Assignment 2 Report

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Part 1

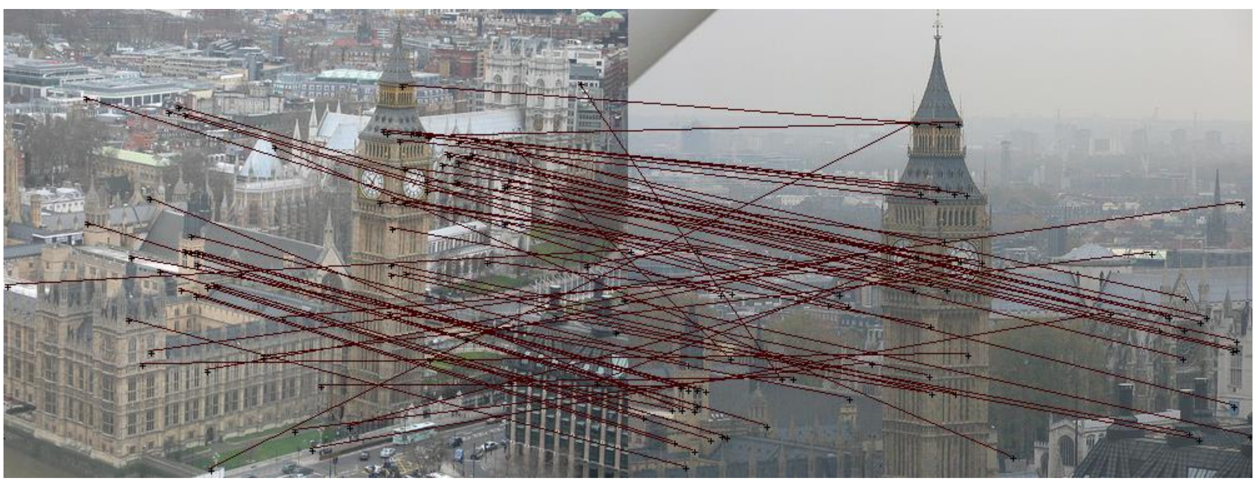
Find matching SIFT descriptors across two images:

Calculated the distance using the Euclidean Distance formula.
The ratio was taken as follows:

(Euclidean distance between descriptor and closest match) / (Euclidean distance between descriptor and second closest match)

The cut off of 0.8 was taken. All the descriptors having the ratio less than 0.8 was considered to be the best matching features.

Threshold taken: **0.8**



When only two images are passed, the output of the closest matched image will be saved as Sift.png

<u>Randomly choose an image in each attractions as the query image, and compare it with all others:</u>

Part1.3 works this out.
It is an extension for part 1.2 just that the first image would not be the query image whereas the query image would be chosen from any of the given images.
The command to run the random selection of query out of all the images is:

./a2 part1.3 a2-images/part1_images/bigben_2.jpg a2-images/part1_images/bigben_12.jpg a2-images/part1_images/bigben_13.jpg a2-images/part1_images/bigben_14.jpg

It returns the output on the terminal, the list of images in the decreasing order of the number of matched descriptors i.e. the very first image will be the most closely matched image.

Implement the image retrieval system:

Implemented in the *"part1"*

When the number of arguments is greater than 4, it automatically considers the first input image as the query image and rest of the images are used for matching.

./a2 part1 a2-images/part1_images/bigben_2.jpg a2-images/part1_images/bigben_12.jpg a2-images/part1_images/bigben_13.jpg a2-images/part1_images/bigben_14.jpg

Return top 10 images in decreasing order of number of matched features:

The code handles this for part1 when the number of arguments is greater than 4. It outputs the list of top 10 images in the decreasing order of the number of matched descriptors i.e. the very first image will be the most closely matched image.

Query Image	Returned Images	Precision
bigben_2.jpg	a2-images/part1_images/bigben_2.jpg a2-images/part1_images/bigben_3.jpg a2-images/part1_images/bigben_14.jpg a2-images/part1_images/bigben_6.jpg a2-images/part1_images/bigben_8.jpg a2-images/part1_images/bigben_12.jpg a2-images/part1_images/trafalgarsquare_22.jpg a2-images/part1_images/colosseum_13.jpg a2-images/part1_images/tatemodern_8.jpg a2-images/part1_images/louvre_13.jpg	60%
colosseum_5.jpg	a2-images/part1_images/colosseum_5.jpg a2-images/part1_images/colosseum_4.jpg a2-images/part1_images/colosseum_15.jpg a2-images/part1_images/trafalgarsquare_22.jpg a2-images/part1_images/tatemodern_13.jpg a2-images/part1_images/notredame_24.jpg a2-images/part1_images/londoneye_13.jpg a2-images/part1_images/bigben_8.jpg a2-images/part1_images/bigben_10.jpg a2-images/part1_images/notredame_25.jpg	30%

eiffel_19.jpg	a2-images/part1_images/eiffel_19.jpg a2-images/part1_images/eiffel_18.jpg a2-images/part1_images/tatemodern_2.jpg a2-images/part1_images/louvre_10.jpg a2-images/part1_images/sanmarco_13.jpg a2-images/part1_images/londoneye_12.jpg a2-images/part1_images/empirestate_16.jpg a2-images/part1_images/louvre_14.jpg a2-images/part1_images/sanmarco_3.jpg a2-images/part1_images/bigben_12.jpg	20%
empirestate_16.jpg	a2-images/part1_images/empirestate_16.jpg a2-images/part1_images/notredame_19.jpg a2-images/part1_images/sanmarco_13.jpg a2-images/part1_images/bigben_8.jpg a2-images/part1_images/empirestate_22.jpg a2-images/part1_images/bigben_6.jpg a2-images/part1_images/bigben_3.jpg a2-images/part1_images/trafalgarsquare_22.jpg a2-images/part1_images/empirestate_27.jpg a2-images/part1_images/trafalgarsquare_15.jpg	30%
londoneye_23.jpg	a2-images/part1_images/londoneye_23.jpg a2-images/part1_images/londoneye_2.jpg a2-images/part1_images/bigben_14.jpg a2-images/part1_images/louvre_11.jpg a2-images/part1_images/trafalgarsquare_25.jpg a2-images/part1_images/londoneye_8.jpg a2-images/part1_images/empirestate_22.jpg a2-images/part1_images/londoneye_13.jpg a2-images/part1_images/louvre_4.jpg a2-images/part1_images/sanmarco_3.jpg	40%
louvre_16.jpg	a2-images/part1_images/louvre_16.jpg a2-images/part1_images/louvre_14.jpg a2-images/part1_images/louvre_11.jpg a2-images/part1_images/louvre_4.jpg a2-images/part1_images/eiffel_15.jpg a2-images/part1_images/tatemodern_4.jpg a2-images/part1_images/louvre_13.jpg a2-images/part1_images/sanmarco_13.jpg a2-images/part1_images/londoneye_21.jpg a2-images/part1_images/notredame_19.jpg	50%
notredame_3.jpg	a2-images/part1_images/notredame_3.jpg a2-images/part1_images/notredame_5.jpg a2-images/part1_images/notredame_14.jpg a2-images/part1_images/notredame_4.jpg a2-images/part1_images/notredame_24.jpg a2-images/part1_images/notredame_25.jpg a2-images/part1_images/notredame_19.jpg a2-images/part1_images/londoneye_17.jpg	70%

	a2-images/part1_images/bigben_14.jpg a2-images/part1_images/sanmarco_5.jpg	
sanmarco_5.jpg	a2-images/part1_images/sanmarco_5.jpg a2-images/part1_images/sanmarco_20.jpg a2-images/part1_images/sanmarco_22.jpg a2-images/part1_images/sanmarco_3.jpg a2-images/part1_images/notredame_24.jpg a2-images/part1_images/notredame_19.jpg a2-images/part1_images/bigben_12.jpg a2-images/part1_images/londoneye_22.jpg a2-images/part1_images/trafalgarsquare_25.jpg a2-images/part1_images/louvre_14.jpg	40%
tatemodern_2.jpg	a2-images/part1_images/tatemodern_2.jpg a2-images/part1_images/tatemodern_8.jpg a2-images/part1_images/londoneye_13.jpg a2-images/part1_images/trafalgarsquare_25.jpg a2-images/part1_images/bigben_12.jpg a2-images/part1_images/tatemodern_9.jpg a2-images/part1_images/louvre_4.jpg a2-images/part1_images/londoneye_21.jpg a2-images/part1_images/tatemodern_4.jpg a2-images/part1_images/louvre_14.jpg	40%
trafalgarsquare_1.jpg	a2-images/part1_images/trafalgarsquare_1.jpg a2-images/part1_images/trafalgarsquare_20.jpg a2-images/part1_images/trafalgarsquare_5.jpg a2-images/part1_images/londoneye_8.jpg a2-images/part1_images/londoneye_23.jpg a2-images/part1_images/trafalgarsquare_22.jpg a2-images/part1_images/louvre_14.jpg a2-images/part1_images/trafalgarsquare_25.jpg a2-images/part1_images/tatemodern_2.jpg a2-images/part1_images/tatemodern_13.jpg	50%

Analysis of attractions which are easiest or most difficult to recognize

Using SIFT, Eiffel Tower was the most difficult one to recognize. It has the accuracy of 20% using just the SIFT algorithm.
The reason why it is the most difficult is maybe due to the different angles using which the pictures were clicked and the some pictures are taken in night time and others in the day time which would make the recognition harder.
The attraction to be recognized most easily is Notre dame. It is maybe because the pattern on the Notre dame is being matched properly to the other Notre dame images.

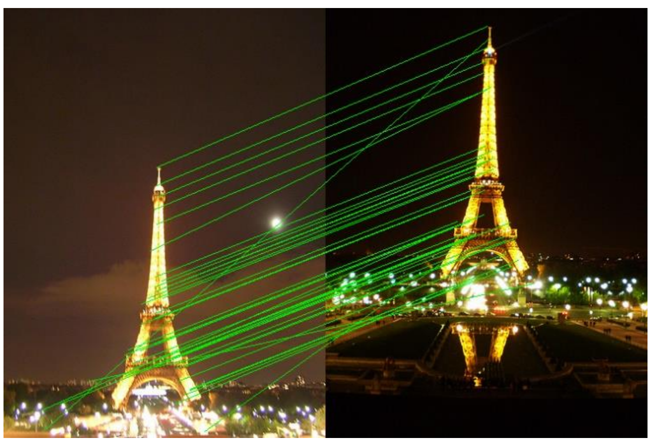
Part 2

Part 2.1
Implement the RANSAC to estimate the homography between two images

Input

To show the cleaner correspondence we will use the following two images as input,

Output



From above image, we can see a clear correspondence and the inliers are perfectly visible.

For finding the images having higher number of matched descriptor and precision for each category of attractions,

Query Image	Images ordered decreasing	Precision
bigben_2.jpg	**a2-images/part1_images/colosseum_8.jpg** **a2-images/part1_images/londoneye_9.jpg** **a2-images/part1_images/eiffel_19.jpg** **a2-images/part1_images/louvre_9.jpg** **a2-images/part1_images/louvre_11.jpg** **a2-images/part1_images/louvre_16.jpg** **a2-images/part1_images/bigben_7.jpg** **a2-images/part1_images/bigben_6.jpg**	**50%**

	a2-images/part1_images/bigben_14.jpg a2-images/part1_images/bigben_3.jpg a2-images/part1_images/bigben_2.jpg	
Colosseum_5.jpg	**a2-images/part1_images/sanmarco_3.jpg a2-images/part1_images/sanmarco_5.jpg a2-images/part1_images/eiffel_2.jpg a2-images/part1_images/colosseum_11.jpg a2-images/part1_images/notredame_24.jpg a2-images/part1_images/trafalgarsquare_22.jpg a2-images/part1_images/eiffel_19.jpg a2-images/part1_images/bigben_16.jpg a2-images/part1_images/colosseum_15.jpg a2-images/part1_images/colosseum_4.jpg a2-images/part1_images/colosseum_5.jpg**	**40%**
Eiffel_5.jpg	**a2-images/part1_images/louvre_4.jpg a2-images/part1_images/trafalgarsquare_22.jpg a2-images/part1_images/bigben_12.jpg a2-images/part1_images/tatemodern_2.jpg a2-images/part1_images/tatemodern_24.jpg a2-images/part1_images/tatemodern_14.jpg a2-images/part1_images/sanmarco_4.jpg a2-images/part1_images/eiffel_22.jpg a2-images/part1_images/eiffel_2.jpg a2-images/part1_images/louvre_14.jpg a2-images/part1_images/empirestate_27.jpg a2-images/part1_images/eiffel_5.jpg**	**30%**
empirestate_16.jpg	**a2-images/part1_images/tatemodern_13.jpg a2-images/part1_images/londoneye_13.jpg a2-images/part1_images/empirestate_9.jpg a2-images/part1_images/empirestate_25.jpg a2-images/part1_images/empirestate_22.jpg a2-images/part1_images/sanmarco_20.jpg a2-images/part1_images/empirestate_15.jpg a2-images/part1_images/trafalgarsquare_25.jpg a2-images/part1_images/trafalgarsquare_22.jpg a2-images/part1_images/empirestate_27.jpg a2-images/part1_images/empirestate_16.jpg**	**50%**
Notredame_5.jpg	**a2-images/part1_images/louvre_16.jpg a2-images/part1_images/empirestate_9.jpg a2-images/part1_images/colosseum_12.jpg a2-images/part1_images/notredame_24.jpg a2-images/part1_images/eiffel_2.jpg a2-images/part1_images/sanmarco_3.jpg a2-images/part1_images/notredame_19.jpg**	**50%**

	a2-images/part1_images/notredame_4.jpg a2-images/part1_images/notredame_14.jpg a2-images/part1_images/notredame_3.jpg a2-images/part1_images/notredame_5.jpg	
Louvre_16.png	**a2-images/part1_images/eiffel_1.jpg a2-images/part1_images/londoneye_16.jpg a2-images/part1_images/londoneye_8.jpg a2-images/part1_images/louvre_13.jpg a2-images/part1_images/louvre_3.jpg a2-images/part1_images/louvre_4.jpg a2-images/part1_images/tatemodern_11.jpg a2-images/part1_images/londoneye_12.jpg a2-images/part1_images/tatemodern_9.jpg a2-images/part1_images/louvre_16.jpg**	**40%**
Sanmarco_3.jpg	**a2-images/part1_images/empirestate_14.jpg a2-images/part1_images/trafalgarsquare_15.jpg a2-images/part1_images/sanmarco_5.jpg a2-images/part1_images/colosseum_5.jpg a2-images/part1_images/notredame_19.jpg a2-images/part1_images/bigben_3.jpg a2-images/part1_images/sanmarco_18.jpg a2-images/part1_images/bigben_12.jpg a2-images/part1_images/trafalgarsquare_22.jpg a2-images/part1_images/sanmarco_3.jpg**	**30%**
Trafalgarsquare_16.jpg	**a2-images/part1_images/colosseum_12.jpg a2-images/part1_images/trafalgarsquare_8.jpg a2-images/part1_images/trafalgarsquare_22.jpg a2-images/part1_images/trafalgarsquare_20.jpg a2-images/part1_images/eiffel_22.jpg a2-images/part1_images/londoneye_2.jpg a2-images/part1_images/tatemodern_13.jpg a2-images/part1_images/trafalgarsquare_1.jpg a2-images/part1_images/tatemodern_6.jpg a2-images/part1_images/tatemodern_24.jpg**	**40%**
Tatemodern_2.jpg	**a2-images/part1_images/empirestate_23.jpg a2-images/part1_images/empirestate_25.jpg a2-images/part1_images/londoneye_23.jpg a2-images/part1_images/louvre_14.jpg**	**30%**

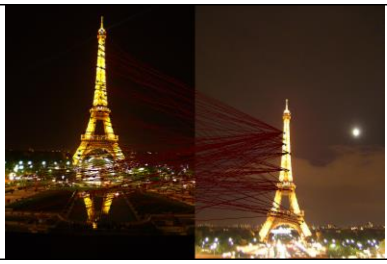
	a2-images/part1_images/tatemodern_9.jpg **a2-images/part1_images/louvre_4.jpg** **a2-images/part1_images/tatemodern_13.jpg** **a2-images/part1_images/trafalgarsquare_15.jpg** **a2-images/part1_images/londoneye_21.jpg** **a2-images/part1_images/tatemodern_8.jpg** **a2-images/part1_images/tatemodern_2.jpg**	
londoneye_23.jpg	**a2-images/part1_images/londoneye_23.jpg** **a2-images/part1_images/londoneye_2.jpg** **a2-images/part1_images/bigben_14.jpg** **a2-images/part1_images/louvre_11.jpg** **a2-images/part1_images/trafalgarsquare_25.jpg** **a2-images/part1_images/londoneye_8.jpg** **a2-images/part1_images/empirestate_22.jpg** **a2-images/part1_images/londoneye_13.jpg** **a2-images/part1_images/louvre_4.jpg** **a2-images/part1_images/sanmarco_3.jpg**	**40%**

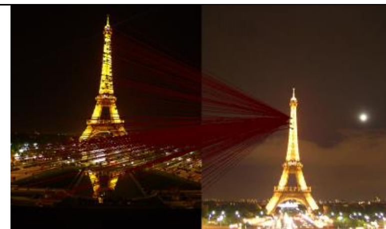
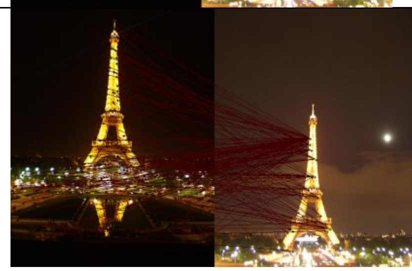
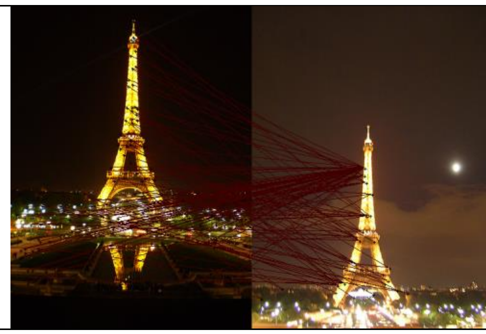
From above table, by using homography estimation through RANSAC, we found **notredame, bigben and empirestate** seems to be good.

The worst among all were **Eiffel, sanmacro and tatemodern** .

Part 2.2:

With image matching using the quantized projection function, the speed of execution is increased. We have calculated summaries of 128 dimensional vectors and used to identify set of possible nearest neighbors.

Value of W	Value of K	SIIFT(Time in Seconds)	Quantized(Time in Seconds)	Image
100	3	1.25	1.15	

100	4	1.23	1.15	
200	3	1.2	1.21	
400	3	1.2	1.15	

Comparing the execution time of SIIFT matching and Quantized SIIFT matching, the Quantized SIIFT matching seems to be faster than other by 20%. But by comparing the accuracy by image matching Quantized SIIFT matching is not accurate.

As we increase ‘w’ and decrease ‘k’ accuracy of Quantized SIIFT matching improved but seems to be stagnant after some point(w=400).

Part 3
Inverse warping

For inverse image warping we applied the following formulae to change the spatial arrangement of the image,

$$\begin{bmatrix} wx \\ wy \\ w \end{bmatrix} = \begin{bmatrix} w_{00} & w_{01} & w_{02} \\ w_{10} & w_{11} & w_{11} \\ w_{20} & w_{21} & 1 \end{bmatrix} * \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

The x and y are the index of destination image and wx and wy are the index of pixel from the source image

Dest_img[x,y] = src$\begin{pmatrix} (w_{00} * x + w_{10} * y + w_{20})/(w_{02} * x + w_{12} * y + w_{22}) \\ (w_{01*x} + w_{11} * y + w_{21})/(w_{02} * x + w_{12} * y + w_{22}) \end{pmatrix}$

The pixel of source image from the calculated value is saved in destination image position x and y. We are using **bilinear interpolation** to get the smoother image warping.

Bilinear Interpolation

After getting the product of homograph matrix we have implemented bilinear interpolation on coordinate transformation matrix, hence we get a clear transformed image without any black mark in the image.

Sample output

The original Lincoln image

The output Lincoln image

Sequenced image warping

Input

The inputs as follows,

Output

The warped image output is as follows, all images except 1 are warped relative to the first input image camera coordinates,