# How to Use MTCNN in Production

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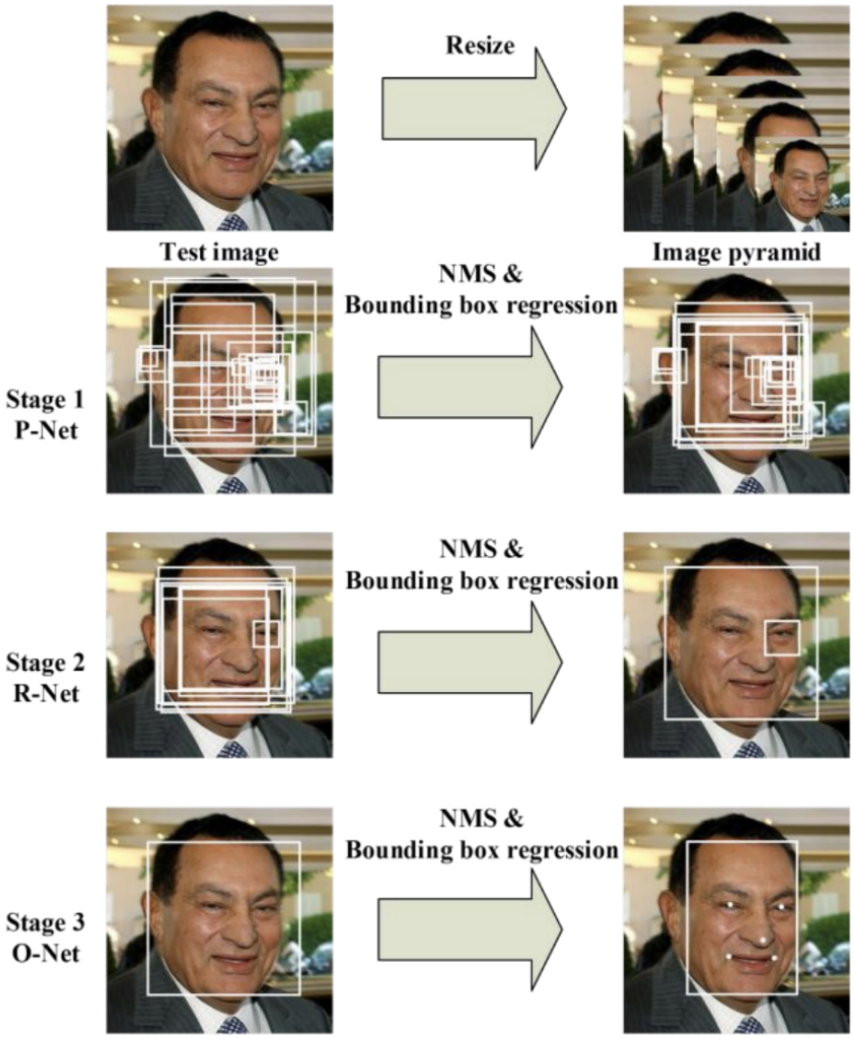
## 1 Introduction

Haar-cascade classifiers proposed by Viola and Jones are known as the first method to perform face detection. Nowadays, Convolutional Neural Network (CNN) is the most popular usage of deep learning models in variety of computer vision tasks such as face detection, face recognition and image classification.

Multi-Task Cascaded Convolutional Neural Network (MTCNN) is one of the most famous CNN models to perform face detection. Face detection as well as face alignment are done jointly using MTCNN in a multi-task training fashion.

MTCNN consist of three stages. In the first stage, it produces candidate windows quickly through a shallow CNN. Then, it refines the windows by rejecting many non-faces windows through the second CNN. Finally, another CNN model is utilized to refine the result again and output five facial landmarks positions.



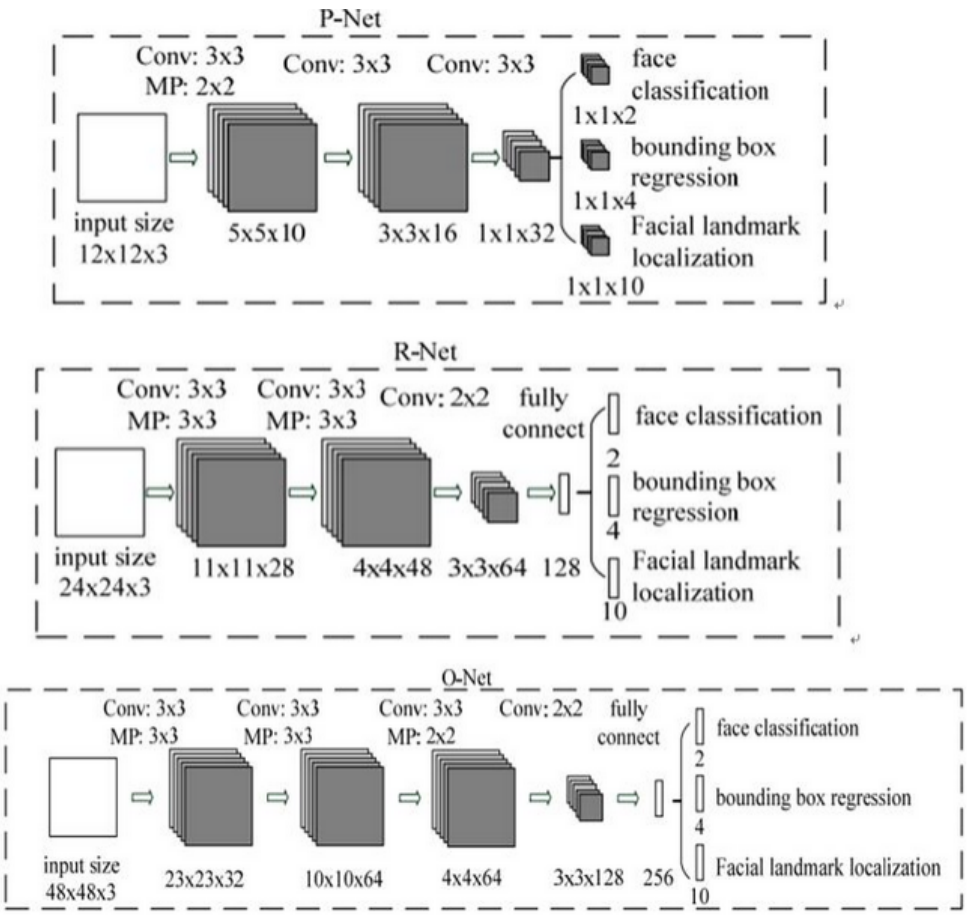

## 2 MTCNN Three Main Steps

**Stage 1**: A fully convolutional network, called Proposal Network (P-Net), to obtain the candidate facial windows and their bounding box regression vectors. P-Net consist of three convolutional layer Then candidates are calibrated based on the estimated bounding box regression vectors. After that, we employ non-maximum suppression (NMS) to merge highly overlapped candidates.

**Stage 2**: All candidates are fed to another CNN, called Refine Network (R-Net), which further rejects a large number of false candidates, performs calibration with bounding box regression, and conducts NMS. R-Net consist of 3 convolutional layer along with a fully connected layer.

**Stage 3**: This stage is similar to the second stage, but in this stage we aim to identify face regions with more supervision. The model has four convolutional layer together

with a fully connected layer. In particular, the network will output five facial landmarks' positions.




# 3 MTCNN in Practice

Face detection is the first step of any facial recognition system. During model selection step, I choose MTCNN as it is fast and accurate. To perform face dtection using python, one need to import MTCNN instance and create detecor. Then detect_faces method is utilized to extract the location of faces, eyes, nose and mouth. The output is a dictionary which containes the face location ('box'), the confidence that the detected object is a face ('confidence') and the location of eyes, nose and mouth ('keypoints'). Lets start.

## 3.1 Necesary Libraries

First, necessary libraries are imported.

```
In [9]: from matplotlib import pyplot
        from matplotlib.patches import Rectangle, Circle
        from PIL import Image
        from mtcnn.mtcnn import MTCNN
        import sys
        import numpy as np
        import os
        import glob
```

## 3.2 Creating MTCNN detector

Then an instance of MTCNN model is created

```
In [12]: detector = MTCNN()
```

As mentioned above the output of model contans the face and key points locations along with the confidence value.

```
In [15]: pixels = pyplot.imread(image01)
         pyplot.imshow(pixels)
         # get the context for drawing boxes
         ax = pyplot.gca()
         results = detector.detect_faces(pixels)
         results
```

```
Out[15]: [{'box': [77, 54, 68, 87],
           'confidence': 0.9999995231628418,
           'keypoints': {'left_eye': (105, 87),
            'right_eye': (136, 88),
            'nose': (127, 110),
            'mouth_left': (106, 122),
            'mouth_right': (131, 124)}}]
```


### 3.3 Face Detection with Basic MTCNN

Here we are going to create a python function to detect faces in a given image. To this end we must apply following steps: - load an image from a file - utilize the detector to detect all faces in the image - return the detected location in the image

```
In [16]: def detect_face_basic(filename):
             #load image from file
             pixels = pyplot.imread(filename)
             pyplot.imshow(pixels)
             # get the context for drawing boxes
             ax = pyplot.gca()
             #detect faces in the image
             results = detector.detect_faces(pixels)
             for result in results:
                 x, y, width, height = result['box']
                 keypoints = result['keypoints']
                 #create the shape
                 rect = Rectangle((x, y), width, height, fill=False, color='red')
                 circ1 = Circle(keypoints['left_eye'], 3, color='blue')
                 circ2 = Circle(keypoints['right_eye'], 3, color='blue')
                 circ3 = Circle(keypoints['nose'], 3, color='yellow')
                 circ4 = Circle(keypoints['mouth_left'], 3, color='green')
```

```
            circ5 = Circle(keypoints['mouth_right'], 3, color='green')
            # draw the box
            ax.add_patch(rect)
            ax.add_patch(circ1)
            ax.add_patch(circ2)
            ax.add_patch(circ3)
            ax.add_patch(circ4)
            ax.add_patch(circ5)
        #show the plot
        pyplot.show()
```

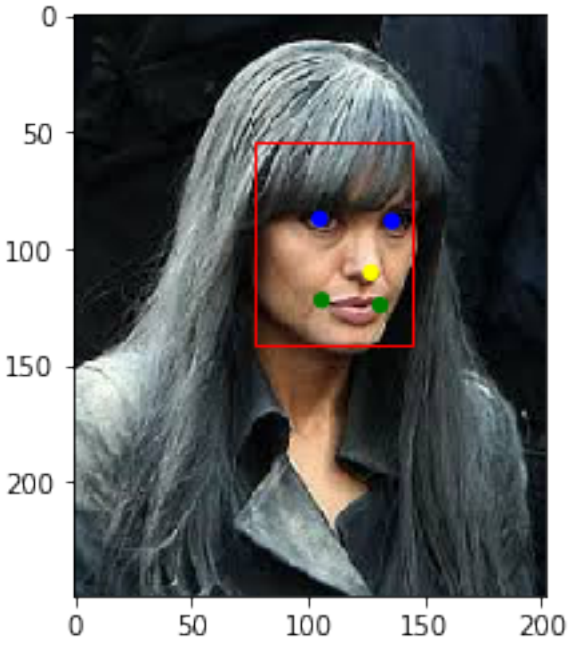
### 3.3.1 Results

To test the performance of my function, I am going to apply my function on the following images.

```
In [14]: image01 = './myimages/joli8.jpeg' # angelina jolie
         image02 = './myimages/af1.jpeg' # african
         image03 = './myimages/1.jpg' # Amin
         image04 = './myimages/1/dog2.jpeg' # Animals
         image05 = './myimages/1/cat1.jpeg' # Animals
         image06 = './myimages/1/gorilla2.jpeg' # Animals
         image07 = './test/test1.jpg' # human with animals
         image08 = './myimages/dog.jpeg' # dog face (not human face)
         image09 = './myimages/gorilla1.jpeg' # gorilla face (not human face)
         image10 = './myimages/dog-test2.jpeg' # dog face (not human face)
         image11 = './myimages/dog-test1.jpeg' # dog face (not human face)
```

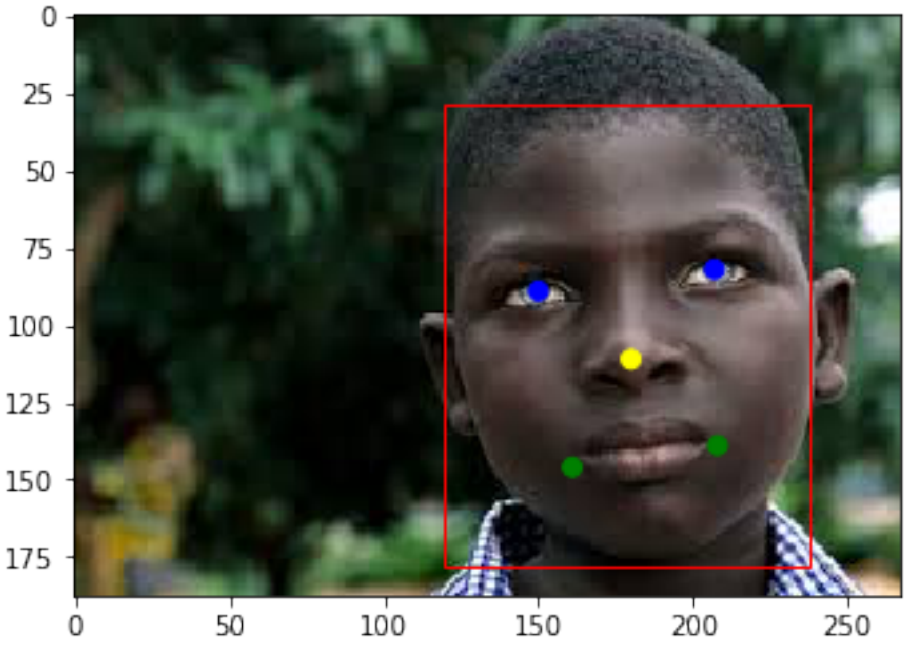
First

```
In [17]: detect_face_basic(image01)
```

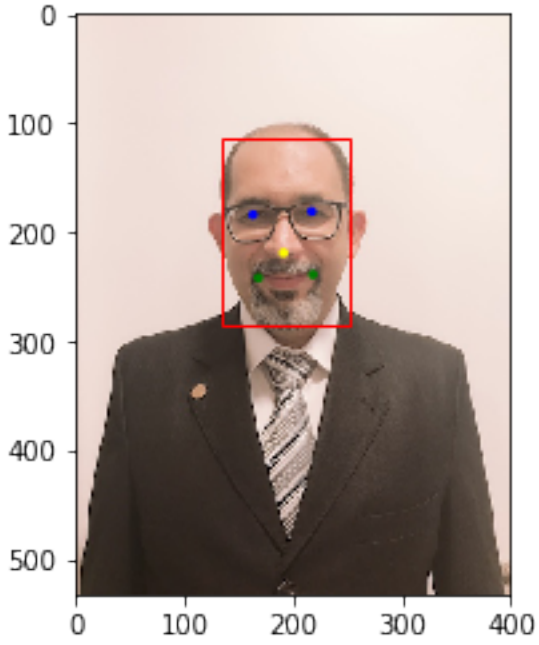



sounds good.

```
In [19]: detect_face_basic(image02)
```



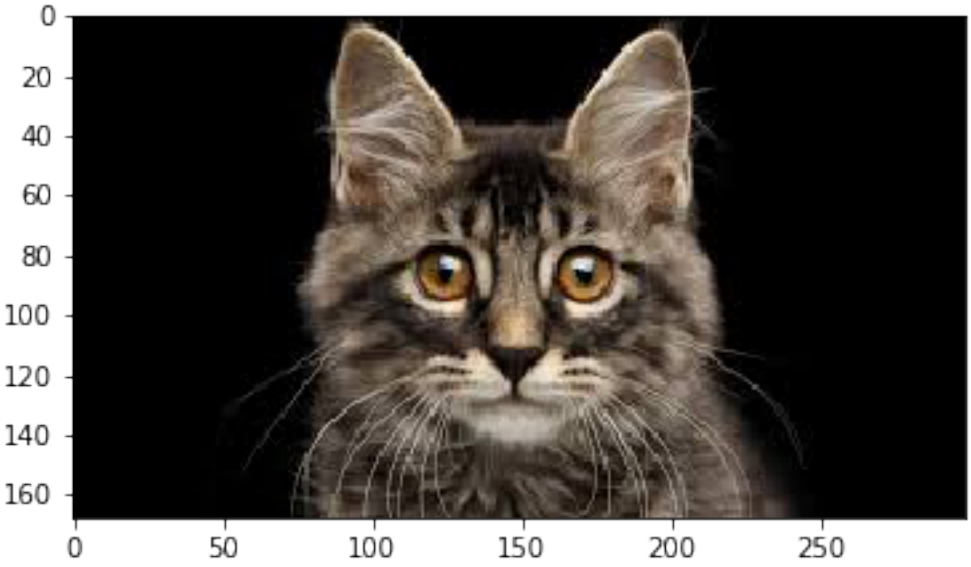
```
In [20]: detect_face_basic(image03)
```



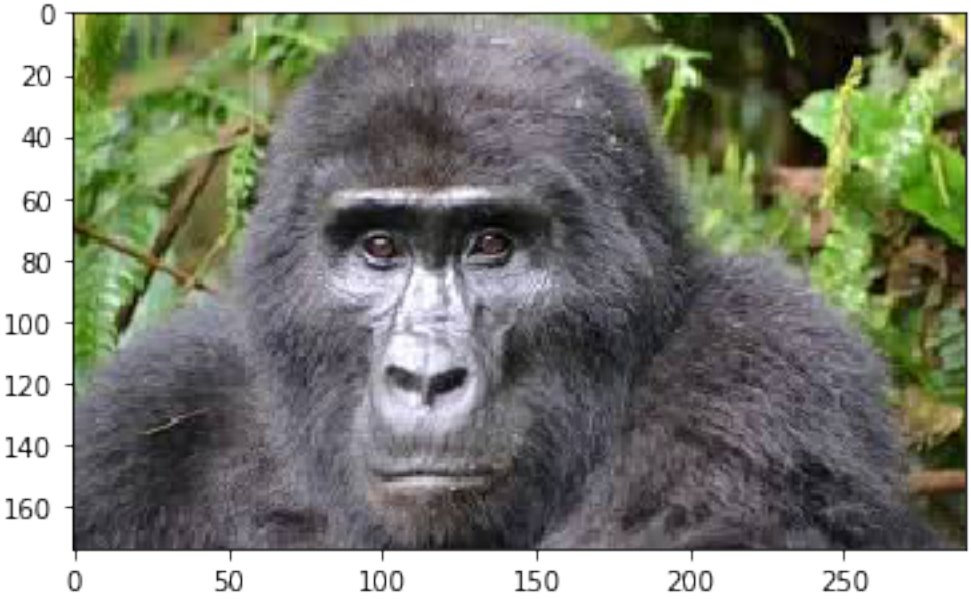

In our application, the aim is to detect just human faces. So let's apply the function on animals faces. In this test case, I use a dog, a cat and a gorilla image and apply my function on those images.

```
In [21]: detect_face_basic(image04)
```

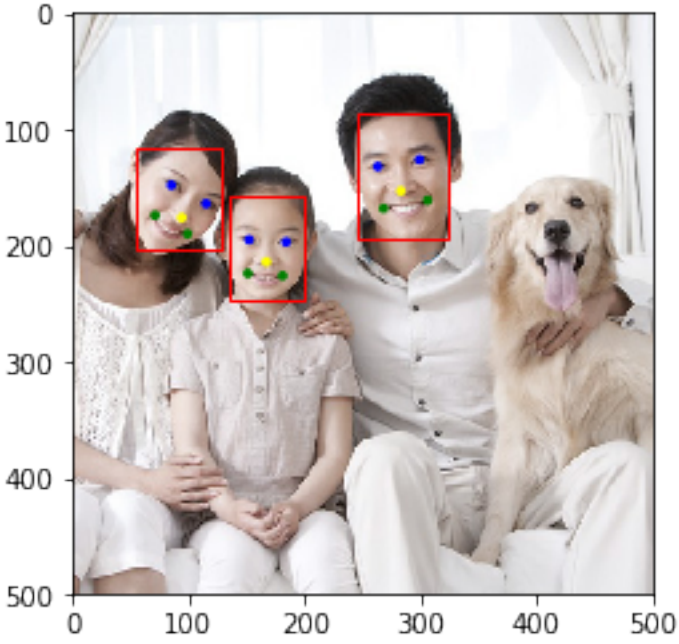
In [22]: detect_face_basic(image05)




In [23]: detect_face_basic(image06)



```
In [24]: detect_face_basic(image07)
```

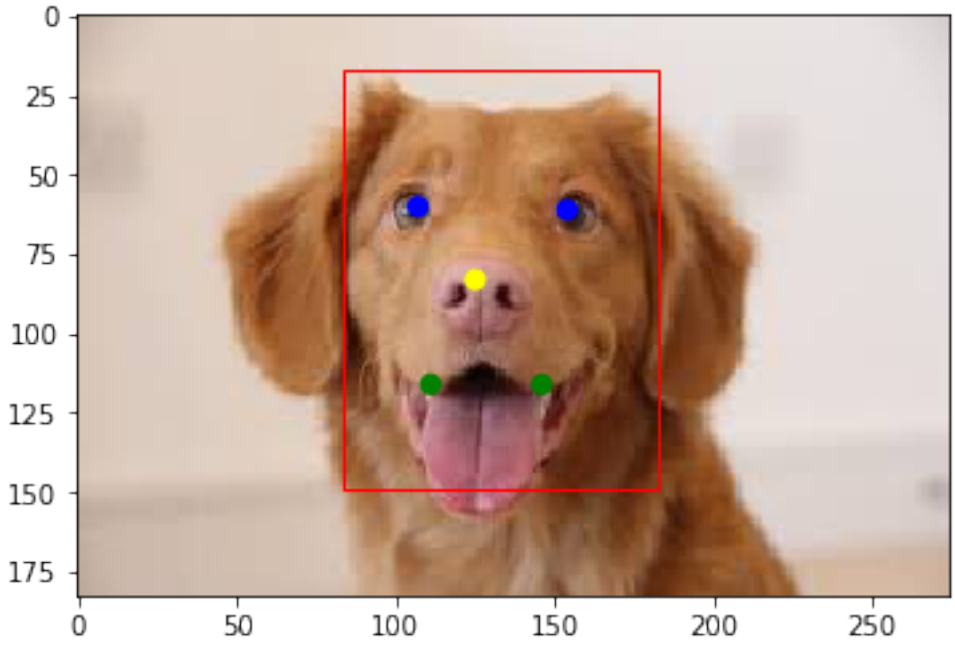



Surprisingly, model is able to detect human faces and ignore the dog face in the last image.

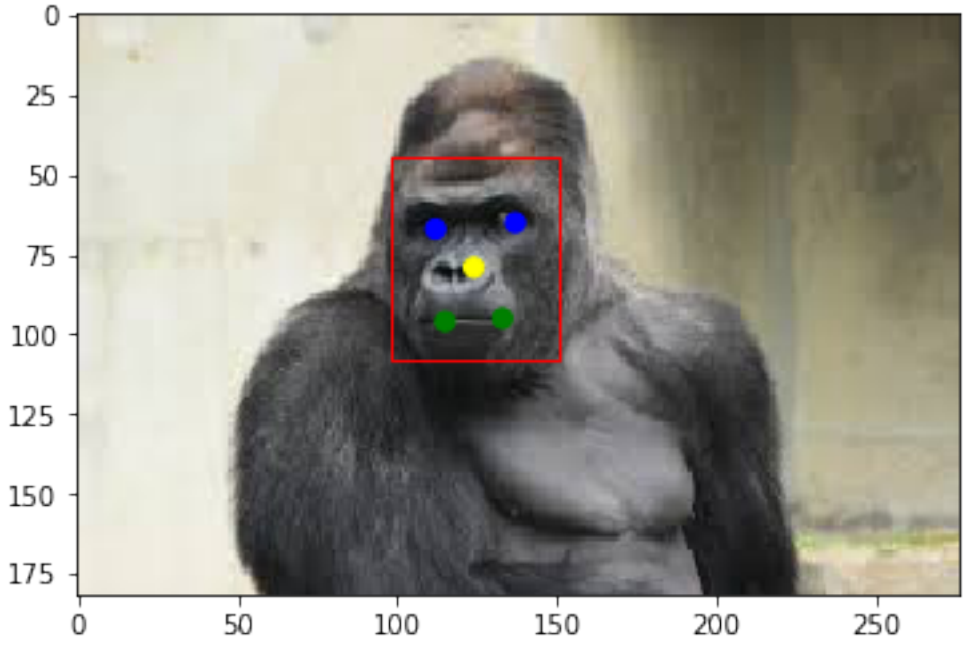
## 3.4 False Positive Example

As mention, it is very critical for us to detect only human face in our application. during my research I could find some false positive examples shown below:

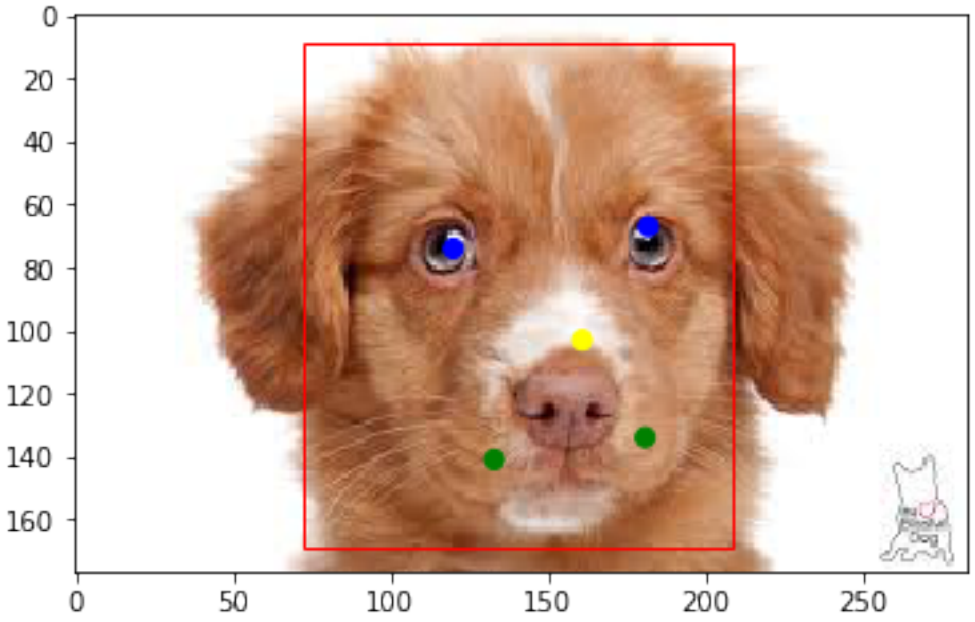
```
In [25]: detect_face_basic(image08)
```




In [26]: `detect_face_basic(image09)`




In [27]: `detect_face_basic(image10)`




## 3.5 How to Set Confidence Value

The main question now is " How can we make sure that our function just detect human faces?". To this end, I first collect some image data including animals and human images. Then I used face detector on those images and analyze the confidence value.

```
In [28]: Ref_Pics_Path='./myimages/'
         images1 = (glob.glob(Ref_Pics_Path + "*.*"))
         images = [image[11:] for image in images1]

In [29]: pixels = [pyplot.imread(image) for image in images1]
         len(pixels)

Out[29]: 68

In [30]: results = []
         for i in range(len(pixels)):
             a = detector.detect_faces(pixels[i])
             if a != []:
                 results.append((images[i],a[0]['confidence']))

In [31]: import pandas as pd
         df = pd.DataFrame(results, columns=['Image', 'Confidence'])

         df.sort_values('Confidence').head(10)
```

```
Out[31]:                    Image  Confidence
         31         dog-test2.jpeg    0.841822
         28          gorilla1.jpeg    0.913521
         24               dog.jpeg    0.976554
         20           joli21.jpeg    0.984447
         45           joli12.jpeg    0.992286
         22  angelina-jolie759.jpg    0.993296
         27           joli14.jpeg    0.998206
         30           joli18.jpeg    0.998602
         46                 2.jpg    0.999114
         6             joli42.jpg    0.999136

In [32]: df.sort_values('Confidence', ascending = False).head(10)

Out[32]:              Image  Confidence
         40        af2.jpeg    1.000000
         21        oa1.jpeg    1.000000
         33     joli19.jpeg    1.000000
         14      joli8.jpeg    1.000000
         15     joli20.jpeg    0.999999
         36     joli15.jpeg    0.999999
         9   goh-test3.jpeg    0.999998
         29        af4.jpeg    0.999997
         51           3.jpg    0.999996
         16         tom.jpg    0.999996

In [39]: df['Confidence'].describe()

Out[39]: count    57.000000
         mean      0.994546
         std       0.023796
         min       0.841822
         25%       0.999482
         50%       0.999885
         75%       0.999992
         max       1.000000
         Name: Confidence, dtype: float64
```

According to the statistical characteristics of `Confodenc` column, we decide to set the confidence thershold equals to 0.999.

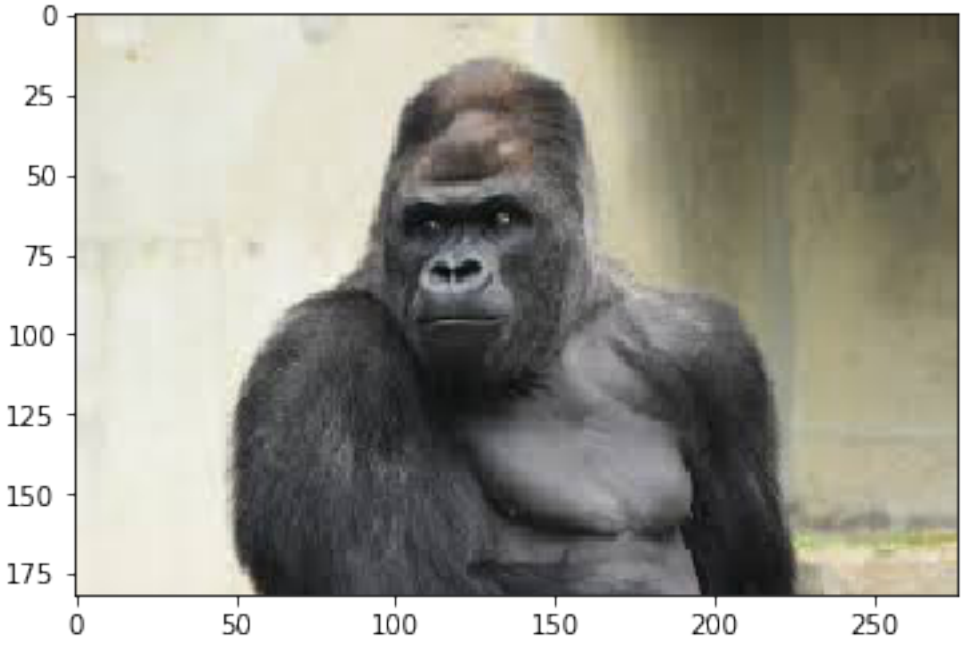
## 3.6 Improving MTCNN

In this section, we improve the basic face detection function by adding a check on the confidence value. Then the new function is applied on the animals image.

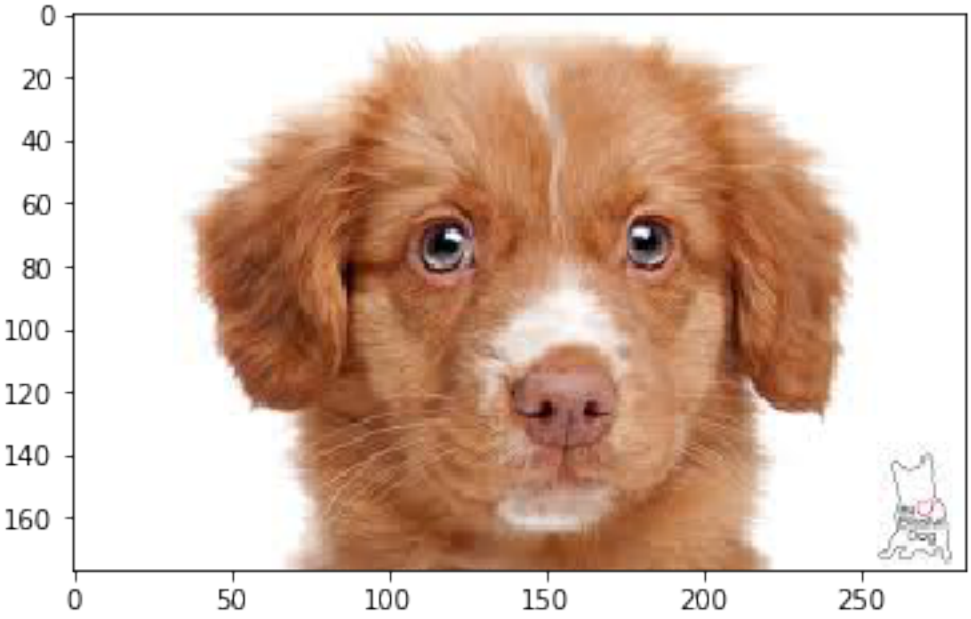
```
In [41]: def detect_face_improved(filename, confidence = 0.999):
             # load image from file
             pixels = pyplot.imread(filename)
             pyplot.imshow(pixels)
             ax = pyplot.gca()
             # detect faces in the image
             results = detector.detect_faces(pixels)
             for result in results:
                 if (result['confidence'] > confidence):
                     x, y, width, height = result['box']
                     keypoints = result['keypoints']
                     rect = Rectangle((x, y), width, height, fill=False, color='green')
                     circ1 = Circle(keypoints['left_eye'], 3, color='blue')
                     circ2 = Circle(keypoints['right_eye'], 3, color='blue')
                     circ3 = Circle(keypoints['nose'], 3, color='red')
                     circ4 = Circle(keypoints['mouth_left'], 3, color='green')
                     circ5 = Circle(keypoints['mouth_right'], 3, color='green')
                     # draw the box
                     ax.add_patch(rect)
                     ax.add_patch(circ1)
                     ax.add_patch(circ2)
                     ax.add_patch(circ3)
                     ax.add_patch(circ4)
                     ax.add_patch(circ5)
             pyplot.show()

In [42]: detect_face_improved(image08)
```

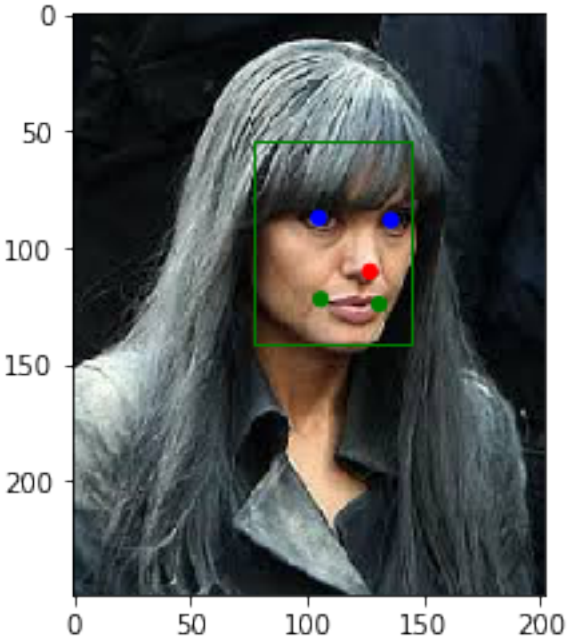
In [43]: detect_face_improved(image09)



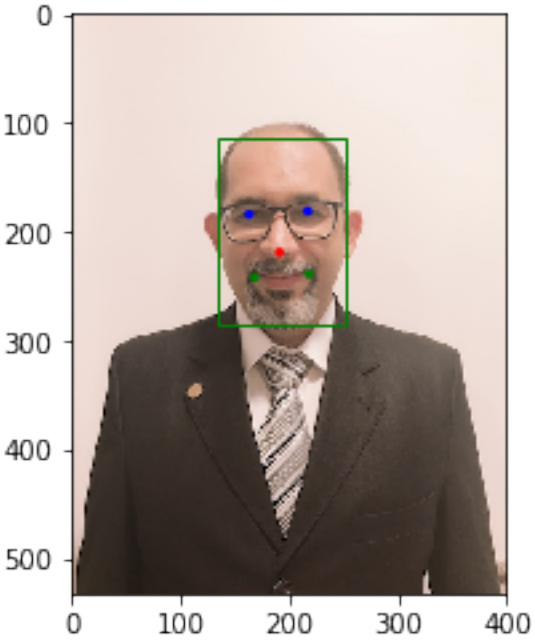

In [44]: detect_face_improved(image10)



In [46]: detect_face_improved(image01)




In [47]: detect_face_improved(image03)



# References


[1] Zhang, K., Zhang, Z., Li, Z., Qiao, Y. (2016). Joint face detection and alignment using multitask cascaded convolutional networks. IEEE Signal Processing Letters, 23(10), 1499-1503.

[2] Kaziakhmedov, E., Kireev, K., Melnikov, G., Pautov, M., Petiushko, A. (2019). Real-world attack on MTCNN face detection system. arXiv preprint arXiv:1910.06261.

[3] Li, H., Lin, Z., Shen, X., Brandt, J., Hua, G. (2015). A convolutional neural network cascade for face detection. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 5325-5334).

[4] https://towardsdatascience.com/face-detection-with-deep-learning-using-multi-tasked-cascased-cnn-8721435531d5

[5] https://towardsdatascience.com/how-does-a-face-detection-program-work-using-neural-networks-17896df8e6ff?

[6] https://medium.com/nodeflux/the-evolution-of-computer-vision-techniques-on-face-detection-part-2-4af3b22df7c2