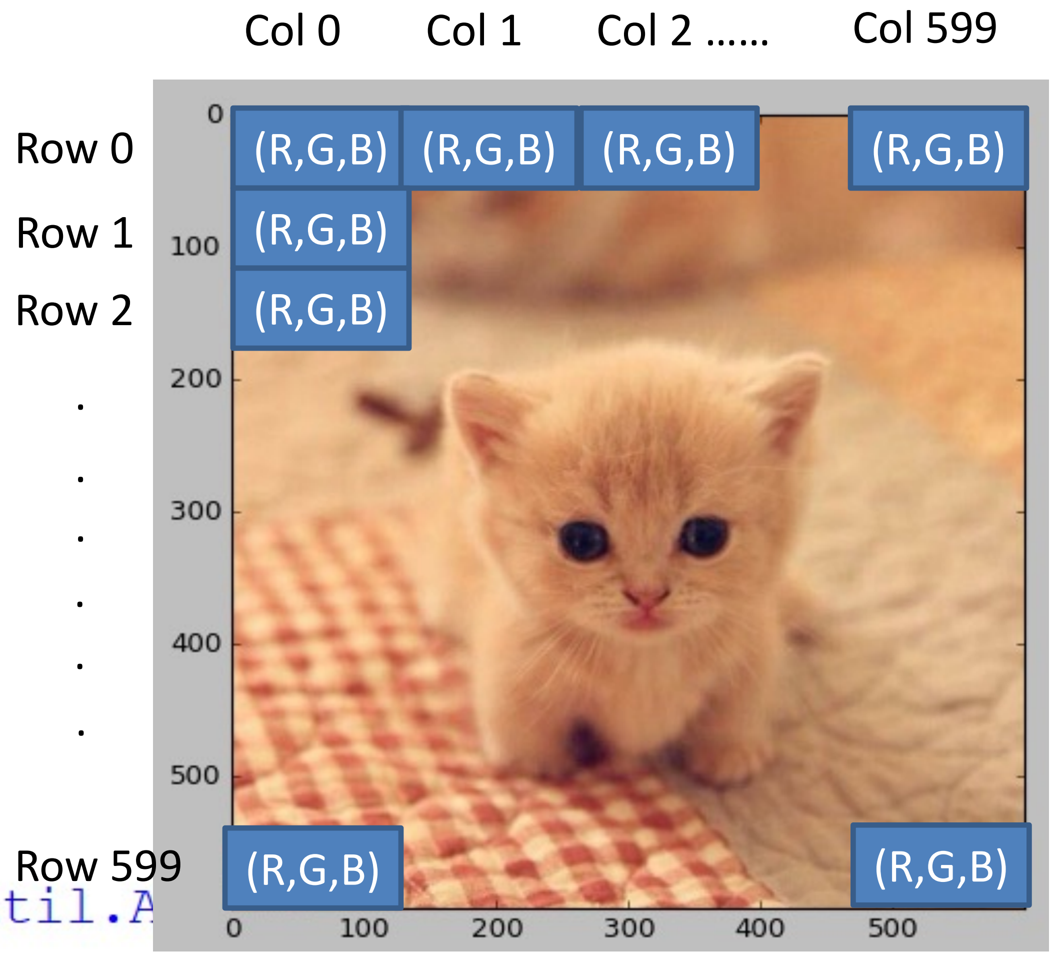


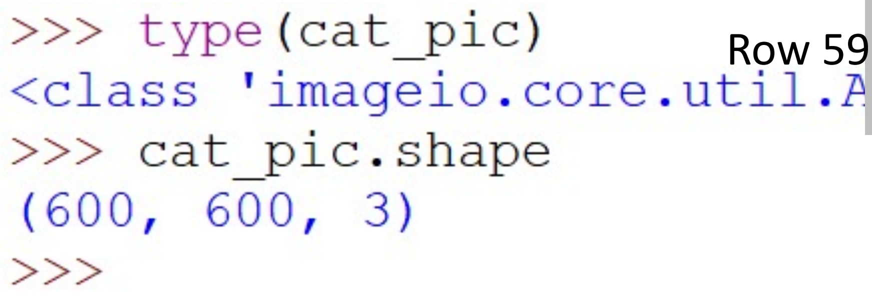


```
>>> type(cat_pic)
<class 'imageio.core.util.A
>>> cat_pic.shape
(600, 600, 3)
>>>
```

# Image Processing

- 600 x 600 pixel
  - [R, G, B]
  - 0 <= R,G,B <=255



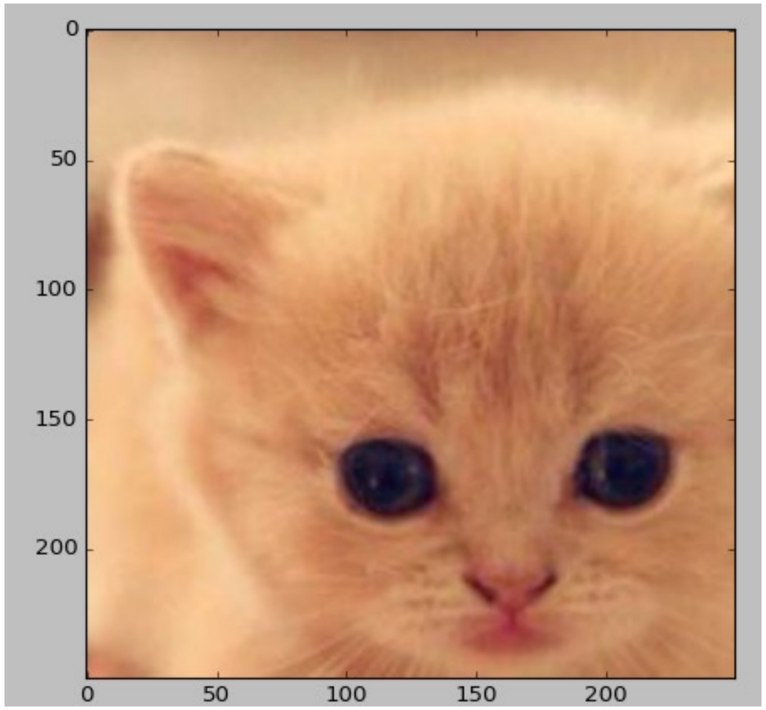


```
>>> type(cat_pic)
<class 'imageio.core.util.A
>>> cat_pic.shape
(600, 600, 3)
>>>
```

# Image Processing

- Remember sub-matrix, string slicing, etc.?

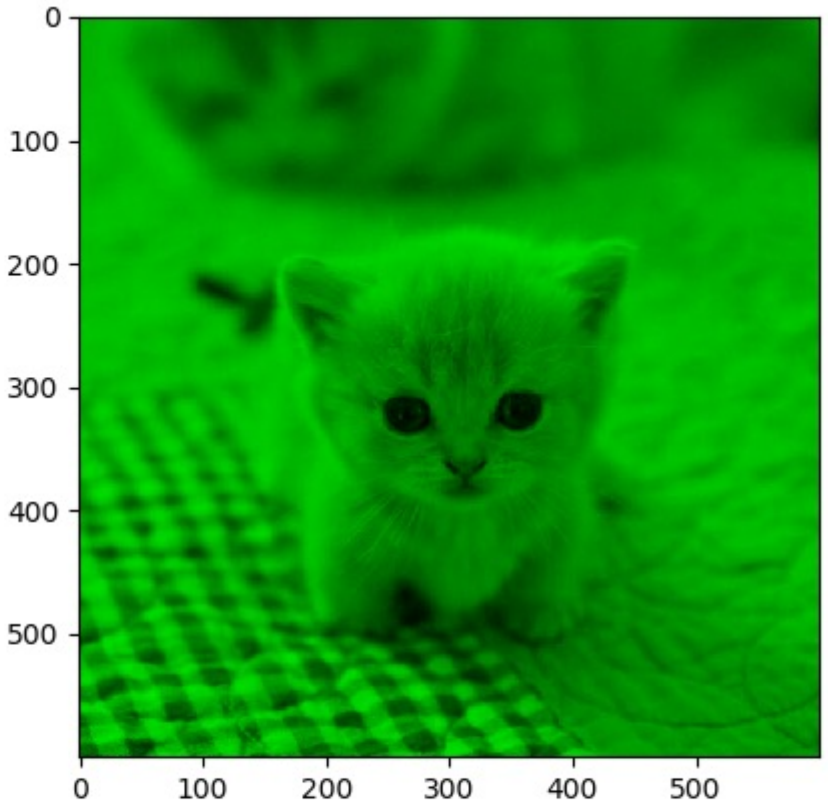
```
cat_pic2 = cat_pic[150:400,150:400]
plt.imshow(cat_pic2)
plt.show()
```



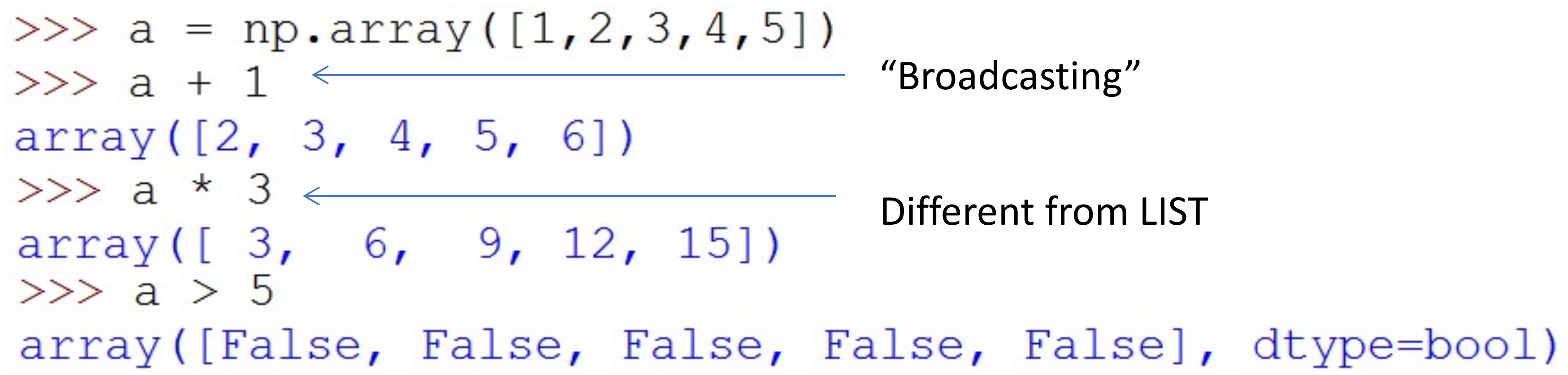
# Broadcasting

```
cat_pic2 = cat_pic * [0, 1, 0]
plt.imshow(cat_pic2)
plt.show()
```

- every pixel multiply by
  - [R,G,B] x [0,1,0] =
  - [R x 0, G x 1, B x 0]
  - [0, G, 0 ]



# Array Broadcasting



```
>>> a = np.array([1,2,3,4,5])
>>> a + 1
array([2, 3, 4, 5, 6])
>>> a * 3
array([ 3,  6,  9, 12, 15])
>>> a > 5
array([False, False, False, False, False], dtype=bool)
```

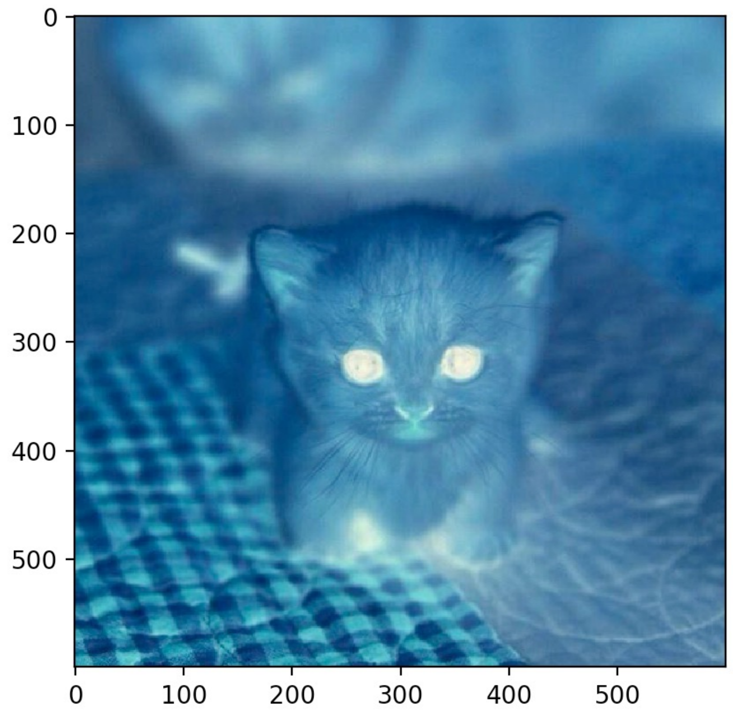
"Broadcasting"

Different from LIST

Create another array with the Boolean results

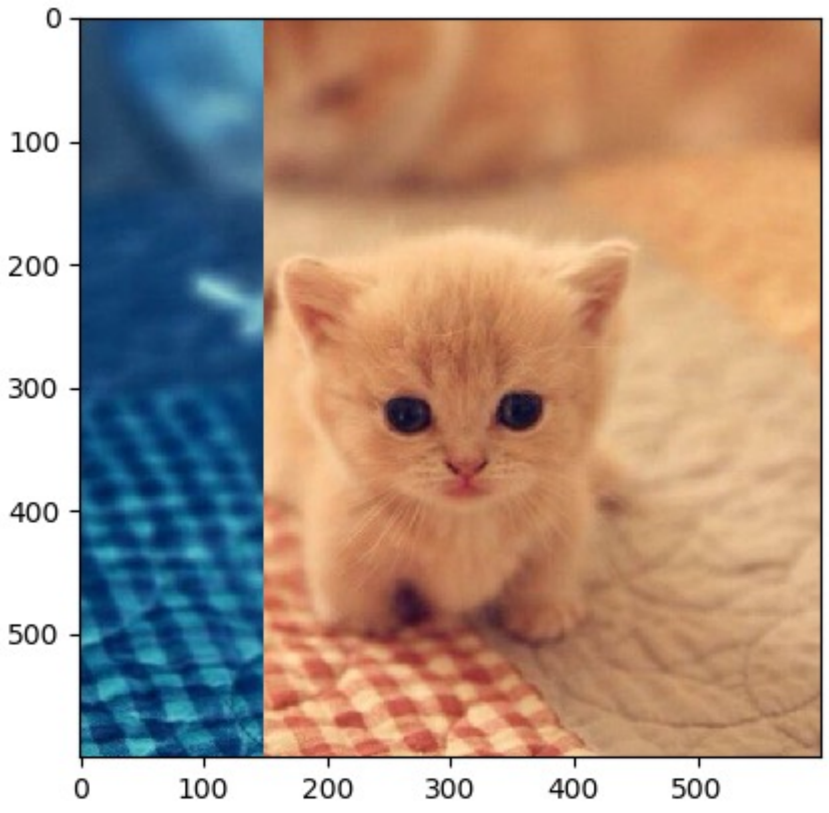
# Negative Image

```
cat_pic2 = 255 - cat_pic
plt.imshow(cat_pic2)
plt.show()
```

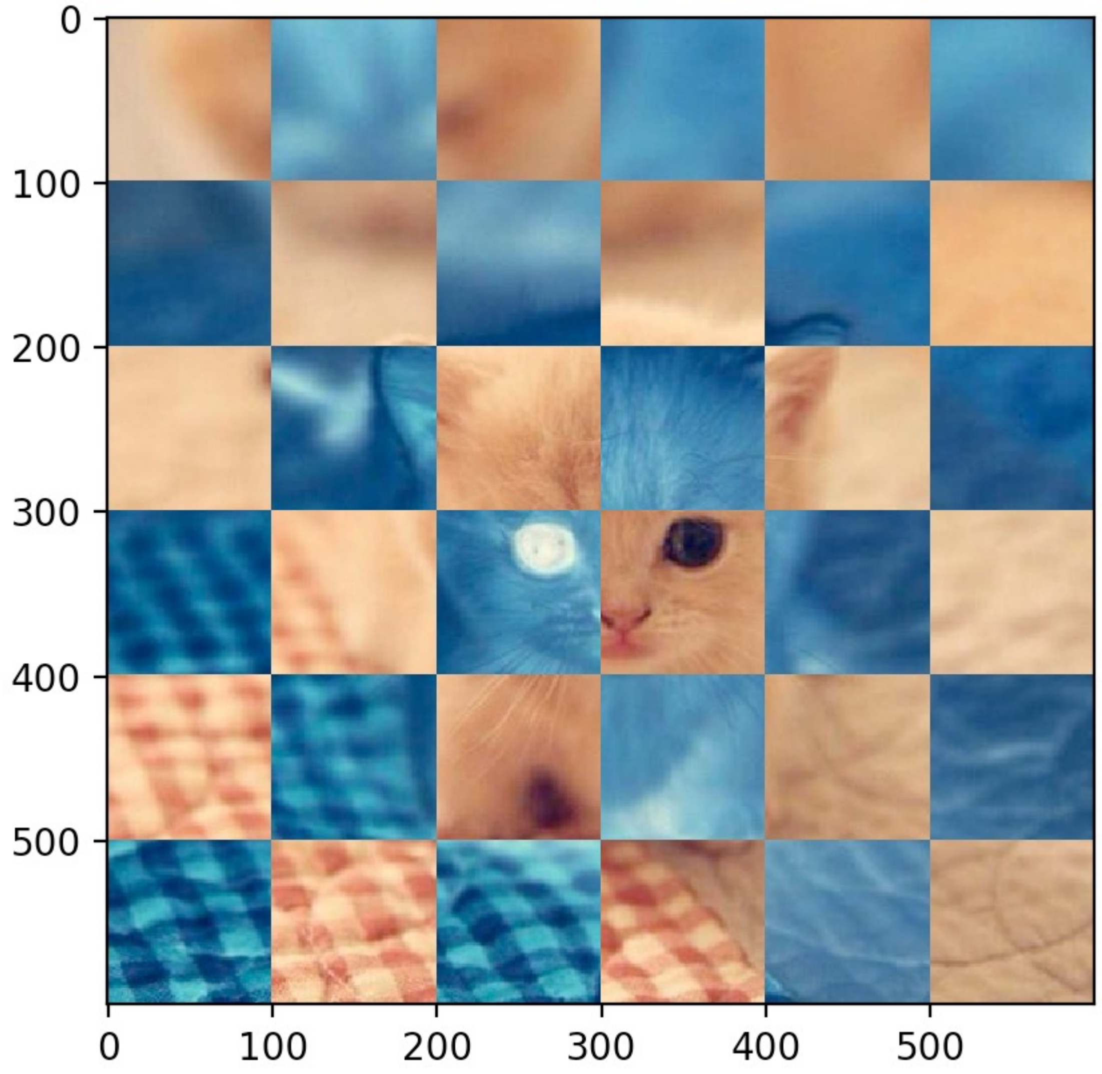


```
for i in range(cat_pic.shape[0]):
    for j in range(cat_pic.shape[1]):
        if j < cat_pic.shape[1]/4:
            cat_pic[i][j] = 255 - cat_pic[i][j]

plt.imshow(cat_pic)
plt.show()
```

2D Array looping

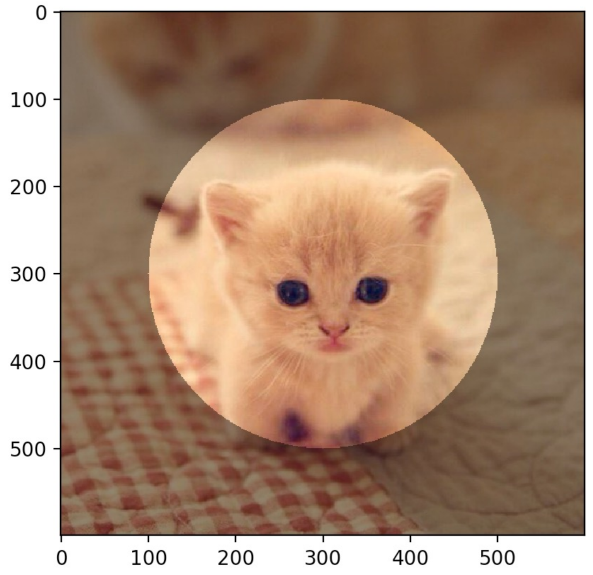


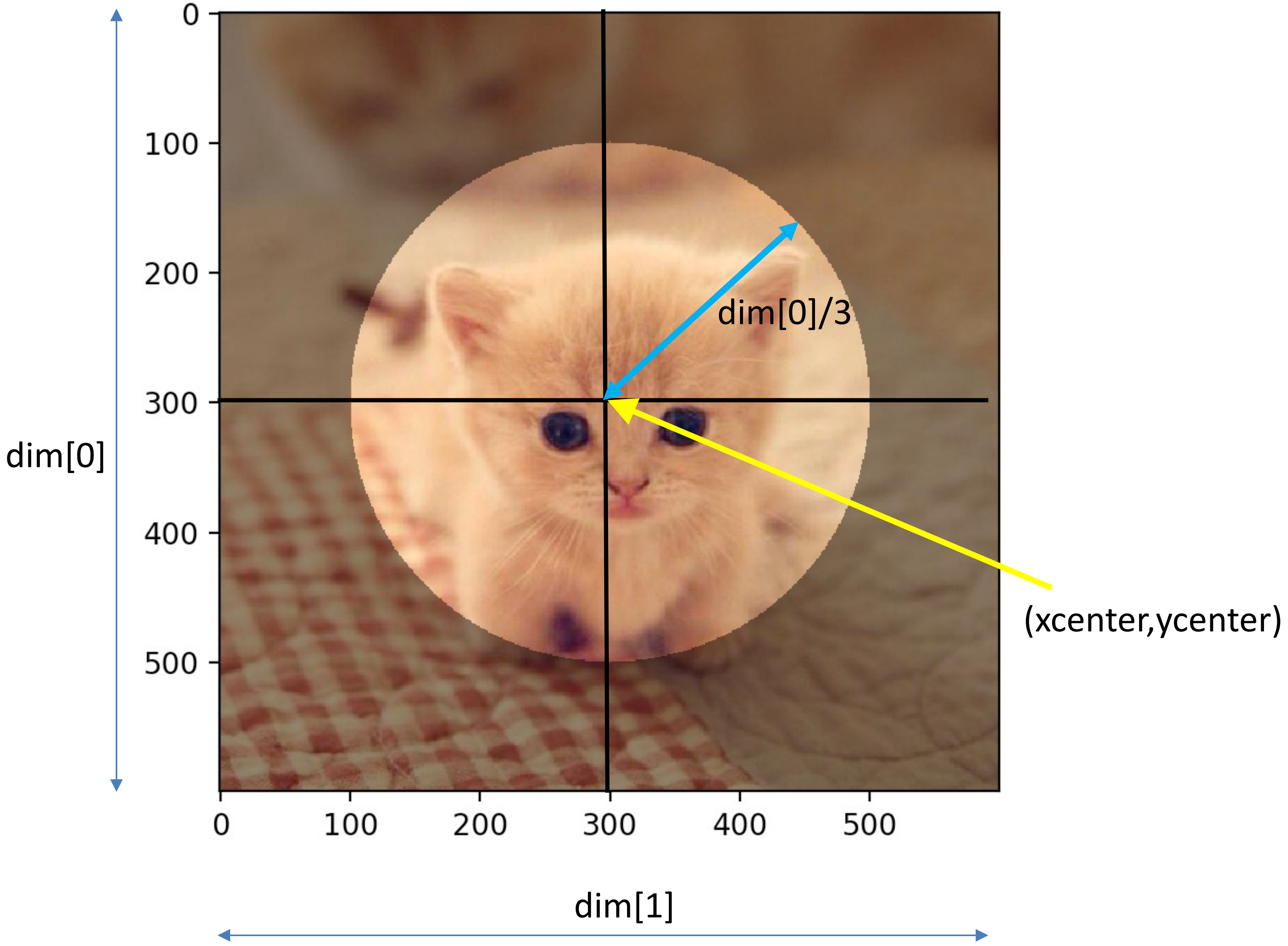
# How to….?



# Making a Mask

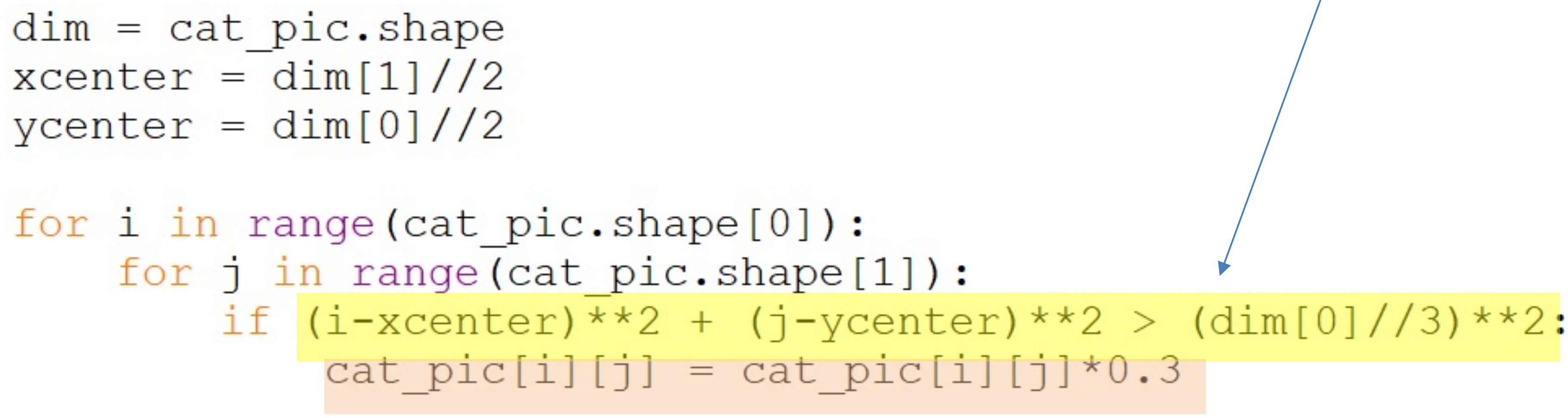
```
dim = cat_pic.shape
xcenter = dim[1]//2
ycenter = dim[0]//2

for i in range(cat_pic.shape[0]):
    for j in range(cat_pic.shape[1]):
        if (i-xcenter)**2 + (j-ycenter)**2 > (dim[0]//3)**2:
            cat_pic[i][j] = cat_pic[i][j]*0.3
```




0
100
200
300
400
500
dim[0]/3
(xcenter,ycenter)
dim[0]
0
100
200
300
400
500
dim[1]

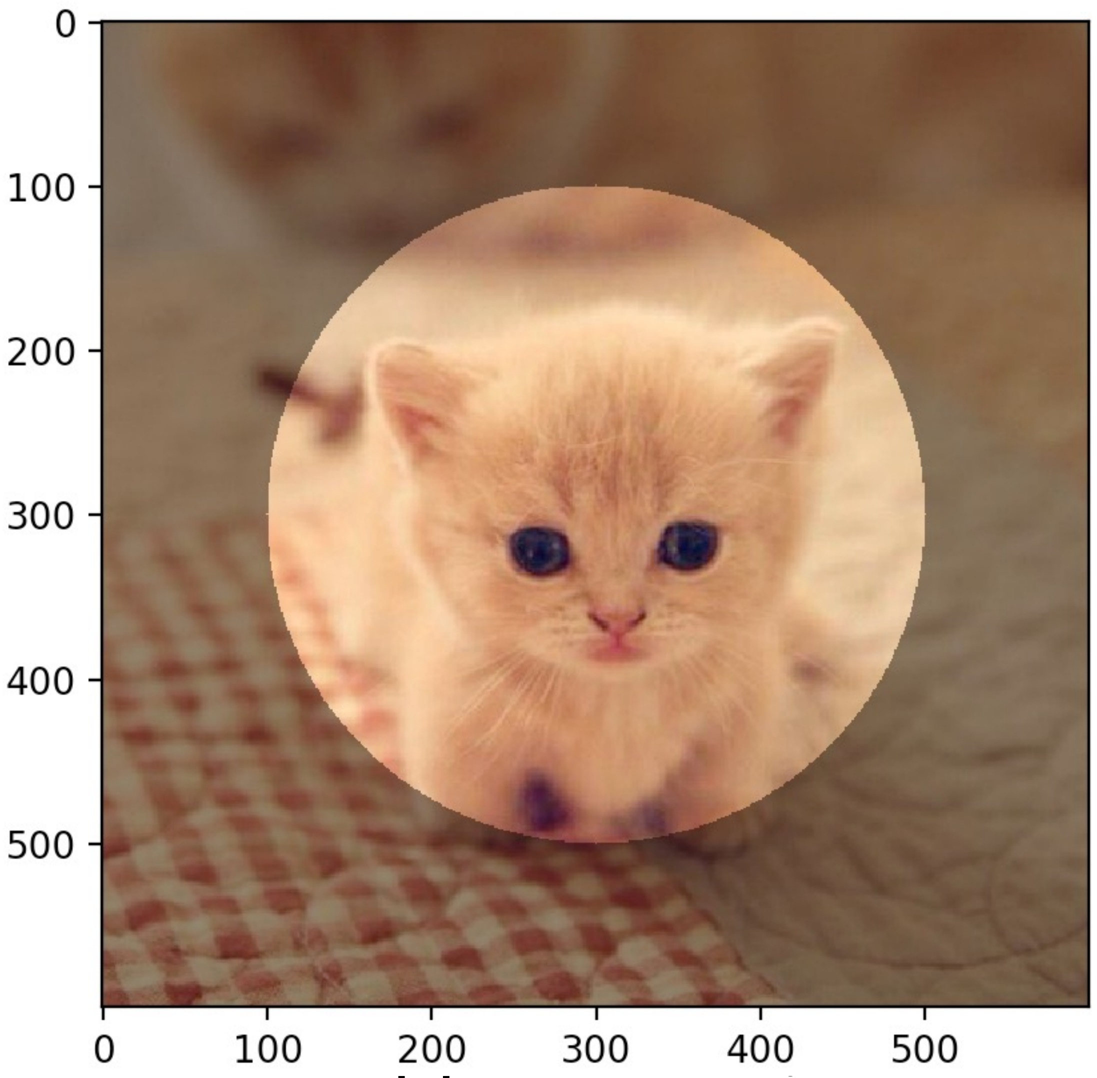
# Making a Mask

If the pixel is out of the circle



```
dim = cat_pic.shape
xcenter = dim[1]//2
ycenter = dim[0]//2

for i in range(cat_pic.shape[0]):
    for j in range(cat_pic.shape[1]):
        if (i-xcenter)**2 + (j-ycenter)**2 > (dim[0]//3)**2:
            cat_pic[i][j] = cat_pic[i][j]*0.3
```

Each color of the pixel is divided by 2



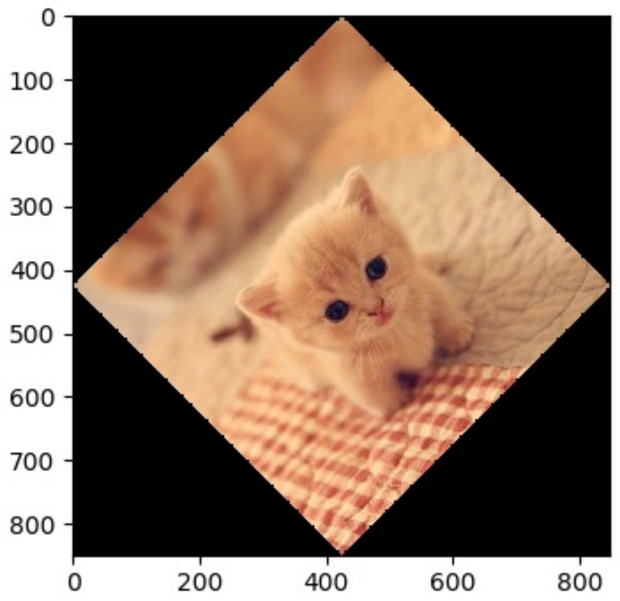
Your picture array

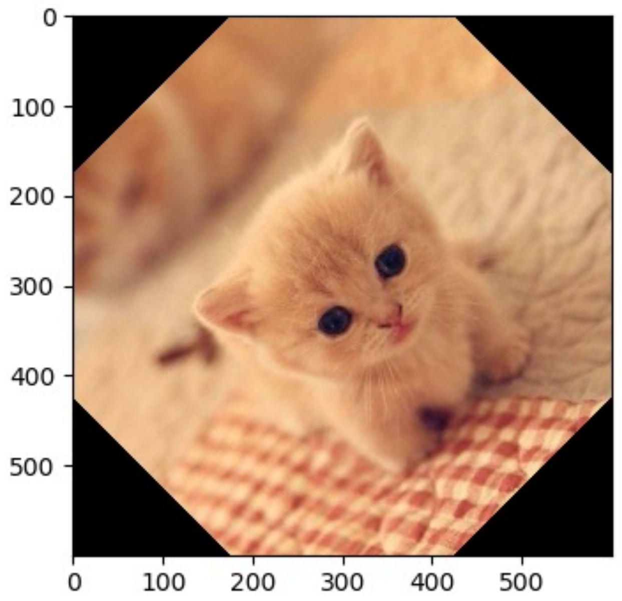
- Any time you want to save an image:

```
imageio.imsave('file name.png', cat_pic)
```

# Rotating an Image

```
from scipy import ndimage
rcat1 = ndimage.rotate(cat_pic,45)
rcat2 = ndimage.rotate(cat_pic,45,reshape=False)
plt.subplot(121)
plt.imshow(rcat1)
plt.subplot(122)
plt.imshow(rcat2)
plt.show()
```

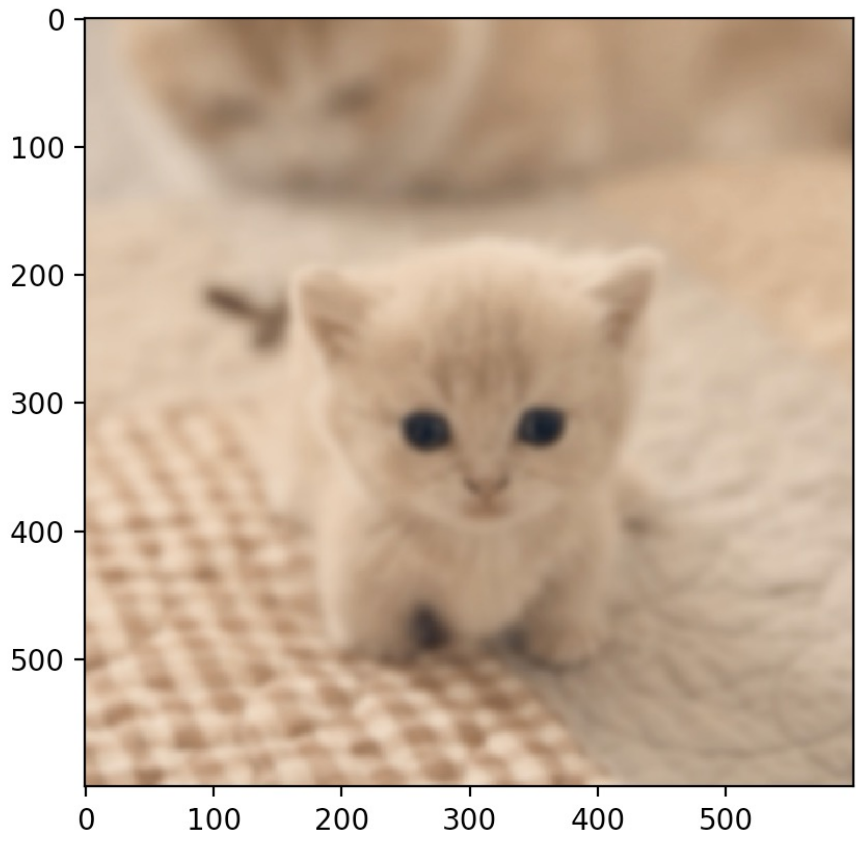


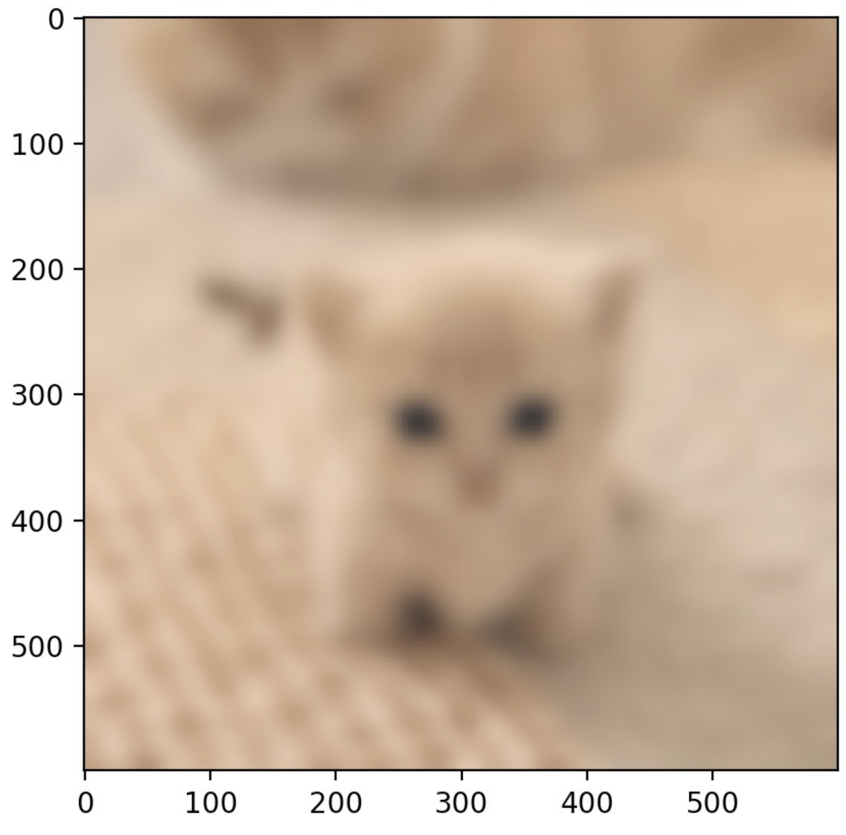


# Applying Filters

```
blurred_cat = ndimage.gaussian_filter(cat_pic,sigma=(9,9,1))
```

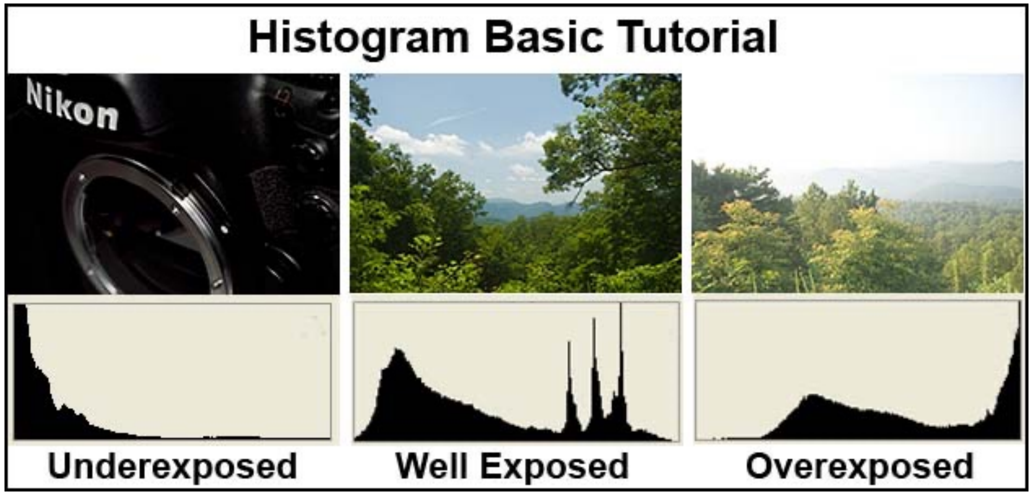
- sigma = (3,3,1)
- sigma = (9,9,1)





# More in Numpy and `Scipy`

- Fourier Transform
- Uniform filter
- Histogram
- Laplace… etc



- More on
  - [https://docs.scipy.org/doc/scipy/reference/ndimage.html](https://docs.scipy.org/doc/scipy/reference/ndimage.html)

## PILLOW

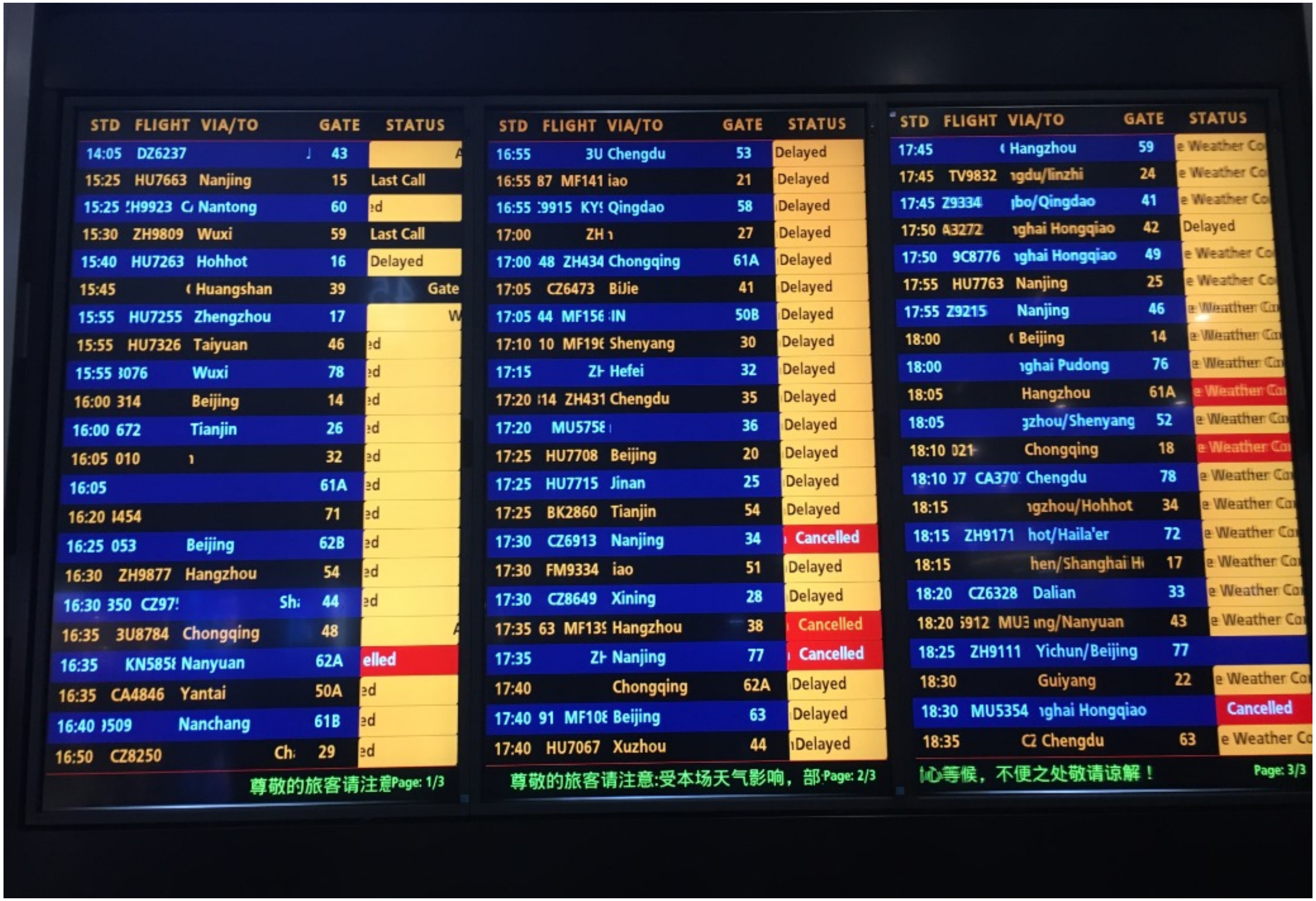
A Fork in PIL

# PILLOW is a fork of PIL

- PIL stands for Python Imaging Library

```python
from PIL import Image

pic = Image.open('my flight delay.JPG')
pic.show()
```

# Let’s get the secret out



| STD | FLIGHT | VIA/TO | GATE | STATUS |
|---|---|---|---|---|
| 14:05 | DZ6237 | J | 43 | A |
| 15:25 | HU7663 | Nanjing | 15 | Last Call |
| 15:25 | !H9923 | C Nantong | 60 | ed |
| 15:30 | ZH9809 | Wuxi | 59 | Last Call |
| 15:40 | HU7263 | Hohhot | 16 | Delayed |
| 15:45 | | ( Huangshan | 39 | Gate |
| 15:55 | HU7255 | Zhengzhou | 17 | W |
| 15:55 | HU7326 | Taiyuan | 46 | ed |
| 15:55 | 3076 | Wuxi | 78 | ed |
| 16:00 | 314 | Beijing | 14 | ed |
| 16:00 | 672 | Tianjin | 26 | ed |
| 16:05 | 010 | ı | 32 | ed |
| 16:05 | | | 61A | ed |
| 16:20 | I454 | | 71 | ed |
| 16:25 | 053 | Beijing | 62B | ed |
| 16:30 | ZH9877 | Hangzhou | 54 | ed |
| 16:30 | 350 CZ97! | Sh: | 44 | ed |
| 16:35 | 3U8784 | Chongqing | 48 | A |
| 16:35 | KN585! | Nanyuan | 62A | elled |
| 16:35 | CA4846 | Yantai | 50A | ed |
| 16:40 | )509 | Nanchang | 61B | ed |
| 16:50 | CZ8250 | Ch: | 29 | ed |

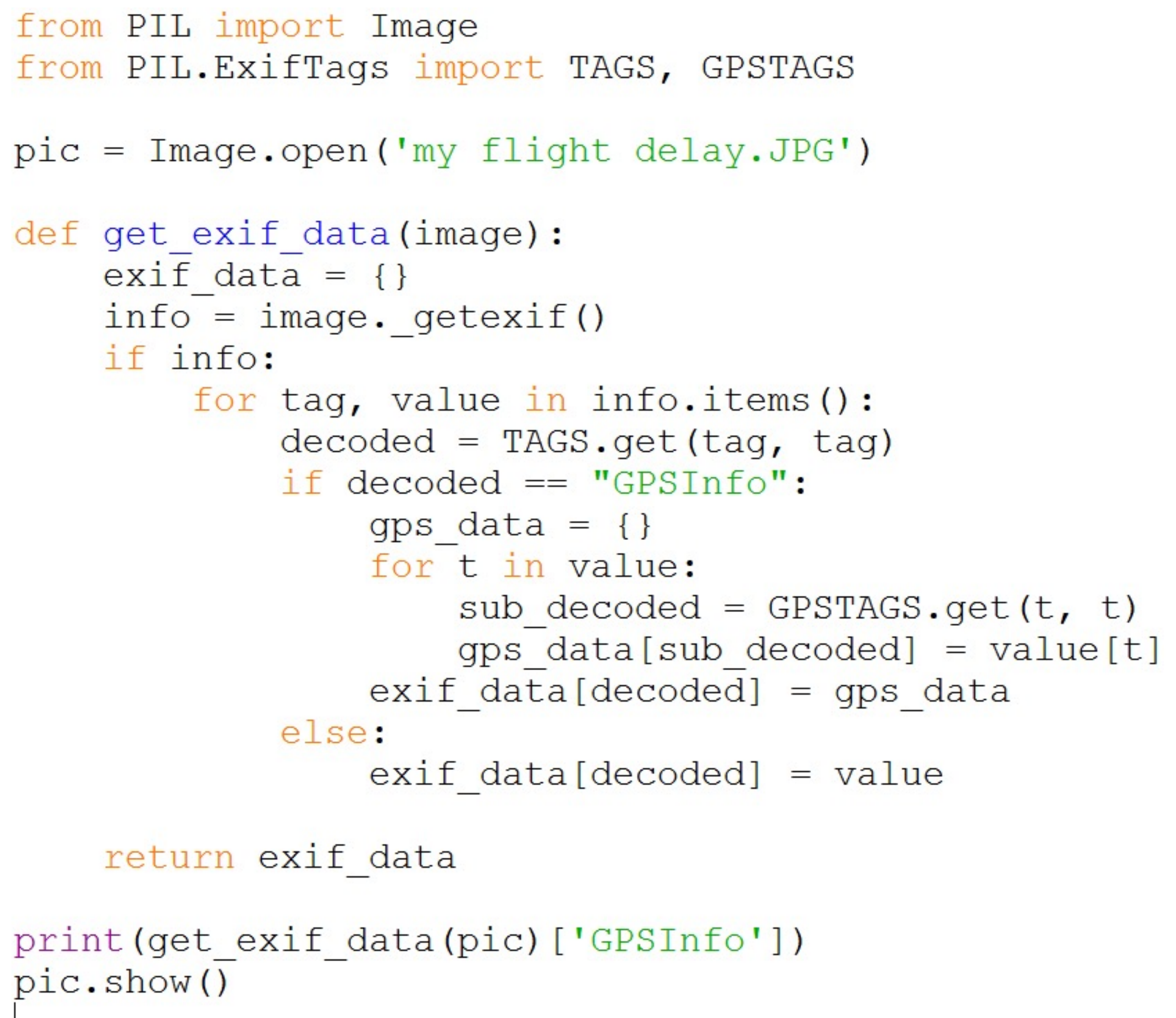
尊敬的旅客请注意Page: 1/3

| STD | FLIGHT | VIA/TO | GATE | STATUS |
|---|---|---|---|---|
| 16:55 | 3U | Chengdu | 53 | Delayed |
| 16:55 | 87 MF141 | iao | 21 | Delayed |
| 16:55 | :9915 KY! | Qingdao | 58 | Delayed |
| 17:00 | ZH | ı | 27 | Delayed |
| 17:00 | 48 ZH434 | Chongqing | 61A | Delayed |
| 17:05 | CZ6473 | BiJie | 41 | Delayed |
| 17:05 | 44 MF156 | :IN | 50B | Delayed |
| 17:10 | 10 MF19( | Shenyang | 30 | Delayed |
| 17:15 | ZH | Hefei | 32 | Delayed |
| 17:20 | !14 ZH431 | Chengdu | 35 | Delayed |
| 17:20 | MU575! | | 36 | Delayed |
| 17:25 | HU7708 | Beijing | 20 | Delayed |
| 17:25 | HU7715 | Jinan | 25 | Delayed |
| 17:25 | BK2860 | Tianjin | 54 | Delayed |
| 17:30 | CZ6913 | Nanjing | 34 | Cancelled |
| 17:30 | FM9334 | iao | 51 | Delayed |
| 17:30 | CZ8649 | Xining | 28 | Delayed |
| 17:35 | 63 MF13! | Hangzhou | 38 | Cancelled |
| 17:35 | ZH | Nanjing | 77 | Cancelled |
| 17:40 | | Chongqing | 62A | Delayed |
| 17:40 | 91 MF10! | Beijing | 63 | Delayed |
| 17:40 | HU7067 | Xuzhou | 44 | Delayed |

尊敬的旅客请注意:受本场天气影响，部Page: 2/3

| STD | FLIGHT | VIA/TO | GATE | STATUS |
|---|---|---|---|---|
| 17:45 | | ( Hangzhou | 59 | e Weather Co |
| 17:45 | TV9832 | ngdu/linzhi | 24 | e Weather Co |
| 17:45 | Z9334 | ıbo/Qingdao | 41 | e Weather Co |
| 17:50 | A3272 | ıghai Hongqiao | 42 | Delayed |
| 17:50 | 9C8776 | ıghai Hongqiao | 49 | e Weather Co |
| 17:55 | HU7763 | Nanjing | 25 | e Weather Co |
| 17:55 | Z9215 | Nanjing | 46 | e Weather Co |
| 18:00 | | ( Beijing | 14 | e Weather Co |
| 18:00 | | ıghai Pudong | 76 | e Weather Co |
| 18:05 | | Hangzhou | 61A | e Weather Co |
| 18:05 | | gzhou/Shenyang | 52 | e Weather Co |
| 18:10 | 021 | Chongqing | 18 | e Weather Co |
| 18:10 | )7 CA370 | Chengdu | 78 | e Weather Co |
| 18:15 | | ıgzhou/Hohhot | 34 | e Weather Co |
| 18:15 | ZH9171 | hot/Haila'er | 72 | e Weather Co |
| 18:15 | | hen/Shanghai H | 17 | e Weather Co |
| 18:20 | CZ6328 | Dalian | 33 | e Weather Co |
| 18:20 | 5912 MU3 | ıng/Nanyuan | 43 | e Weather Co |
| 18:25 | ZH9111 | Yichun/Beijing | 77 | |
| 18:30 | | Guiyang | 22 | e Weather Co |
| 18:30 | MU5354 | ıghai Hongqiao | | Cancelled |
| 18:35 | CZ | Chengdu | 63 | e Weather Co |

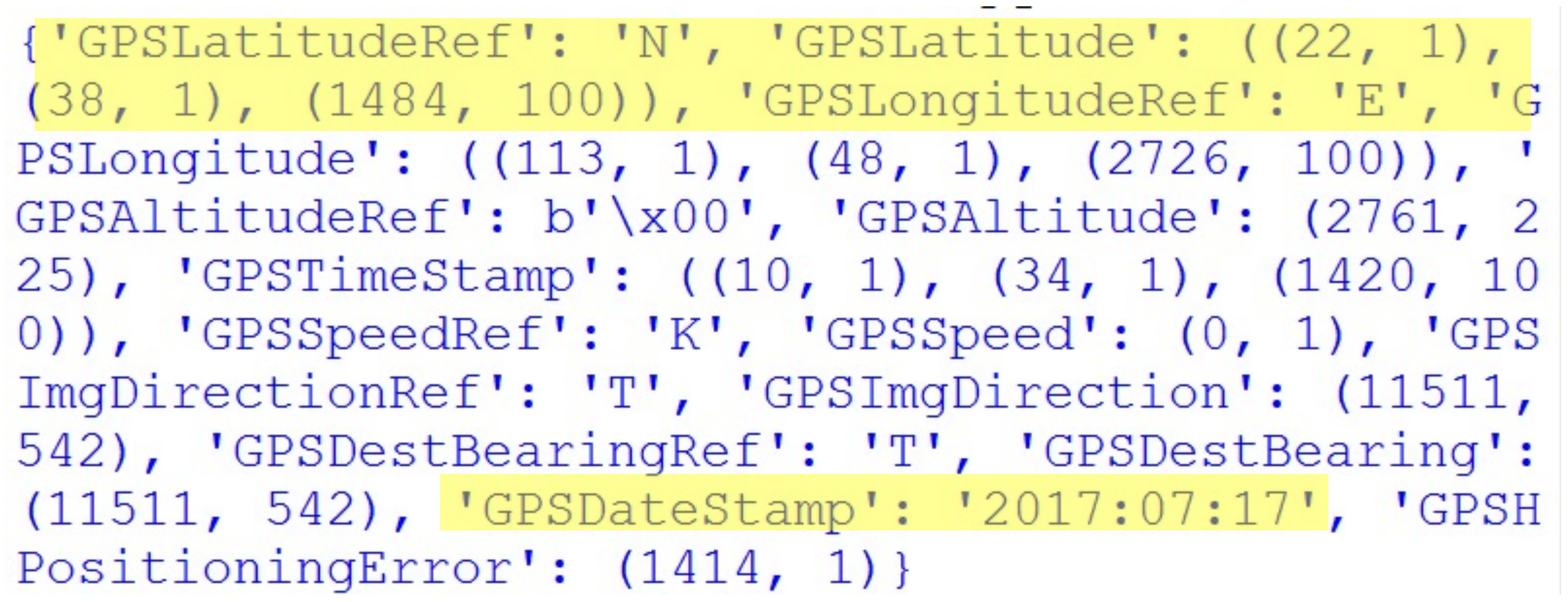
心等候，不便之处敬请谅解！ Page: 3/3



```python
from PIL import Image
from PIL.ExifTags import TAGS, GPSTAGS

pic = Image.open('my flight delay.JPG')

def get_exif_data(image):
    exif_data = {}
    info = image._getexif()
    if info:
        for tag, value in info.items():
            decoded = TAGS.get(tag, tag)
            if decoded == "GPSInfo":
                gps_data = {}
                for t in value:
                    sub_decoded = GPSTAGS.get(t, t)
                    gps_data[sub_decoded] = value[t]
                exif_data[decoded] = gps_data
            else:
                exif_data[decoded] = value

    return exif_data

print(get_exif_data(pic)['GPSInfo'])
pic.show()
```

# PILLOW

- Cannot escape!

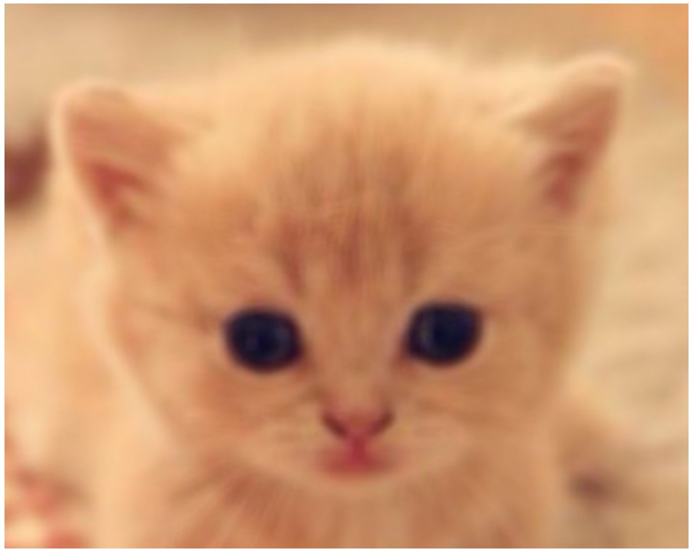


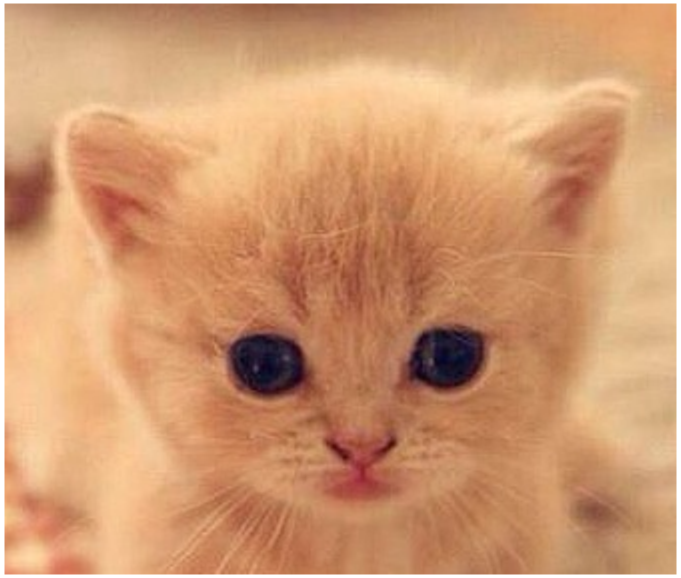
```
{'GPSLatitudeRef': 'N', 'GPSLatitude': ((22, 1),
(38, 1), (1484, 100)), 'GPSLongitudeRef': 'E', 'G
PSLongitude': ((113, 1), (48, 1), (2726, 100)), '
GPSAltitudeRef': b'\x00', 'GPSAltitude': (2761, 2
25), 'GPSTimeStamp': ((10, 1), (34, 1), (1420, 10
0)), 'GPSSpeedRef': 'K', 'GPSSpeed': (0, 1), 'GPS
ImgDirectionRef': 'T', 'GPSImgDirection': (11511,
542), 'GPSDestBearingRef': 'T', 'GPSDestBearing':
(11511, 542), 'GPSDateStamp': '2017:07:17', 'GPSH
PositioningError': (1414, 1)}
```

# PILLOW

```
from PIL import Image
from PIL import ImageFilter
pic = Image.open('cute cat.jpg')

pic.show()

blurred_pic =  pic.filter(ImageFilter.BLUR)
blurred_pic.show()

sharpen_pic =  pic.filter(ImageFilter.SHARPEN)
sharpen_pic.show()
```

Original


Blurred

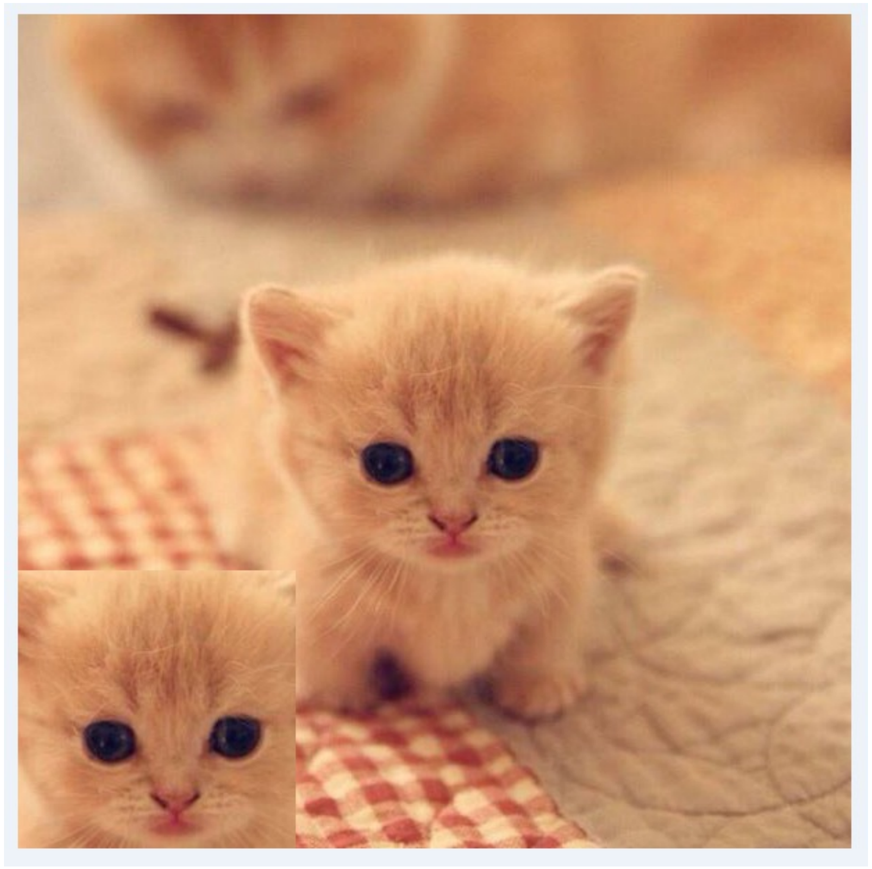

Sharpen

# Copy And Paste

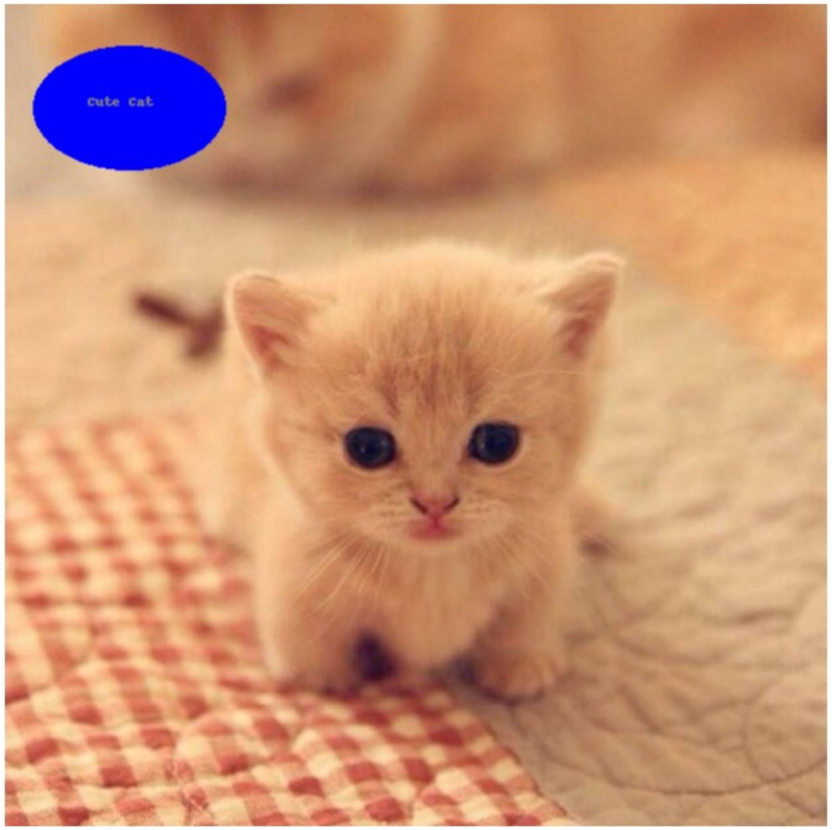
```
from PIL import Image

pic = Image.open('cute cat.JPG')
part = pic.crop((200,200,400,400))

pic.paste(part,(0,400))
pic.show()
```

Copy (crop) the part of the picture

Paste it on the position (0,400)



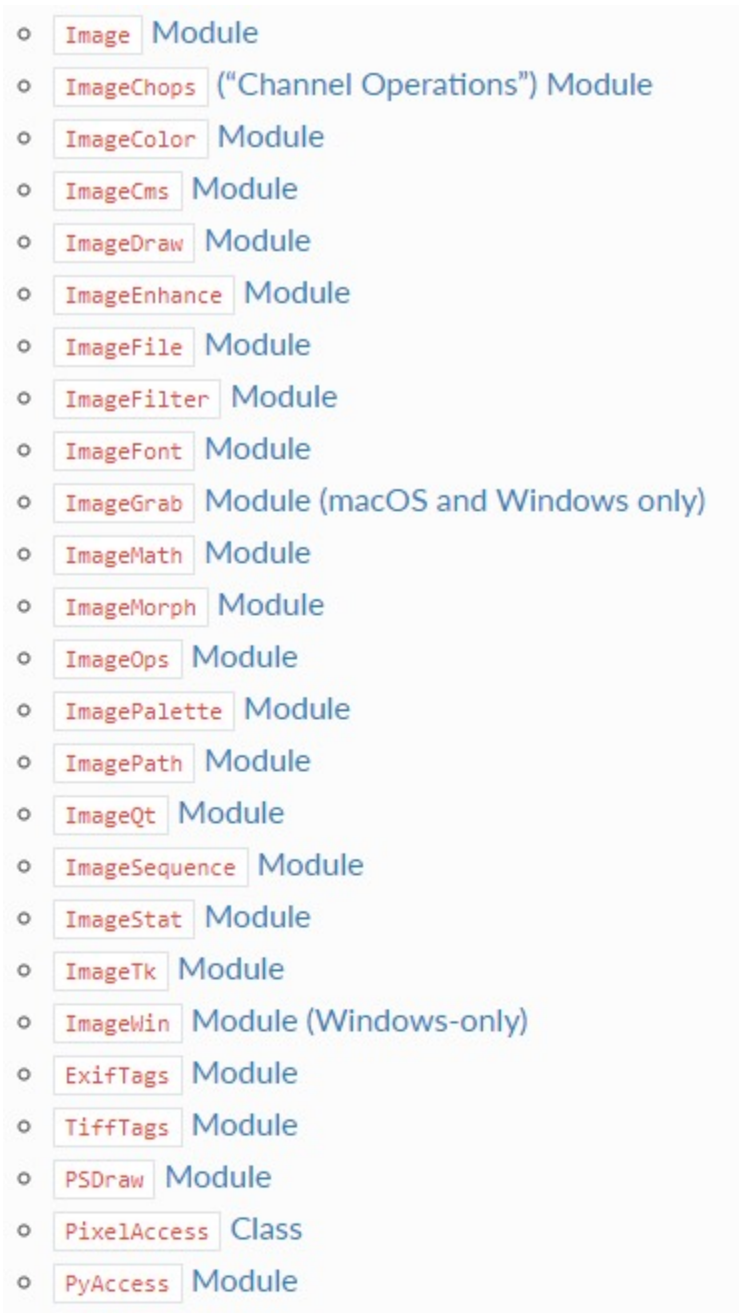
```
from PIL import Image, ImageDraw, ImageFont

pic = Image.open('cute cat.JPG')

draw = ImageDraw.Draw(pic)
draw.ellipse((20, 30, 160, 120), fill='blue')
draw.text((60,65),'Cute Cat', fill = 'gray')

pic.show()
```



## Other operations

- resize
- rotation/flipping
- traspose
- Drawing shapes
- etc. etc..

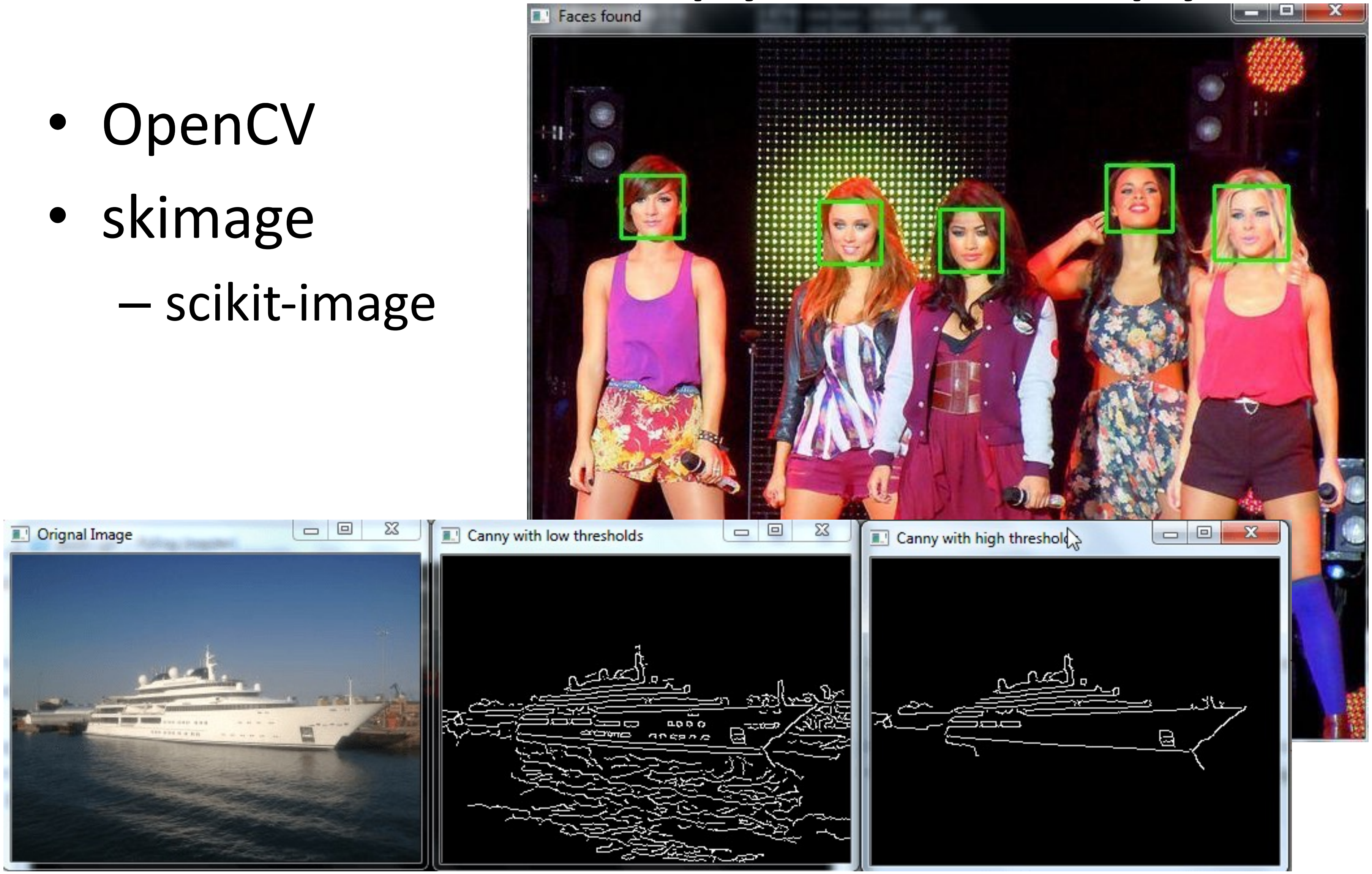
https://pillow.readthedocs.io/en/stable/



- `Image` Module
- `ImageChops` ("Channel Operations") Module
- `ImageColor` Module
- `ImageCms` Module
- `ImageDraw` Module
- `ImageEnhance` Module
- `ImageFile` Module
- `ImageFilter` Module
- `ImageFont` Module
- `ImageGrab` Module (macOS and Windows only)
- `ImageMath` Module
- `ImageMorph` Module
- `ImageOps` Module
- `ImagePalette` Module
- `ImagePath` Module
- `ImageQt` Module
- `ImageSequence` Module
- `ImageStat` Module
- `ImageTk` Module
- `ImageWin` Module (Windows-only)
- `ExifTags` Module
- `TiffTags` Module
- `PSDraw` Module
- `PixelAccess` Class
- `PyAccess` Module

# Other Than Scipy and Numpy

- OpenCV
- skimage
  - scikit-image


Faces found
Orignal Image
Canny with low thresholds
Canny with high threshol