In solving the questions in this assignment, I worked together with my classmate YiYun Ding & 1004795214

I confirm that I have written the solutions/code/report in my own words.

1. $\vec{p} = K\vec{p} = \begin{pmatrix} f & 0 & P_x \\ 0 & f & P_y \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_0 + td_x \\ Y_0 + td_y \\ Z_0 + td_z \end{pmatrix}$

$= \begin{pmatrix} fx_0 + ftd_x + P_x Z_0 + P_x td_z \\ fY_0 + ftd_y + P_y Z_0 + P_y td_z \\ Z_0 + td_z \end{pmatrix}$

when $t \to \infty$, it is vanishing point

$$x = \frac{fx_0 + ftd_x + P_x Z_0 + P_x t d_z}{Z_0 + td_z} = \frac{fd_x + P_x d_z}{dz}$$

$$y = \frac{fY_0 + ftd_y + P_y Z_0 + P_y t d_z}{Z_0 + td_z} = \frac{fd_y + P_y d_z}{dz}$$

$$\vec{V} = \begin{bmatrix} \frac{fd_x + P_x dz}{dz} \\ \frac{fd_y + P_y dz}{dz} \end{bmatrix} = \frac{f}{dz}\begin{bmatrix} dx \\ dy \end{bmatrix} + \begin{bmatrix} P_x \\ P_y \end{bmatrix}$$

2) Choose direction $\vec{d_0}$

$$\vec{V_0} = \frac{f}{dz_0}\vec{d_0} + \begin{bmatrix} P_x \\ P_y \end{bmatrix}$$

Choose arbitrary direction $\vec{d_1}$

$$\vec{V_1} = \frac{f}{dz_1}\vec{d_1} + \begin{bmatrix} P_x \\ P_y \end{bmatrix}$$

$\because$ $\vec{d_0}$ and $\vec{d_1}$ on one plane

$$\vec{d_0} \cdot \vec{n} = \vec{d_1} \cdot \vec{n} = 0$$

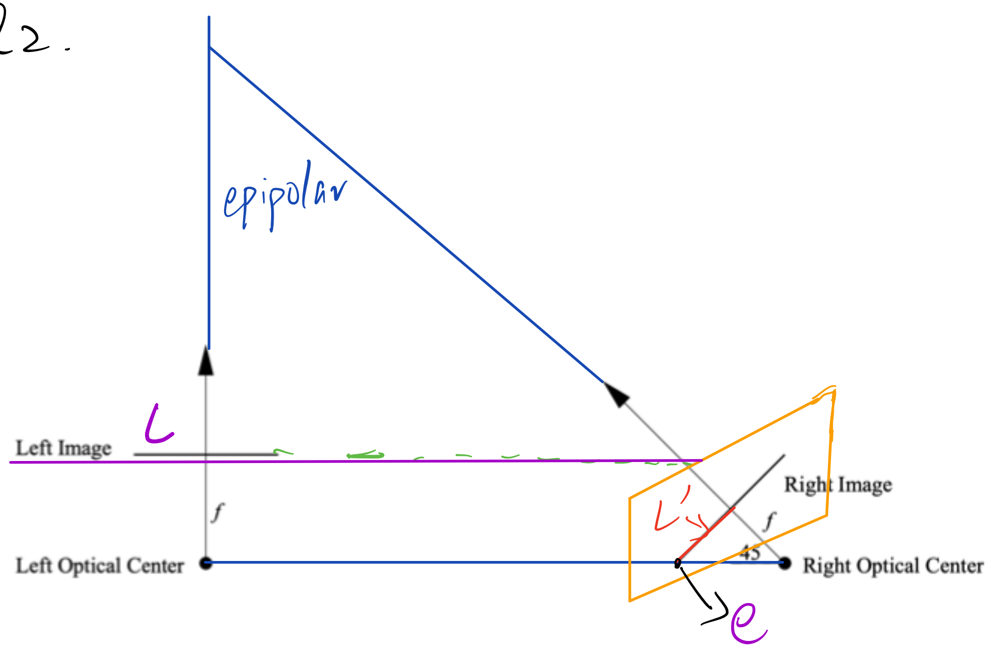
$$(\vec{V_1} - \vec{V_0}) \cdot \vec{n} = \left(\frac{f}{dz}\vec{d_1} - \frac{f}{dz_0}\vec{d_0}\right) \cdot \vec{n}$$

$$= \frac{f}{dz_1} \vec{d_1} \cdot \vec{n} - \frac{f}{dz_0} \cdot \vec{d_0} \cdot \vec{n}$$

$$= 0$$

Since there is only one line on image plane perpendicular to $\vec{n}$ and passes $\vec{v_0}$, so all vanishing points on the plane form the line.

Q2.



epipole is the intersection of baseline with the image plane. epipolar line is the straight line of intersection of epipolar plane with image plane.

left image: image plane parallel to baseline. epipoles are at infinity, epipolar parallel to l.

For right image, epipole is e, epipolar line is l'.

Q3

$l: a_1 x + b_1 y + c_1 = 0$

$l': a_2 x + b_2 y + c_2 = 0$

$$l \times l' = \begin{pmatrix} i & j & k \\ a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \end{pmatrix}$$

$$= (b_1 c_2 - b_2 c_1) i - (a_1 c_2 - a_2 c_1) j + (a_1 b_2 - a_2 b_1) k$$

$\Rightarrow$ intersection $\left(\frac{b_1 c_2 - b_2 c_1}{a_1 b_2 - a_2 b_1}, \frac{-a_1 c_2 + a_2 c_1}{a_1 b_2 - a_2 b_1} \right)$

$l: a_1 x + b_1 y + c_1$

$$= a_1 \left(\frac{b_1 c_2 - b_2 c_1}{a_1 b_2 - a_2 b_1} \right) + b_1 \left(\frac{-a_1 c_2 + a_2 c_1}{a_1 b_2 - a_2 b_1} \right) + \frac{a_1 b_2 c_1 - a_2 b_1 c_1}{a_1 b_2 - a_2 b_1}$$

$= 0$

$l': a_2 x + b_2 y + c_2$

$$= a_2\left(\frac{b_1c_2-b_2c_1}{a_1b_2-a_2b_1}\right)+b_2\left(\frac{-a_1c_2+a_2c_1}{a_1b_2-a_2b_1}\right)+\frac{a_1b_2c_2-a_2b_1c_2}{a_1b_2-a_2b_1}$$

$= 0$

$\Rightarrow$ The result of $l \times l'$ is intersection since the point on both l and l'

2. $\vec{p} = (a_1, b_1)$ $\quad \vec{p'} = (a_2, b_2)$

$$\vec{p} \times \vec{p'} = \begin{vmatrix} i & j & k \\ a_1 & b_1 & 1 \\ a_2 & b_2 & 1 \end{vmatrix}$$

$= (b_1 - b_2)i - (a_1 - a_2)j + (a_1b_2 - a_2b_1)k$

plug in $(a_1, b_1, 1)$

$(b_1 - b_2)a_1 - (a_1 - a_2)b_1 + a_1b_2 - a_2b_1$

$= b_1a_1 - b_2a_1 - a_1b_1 + a_2b_1 + a_1b_2 - a_2b_1$

$= 0$

plug in $(a_2, b_2, 1)$

$(b_1 - b_2)a_2 - (a_1 - a_2)b_2 + a_1b_2 - a_2b_1$

$= b_1a_2 - b_2a_2 - a_1b_2 + a_2b_2 + a_1b_2 - a_2b_1$

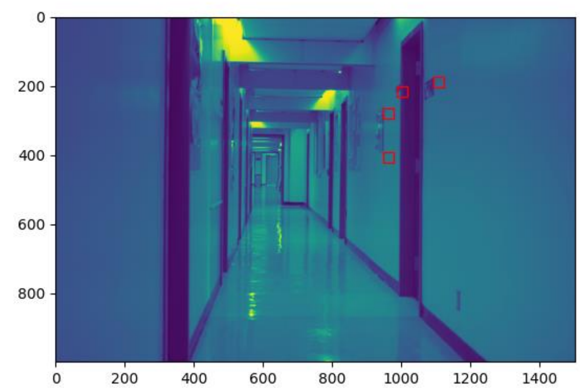
$= 0$

$\Rightarrow$ The line from $p \times p'$ intersects p and p'.

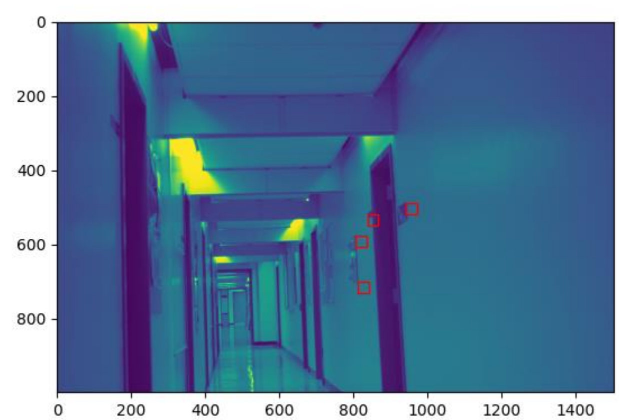
Case A:

1)

hallway1



Hallway2



2)

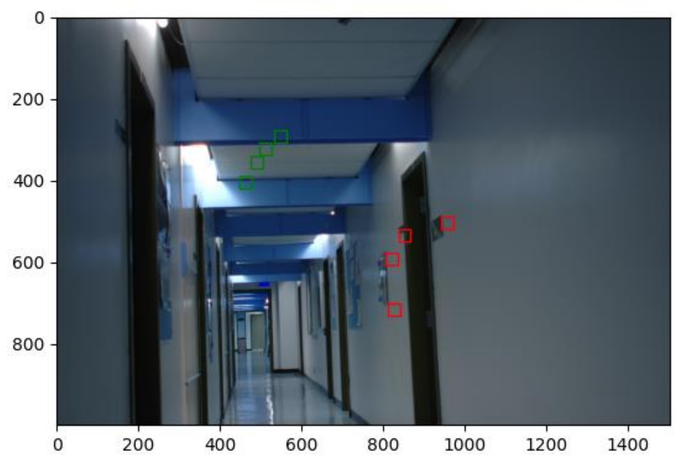
[[2.74690120e-01 -1.98457333e-01 2.66420332e+02]

 [-2.07263682e-01 3.77382439e-01 4.37302939e+02]

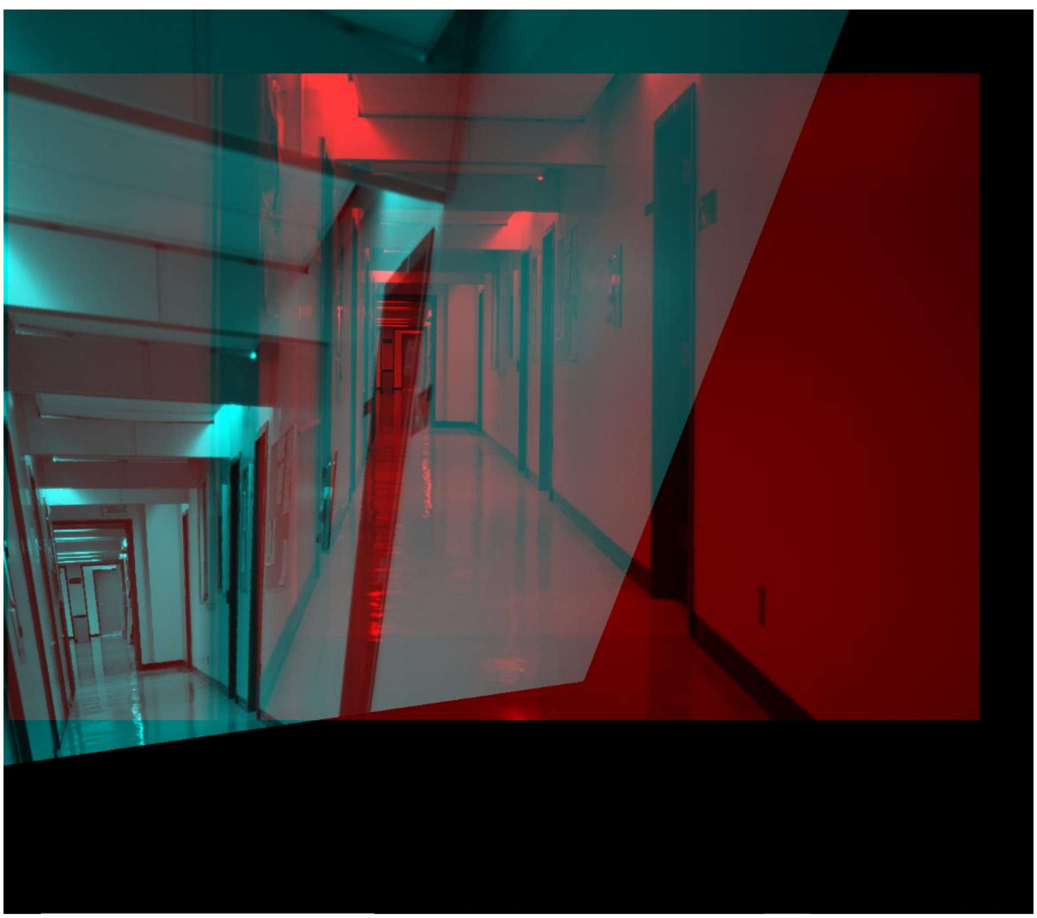
 [-3.51838596e-04 -2.89561136e-04 1.00000000e+00]]

Translate down, scale down

3)



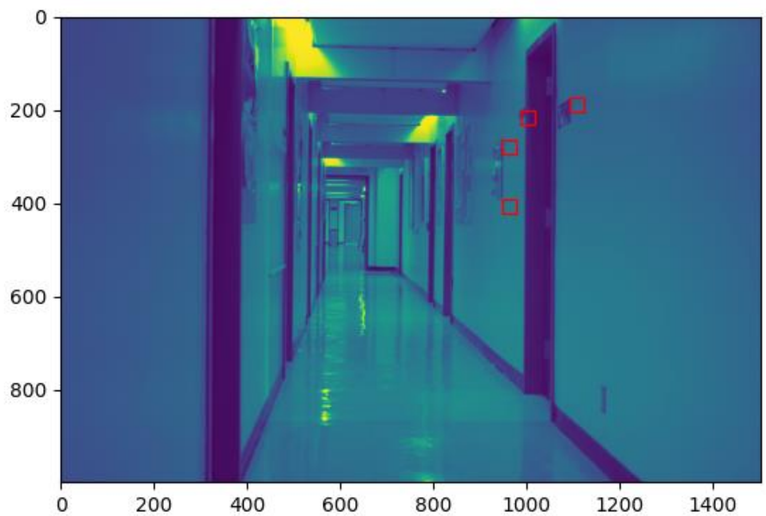
4)



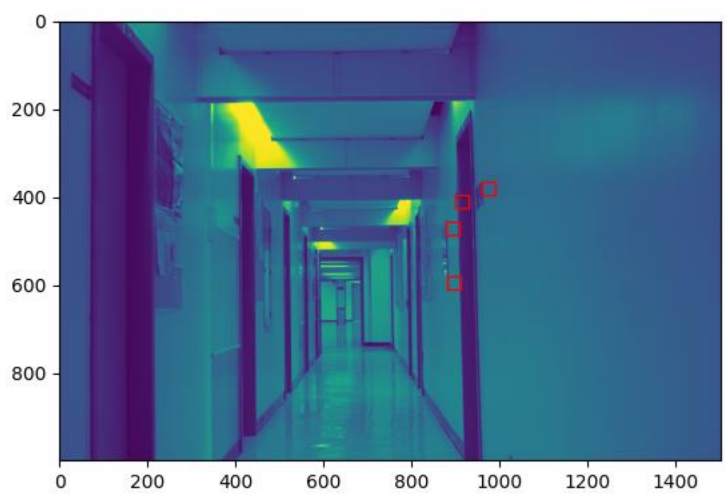
Case B

1)

Hallway1



Hallway3



2)_

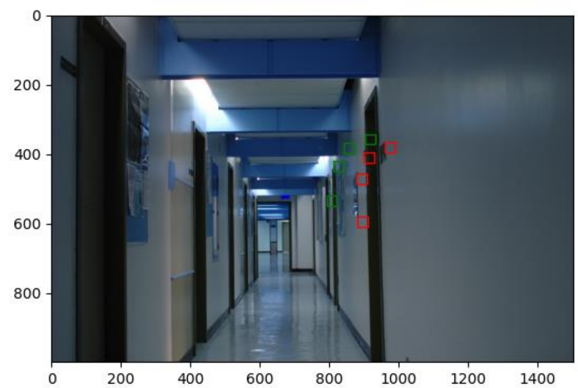
[[5.36708181e-01 -1.49974292e-01 3.42376115e+02]

 [-6.21171427e-02 7.78728611e-01 2.74084875e+02]

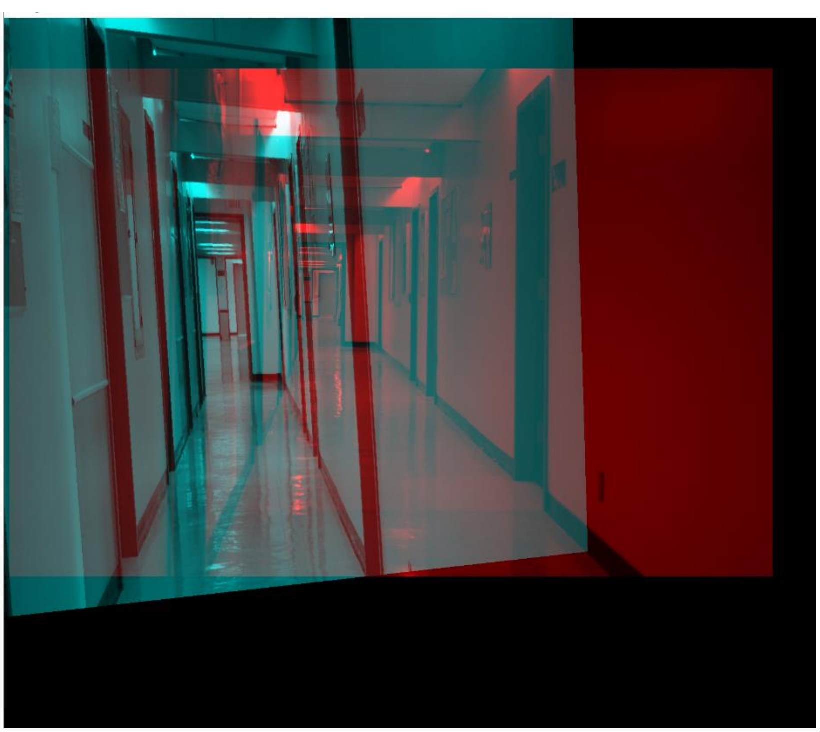
 [-2.03369346e-05 -2.12715763e-04 1.00000000e+00]]

Translate down, shear

3)



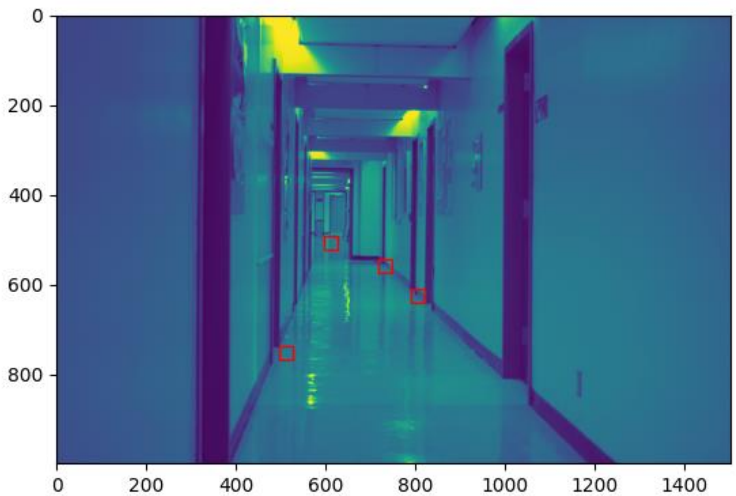
4)



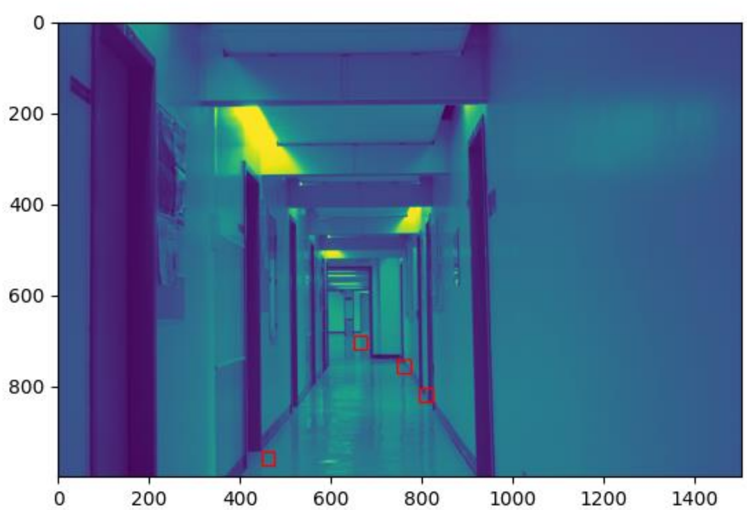
Case C

1)

Hallway1



Hallway3



2)

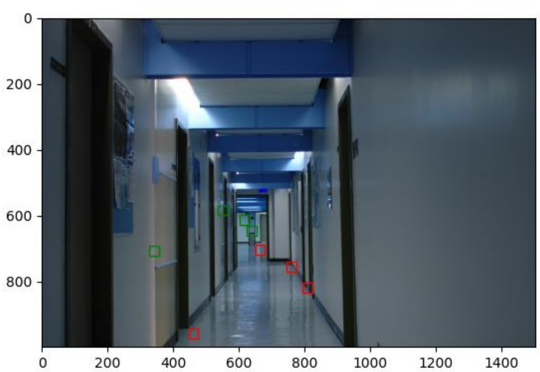
[[7.76672217e-01 -5.40261080e-01 3.40238205e+02]

 [2.00692428e-02 5.01484609e-01 3.10874283e+02]

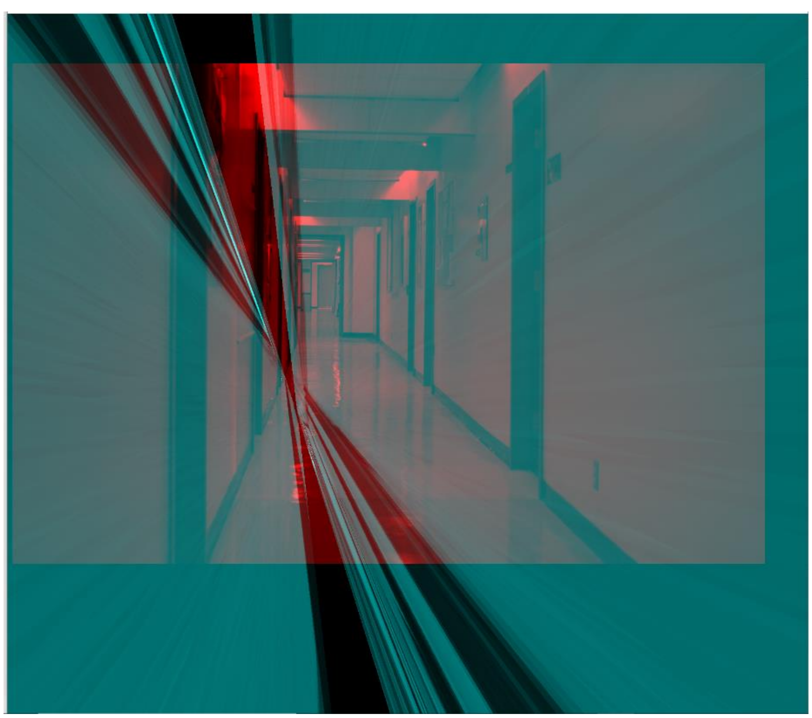
 [1.60364218e-05 -3.71751452e-04 1.00000000e+00]]

Translate down

3)



4)



Explanation:

Comparing Hallway1 and Hallway2, the camera position is more upward and close to right wall for Hallway2 than Hallway1, also the camera rotate a little bit.

Comparing Hallway1 and Hallway3, the camera position is more upward and close to right wall for Hallway2 than Hallway1.

The surface reflectance of the right wall is less Lembertian, and the the surface of floor is more Lembertian.

5)

Check Q4.py

Q5

1） red – Tracked box

green – Detected box

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0.6725686262021527
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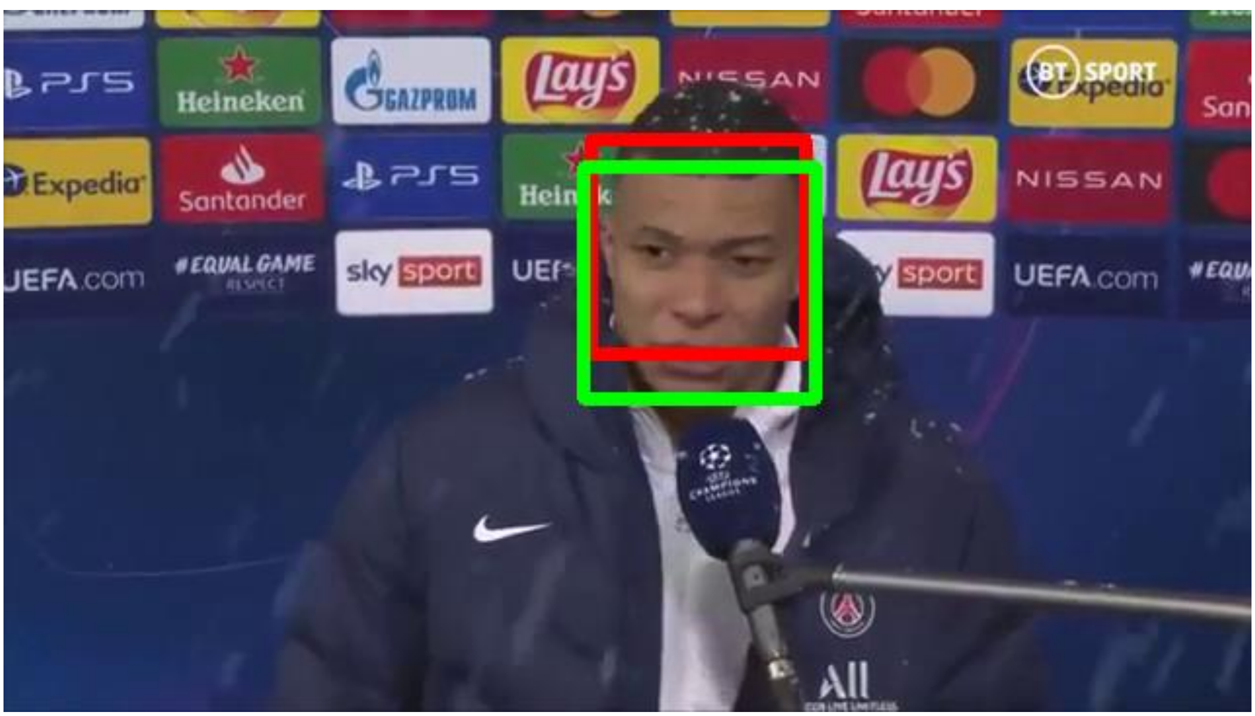


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0.5417733302303933
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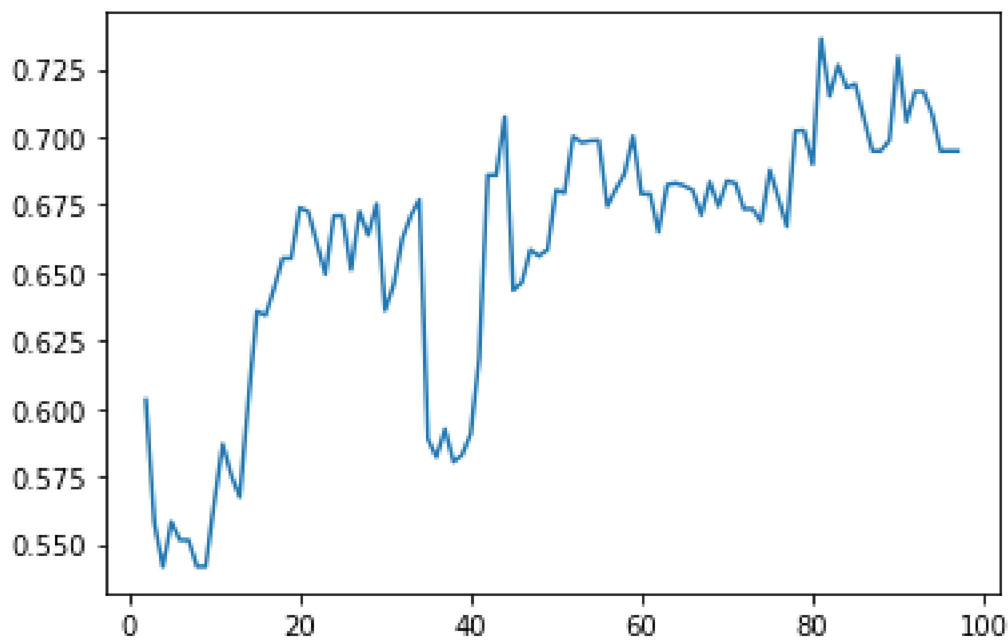
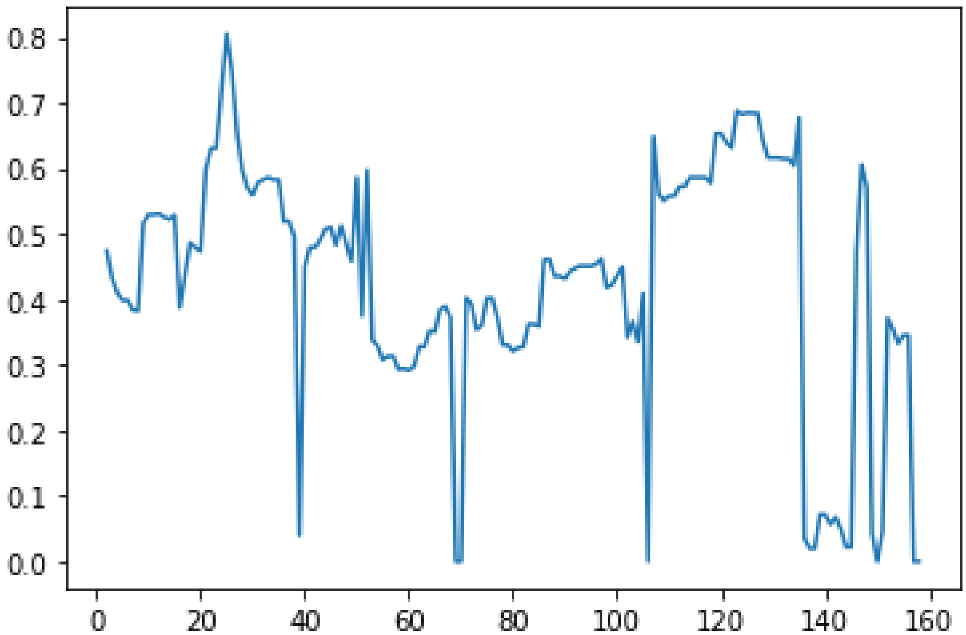


Tracked box corrects more. Since the detected box detect each frame independently and track box detects the face based on previous frame, so if previous frame detects correctly, then Traack box is more accurate.

2) red – Tracked box

green – Detected box



0.8062151861624157