In solving the questions in this assignment, I worked together with my classmate Yi Yun Ding & 10047952I4
I confirm that I have written the solutions/code/report in my own words.

Q1

1. The maximum response is align with the circle and $\nabla^2 G(x,y,\sigma) = 0$

since $\frac{1}{\pi\sigma^4} \neq 0$ and $e^{-\frac{x^2+y^2}{2\sigma^2}} \neq 0$

$$\Rightarrow \frac{x^2+y^2}{2\sigma^2} - 1 = 0, \quad x^2+y^2 = \left(\frac{D}{2}\right)^2$$

$$\left(\frac{D}{2}\right)^2 = 2\sigma^2 \Rightarrow \sigma^2 = \frac{D^2}{8} \Rightarrow \sigma = \frac{D}{2\sqrt{2}}$$

2. The scale should be the same with part I.

$$\sigma = \frac{D}{2\sqrt{2}}$$

3. Implement it by set filter size as 1000×1000, update sigma to get optimal value, experimentally when sigma equals 40. magnitude is maximized to be 184.

Q2

1. $\det(\lambda I - A) = 0$

$$\det\left(\begin{pmatrix}\lambda & 0\\ 0 & \lambda\end{pmatrix} - \begin{pmatrix}I_x^2 & I_xI_y\\ I_xI_y & I_y^2\end{pmatrix}\right) = 0$$

$$\det\begin{pmatrix}\lambda - I_x^2 & -I_xI_y\\ -I_xI_y & \lambda - I_y^2\end{pmatrix} = 0$$

$$(\lambda - I_x^2)(\lambda - I_y^2) - I_x^2 I_y^2 = 0$$

$$\lambda^2 - I_x^2\cdot\lambda - I_y^2\cdot\lambda + I_x^2 I_y^2 - I_x^2 I_y^2 = 0$$

$$\lambda(\lambda - I_x^2 - I_y^2) = 0$$

$$\Rightarrow \lambda_1 = 0 \qquad \lambda_2 = I_x^2 + I_y^2$$

2. by part 1), the two eigenvalues 0 and $I_x^2 + I_y^2$ is nonnegative, so matrix N is positive semidefinite.

since $v'Av \geq 0$ and $v'Bv \geq 0$

$\Rightarrow v'(A+B)v \geq 0$

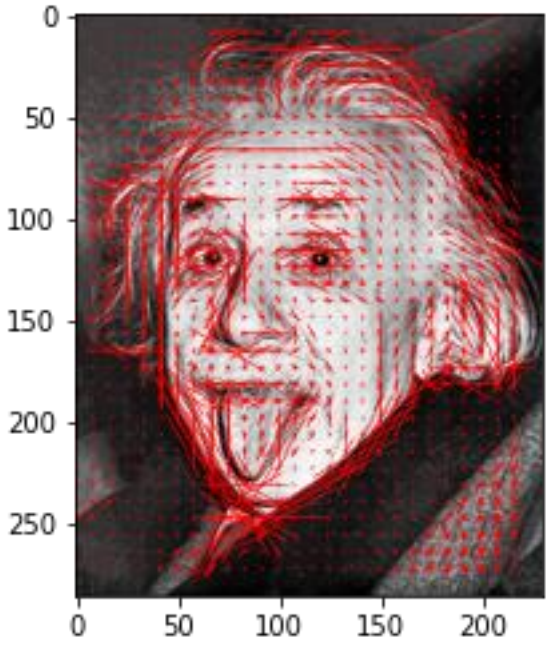
$\Rightarrow$ eigenvalues of M is also nonnegative

so M is positive semidefinite.

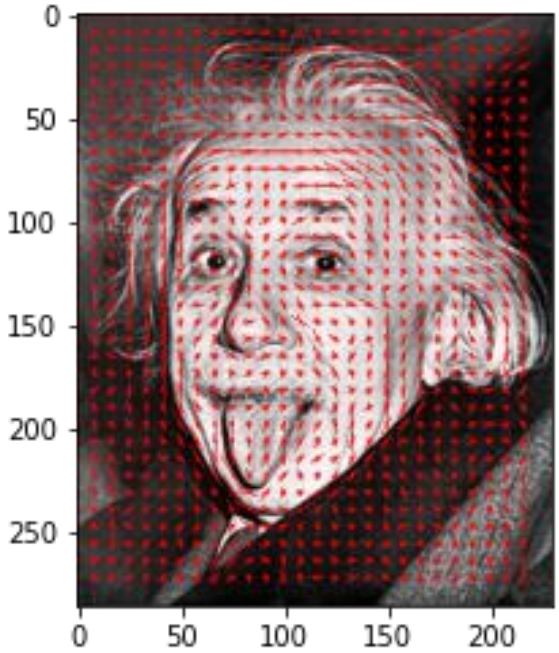
Q3

1.Threshold: 10 Cell size:8

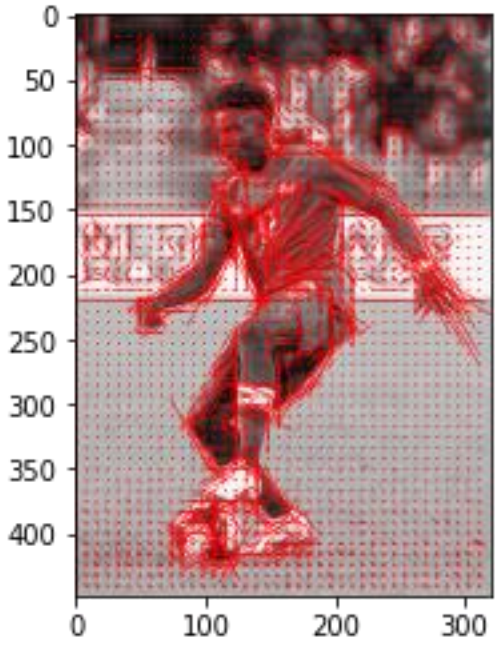
First Approach: accumulated gradient magnitudes



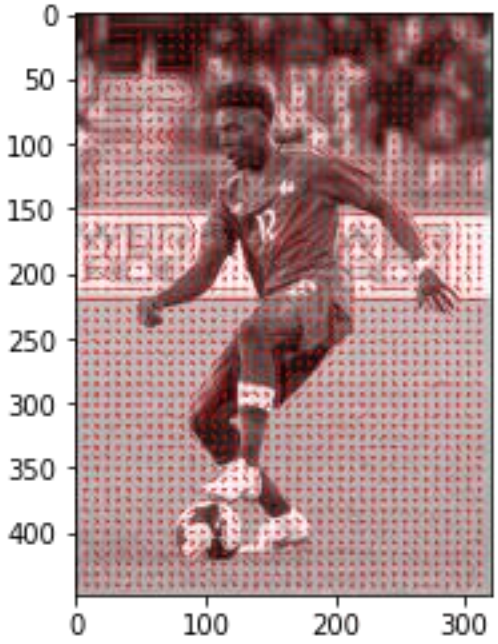
Another approach: count occurrence



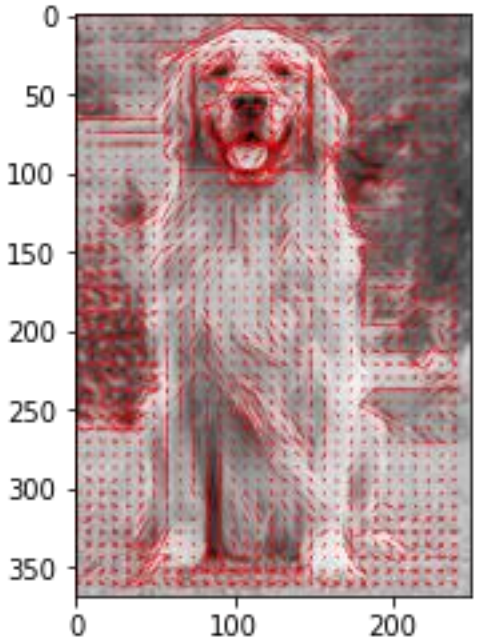
First Approach: accumulated gradient magnitudes



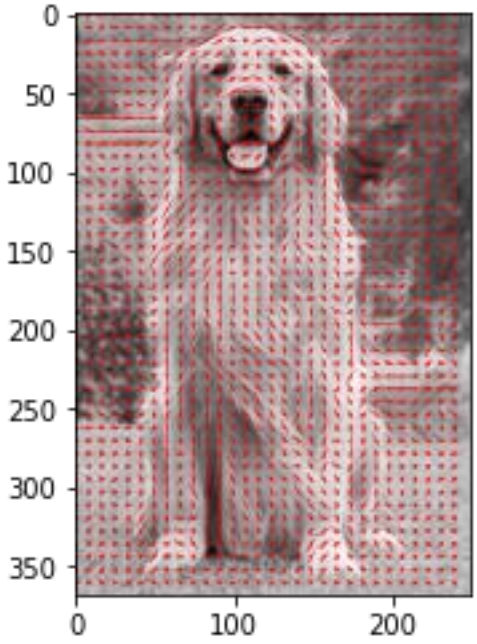
Another approach: count occurrence



First Approach: accumulated gradient magnitudes



Another approach: count occurrence

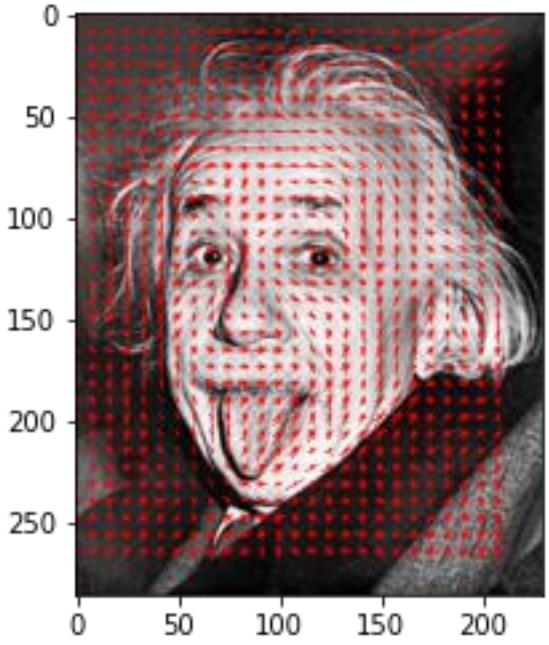


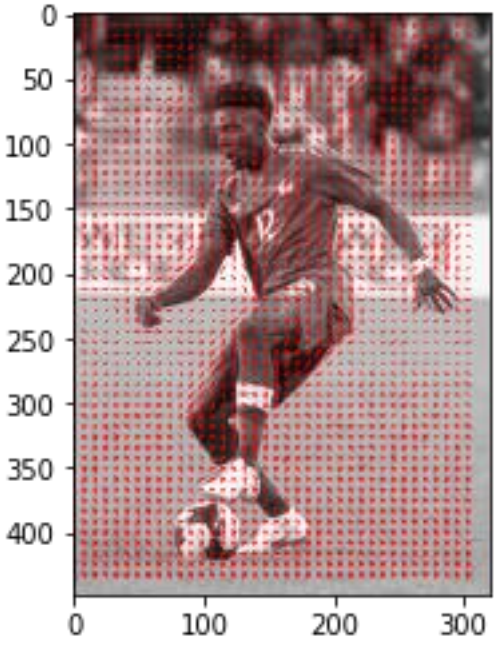
Explanation:

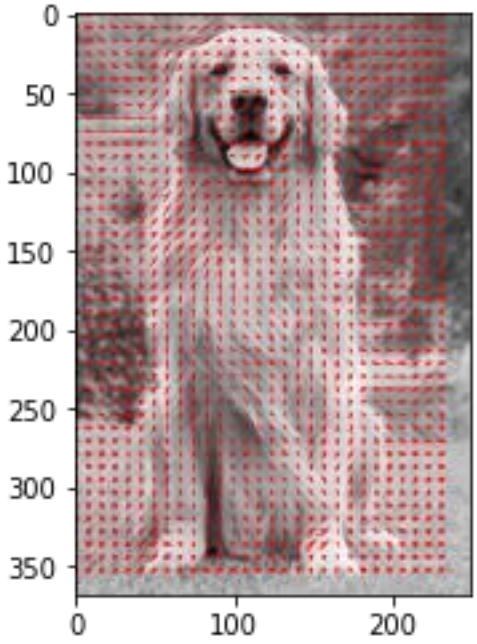
For approach of accumulated magnitude, the magnitude of gradient is larger and intensive during some highlighted area.

For approach of count occurrence, the HOG shows mostly the direction of the object line, all the area almost has the same magnitude of gradient.

2) normalized images





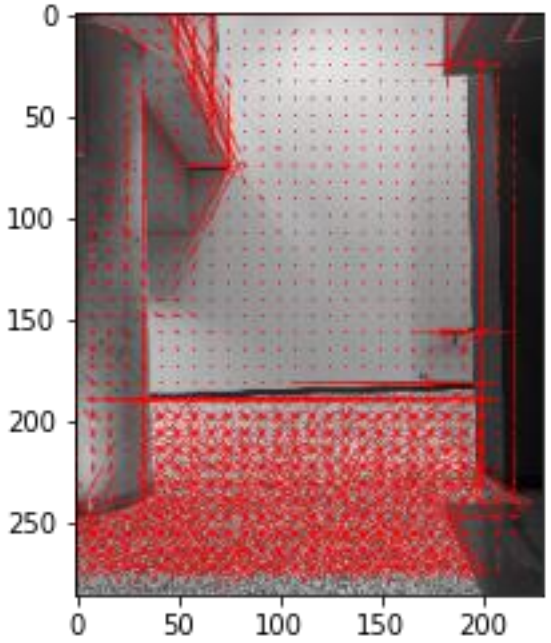


3)

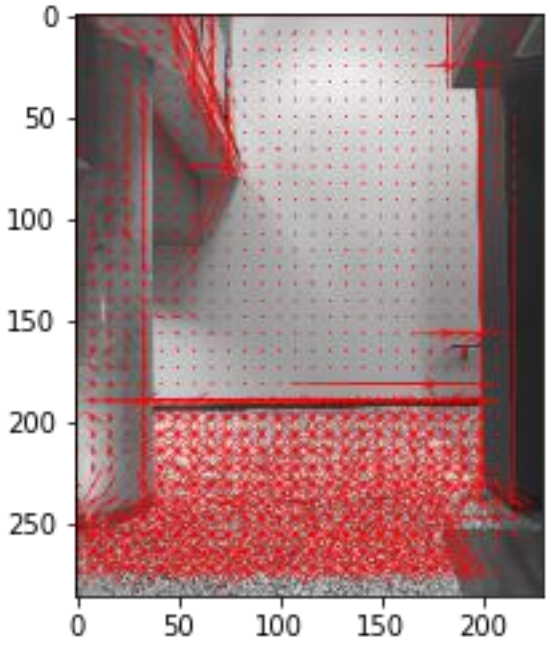
Original image: BA-without flash

BA-with flash

For image BA-without flash

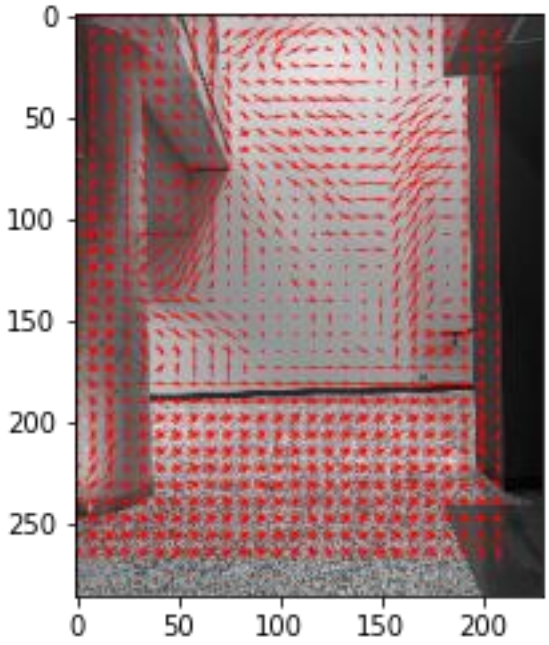


For image BA-with flash

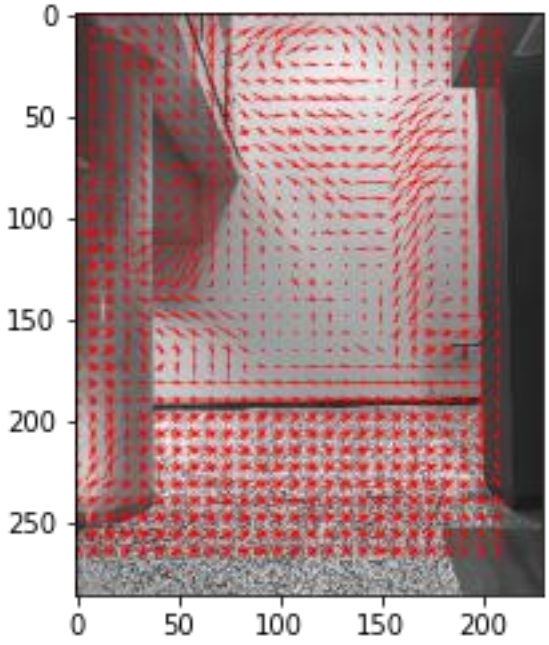


4)Normalized images

BA-without flash



BA-with flash



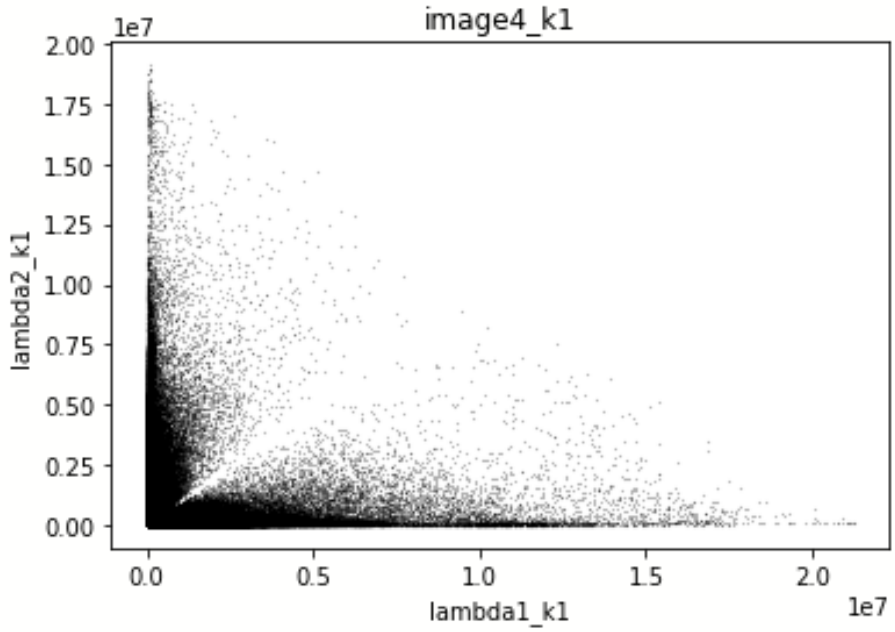
Compared to non-flash image, the HOG for flash image is more accuracy, which means the gradient direction is closer to the real direction of object. Despite that, the two HOGs are almost the same, no matter in the direction and the magnitude.

After normalizing, the magnitude difference for gradient decreases a lot, and the direction of gradient is more obvious, the intensity can also be captured directly by the thickness of the gradient.

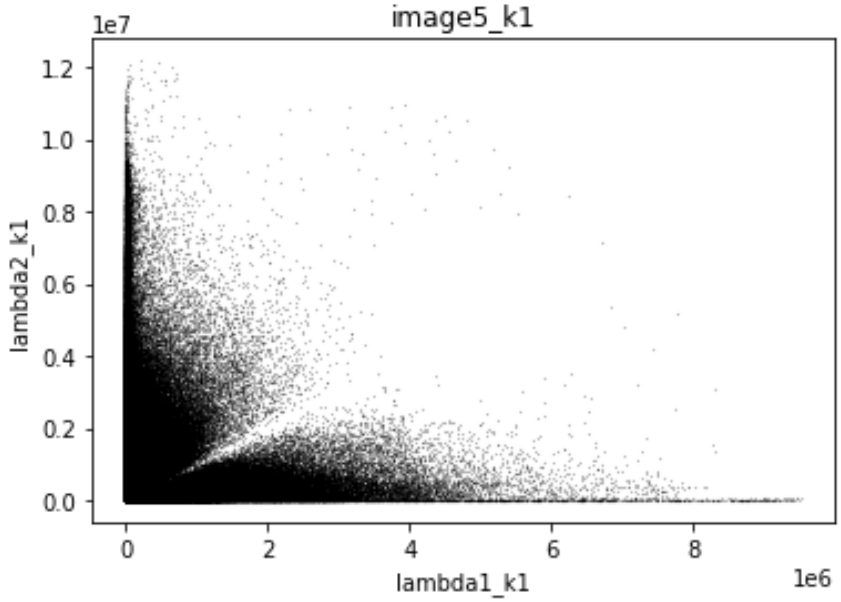
Q4

2) sigma = 1

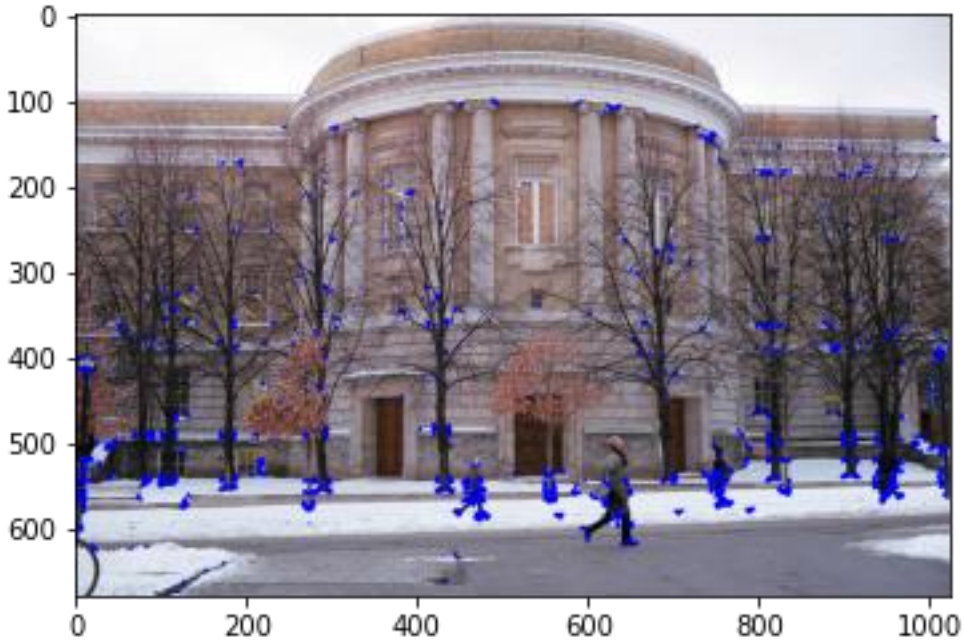
For sandford_Fleming_Building_2011_Toronto.jpg

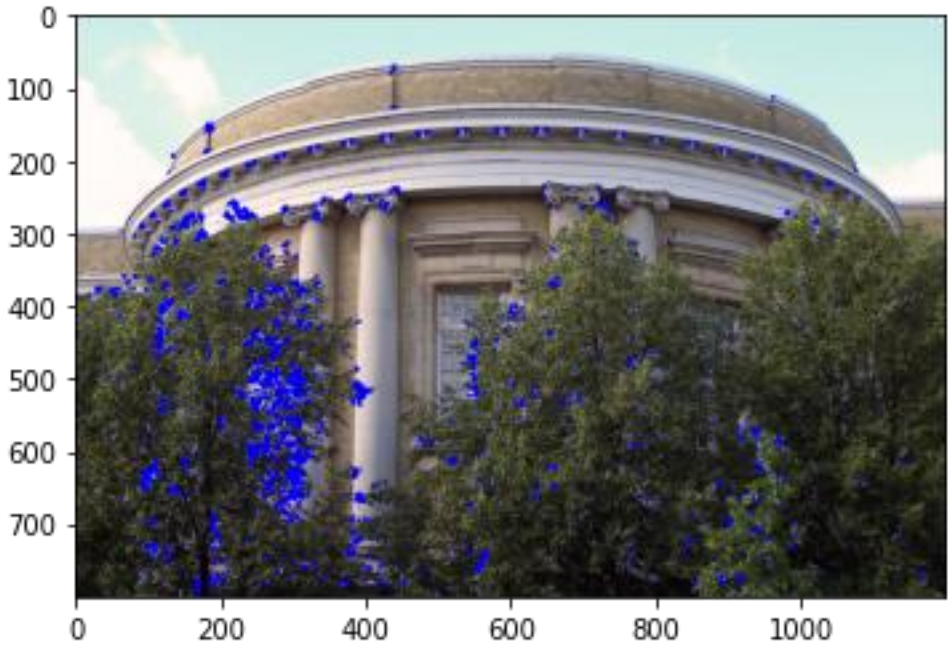


Uoft_SF-01.jpg



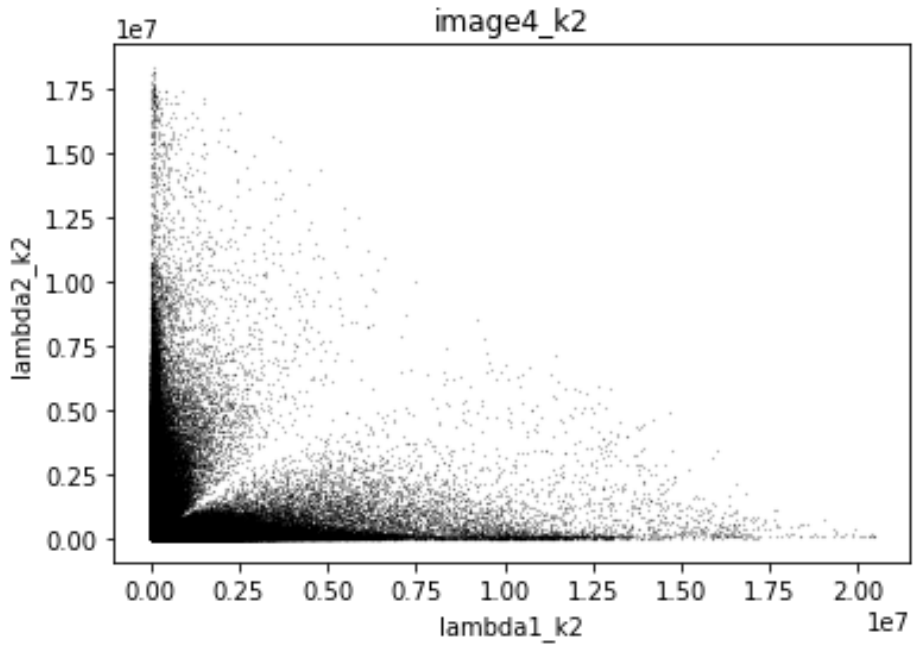
3. threshold value = 500,000



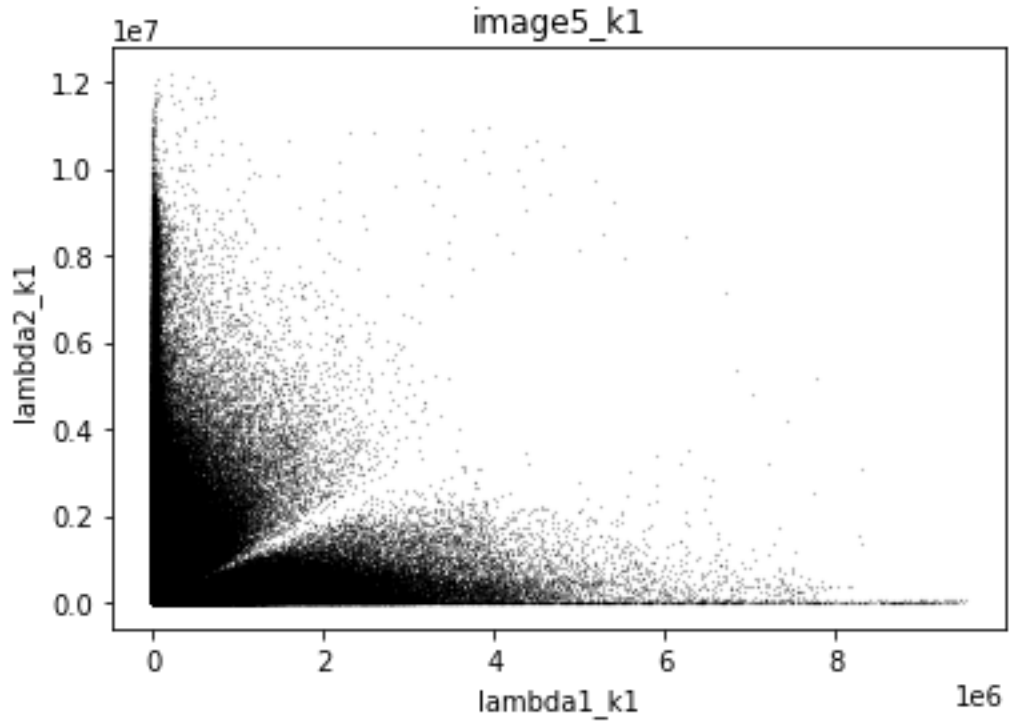


4) sigma = 10000

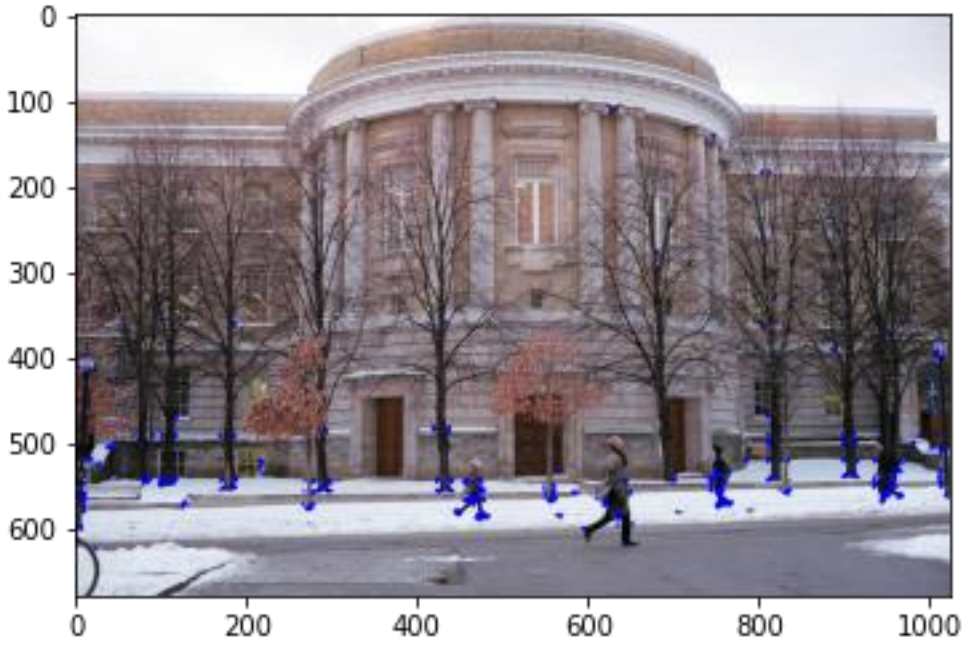
For sandford_Fleming_Building_2011_Toronto.jpg

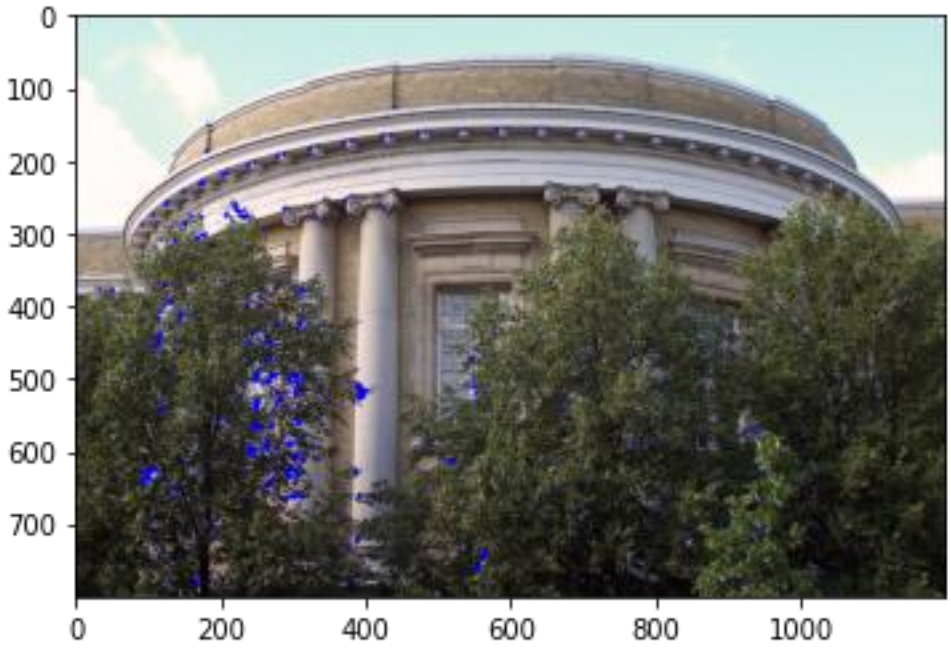


Uoft_SF-01.jpg



Threshold = 1000,000





Sigma decides the scale of objects being simplified. Smaller filters cause less blurring, and allow detection of small, sharp lines. A larger filter causes more blurring, can detect larger, smoother.