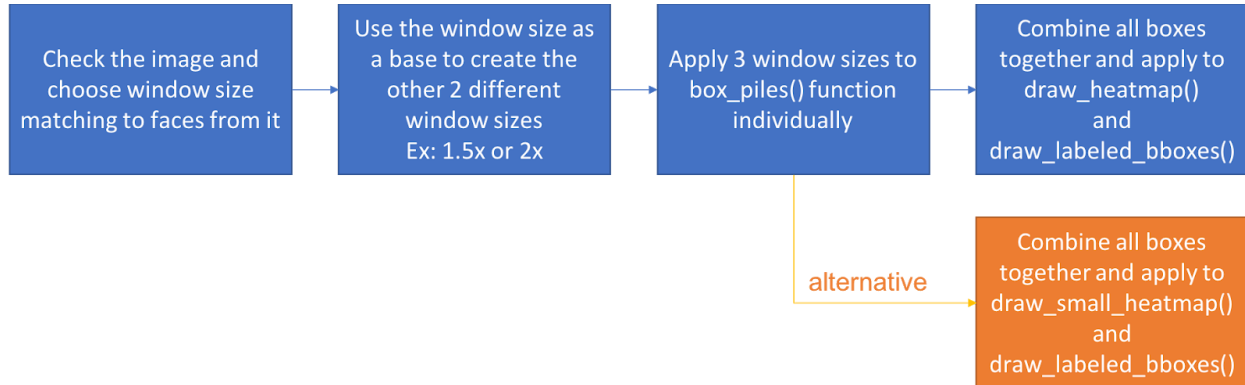
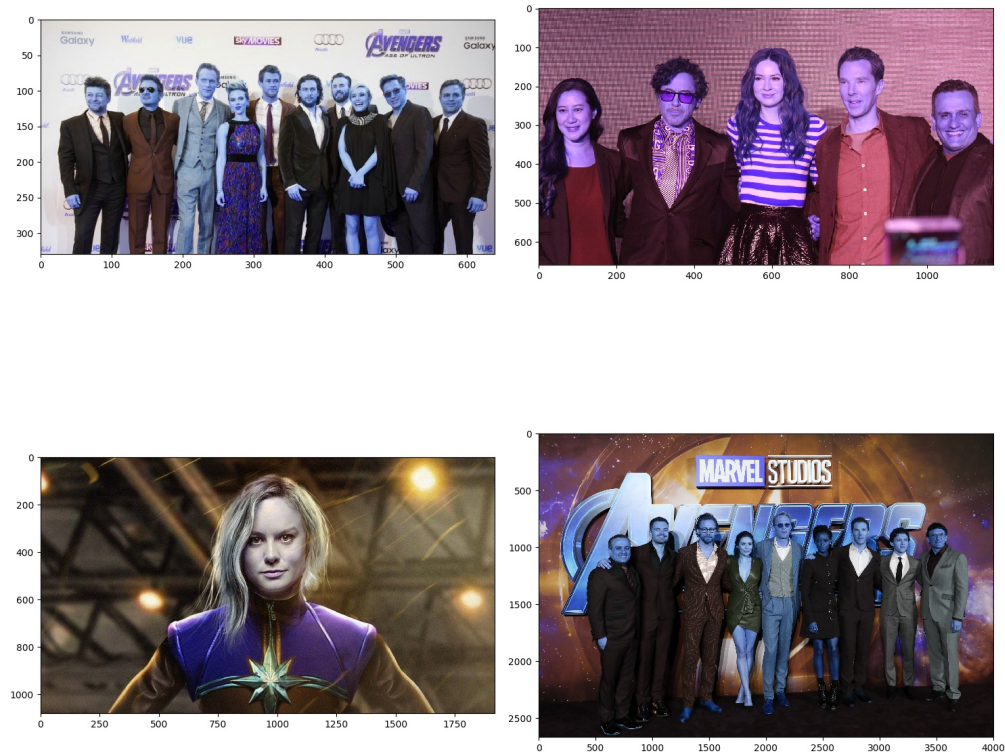


Here I am using facial recognition classifier (model8) + sliding windows tool + heatmap tool to localize where are faces in the images.

### Pipeline for testing images:



### Testing images:



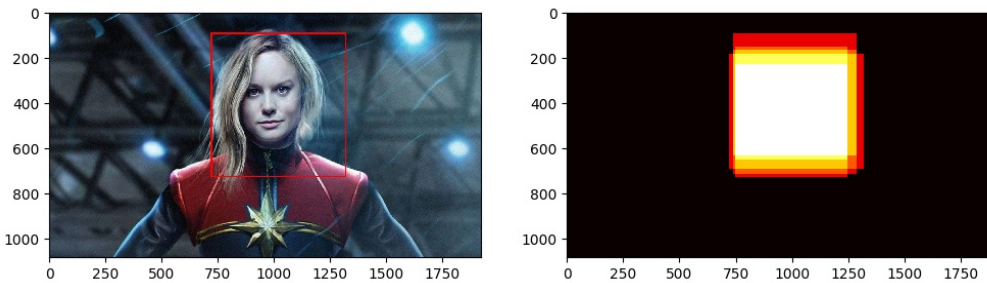
## Results:

- 1) The image with 1 face is easy for us to identify. In the heat map, accumulated pixels would change the color, which represents a high confidence of facial location.

Threshold=1,

Window size= 500x500, 550x550, 600x600,

Functions: draw\_heat(), draw\_heatmap()

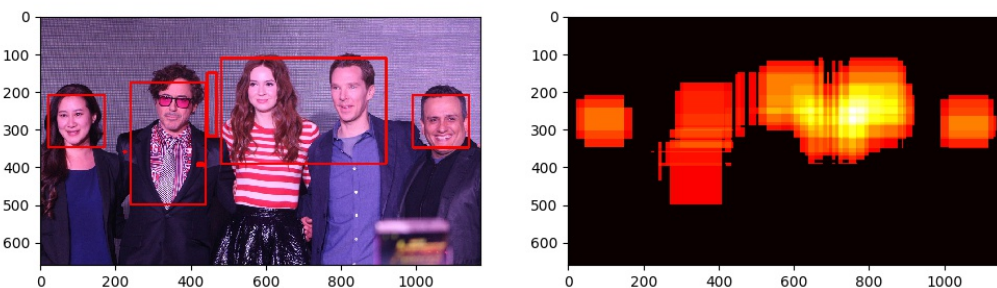


- 2) The image with 5 faces seems to have some overlapping issues. If boxes are too closed to each other, label() function would group them together and underestimate the counting number. I can increase more threshold, but it would zero out other faces.

Threshold = 12,

Window size = 150x150, 200x200, 250x250,

Functions: draw\_heat(), draw\_heatmap()

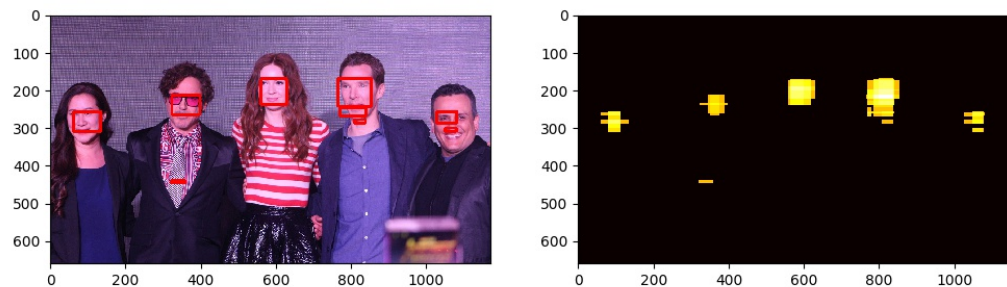


Here I use functions of heat map with shrunk windows to make the situation better.

Threshold = 12,

Window size= 150x150, 200x200, 250x250,

Functions: draw\_small\_heat(), draw\_small\_heatmap()

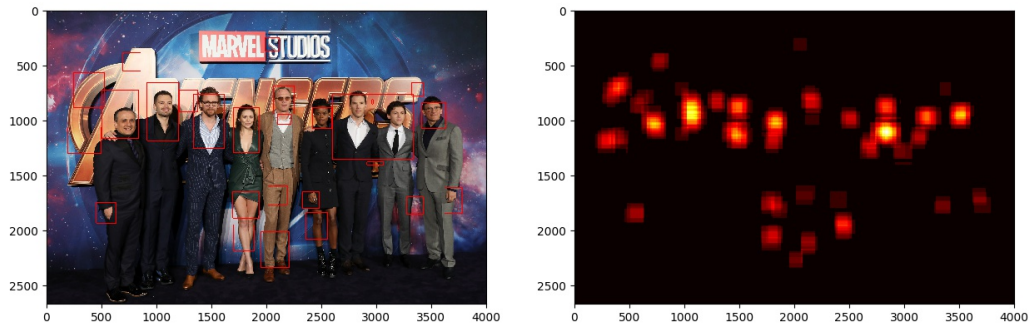


3) The image with 9 faces seem to have noises from the background.

Threshold = 1,

Window size = 250x250, 300x300, 350x350,

Functions: draw\_small\_heat(), draw\_small\_heatmap()

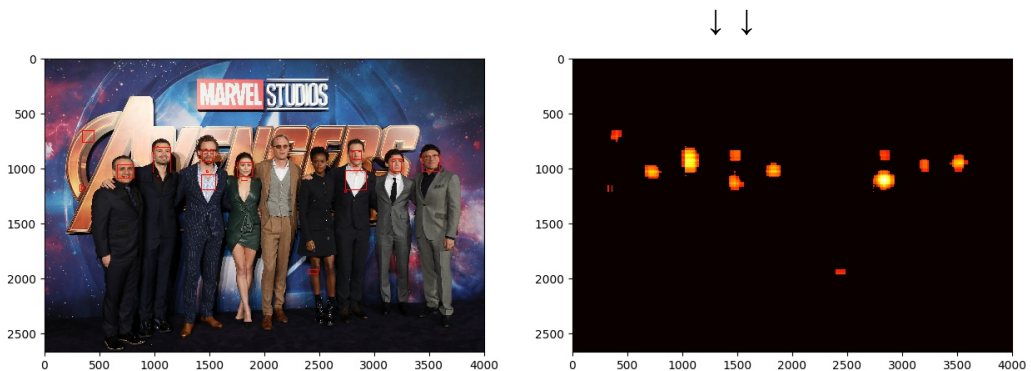


After I increase the threshold to 10, I get rid of noises but I also lose two faces in the middle of the image (↓).

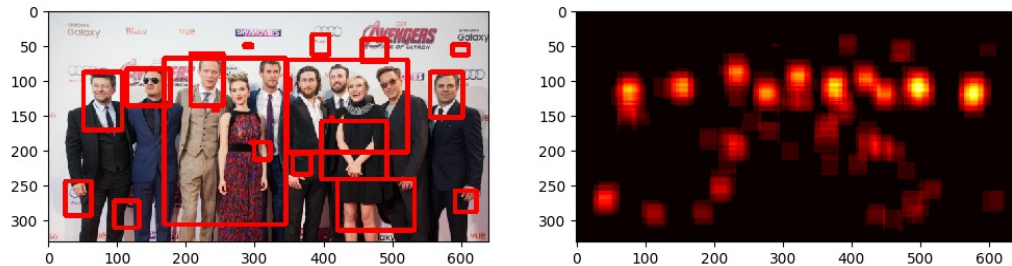
Threshold = 10,

Window size = 250x250, 300x300, 350x350,

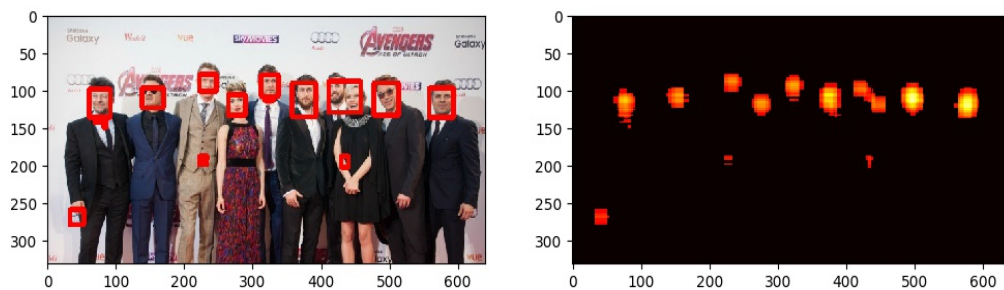
Functions: draw\_small\_heat(), draw\_small\_heatmap()



- 4) The image with 10 faces seem to have some noises from the background.  
Threshold = 1,  
Window size = 50x50, 60x60, 70x70,  
Functions: draw\_small\_heat(), draw\_small\_heatmap()

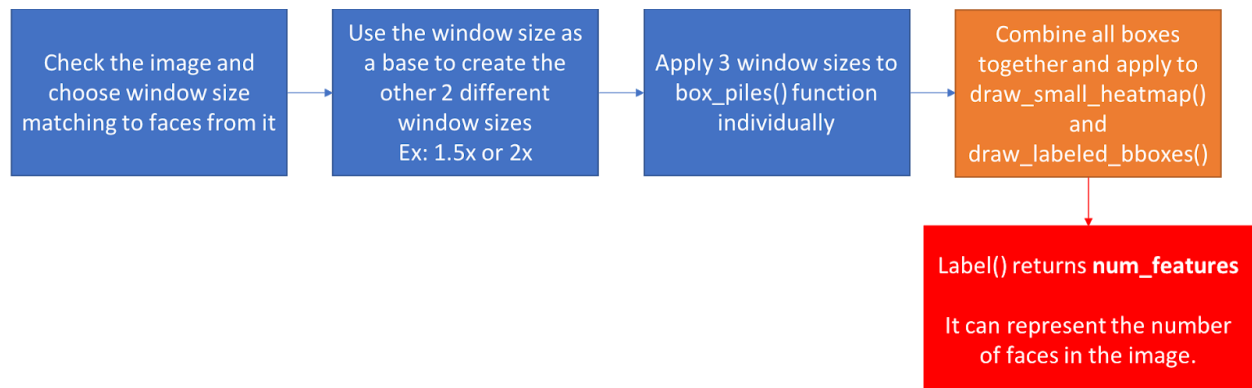


After I increase the threshold to 10, the boxes are more gathered on their faces.  
Threshold = 10,  
Window size = 50x50, 60x60, 70x70,  
Functions: draw\_small\_heat(), draw\_small\_heatmap()

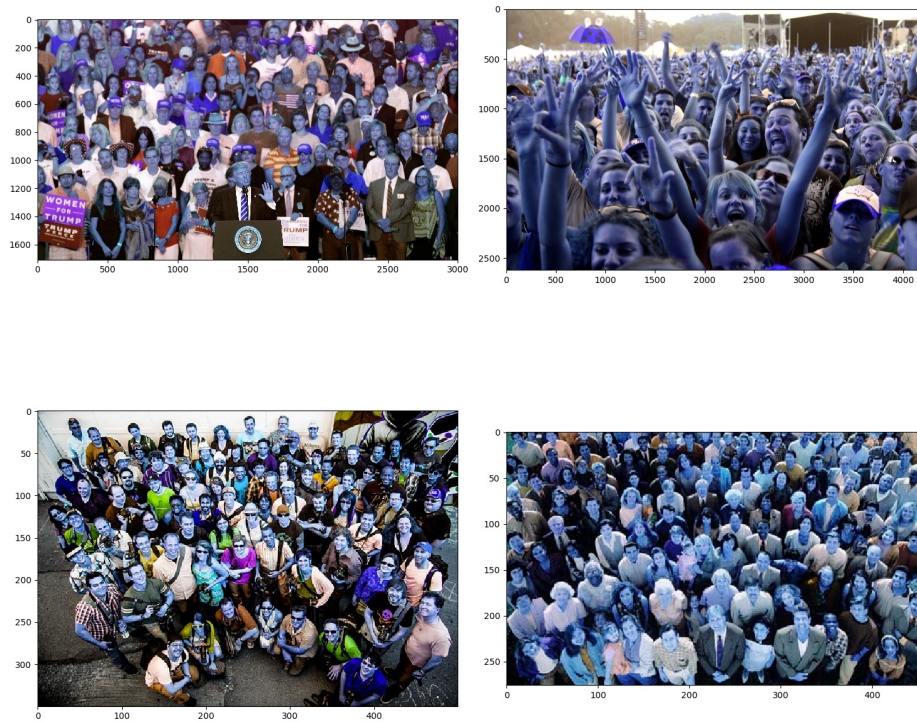




## Pipeline for crowd images:



## Crowd images:



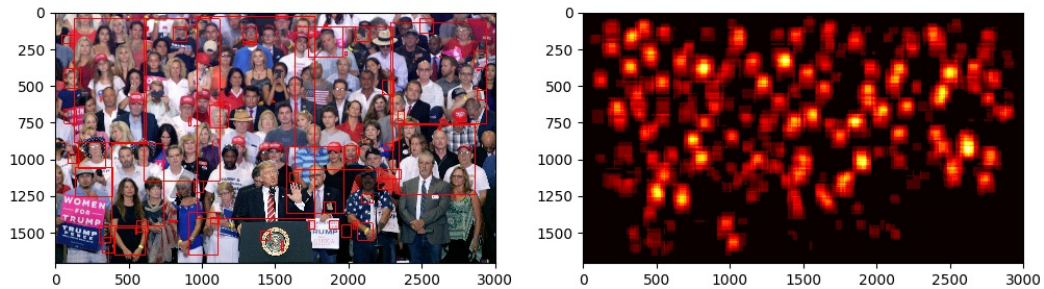
## Results:

1) The test4.jpg is a campaign's photo with ~120 faces.

Threshold = 1,

Window size = 125x125, 190x190, 250x250,

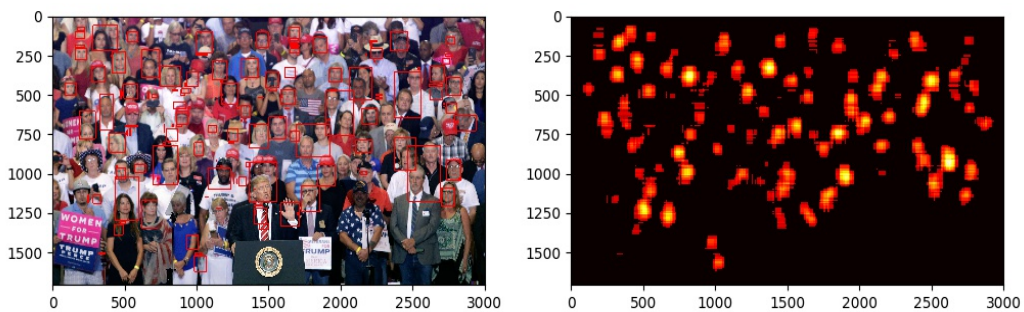
Functions: draw\_small\_heat(), draw\_small\_heatmap()



Threshold = 5,

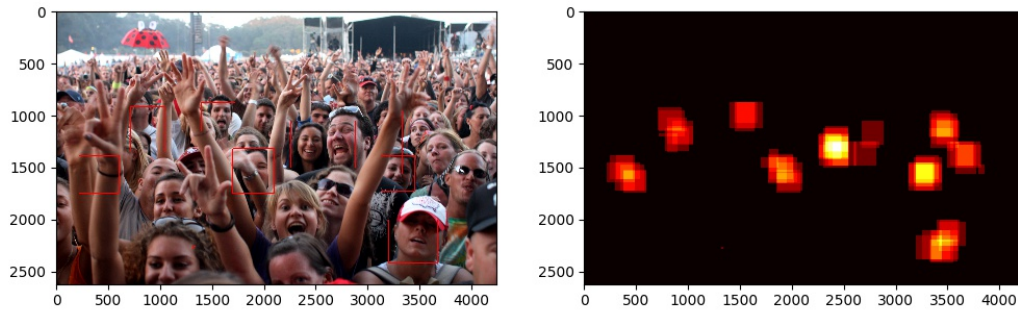
Window size = 100x100, 150x150, 200x200,

Functions: draw\_small\_heat(), draw\_small\_heatmap()



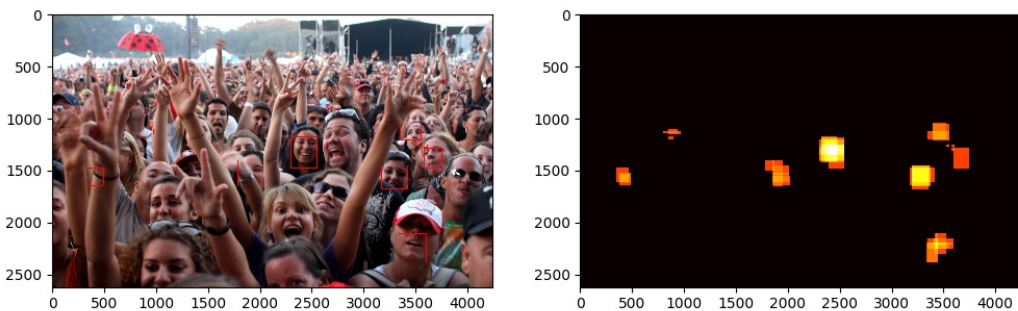
Estimated faces: 167

- 2) Our strategy is not useful for the test1.jpg. It has a lot of incomplete faces and arms.  
Threshold = 1,  
Window size = 450x450, 500x500, 550x550,  
Functions: draw\_small\_heat(), draw\_small\_heatmap()



Increasing threshold can get rid of noises, but it can not fix the recognition issues.

Threshold = 5,  
Window size = 450x450, 500x500, 550x550,  
Functions: draw\_small\_heat(), draw\_small\_heatmap()

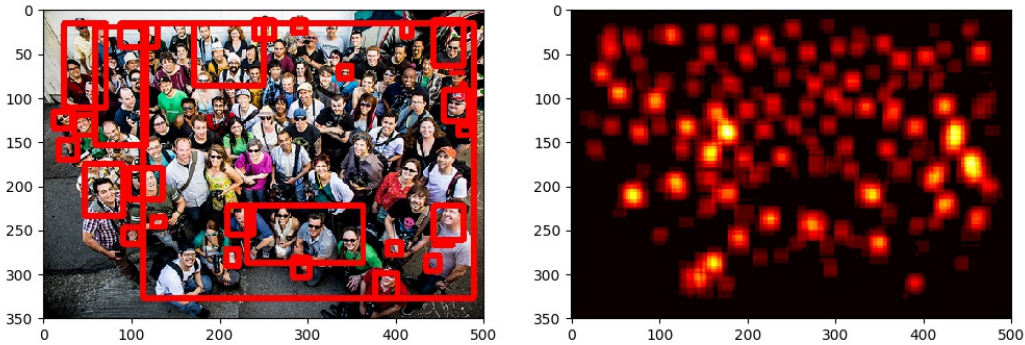


3) The test3.jpg is a photo with ~84 faces.

Threshold = 1,

Window size = 30x30, 45x45, 60x60,

Functions: draw\_small\_heat(), draw\_small\_heatmap()

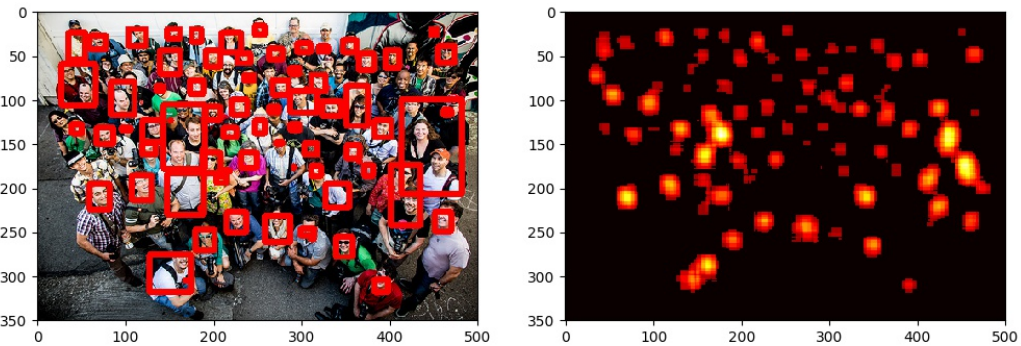


Increasing threshold shows more positive boxes in the left image.

Threshold = 5,

Window size = 30x30, 45x45, 60x60,

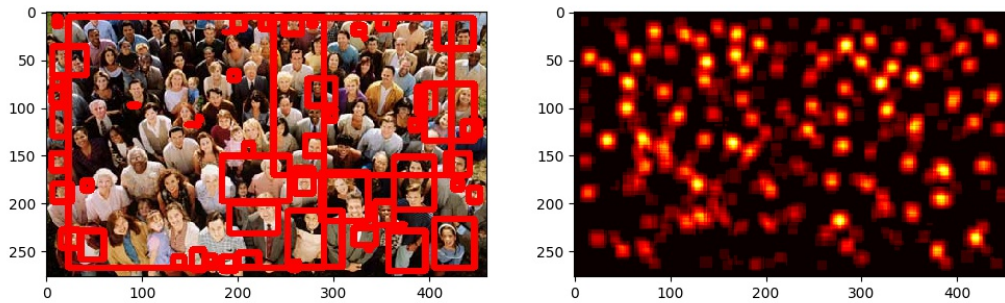
Functions: draw\_small\_heat(), draw\_small\_heatmap()



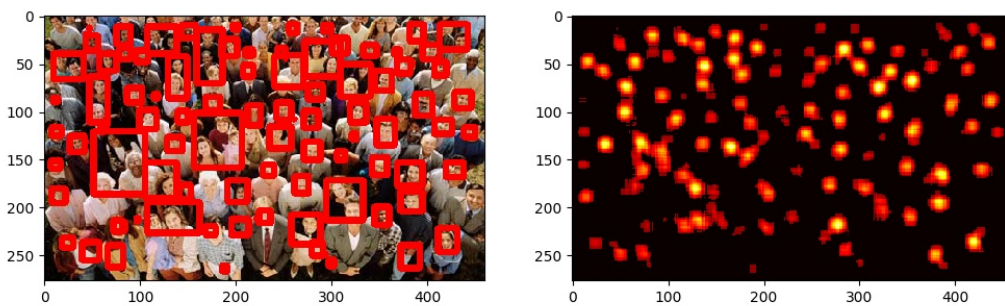
Estimated faces: 77



- 4) The test2.jpg is a photo with ~110 faces.  
Threshold = 1,  
Window size = 20x20, 25x25, 30x30,  
Functions: draw\_small\_heat(), draw\_small\_heatmap()



Threshold = 5,  
Window size = 20x20, 25x25, 30x30,  
Functions: draw\_small\_heat(), draw\_small\_heatmap()



Estimated faces: 104

## Q & A:

A) Why the color of those images looks weird?

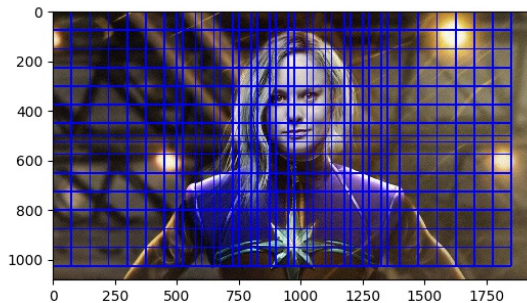
`cv2.imread()` transforms images into BGR format by default (Regular images present under RGB format). When I train my model, I directly use BGR images to train my models. It is possible to show RGB images by `plt.imshow(img[:, :, ::-1])`.

B) Why use model8 instead of other models?

In the model evaluation, model5 and model8 both have the best performance. However, model5 has a better performance in two datasets with full body images compared to model8. I concern that model5 will have more noises so I choose model8.

C) What is sliding window?

First thing is to create a grid with a lot of boxes (windows) on the image. Then, I check each box with the classifier and collect all boxes with high probability of face labels.



D) What is heatmap?

After collecting all boxes indicating face location, I add each box back to the original image with zero in each pixel as 1. If boxes localize the same area, pixels are accumulated to more than 1. When I apply the result to the heat map, it would show different color based on the pixel values.

## Reference:

1 face image

<https://www.thewrap.com/captain-marvel-trailer-avengers-infinity-war-ending-endgame-quasar-ant-man-thanos-mar-vell/>

5 face images

<https://geekculture.co/avengers-infinity-war-press-conference-singapore/>

10 face images

<https://thepeoplesmovies.com/2015/04/avengersage-of-ultron-london-press-conference-21st-april-2015/>

Crowd test1

[https://commons.wikimedia.org/wiki/File:Flickr\\_-\\_moses\\_namkung\\_-\\_The\\_Crowd\\_For\\_DMB\\_1.jpg](https://commons.wikimedia.org/wiki/File:Flickr_-_moses_namkung_-_The_Crowd_For_DMB_1.jpg)

Crowd test2 (~110 faces)

<http://reibun.skry.info/?p=8464>

Crowd test3 (~84 faces)

<https://croads.jp/activatite-the-community/>

Crowd test4 (~120 faces)

<http://www.asyura2.com/17/lunchbreak54/msg/277.html>