Assignment2

April 9, 2022

1 Computer Vision 2022 Assignment 2: Image matching and retrieval

In this assignment, you will experiment with image feature detectors, descriptors and matching. There are 3 main parts to the assignment:

- matching an object in a pair of images
- searching for an object in a collection of images
- analysis and discussion of results

This assignment will have a minimum hurdle of 40%. You will fail if you can not reach the minimum hurdle.

1.1 General instructions

As before, you will use this notebook to run your code and display your results and analysis. Again we will mark a PDF conversion of your notebook, referring to your code if necessary, so you should ensure your code output is formatted neatly.

When converting to PDF, include the outputs and analysis only, not your code. You can do this from the command line using the `nbconvert` command (installed as part of Jupyter) as follows:

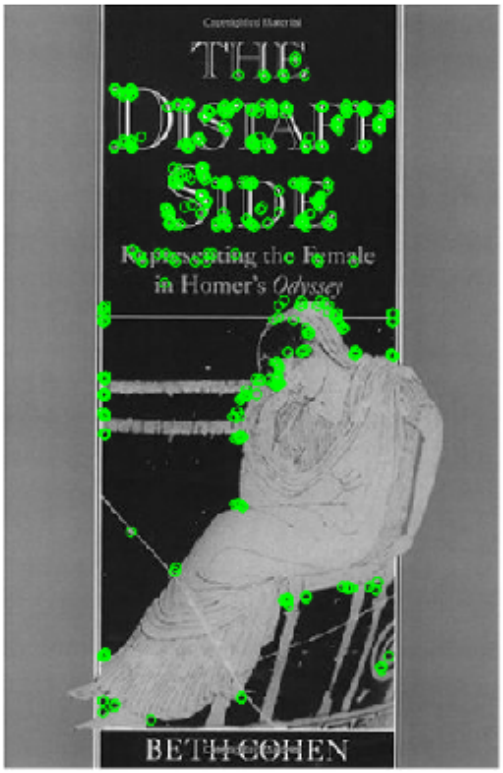
```
jupyter nbconvert Assignment2.ipynb --to pdf --no-input --TagRemovePreprocessor.remove_cell_tag
# Or
jupyter nbconvert Assignment2.ipynb --TagRemovePreprocessor.remove_cell_tags='{"remove_cell"}'
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
```

2 Matching an object in a pair of images (45%)

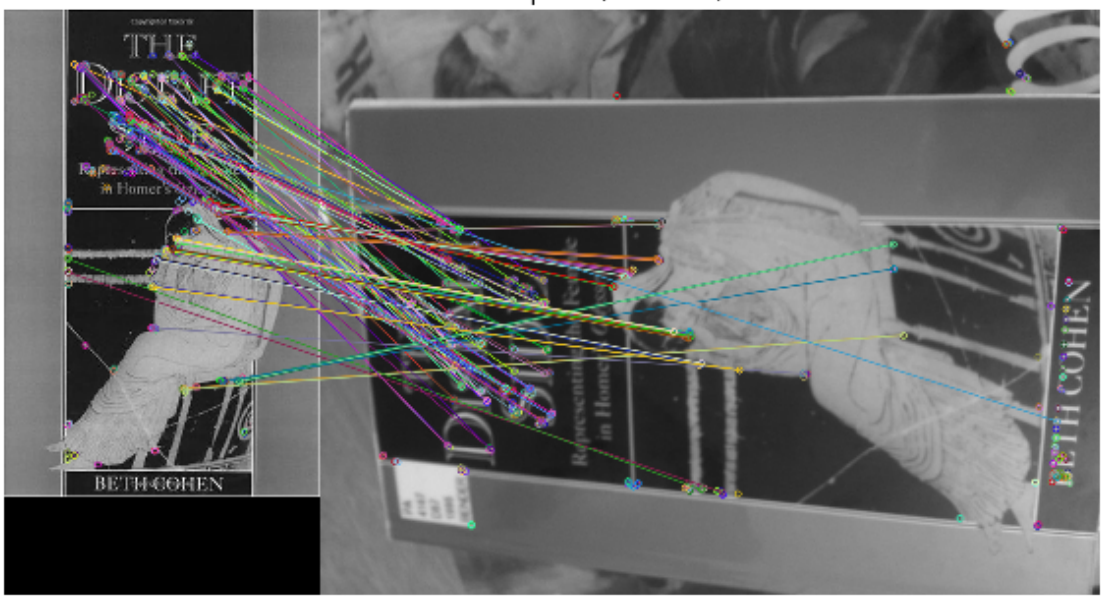
2.0.1 draw key points and macthes by using orb method

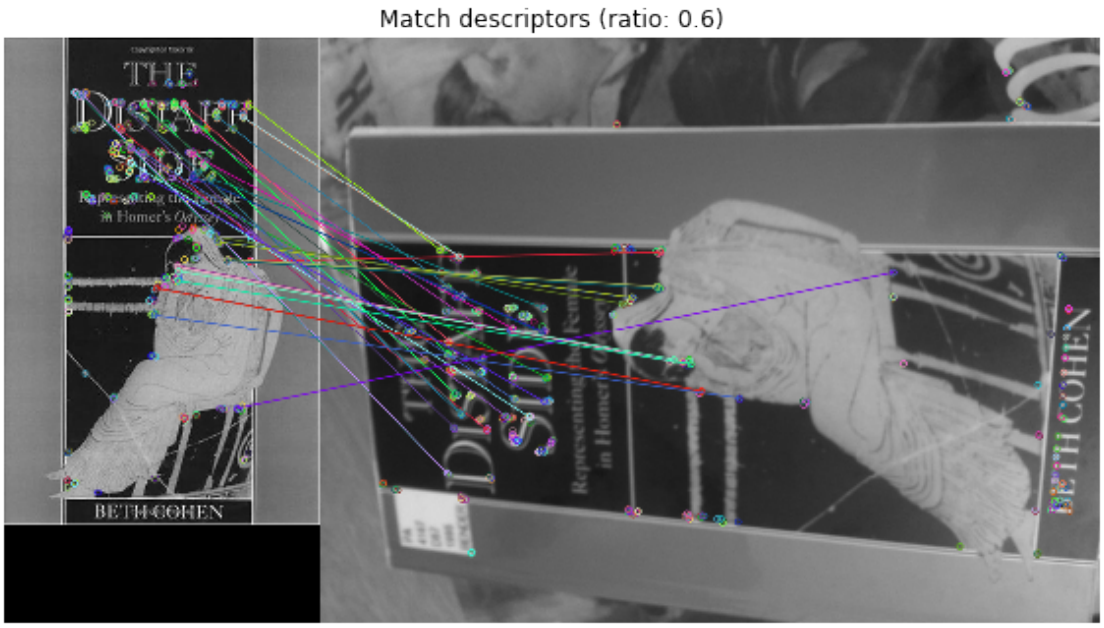
keypoints of reference image (orb)



keypoints of query image (orb)

Match descriptors (ratio: 0.8)



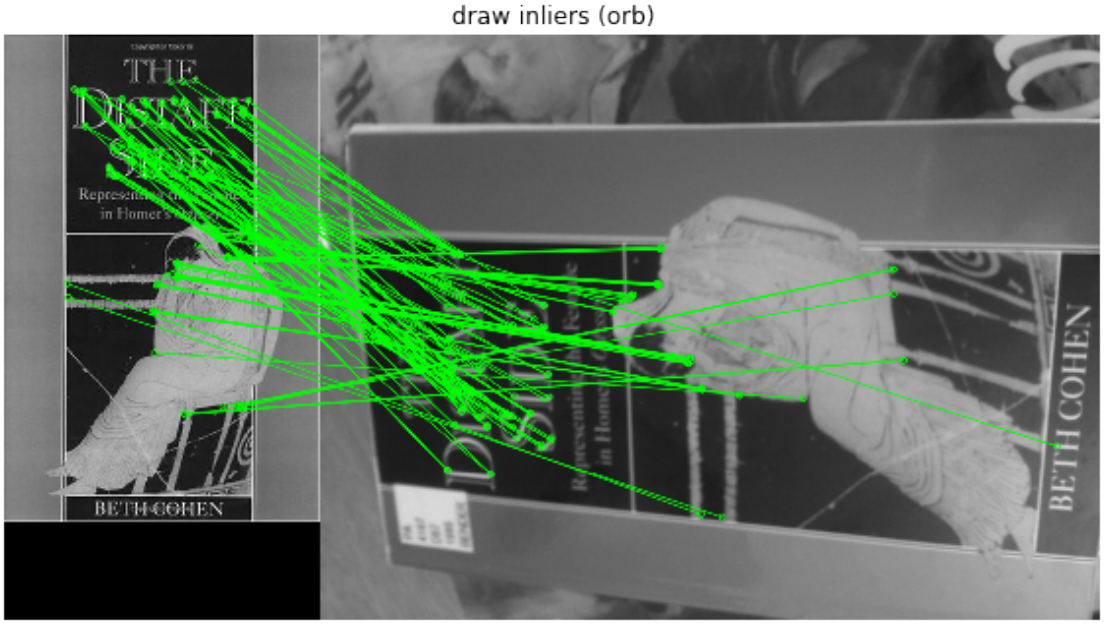


Change the ratio

By compare the ration 0.6 and the rtatio 0.8, we can get:

- when the ratio become small, the keypoints and match numbers become less.
- when the ratio become large, the keypoints and match numbers become more.

2.0.2 draw outline and inliers by using regular method

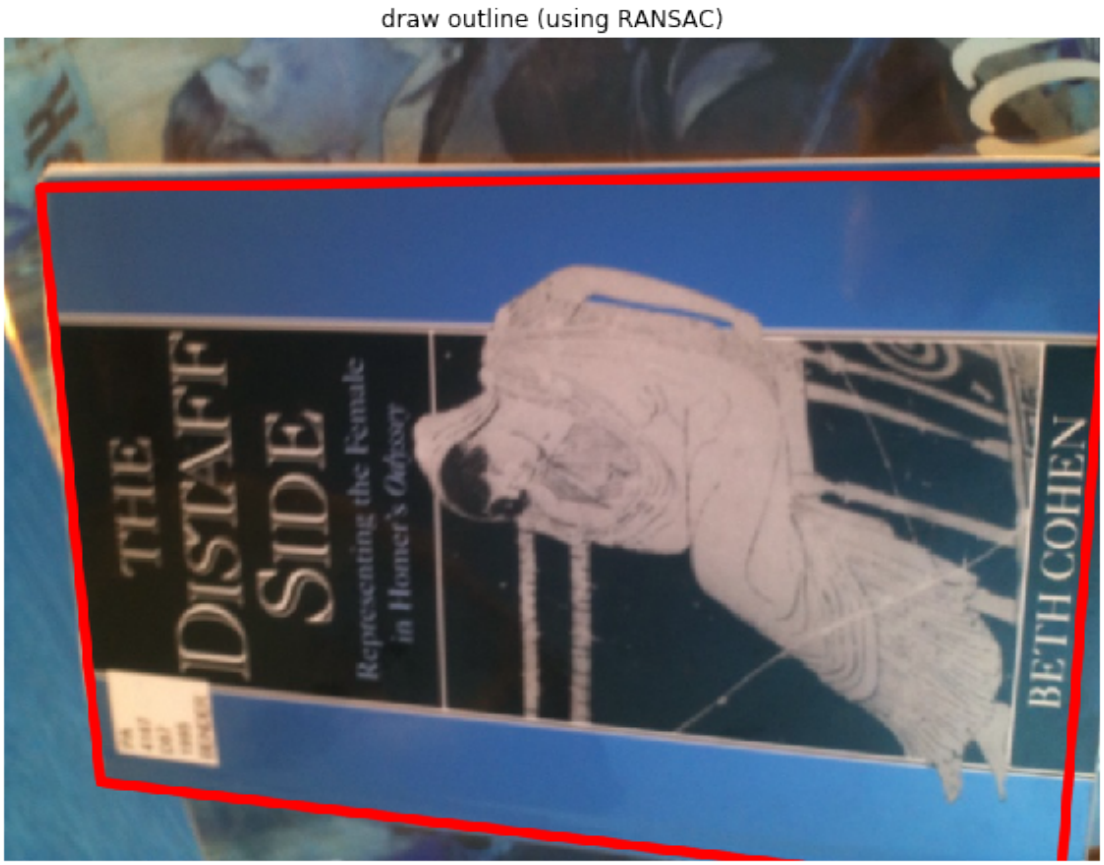


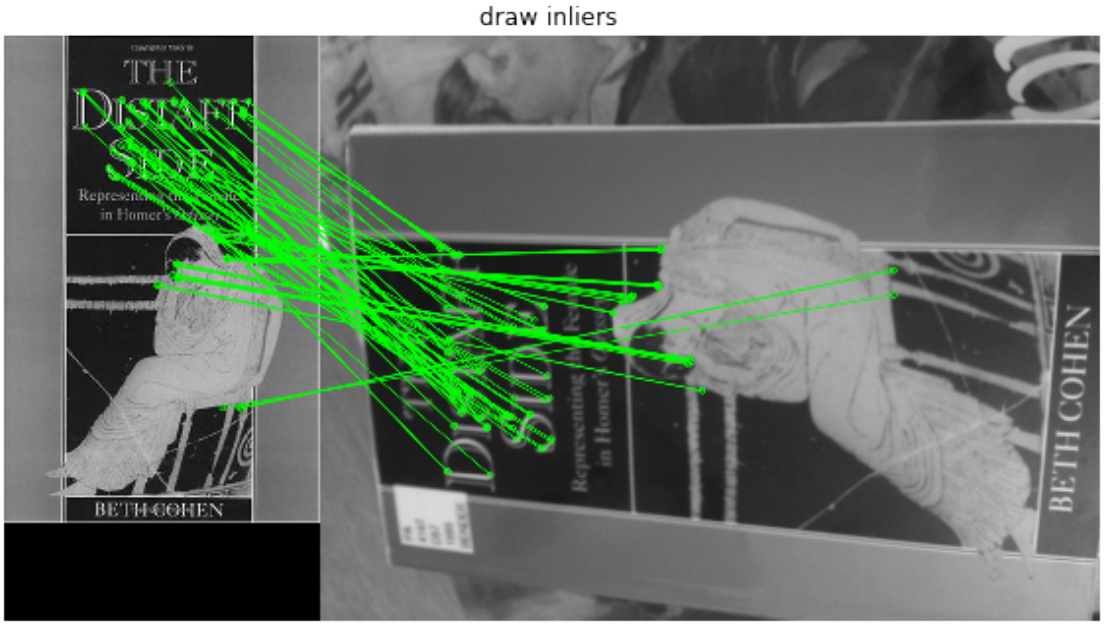
```
number of detected inliers:  131
number of detected outliers:  0.0
```

Summary

When I try to use regular method, I notice draw oulines does not work correctly.

2.0.3 Draw outline and inliers by using RANSAC






```
number of detected inliers:  100
number of detected outliers:  31.0
```

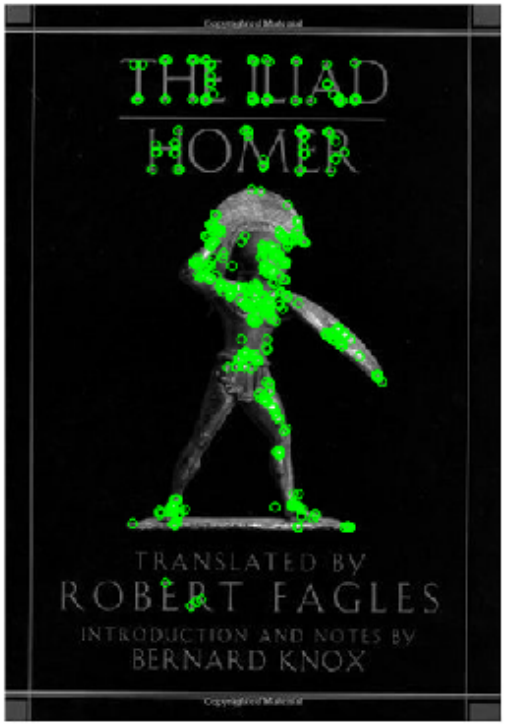
Summary

Compare to the RANSAC and the regular method, I notice the number of dectected inliers is different. The ***total number of detected points are 131***, and when I use ***RANSAC*** method, the number of detected inliers are ***only 100***, however, when I use ***regular method***, the number of detected inliers are ***131***. There is ***a difference of 31 points***. However, it may influence when draw outlines because these 31 points should not be caculated in the inliers.

2.1 Book cover (example book_cover_025)

2.1.1 draw keypoints of reference image and query image (using orb, brisk and sift)

keypoints of reference image (orb)

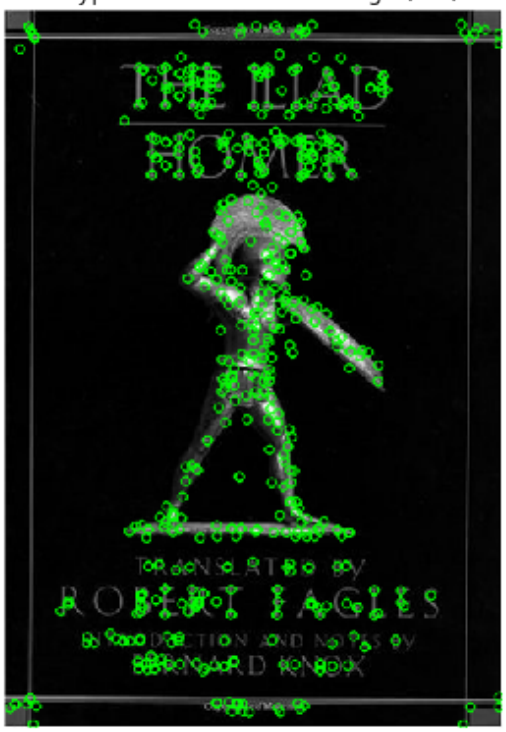


keypoints of query image (orb)

keypoints of reference image (brisk)

keypoints of query image (brisk)

keypoints of reference image (sift)

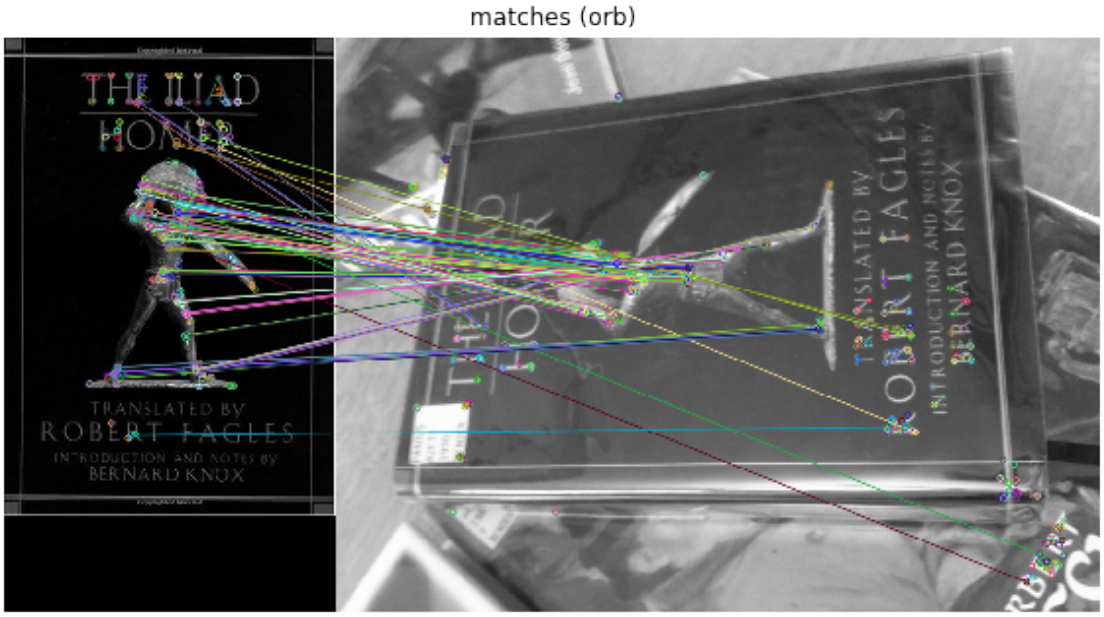


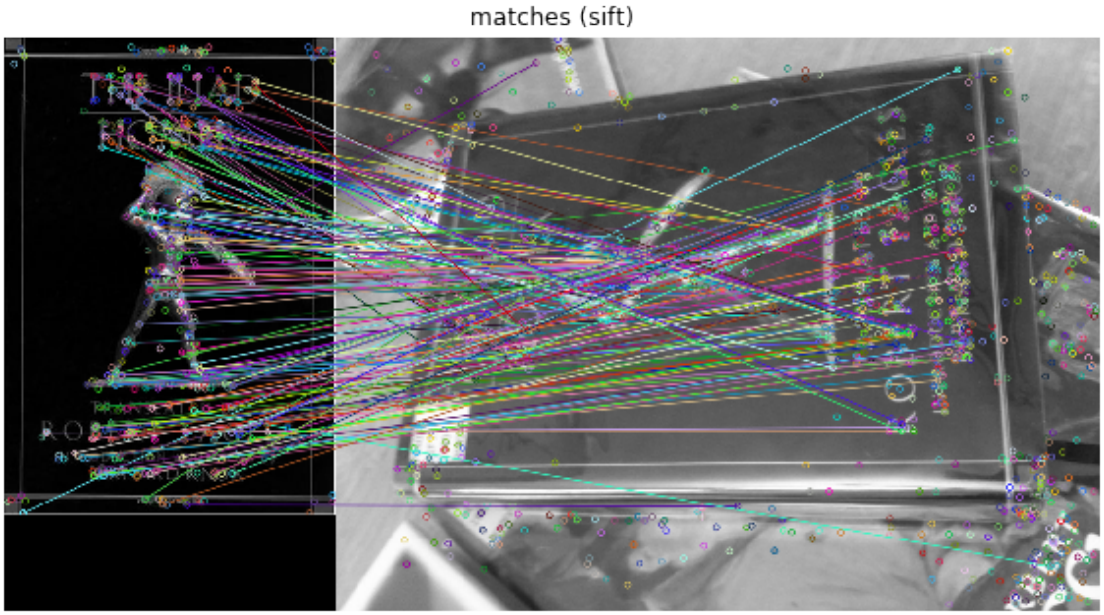
keypoints of query image (sift)

2.1.2 summary of finding key ponits part

In **getting keypoints**, the shift and brisk are working better than orb, it returns more key points in the query image and the reference image.

2.1.3 Draw match part (using orb and sift)

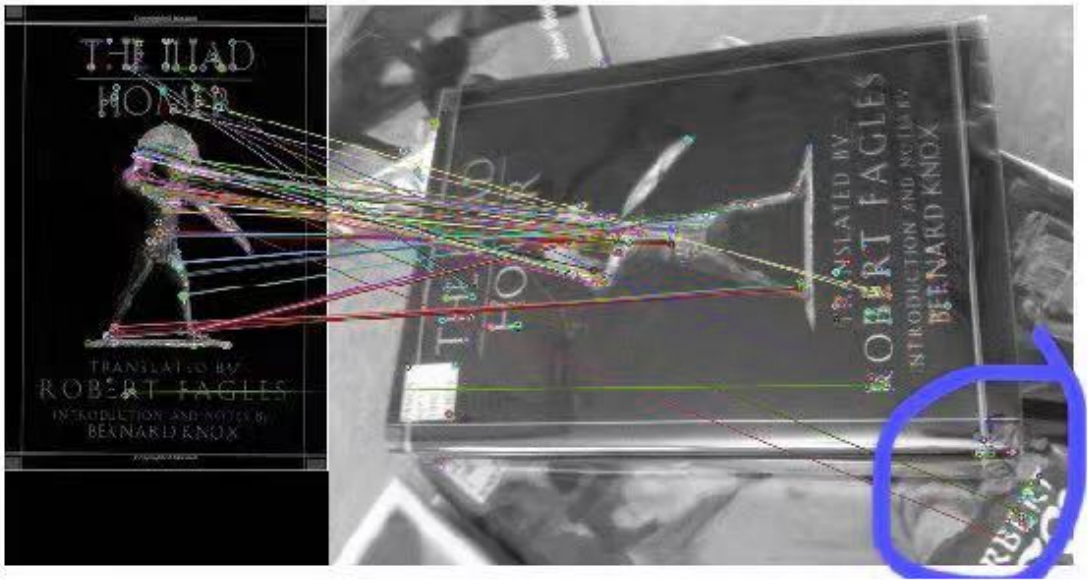




2.1.4 Summary of drawing match part

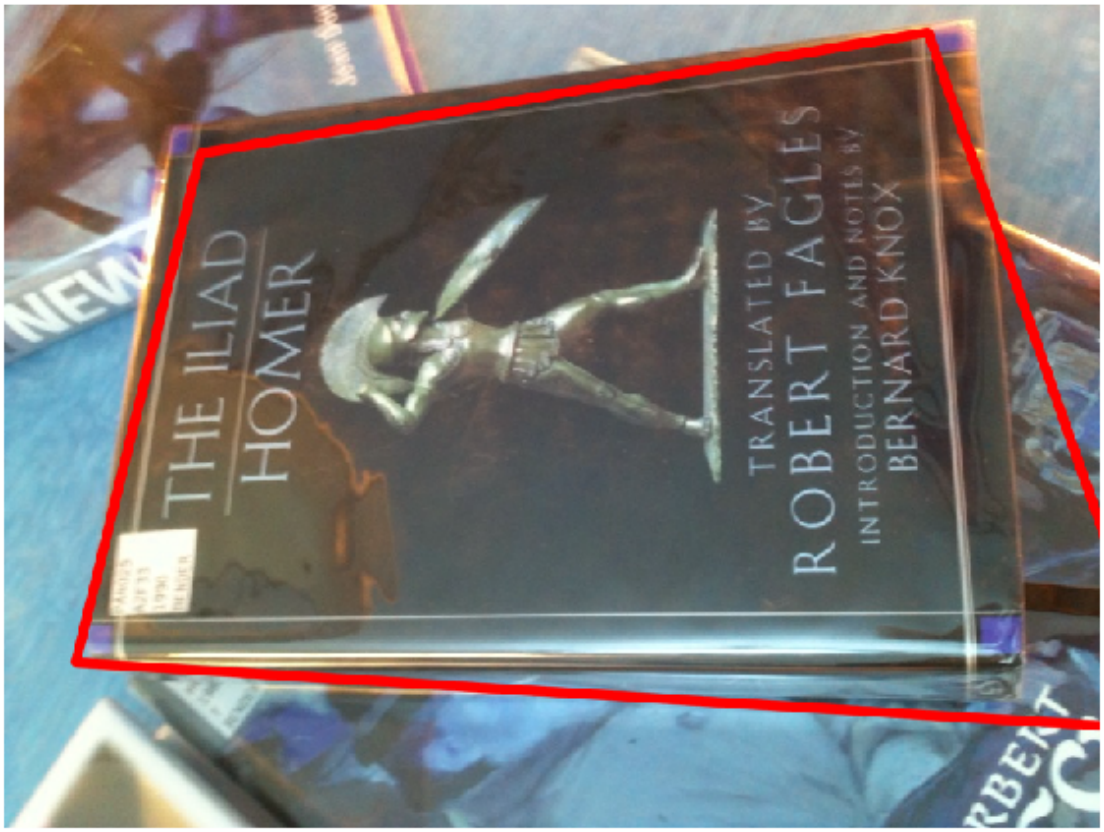
In this part, I notice some macthes in ***orb method*** matches the keypoints ***outside the reference book***, which are ***wrong matches***. (shown in the picture: wrong matches)

picture: wrong matches (orb)

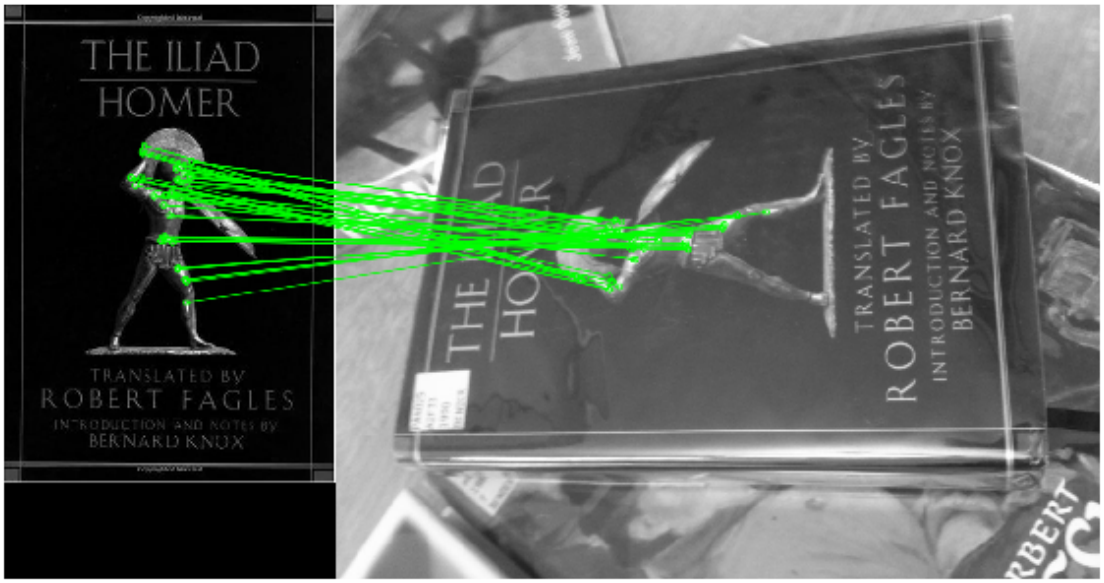


2.1.5 Draw outlines and inliers (using orb)

draw outline (orb)

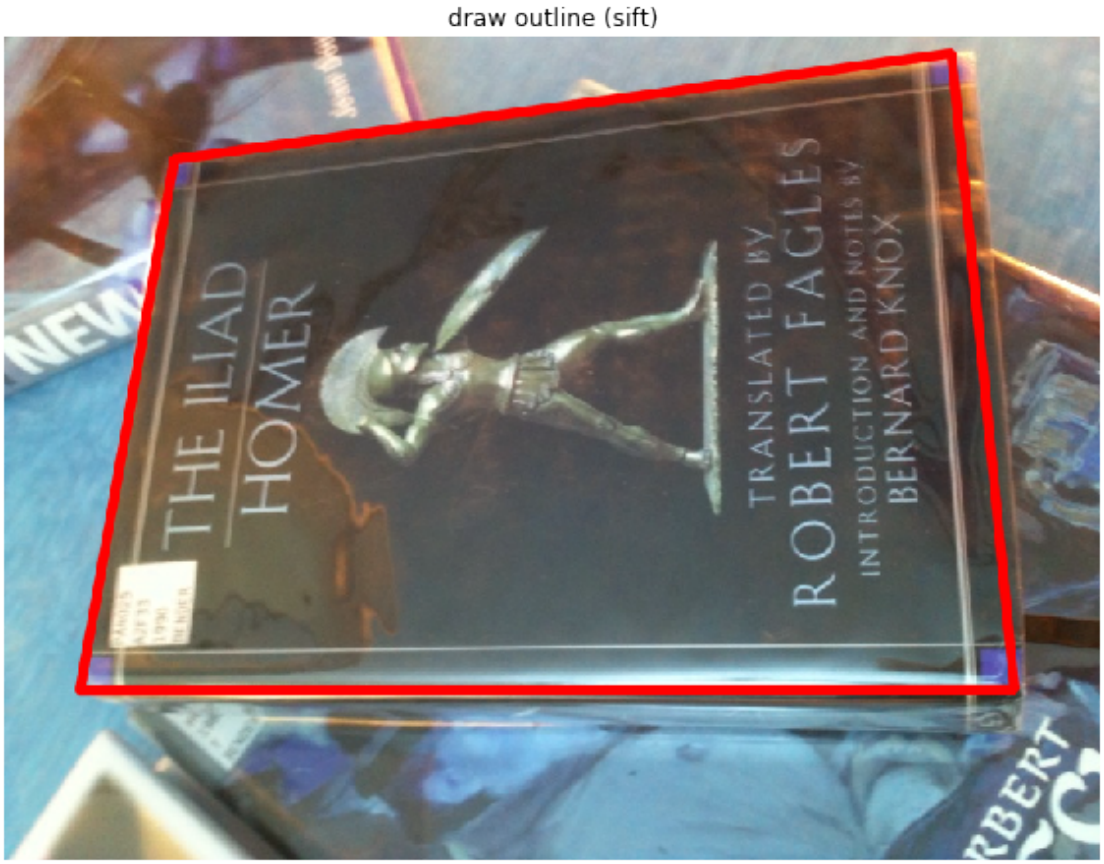


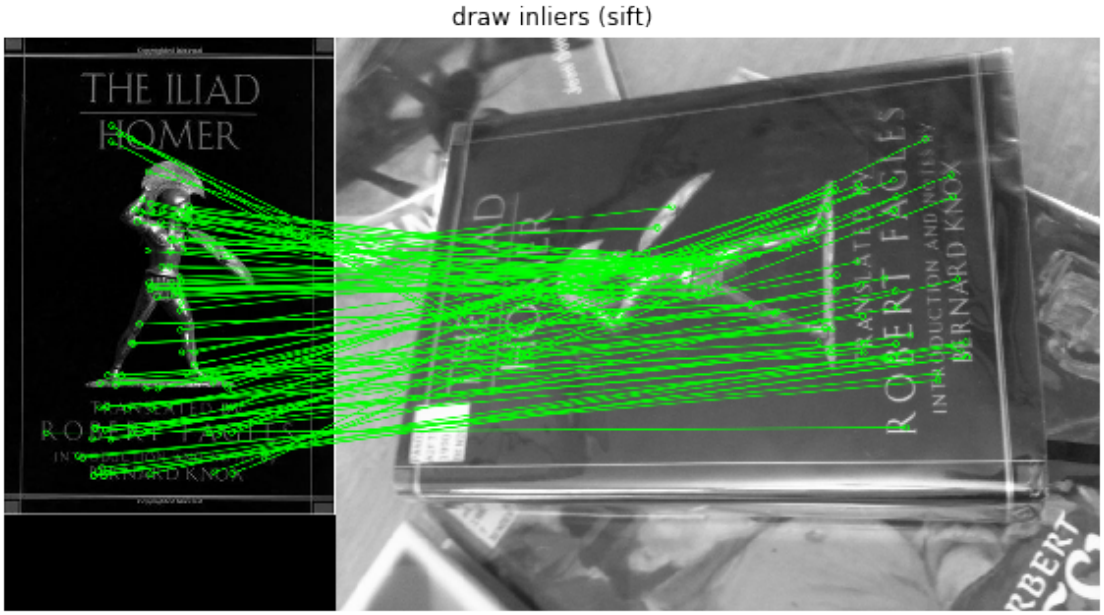
draw inliers (orb)



```
number of detected inliers:  57
number of detected outliers:  36.0
Ratio:  0.6129032258064516
```

2.1.6 Draw outlines and inliers (using sift)






```
number of detected inliers:  106
number of detected outliers:  70.0
Ratio:  0.6022727272727273
```

2.1.7 Summary

In image 25 from book_covers. we can see when we use orb method to get the outline, it is not very precise, however, sift method works good.

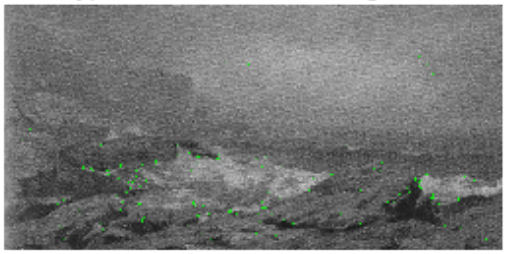
Reason (why orb method will fail): when I use orb method, the keypoints of query image do not detect many keypoints in this area (draw in the picture_01), the key points which are detected are focus on the person (middle in the book cover). So when do matches, some keypoints which outside the book cover may interfere with drawing outlines, this is why we can not get the correct area when we draw outlines.

picture_01

2.2 museum paintings (example museum_paintings_064)

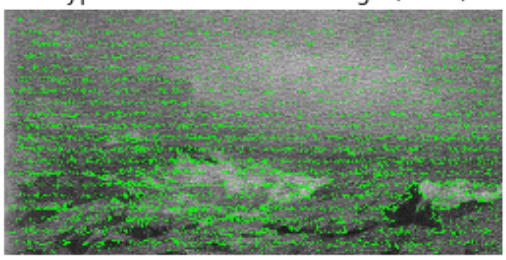
2.2.1 draw keypoints of reference image and query image (using orb, brisk and sift)

keypoints of reference image (orb)



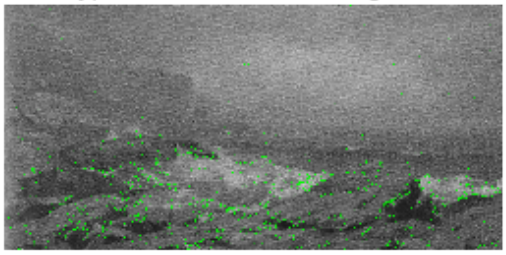
keypoints of query image (orb)

keypoints of reference image (brisk)



keypoints of query image (brisk)

keypoints of reference image (sift)

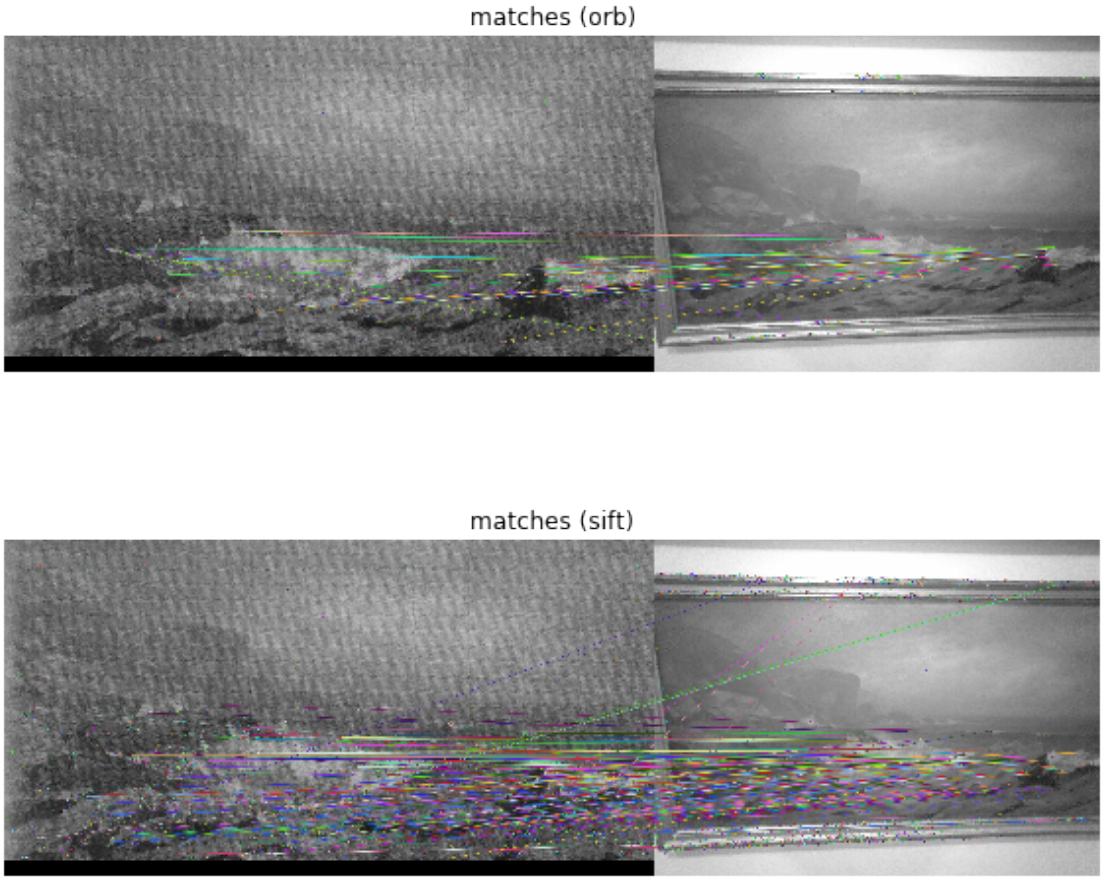


keypoints of query image (sift)

2.2.2 summary of finding key ponits part

In **getting keypoints**, the shift and brisk are working better than orb, it returns more key points in the query image and the reference image.

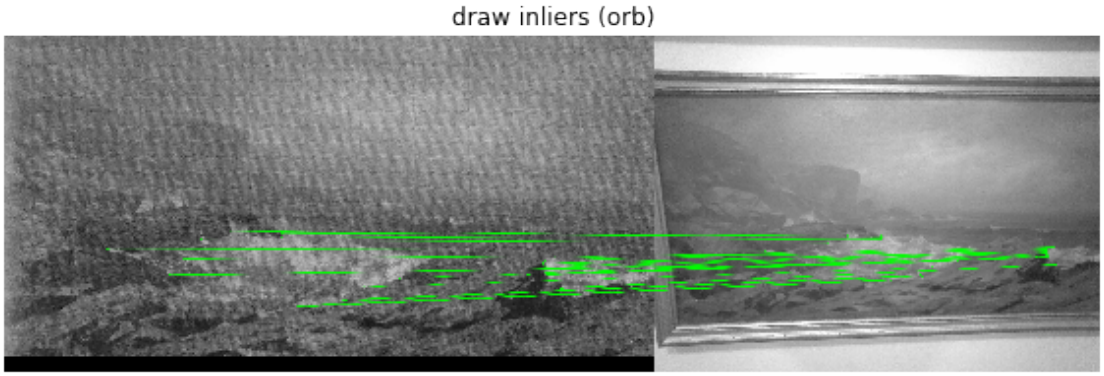
2.2.3 Draw match part (using orb and sift)



2.2.4 Summary of drawing match part

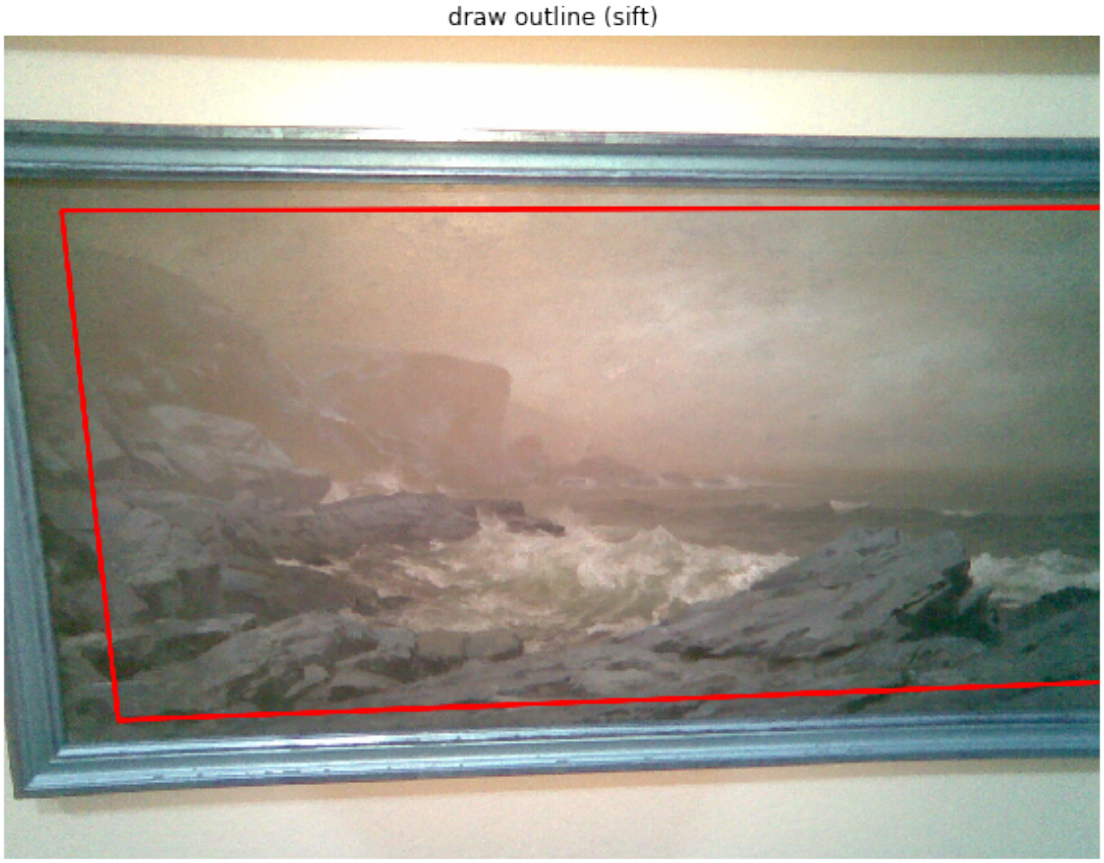
In this part, two pictures are draw all mactches correctly.

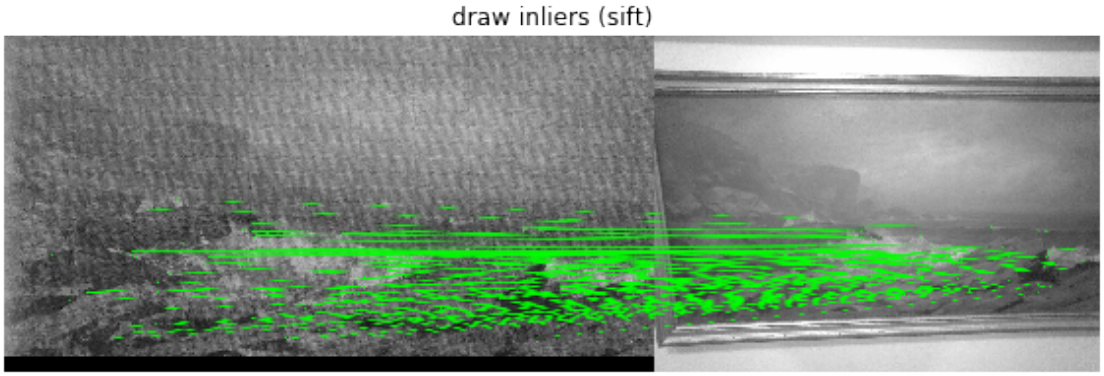
2.2.5 Draw outlines and inliers (using orb)




```
number of detected inliers:  52
number of detected outliers:  9.0
Ratio:  0.8524590163934426
```

2.2.6 Draw outlines and inliers (using sift)






```
number of detected inliers:  142
number of detected outliers:  48.0
Ratio:  0.7473684210526316
```

2.2.7 Summary

Ratio = number of inlier/number of matches

I compare the ratio of two method (orb and sift), when the ratio become smaller (should bigger than 0), the ouline will become more acurrate. By compare ***picture draw outline (orb)*** and ***picture draw outline (sift)***, we can see the **picture draw outline (sift)** works better. By the way, the ratio is 0.747 (sift method) which is smaller than 0.852 (orb method).

---

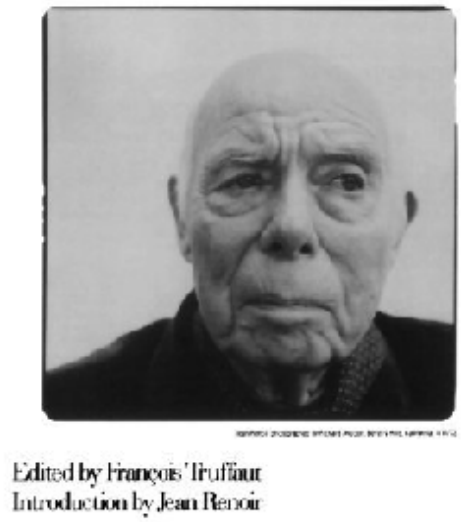
3 What am I looking at? (40%)

3.0.1 At first, I try use orb method to get matches

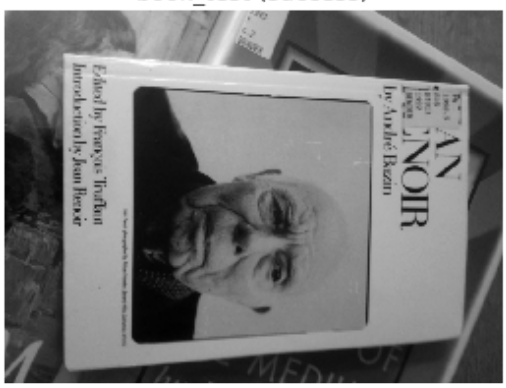
this case is one of a suucessful cases (book_covers 12) :

`We get the number 18 image is the best, it has best score : 56 (points matches).`

book_reference (success)



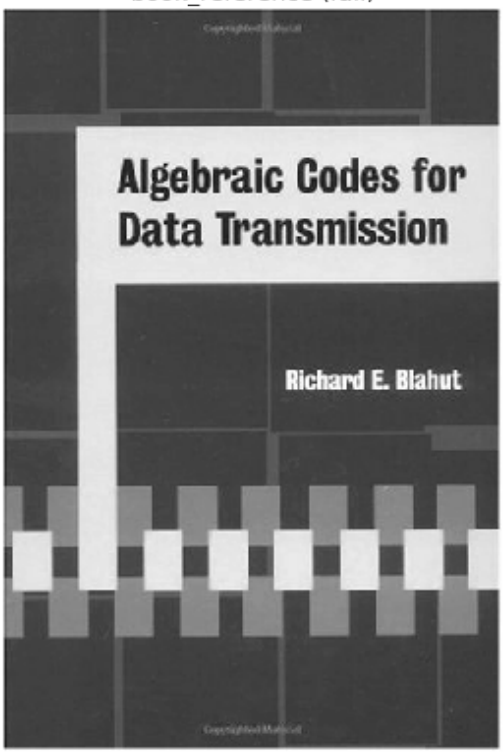
book_test (success)



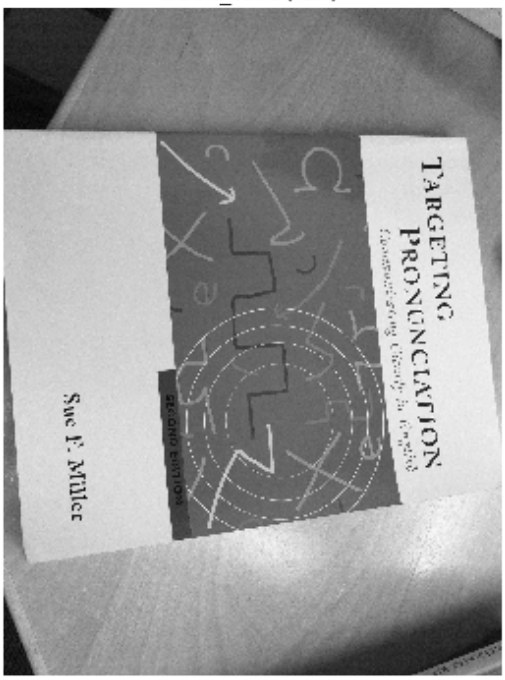
this case is one of a failed cases (book_covers 59) :

`We get the number 71 image is the best, it has best score : 11 (points matches).`

book_reference (fail)



book_test (fail)



3.0.2 Result (use orb)

test case : 01, 12, 13, 23, 59, 73, 56, 89, 46, 81, 86

Accuracy : 54.55% –> (6/11)

The details are :

```
** case ******* score ********* result **

image 01          100             success

image 12          56              success

image 13          54              success

image 23          48              success

image 59          11              fail

image 73          13              fail

image 56          12              fail
```

```
image 89          9               fail

image 46          9               fail

image 81          23              success

image 86          20              success
```

3.0.3 Summary

what we used :

feature detector : **orb**

matching strategy : **KNN**

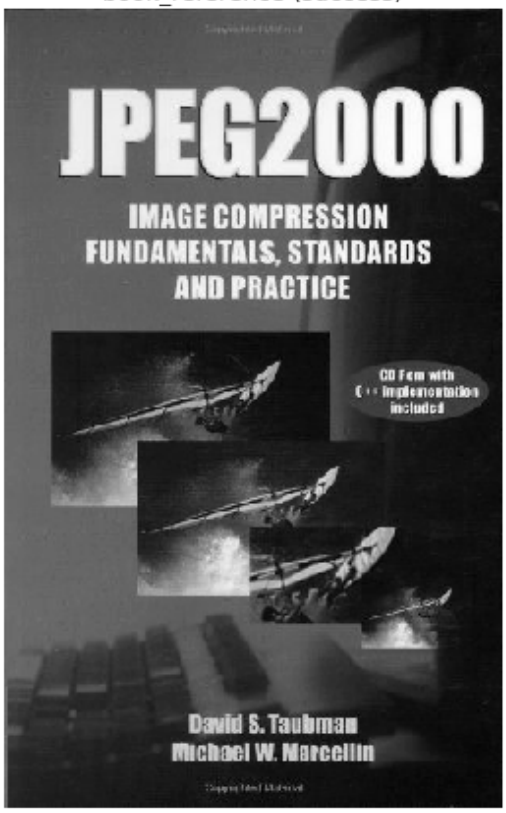
I notice if the score (numbers of key points) which the image get is more than 20 (>= 20), the result will return the correct image.

3.0.4 Using sift method to get matches

this case is one of a sucessful cases (book_covers 89)

`We get the number 27 image is the best, it has best score : 52 (points matches).`

book_reference (success)



book_test (success)

3.0.5 Result (use sift)

test case : 01, 12, 13, 23, 59, 73, 56, 89, 46, 81, 86

Accuracy : 90.91% –> (10/11)

The details are :

```
** case ******* score ********* result **

image 01         127            success

image 12         163            success

image 13         411            success

image 23         30             fail

image 59         138            success

image 73         160            success

image 56         320            success

image 89         52             success

image 46         154            success

image 81         155            success

image 86         120            success
```

3.0.6 Summary

what we used :

feature detector : **sift**

matching strategy : **KNN**

I notice if the score (numbers of key points) which the image get is more than 52 (>= 52), the result will return the correct image.

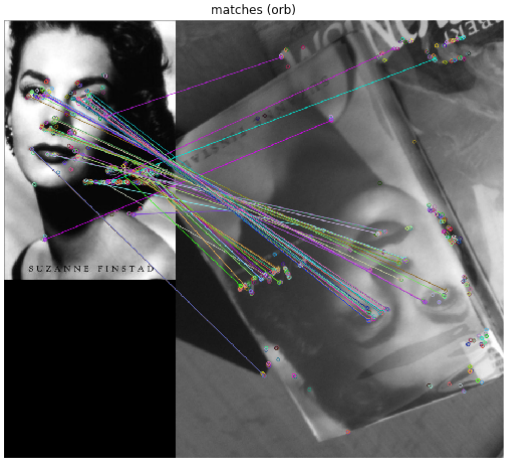
I change the moethod of **feature detector**, from orb method to sift method. It works good and the accuracy increase almost **36%** (from 54.55% to 90.91%).

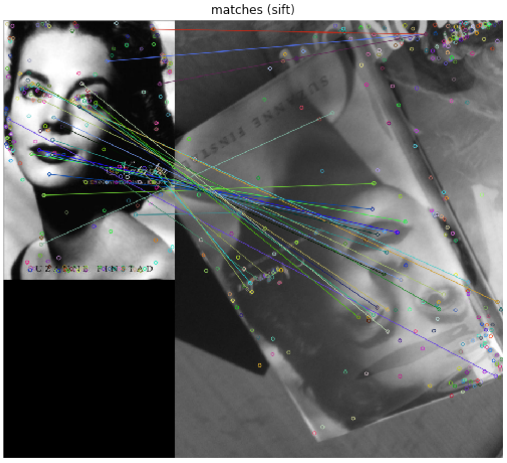
keypoints of reference image (orb)

keypoints of query image (orb)

keypoints of reference image (sift)

keypoints of query image (sift)





From the images (macthes (orb), matches (sift)), we can see orb method works better.

6. Repeat step 4 and 5 for at least one other set of reference images from museum_paintings or landmarks, and compare the accuracy obtained. Analyse both your overall result and individual image matches to diagnose where problems are occurring, and what you could do to improve performance. Test at least one of your proposed improvements and report its effect on accuracy.

Your description of what you have done, and explanation of results, here

4 Question 3 (10%)

In Question 1, We hope that `ratio_test` can provide reasonable results for RANSAC. However, if it fails, the RANSAC may not get good results. In this case, we would like to try an improved matching method to replace the `ratio_test`. Here, the `gms_matcher` is recommened. You need to implement it and save results of 3 image pairs (you can select any image pairs from the dataset), where you new method is better than 'ratio_test'.

1. Hint 1: `cv2.xfeatures2d.matchGMS()` can be used, but you need to install the opencv-contrib by `pip install opencv-contrib-python`
2. Hint 2: You do not need use KNN matching, because GMS does not require second nearest neighbor.
3. Hint 3: You need to change the parameters in `cv2.ORB_create()` for best results. See the setting in Github.
4. Hint 4: If your are interested in more details. Read the paper "GMS: Grid-based Motion Statistics for Fast, Ultra-robust Feature Correspondence", and the Github "https://github.com/JiawangBian/GMS-Feature-Matcher".

Your results here

5 Question 4: Reflection Questions (5%)

1. Describe the hardest situation you faced during the first two assignments. And how you overcome it? (3%)
2. How do you plan to finish the assignment to meet tight deadline? (2%)