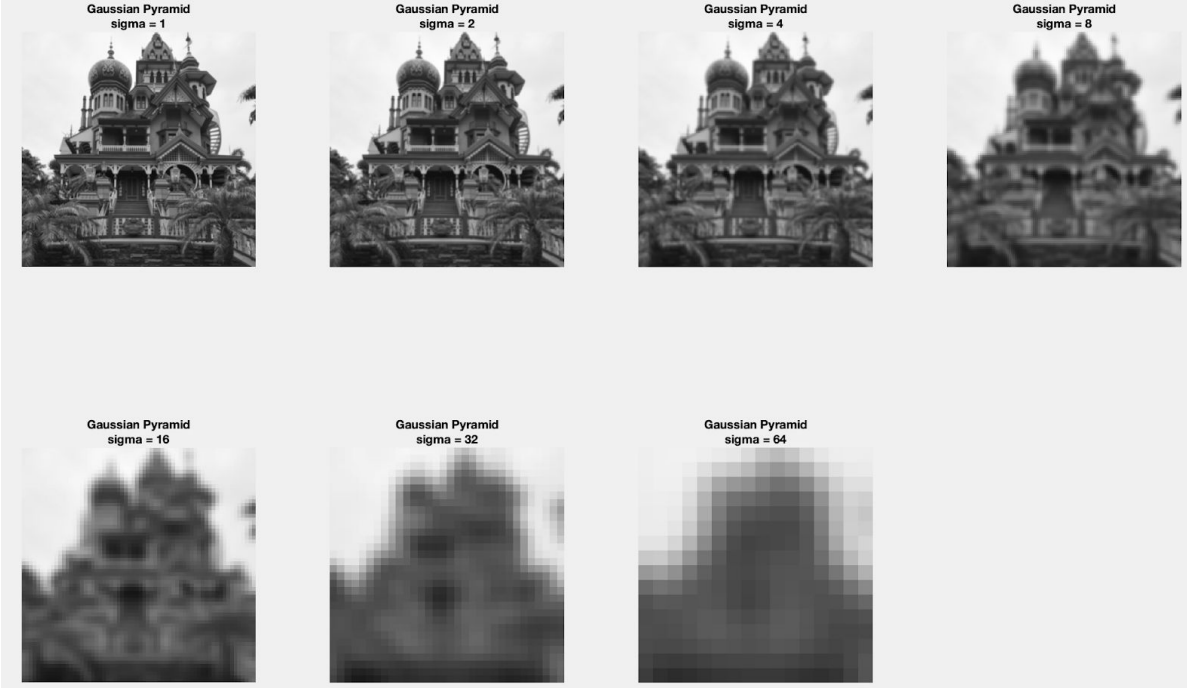
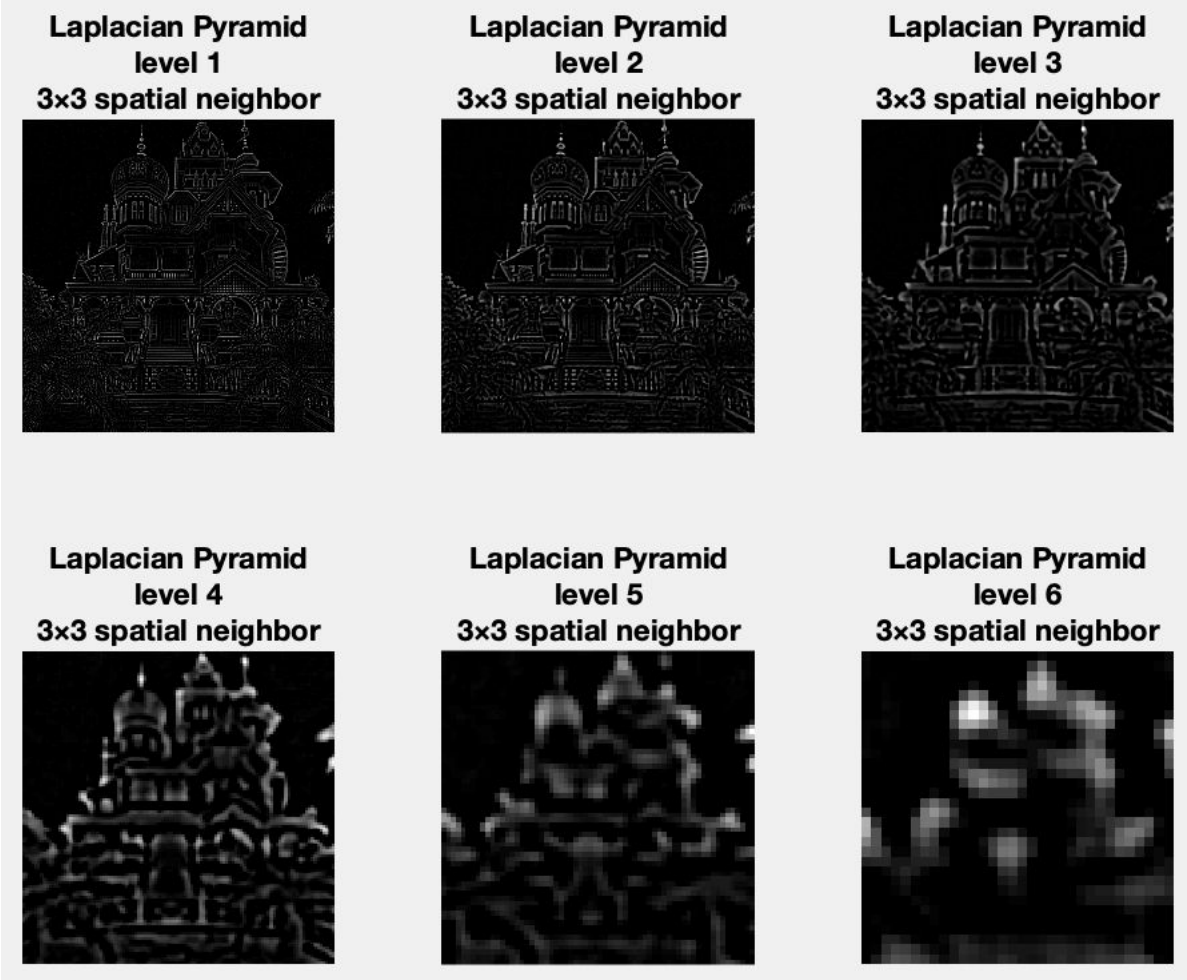
Q1.


Gaussian Pyramid
sigma = 1
Gaussian Pyramid
sigma = 2
Gaussian Pyramid
sigma = 4
Gaussian Pyramid
sigma = 8
Gaussian Pyramid
sigma = 16
Gaussian Pyramid
sigma = 32
Gaussian Pyramid
sigma = 64

Q2.


Laplacian Pyramid
level 1
3×3 spatial neighbor
Laplacian Pyramid
level 2
3×3 spatial neighbor
Laplacian Pyramid
level 3
3×3 spatial neighbor
Laplacian Pyramid
level 4
3×3 spatial neighbor
Laplacian Pyramid
level 5
3×3 spatial neighbor
Laplacian Pyramid
level 6
3×3 spatial neighbor

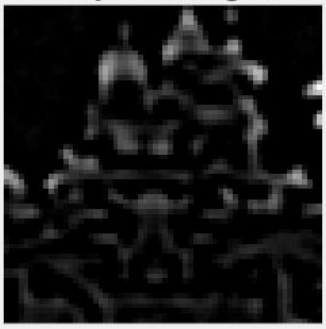
Laplacian Pyramid
level 1
5×5 spatial neighbor

Laplacian Pyramid
level 2
5×5 spatial neighbor

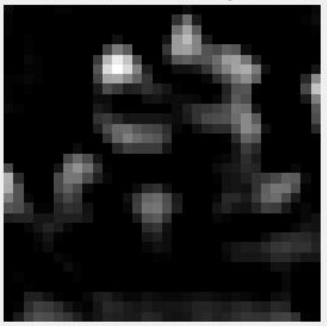
Laplacian Pyramid
level 3
5×5 spatial neighbor

Laplacian Pyramid
level 4
5×5 spatial neighbor

Laplacian Pyramid
level 5
5×5 spatial neighbor

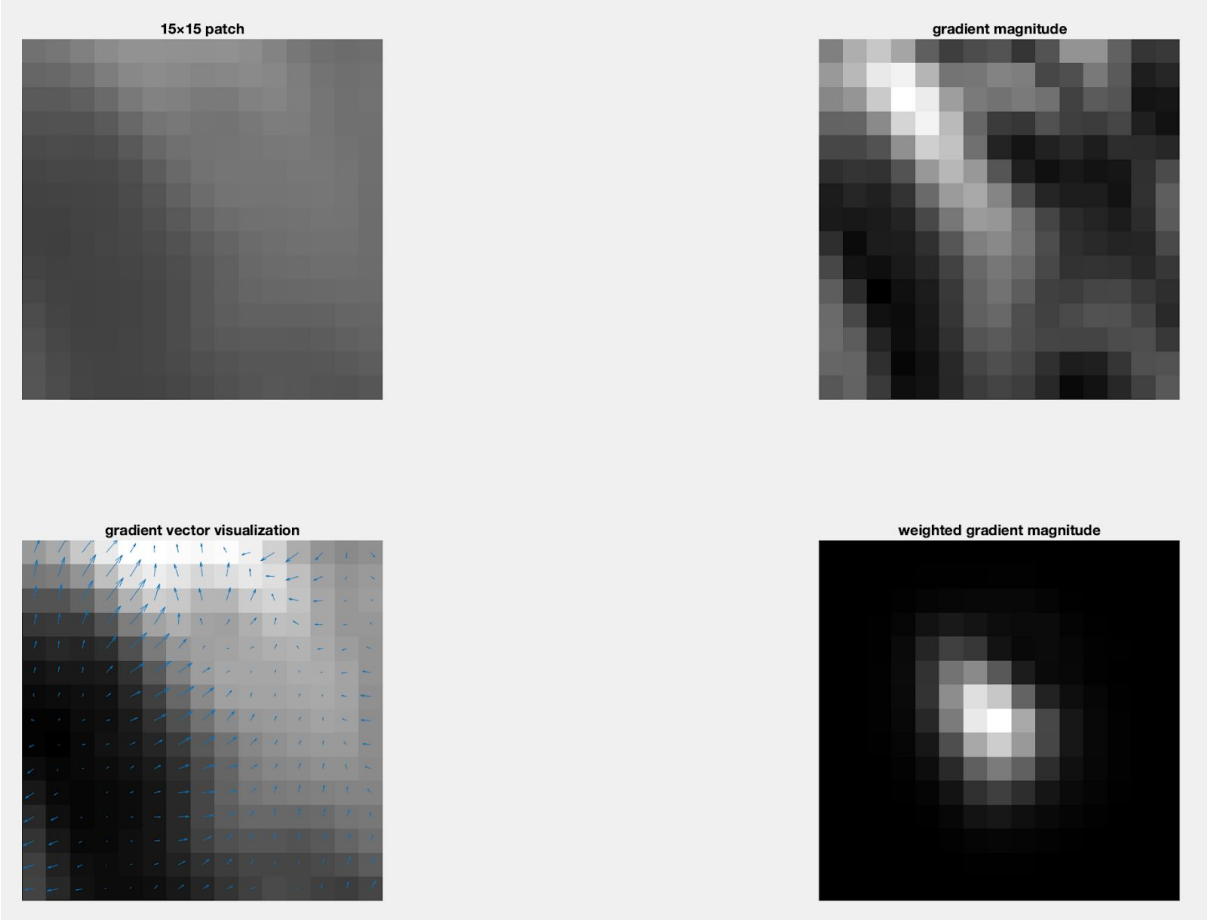


Laplacian Pyramid
level 6
5×5 spatial neighbor

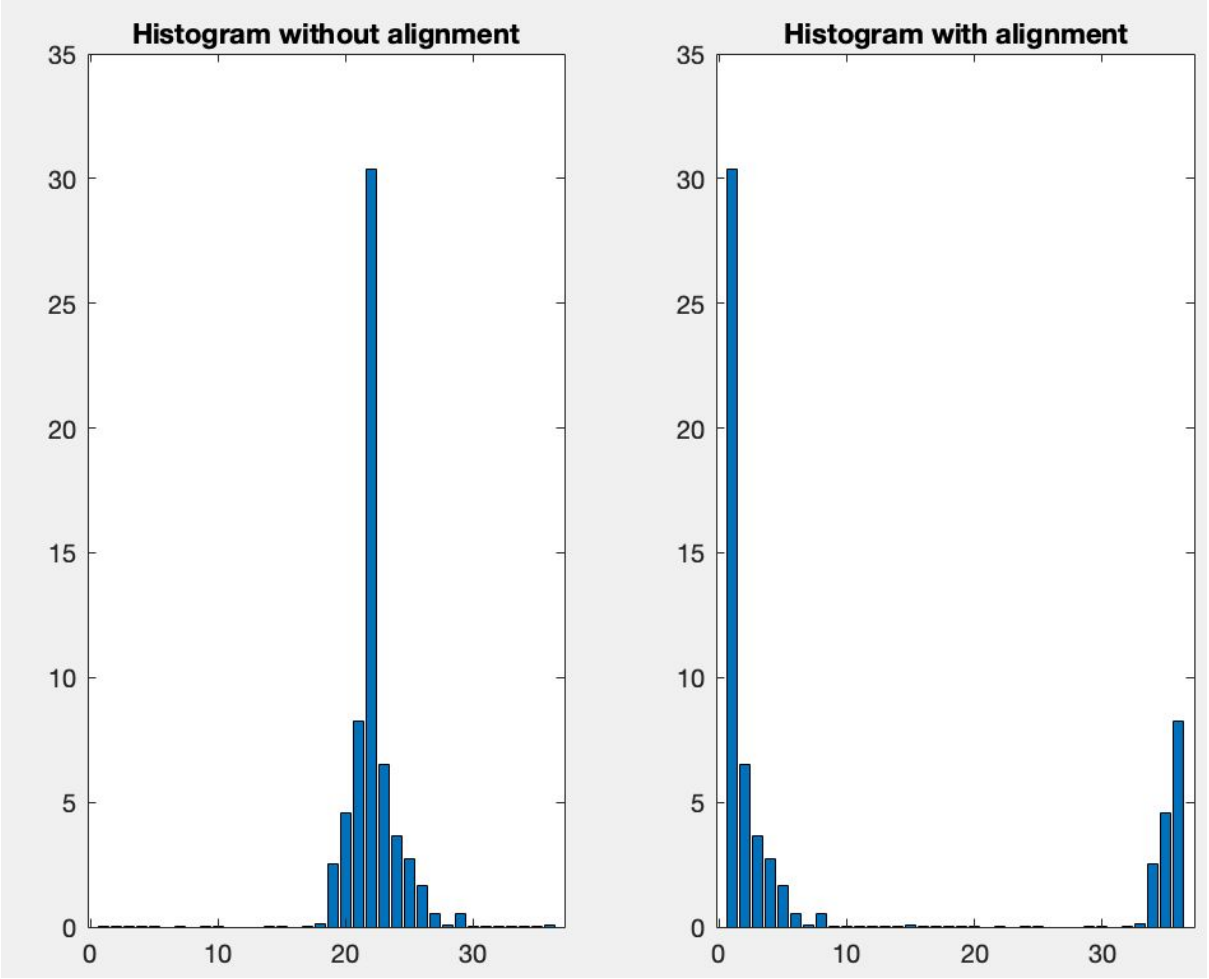


Q3.

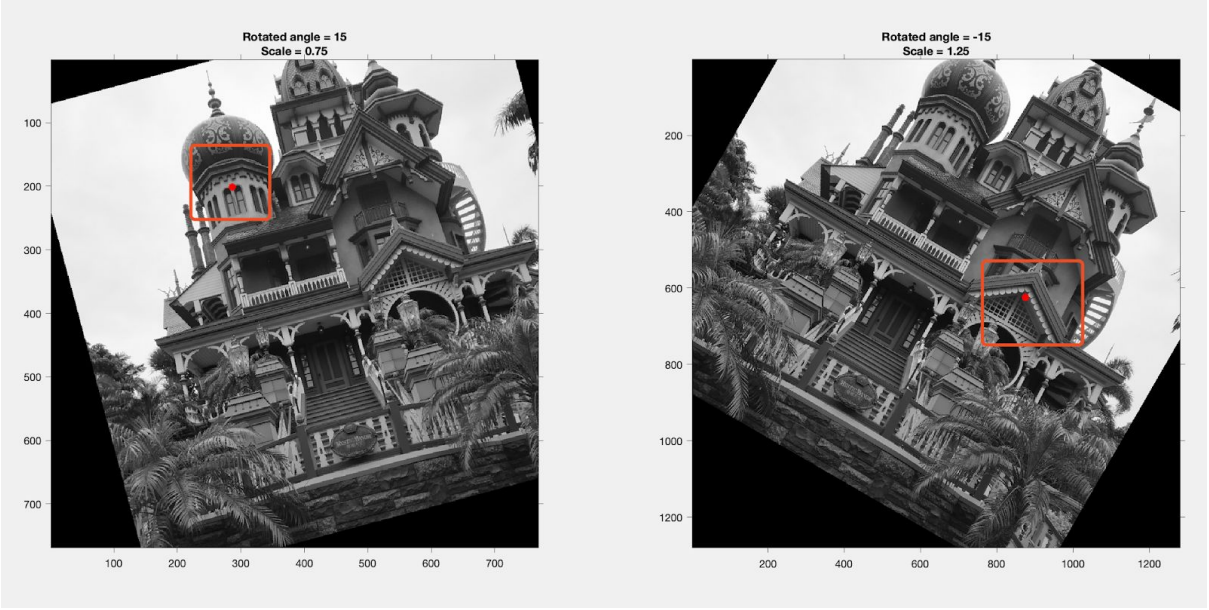
Q4.


15×15 patch
gradient magnitude
gradient vector visualization
weighted gradient magnitude

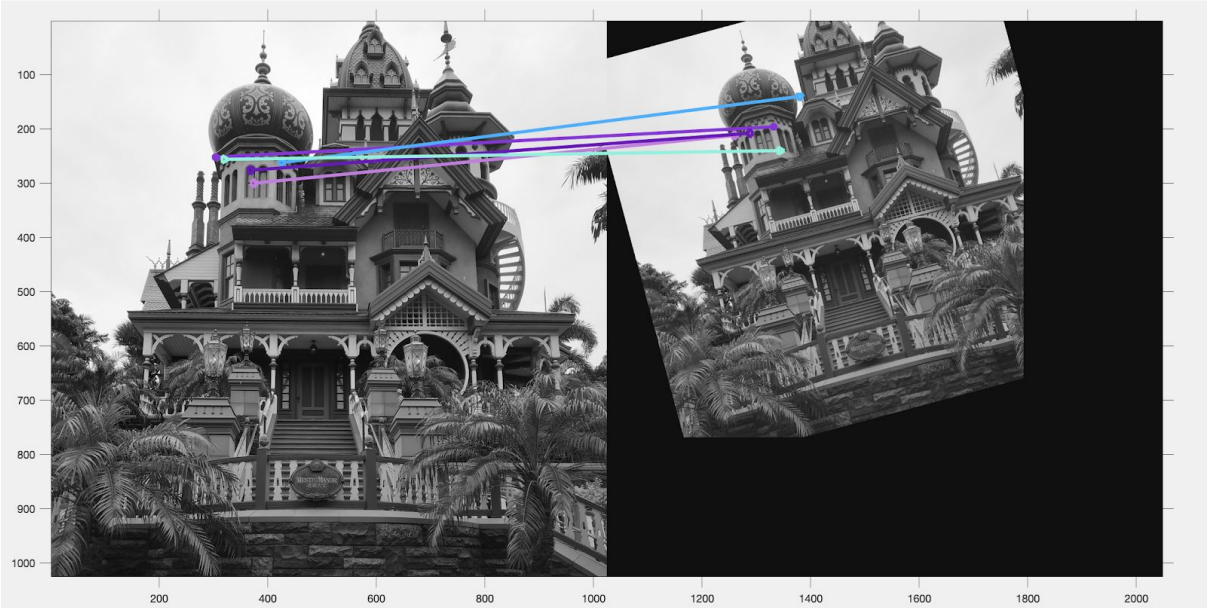
Q5.

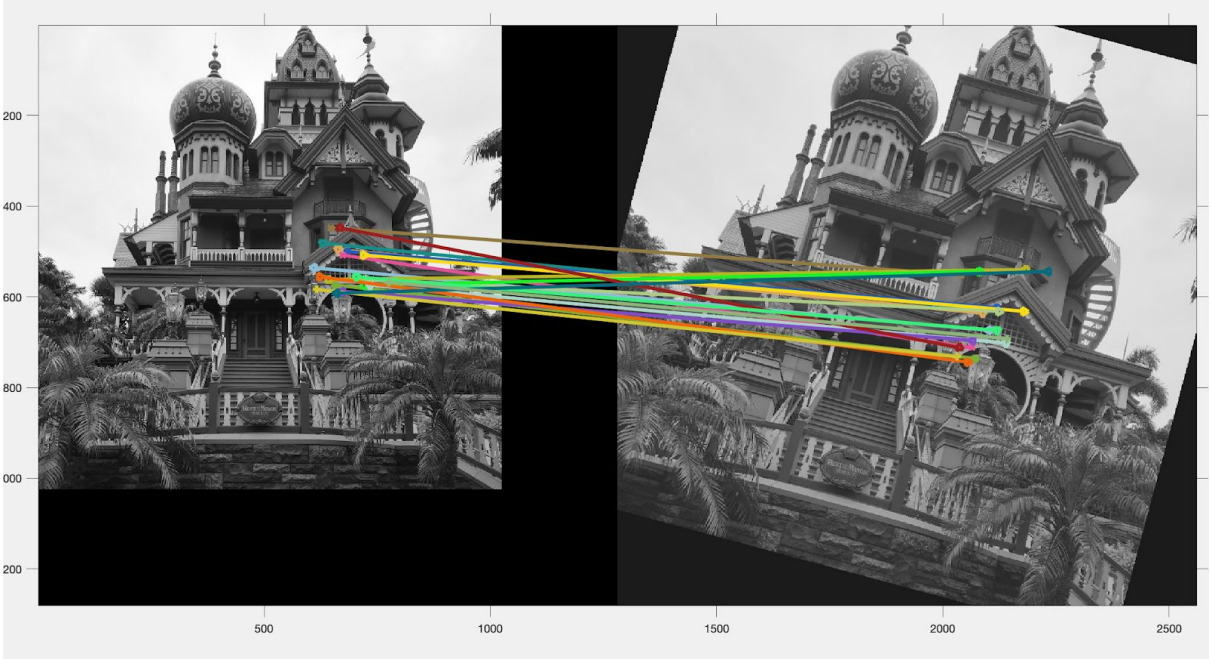

Histogram without alignment
Histogram with alignment
0
5
10
15
20
25
30
35
0
10
20
30

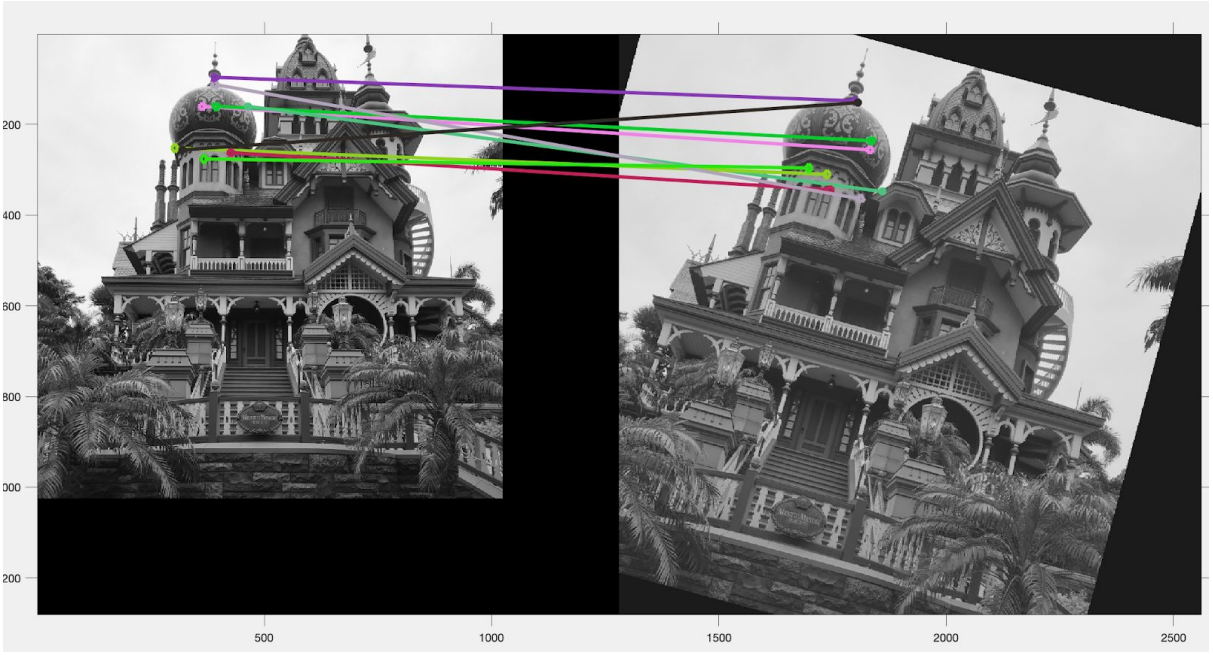
Q6.


Rotated angle = 15
Scale = 0.75
Rotated angle = -15
Scale = 1.25
100
200
300
400
500
600
700
200
400
600
800
1000
1200

Q7.


100
200
300
400
500
600
700
800
900
1000
200
400
600
800
1000
1200
1400
1600
1800
2000


200
400
600
800
000
200
500
1000
1500
2000
2500



From the figures shown above, we could see that not every point is matched successfully. Some matching pairs are hard to interpret so we can simply treat them as outliers. While some of the mismatching pairs are the results of similar pattern matching. For example, from figure3, we can see that some middle window points are matched to the side window points because there is not much distortion between the middle window and side window. Also, from figure3, we can see the round dome textual pattern mismatching. This is because of the repetitive textual pattern on it.

Q8.

1. Edges and low contrast are bad keypoints. So we could eliminate some of such key points to make the algorithm more robust. We can use the Harris Corner Detection technique to detect possible edges.
2. We can set a threshold to eliminate pairs with large Bhattacharya distance. From the figures shown above, we can observe that not every key point in the original image will have a corresponding point in the transformed image. By our algorithm, such outliers will also have a matching point but with possibly larger Bhattacharya distance than the regular matching pairs.