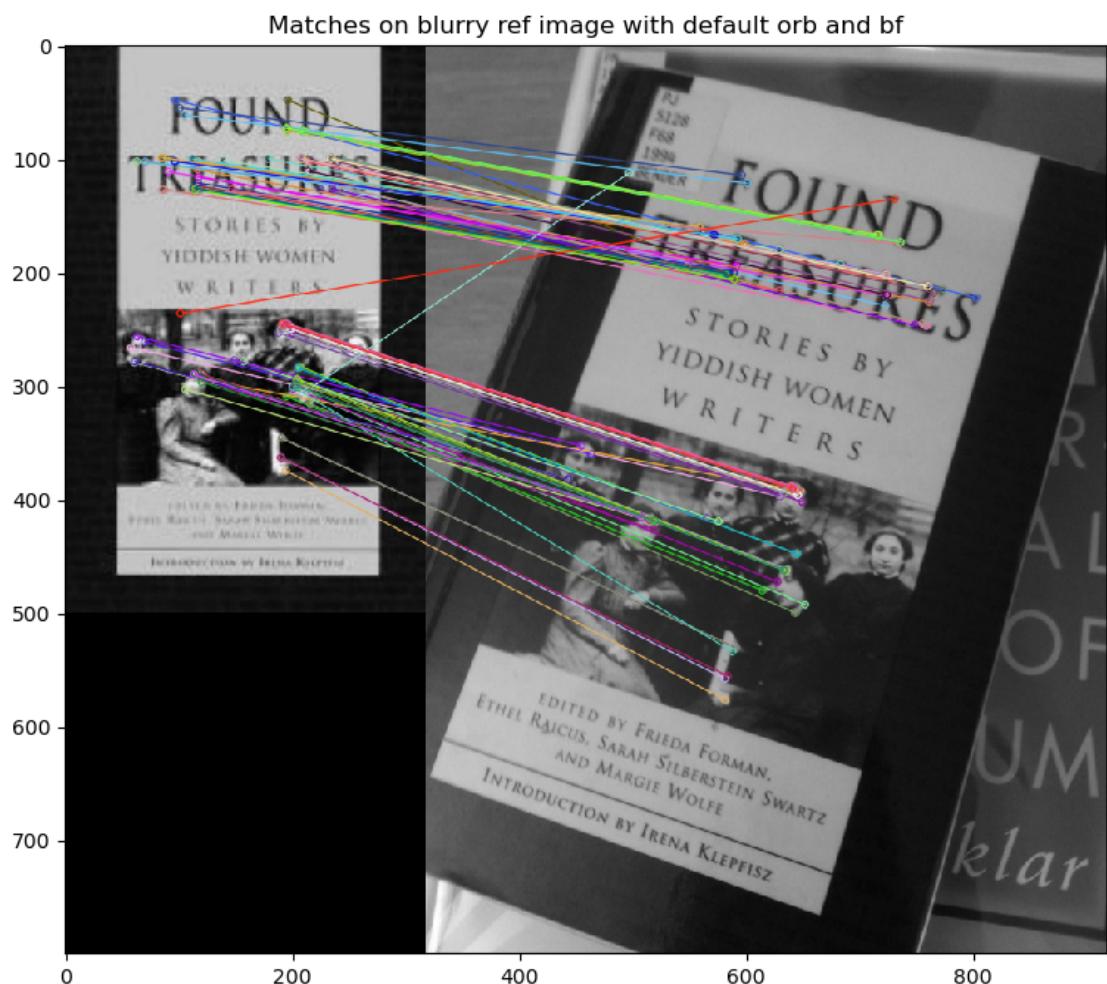


Assignment2

April 30, 2023

1 Question 1: Matching an object in a pair of images (60%)

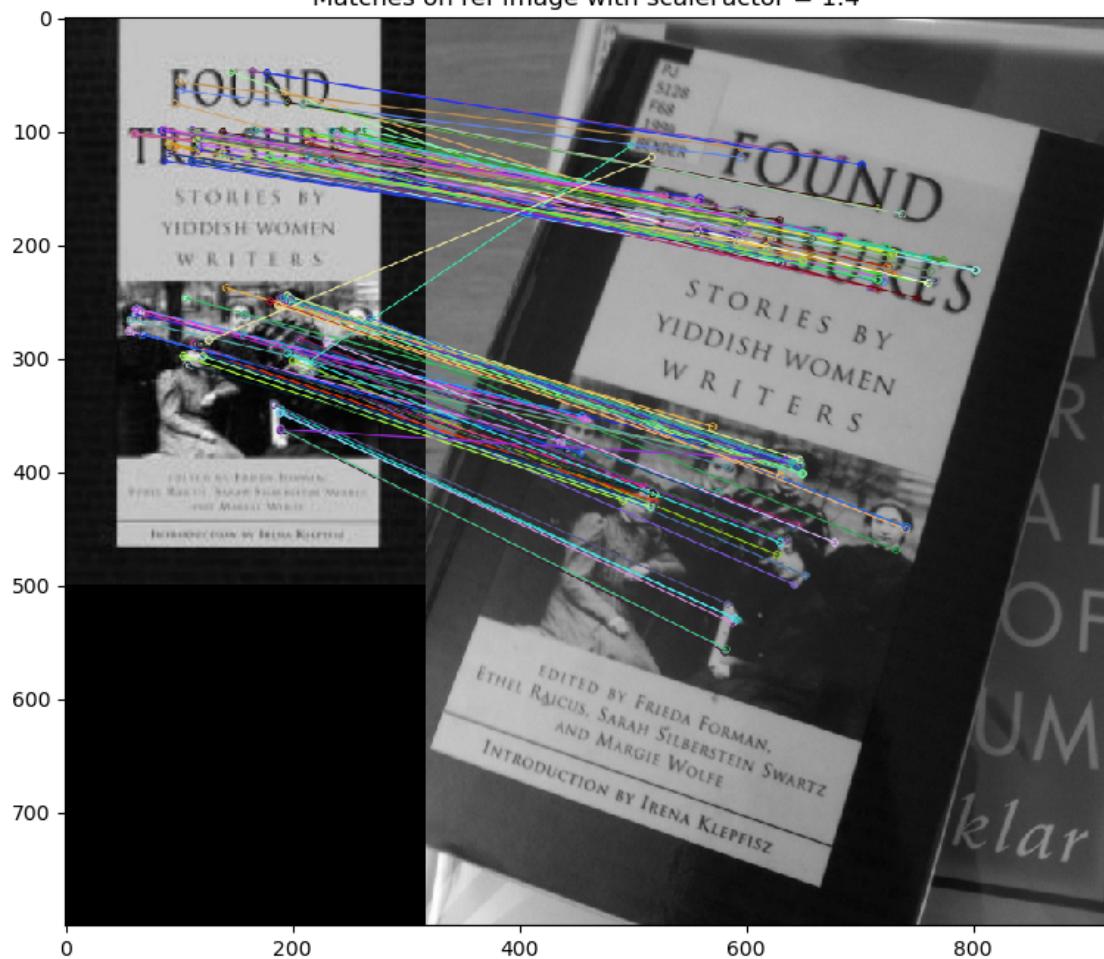


kp for reference: 500

kp for query: 500

good matches: 101

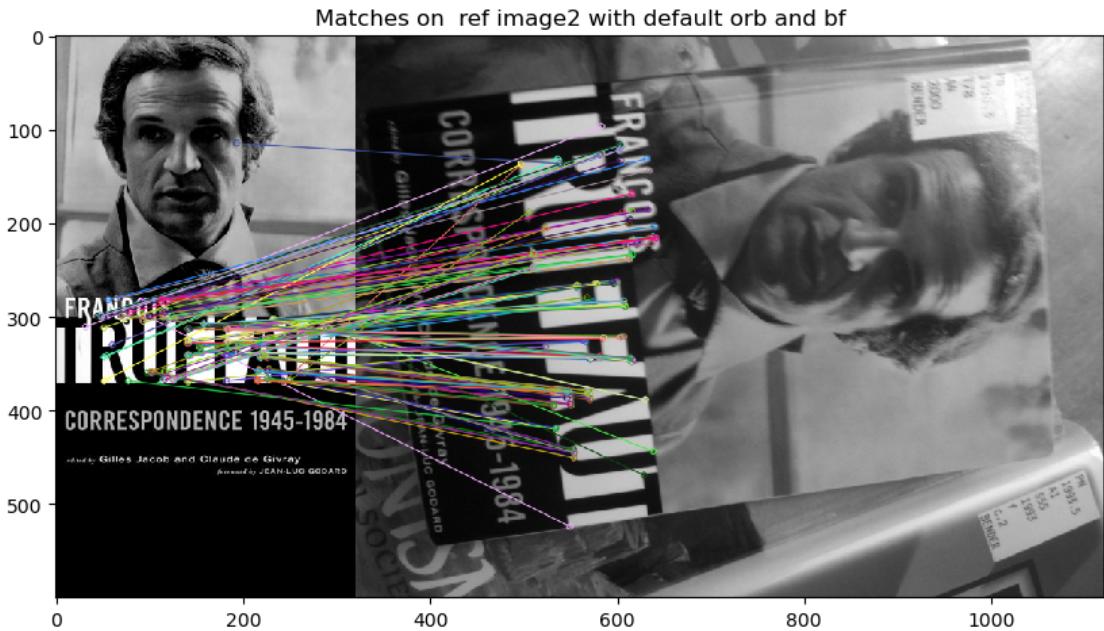
Matches on ref image with scaleFactor = 1.4



kp for reference: 436

kp for query: 484

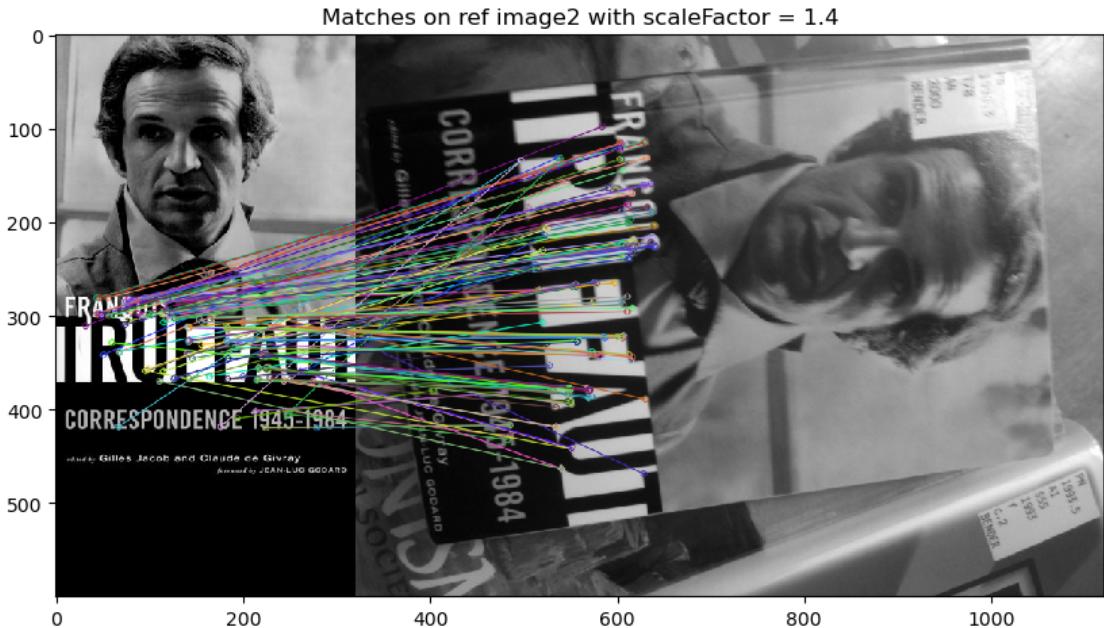
good matches: 124



kp for reference: 500

kp for query: 500

good matches: 139

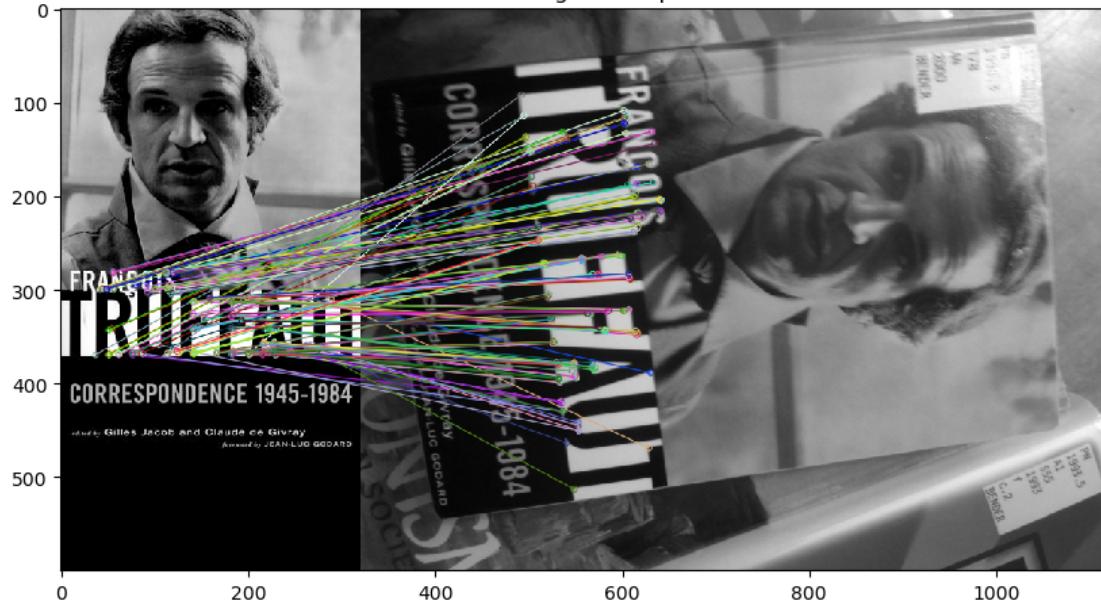


kp for reference: 436

kp for query: 484

good matches: 124

Matches on ref image2 with patchSize = 35

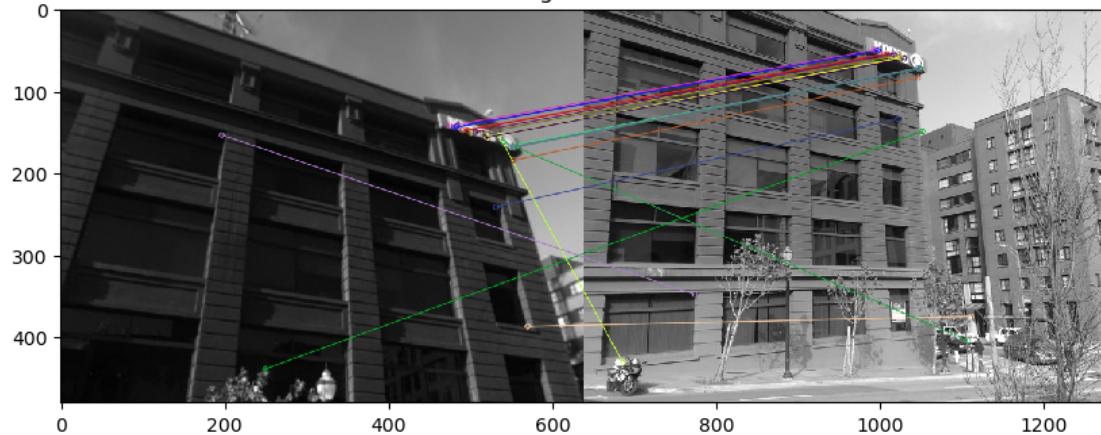


kp for reference: 500

kp for query: 500

good matches: 149

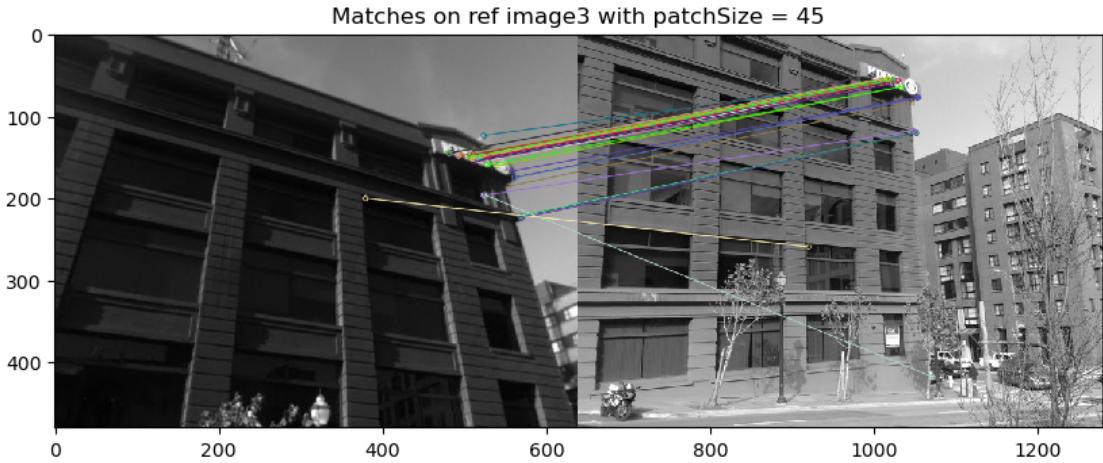
Matches on ref image3 with default orb and bf



kp for reference: 500

kp for query: 500

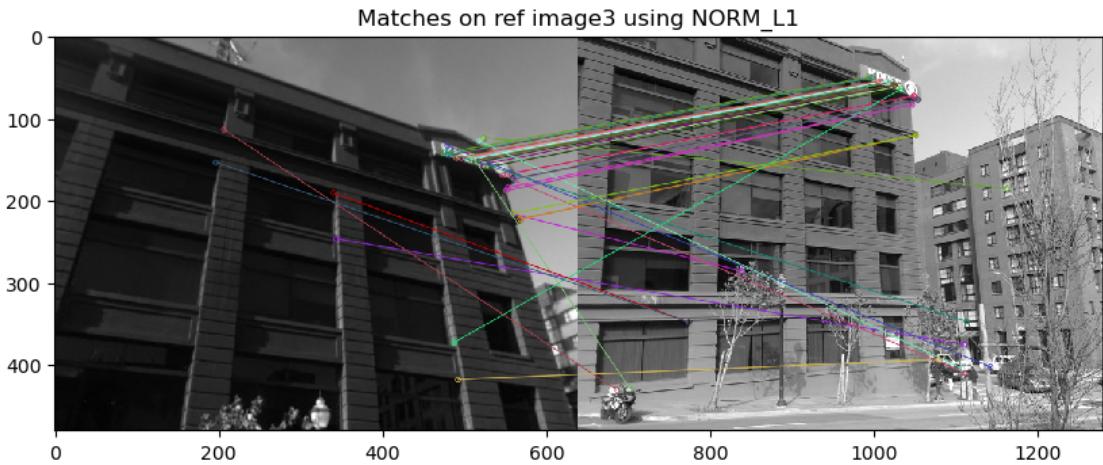
good matches: 24



```

kp for reference: 500
kp for query: 500
good matches: 33

```



```

kp for reference: 500
kp for query: 500
good matches: 40

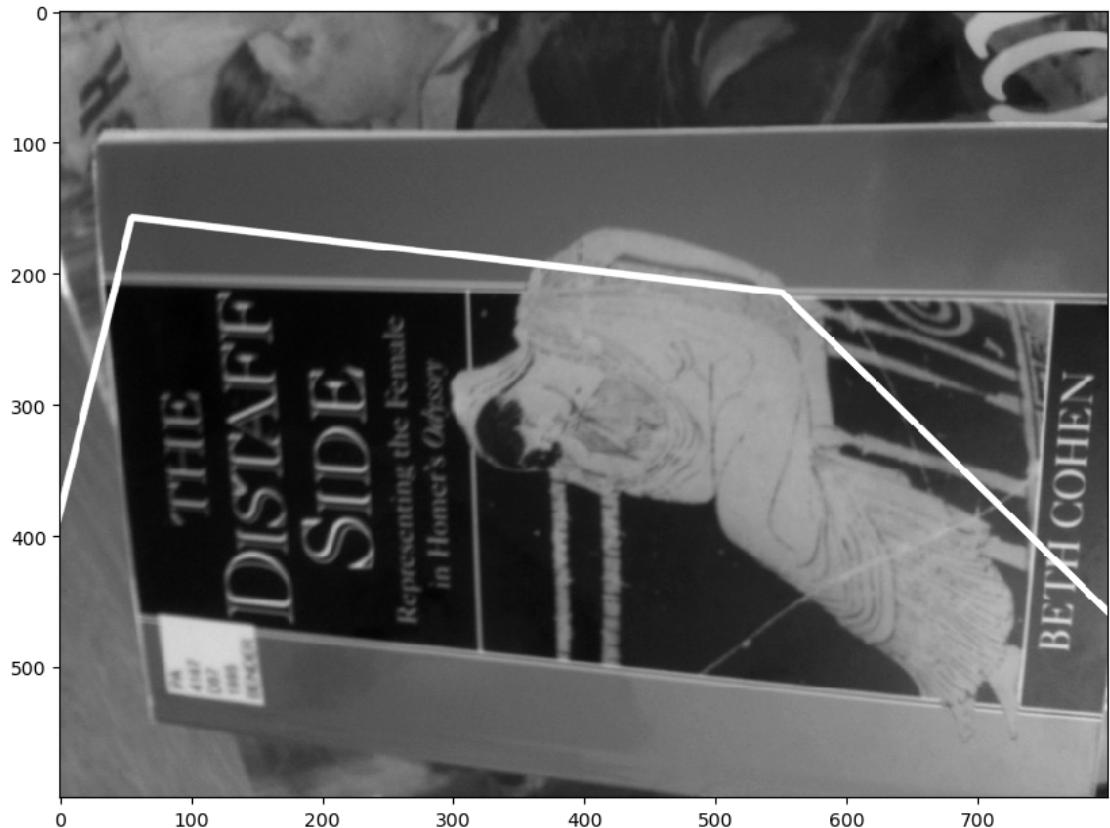
```

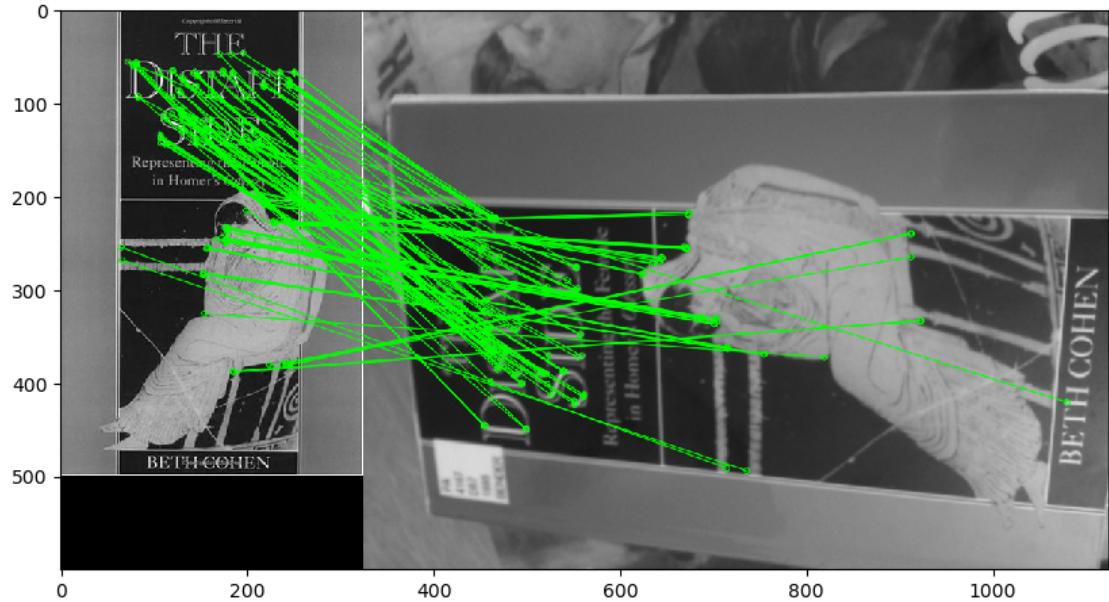
In the first image, all defaults are used in the image to set a baseline. The amount of good matches for this is 101. When observing the reference image, it seems to be more blurry and there are only really good defined lines in the title “Found treasures” and then obviously the features on the image. However, since it was a relatively blurry image I increased the scaleFactor to 1.4. This decreased the keypoints on both the reference and query images from 500 to 436 and 484 respectively, however the good matches increased to 124. As the image becomes more blurry, fine details are lost in the reference image, so increasing the scale factor allows the algorithm to become more sensitive to

larger scale features.

Next, on image 2, we have another book. For a baseline, all defaults are used. We have kp for reference and query as 500, and 139 good matches. As comparison for the last image, the scalefactor was increased to 1.4 again but in this scenario the good matches decreased by 15. This shows that with a better image, the scale factor increase is not beneficial. Another parameter was changed instead, this time, patchSize was changed to 35 which increased the matches from baseline by 10. Increasing the patch size allows the algorithm to consider a larger context around the keypoints allowing it to capture more distinct features, which are prominent in the title of this book.

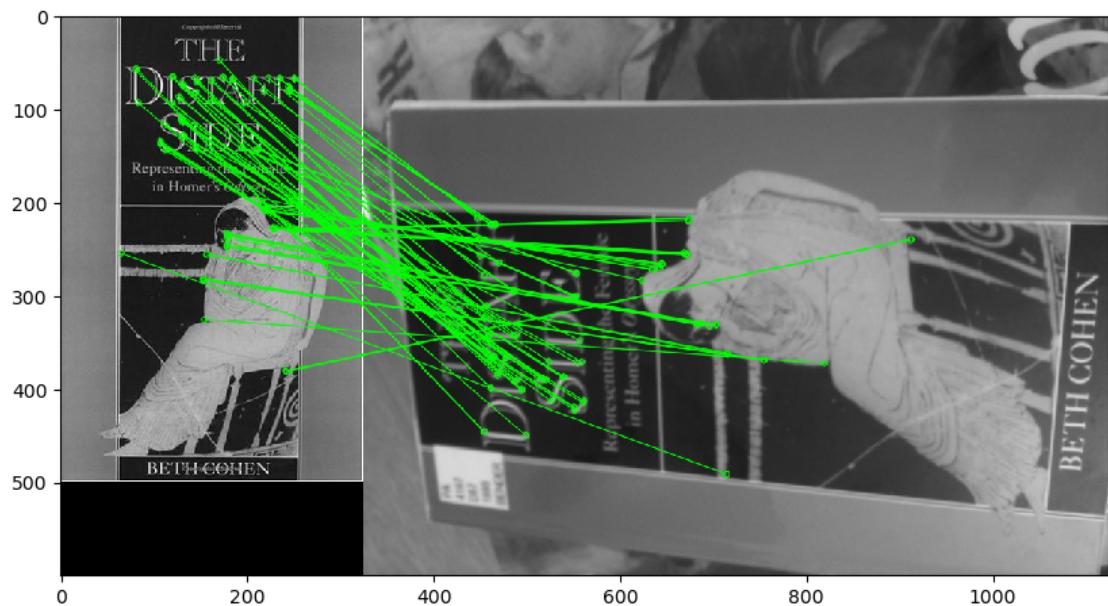
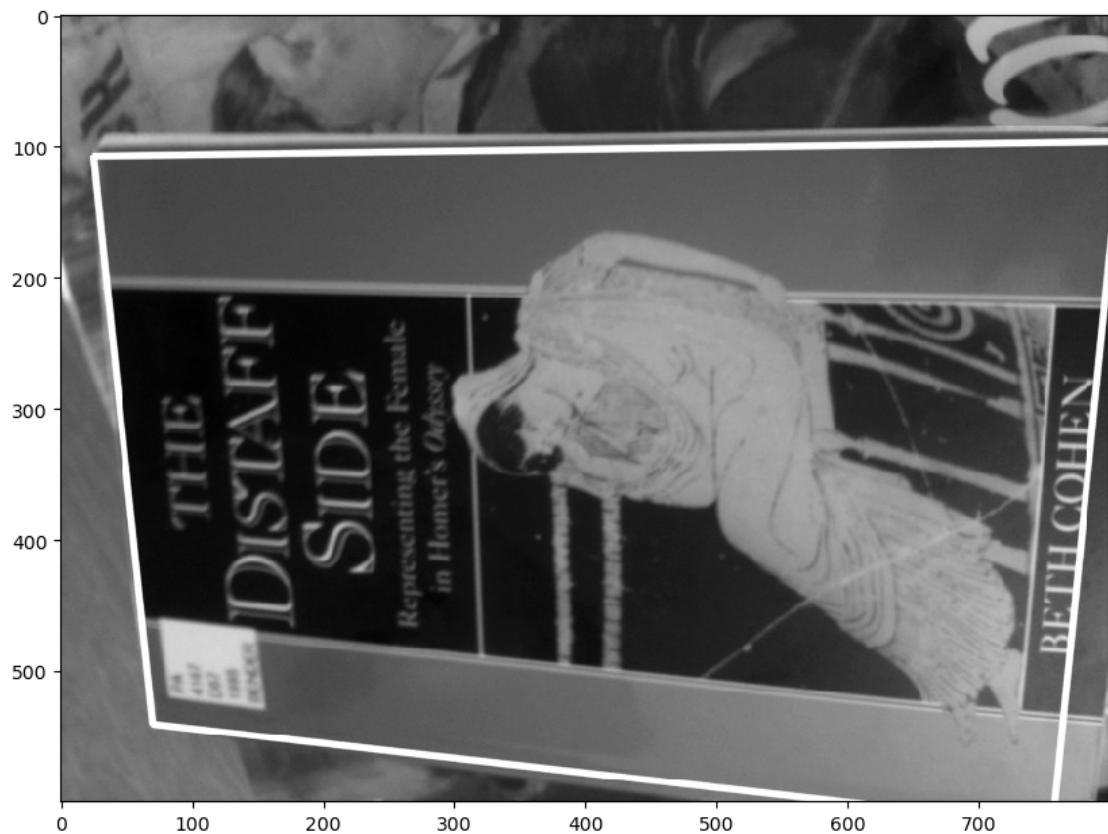
Finally, on image 3, we have two photos of a building. On baseline, we only have 24 good matches upon which we can see that 4 are false positives. Again, I increased the patchSize to 35 which increased the good matches to 33, upon which we can see only 2 are false positives. Increasing the patch size allowed the algorithm to find more matches upon the “sign” on the top right of the building. Next, I used NORM_L1 as a distance metric. It increased the good matches again to 40, however also more false positives. This is likely since norm_l1 is less sensitive to small changes in descriptor values compared to norm_hamming. So while it might identify more true matches, it can also result in higher rate of false matches





Visually, we can see that the homography did not match with the book cover. It is clear that it is basing it on the matches, not the cover of the book and does not take into consideration the perspective. The perspective distortion and changes in viewpoint between the two images is likely the cause for this error, since homography transformation assumes the scene is planar.

Try the RANSAC option to compute homography. Change the RANSAC parameters, and explain your results. Print and analyze the inlier numbers.

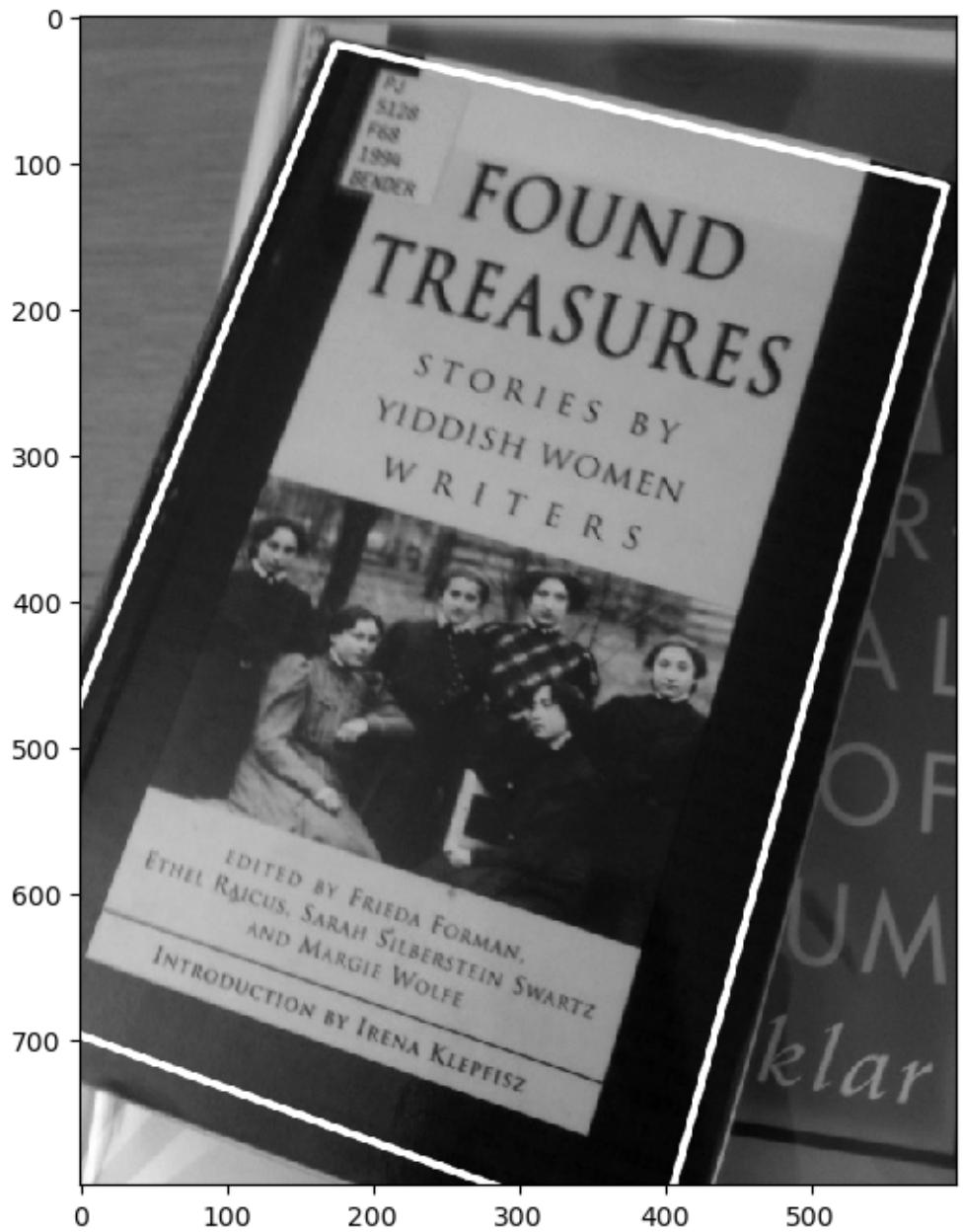


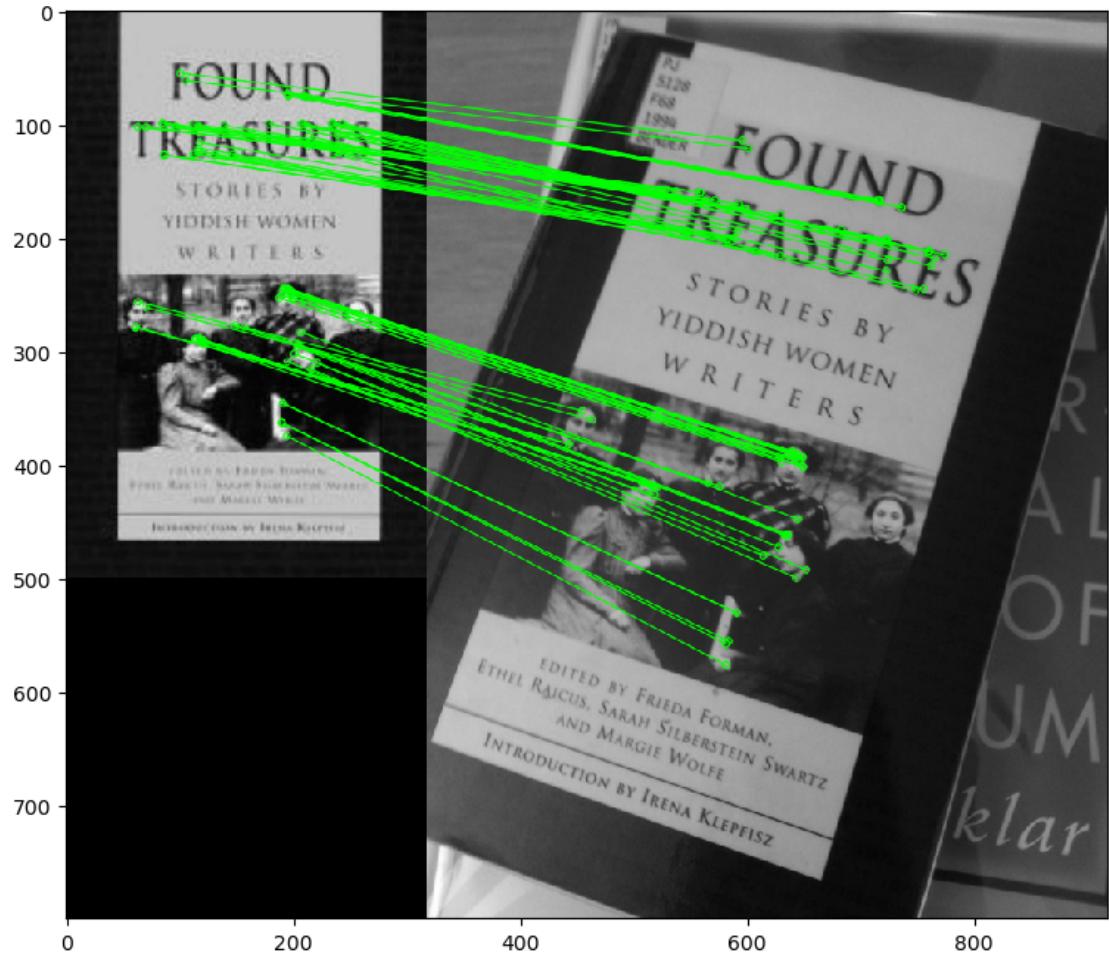
```
inlier with no parameter change : 94
inlier with ransacReprojThreshold = 5 : 100
inlier with confidence = 0.8 : 94
```

Using RANSAC to compute the homography sees a big change in the accuracy. It accurately performs a transformation onto the book. There were 3 cases for the RANSAC parameters. First one was a baseline with no parameter change, which found 94 inliers.

Then, I changed `ransacReprojThreshold = 5` which increased the inliers to 100. This would be because increasing the `ransacReprojThreshold` increases the allowed reprojection error threshold which increases the number of inliers. While this gives more inliers, this could lead to increased false positives given the threshold is set too high.

Next, I set the confidence threshold to 0.8. Since the inliers did not change when I did this, it suggests that the original threshold was already appropriately set. If the inliers changed, that would mean that more matches are being considered valid which could potentially mean in better overall matching between the images.

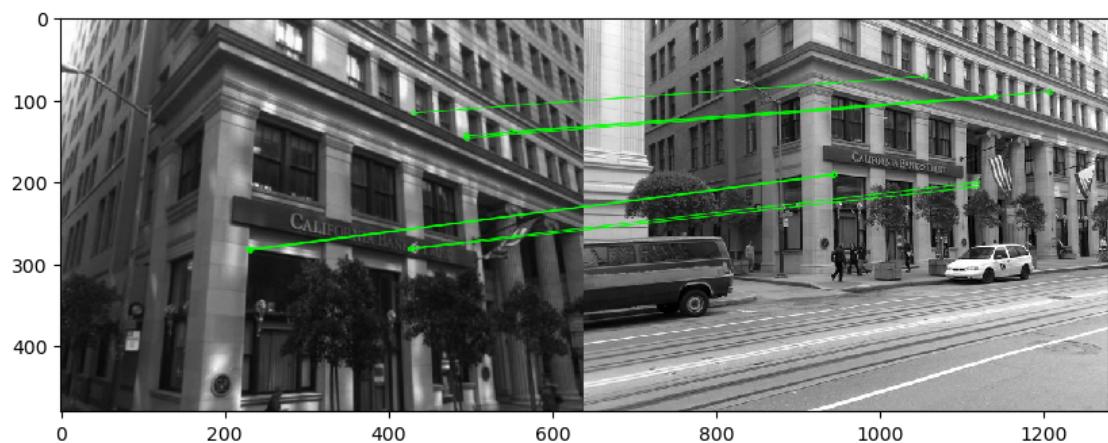
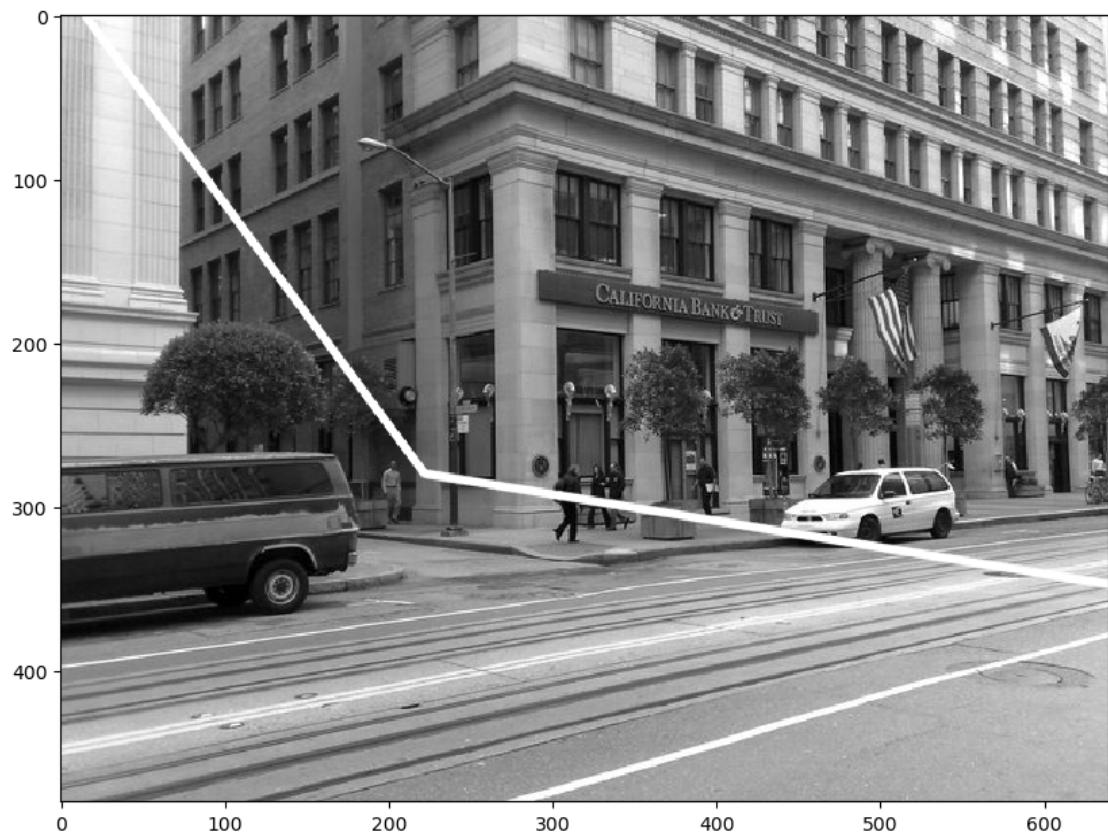




kp for reference: 500

kp for query: 500

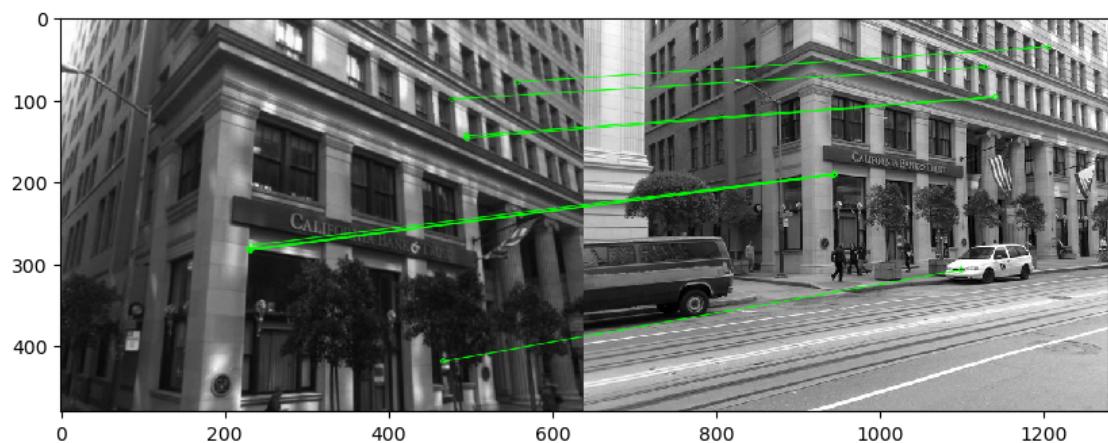
inliers: 82



kp for reference: 500

kp for query: 500

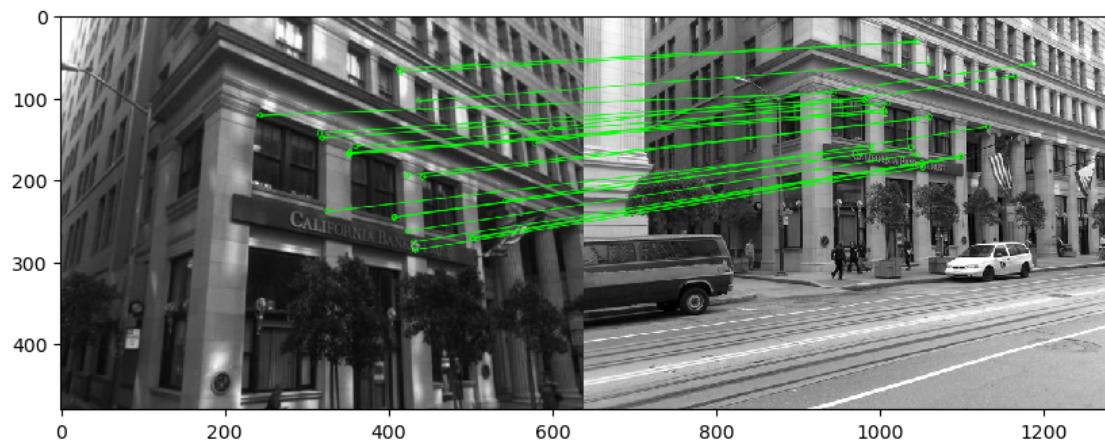
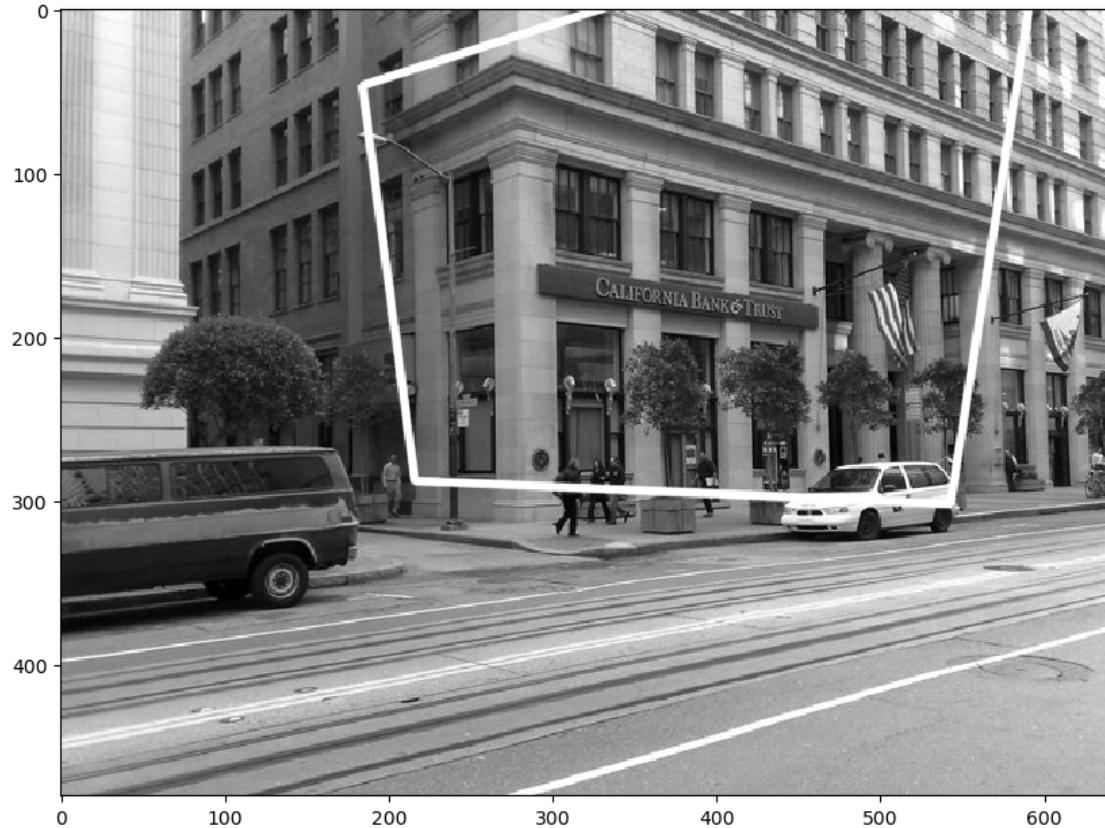
inliers: 9



kp for reference: 512

kp for query: 502

inliers: 9



kp for reference: 2046

kp for query: 2038

inliers: 23

Success case is the book. This was the easiest to match. RANSAC found a good match around the book cover, and the matches visually appeared to be all true positives. I chose this example

because I looked at this one previously, which visually had some false positives, including one that matched the sticker on the query image to something irrelevant. The parameter settings for this was default, but successful.

The failure case is a building. The reference photo is from across the street, where the query image is next to the footpath taken upwards. without any changes, the inliers is 9 and the homography transformation is in the right realm, but inaccurate. To improve that, the paramater scoreType = cv2.ORB_FAST_SCORE was used. This improved the perspective, but the inliers stayed the same. This would be because there are lots of corners in the image. To further refine this, the changes nfeatures = 2000 and patchSize = 30 were performed which narrowed down the homography transformation almost exactly to the perspective of the query. This increased the inliers to 23, which is to be expected when the nfeatures is increased, but they seem to be mostly true positives on inspection.

2 Question 2: What am I looking at? (40%)

```
No match found for .DS_Store  
-----  
Match found, 001.jpg and 001.jpg with 105 inliers.  
-----  
No match found for 001unrelatedimage.jpg  
-----  
Match found, 002.jpg and 002.jpg with 72 inliers.  
-----  
No match found for 002unrelatedimage.jpg  
-----  
Match found, 003.jpg and 003.jpg with 95 inliers.  
-----  
No match found for 003unrelatedimage.jpg  
-----  
Match found, 004.jpg and 004.jpg with 26 inliers.  
-----  
Match found, 005.jpg and 005.jpg with 45 inliers.  
-----  
Match found, 006.jpg and 006.jpg with 83 inliers.  
-----  
Match found, 007.jpg and 007.jpg with 46 inliers.  
-----  
Match found, 008.jpg and 008.jpg with 26 inliers.  
-----  
Match found, 009.jpg and 009.jpg with 75 inliers.  
-----  
Match found, 010.jpg and 010.jpg with 120 inliers.  
-----  
Match found, 011.jpg and 011.jpg with 111 inliers.  
-----  
Match found, 012.jpg and 012.jpg with 62 inliers.  
-----
```

Match found, 013.jpg and 013.jpg with 85 inliers.

Match found, 014.jpg and 014.jpg with 79 inliers.

Match found, 015.jpg and 015.jpg with 56 inliers.

Match found, 016.jpg and 016.jpg with 35 inliers.

Match found, 017.jpg and 017.jpg with 82 inliers.

No match found for 018.jpg

Match found, 019.jpg and 019.jpg with 41 inliers.

Match found, 020.jpg and 020.jpg with 134 inliers.

Match found, 021.jpg and 021.jpg with 70 inliers.

Match found, 022.jpg and 022.jpg with 23 inliers.

Match found, 023.jpg and 023.jpg with 44 inliers.

Match found, 024.jpg and 024.jpg with 52 inliers.

Match found, 025.jpg and 025.jpg with 39 inliers.

Match found, 026.jpg and 026.jpg with 39 inliers.

Match found, 027.jpg and 027.jpg with 38 inliers.

Match found, 028.jpg and 028.jpg with 114 inliers.

Match found, 029.jpg and 029.jpg with 36 inliers.

Match found, 030.jpg and 030.jpg with 74 inliers.

Match found, 031.jpg and 031.jpg with 48 inliers.

Match found, 032.jpg and 032.jpg with 68 inliers.

No match found for 033.jpg

Match found, 034.jpg and 034.jpg with 65 inliers.

Match found, 035.jpg and 035.jpg with 53 inliers.

Match found, 036.jpg and 036.jpg with 22 inliers.

What my code does is it matches the reference images to the query images by iterating over every the query image files and comparing them to the reference images using the matchImageImproved function to find the inliers. It then works out the image with the most inliers, and has a threshold of must having 20 inliers to pass. Overall accuracy for this function is 36/39 (92%), which is good. The only three matches it did not find were on image 18, 33 and 37, which must have matches under the threshold of 20 inliers. Upon individual analysis of those images, image 18 has mild glare and the image is slightly washed, the distinctive features are only the text. Image 33's image only has significant contrast from the picture and the background, which may decrease inliers and finally image 37 appears to be blurry.

Running the program with no threshold, 18 got a match with 18 with inliners = 18. However 33 matched with 6 then 12, and 37 matched with 3 then 15. Running a top k accuracy measure might have a small impact in this dataset, as it would have allowed a match with 18. However, there would be false positives with img 33 and 37.

Incomplete.

```
No match found for .DS_Store
Match found, 001.jpg and 001.jpg with 105 inliers.
-----
No match found for 001unrelatedimage.jpg
Match found, 002.jpg and 002.jpg with 72 inliers.
-----
No match found for 002unrelatedimage.jpg
Match found, 003.jpg and 003.jpg with 95 inliers.
-----
No match found for 003unrelatedimage.jpg
Match found, 004.jpg and 004.jpg with 26 inliers.
-----
Match found, 005.jpg and 005.jpg with 45 inliers.
-----
Match found, 006.jpg and 006.jpg with 83 inliers.
-----
Match found, 007.jpg and 007.jpg with 46 inliers.
-----
Match found, 008.jpg and 008.jpg with 26 inliers.
-----
Match found, 009.jpg and 009.jpg with 75 inliers.
-----
Match found, 010.jpg and 010.jpg with 120 inliers.
-----
Match found, 011.jpg and 011.jpg with 111 inliers.
-----
Match found, 012.jpg and 012.jpg with 62 inliers.
-----
Match found, 013.jpg and 013.jpg with 85 inliers.
-----
Match found, 014.jpg and 014.jpg with 79 inliers.
```

```
Match found, 015.jpg and 015.jpg with 56 inliers.  
-----  
Match found, 016.jpg and 016.jpg with 35 inliers.  
-----  
Match found, 017.jpg and 017.jpg with 82 inliers.  
-----  
No match found for 018.jpg  
Match found, 019.jpg and 019.jpg with 41 inliers.  
-----  
Match found, 020.jpg and 020.jpg with 134 inliers.  
-----  
Match found, 021.jpg and 021.jpg with 70 inliers.  
-----  
Match found, 022.jpg and 022.jpg with 23 inliers.  
-----  
Match found, 023.jpg and 023.jpg with 44 inliers.  
-----  
Match found, 024.jpg and 024.jpg with 52 inliers.  
-----  
Match found, 025.jpg and 025.jpg with 39 inliers.  
-----  
Match found, 026.jpg and 026.jpg with 39 inliers.  
-----  
Match found, 027.jpg and 027.jpg with 38 inliers.  
-----  
Match found, 028.jpg and 028.jpg with 114 inliers.  
-----  
Match found, 029.jpg and 029.jpg with 36 inliers.  
-----  
Match found, 030.jpg and 030.jpg with 74 inliers.  
-----  
Match found, 031.jpg and 031.jpg with 48 inliers.  
-----  
Match found, 032.jpg and 032.jpg with 68 inliers.  
-----  
No match found for 033.jpg  
Match found, 034.jpg and 034.jpg with 65 inliers.  
-----  
Match found, 035.jpg and 035.jpg with 53 inliers.  
-----  
Match found, 036.jpg and 036.jpg with 22 inliers.  
-----
```

I put 3 “phony” images in, 001unrelatedimage.jpg, 002unrelatedimage.jpg and 003unrelatedimage.jpg. Accuracy slightly increases to 37/39 (95%) since the phony images made it so the function misses the image that did not match. No changes were made to improve performance, this functionality was built in from previous step.

```
Match found, 001.jpg and 001.jpg with 116 inliers.
```

```
-----  
No match found for 001sunflower.jpg  
-----  
No match found for 002.jpg  
-----  
No match found for 002dudewithhat.jpg  
-----  
Match found, 003.jpg and 003.jpg with 55 inliers.  
-----  
No match found for 003scarf.jpg  
-----  
Match found, 004.jpg and 004.jpg with 26 inliers.  
-----  
No match found for 005.jpg  
-----  
Match found, 006.jpg and 006.jpg with 72 inliers.  
-----  
Match found, 007.jpg and 007.jpg with 128 inliers.  
-----  
Match found, 008.jpg and 008.jpg with 219 inliers.  
-----  
No match found for 009.jpg  
-----  
Match found, 010.jpg and 010.jpg with 83 inliers.  
-----  
Match found, 011.jpg and 011.jpg with 157 inliers.  
-----  
Match found, 012.jpg and 012.jpg with 111 inliers.  
-----  
No match found for 013.jpg  
-----  
Match found, 014.jpg and 014.jpg with 87 inliers.  
-----  
Match found, 015.jpg and 015.jpg with 31 inliers.  
-----  
Match found, 016.jpg and 016.jpg with 74 inliers.  
-----  
Match found, 017.jpg and 017.jpg with 175 inliers.  
-----  
Match found, 018.jpg and 018.jpg with 217 inliers.  
-----  
Match found, 019.jpg and 019.jpg with 110 inliers.  
-----  
Match found, 020.jpg and 020.jpg with 71 inliers.  
-----  
Match found, 021.jpg and 021.jpg with 32 inliers.  
-----  
Match found, 022.jpg and 022.jpg with 37 inliers.
```

```
-----  
Match found, 023.jpg and 023.jpg with 77 inliers.  
-----  
Match found, 024.jpg and 024.jpg with 36 inliers.  
-----  
No match found for 025.jpg  
-----  
No match found for 026.jpg  
-----  
Match found, 027.jpg and 027.jpg with 26 inliers.  
-----  
No match found for 028.jpg  
-----  
Match found, 029.jpg and 029.jpg with 164 inliers.  
-----  
No match found for 030.jpg  
-----  
No match found for 031.jpg  
-----  
Match found, 032.jpg and 032.jpg with 37 inliers.  
-----  
Match found, 033.jpg and 033.jpg with 93 inliers.  
-----  
No match found for 034.jpg  
-----  
No match found for 035.jpg  
-----  
No match found for 036.jpg  
-----  
No match found for 037.jpg  
-----
```

For this, the museum_paintings folder was chosen and 3 images were put in, 001sunflower.jpg, 002dudewithhat.jpg and 003scarf.jpg. The accuracy for this was significantly lower than the book covers, being 22/40 (55%). All the phony images were correctly found, so of the images that had a reference photo, 20/40 (50%) were correctly identified. 2 of the images had false matches with enough inliers to pass through the threshold.

```
-----  
Match found, 001.jpg and 001.jpg with 116 inliers.  
-----  
No match found for 001sunflower.jpg  
-----  
No match found for 002.jpg  
-----  
No match found for 002dudewithhat.jpg  
-----  
Match found, 003.jpg and 003.jpg with 55 inliers.  
-----  
No match found for 003scarf.jpg
```

```
-----  
Match found, 004.jpg and 004.jpg with 26 inliers.  
-----  
No match found for 005.jpg  
-----  
Match found, 006.jpg and 006.jpg with 72 inliers.  
-----  
Match found, 007.jpg and 007.jpg with 128 inliers.  
-----  
Match found, 008.jpg and 008.jpg with 219 inliers.  
-----  
No match found for 009.jpg  
-----  
Match found, 010.jpg and 010.jpg with 83 inliers.  
-----  
Match found, 011.jpg and 011.jpg with 157 inliers.  
-----  
Match found, 012.jpg and 012.jpg with 111 inliers.  
-----  
No match found for 013.jpg  
-----  
Match found, 014.jpg and 014.jpg with 87 inliers.  
-----  
Match found, 015.jpg and 015.jpg with 31 inliers.  
-----  
Match found, 016.jpg and 016.jpg with 74 inliers.  
-----  
Match found, 017.jpg and 017.jpg with 175 inliers.  
-----  
Match found, 018.jpg and 018.jpg with 217 inliers.  
-----  
Match found, 019.jpg and 019.jpg with 110 inliers.  
-----  
Match found, 020.jpg and 020.jpg with 71 inliers.  
-----  
Match found, 021.jpg and 021.jpg with 32 inliers.  
-----  
Match found, 022.jpg and 022.jpg with 37 inliers.  
-----  
Match found, 023.jpg and 023.jpg with 77 inliers.  
-----  
Match found, 024.jpg and 024.jpg with 36 inliers.  
-----  
No match found for 025.jpg  
-----  
No match found for 026.jpg  
-----  
Match found, 027.jpg and 027.jpg with 26 inliers.
```

```
-----  
No match found for 028.jpg  
-----  
Match found, 029.jpg and 029.jpg with 164 inliers.  
-----  
No match found for 030.jpg  
-----  
No match found for 031.jpg  
-----  
Match found, 032.jpg and 032.jpg with 37 inliers.  
-----  
Match found, 033.jpg and 033.jpg with 93 inliers.  
-----  
No match found for 034.jpg  
-----  
No match found for 035.jpg  
-----  
No match found for 036.jpg  
-----  
No match found for 037.jpg  
-----
```

To improve on this problem, I analysed individual images to see that the features might be missed by blurs. To improve the performance, i increased the feature numbers and also changed the scalefactor to 1.4. This would allow there to be more points to be matched, reduce the impact of the blurs by focusing on bigger feature areas, and also allow more images through the filter. This was successful, as there were now no false positives, and the accuracy was 27/40 (67%) which is a big increase overall.