Assignment 3

1. Program Description

The main motive of the assignment is to locate desired objects in images with the help of SIFT descriptors. SIFT is scale-invariant and tolerates rotation in moderation. We are given 3 source images that represent same object (book) but look different from each other in terms of the book cover. And we are given 2 destination images that contain these books but are aligned in different orientations.

SIFT

We used OpenCV libraries to detect SIFT features in the images, match the different key points obtained and compute the homography matrices.

The libraries have inbuilt functions to show the key points with varied dimensions and rotations in the main image. In Section 2 the detected SIFT features are shown for each image.

BFMATCHER

Given the key points, we can now match them to find the corresponding points in the source and destination images. Each source image is compared with each destination image.

The BFMATCHER compares each pair of key points to find the top 2 best matches. We then apply Lowe's ratio test to filter out the best matches.

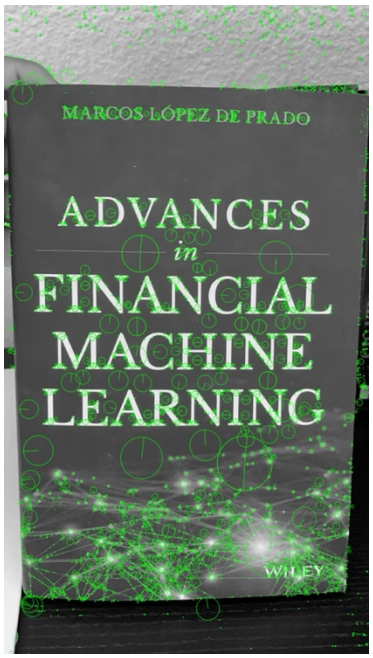
Section 3 shows the top 20 matches found by the BFMATCHER. This section also has a table showing the number of matches found, number of good matches found and the number of inliers.

HOMOGRAPHY ESTIMATION

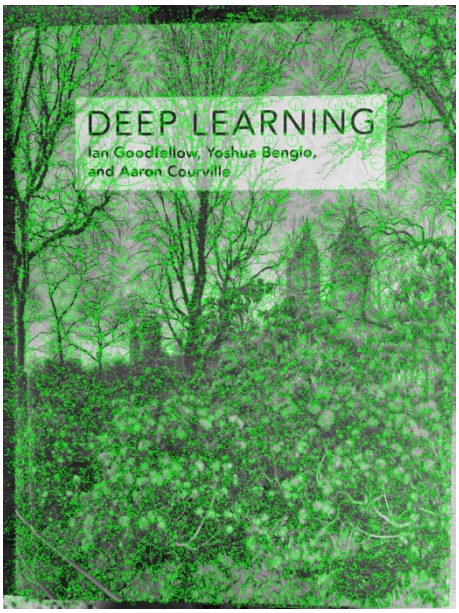
In this we used RANSAC to estimate the Homography matrix M that maps the best points in source image and the destination image. Section 5 shows the homography matrices obtained for each pair.

2. SIFT Features

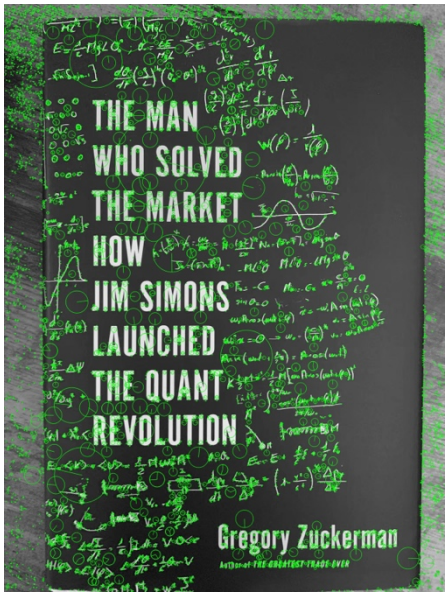
The SIFT features detected in source images src_0.jpg, src_1.jpg and src_2.jpg are 5258, 42479, 13005 respectively and these are displayed below. Each circle in the images corresponds to a key point. It shows the size and direction of the key point. The SIFT algorithm has found many key points in src_2 because it is crowded.



SIFT on src_0



SIFT on src_1



SIFT on src_2

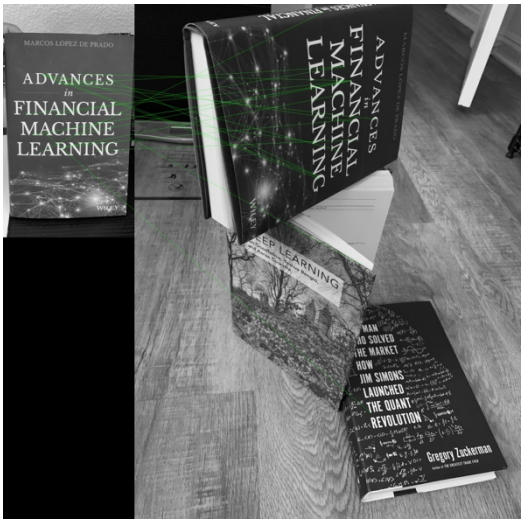
The number of SIFT features calculated for the destination images dst_0.jpg and dst_1.jpg are 50006 and 10651 respectively. The respective features are shown below in their images.

SIFT on dst_0

SIFT on dst_1

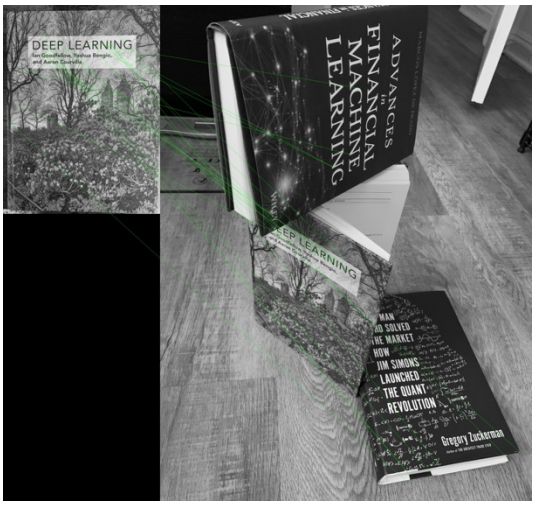
3. Top-20 scoring matches found by BFMatcher

Feature matching was done using Brute-force matcher, it was followed by Lowe's ratio test (ratio = 0.7). Top 20 good features detected for each pair are shown in the images below. The number of good matches for each pair found are specified in the captions.



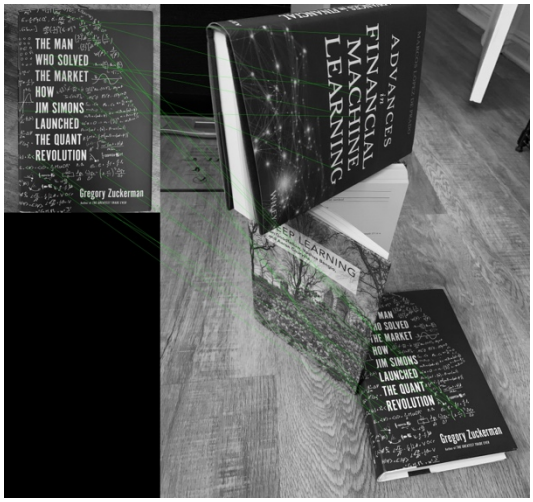
Top 20 matches between src_0 and dst_0
Total number of matches:5258
Number of good features: 132

Top 20 matches between src_0 and dst_1
Total number of matches:5258
Number of good features: 393

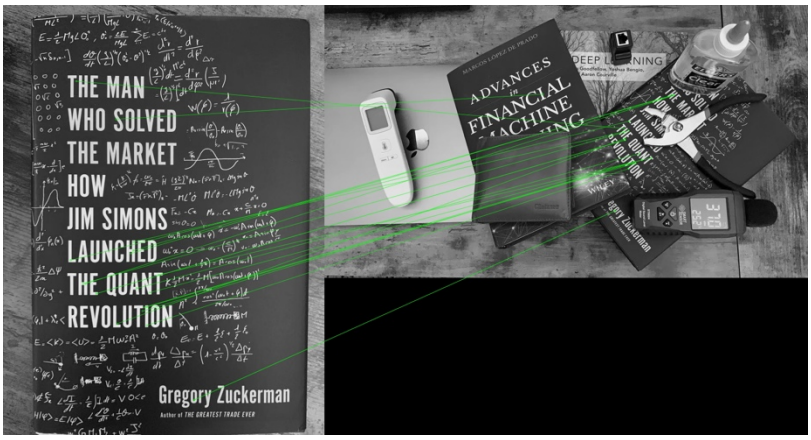


Top 20 matches between src_1 and dst_0
Total number of matches: 42479
Number of good features: 56

Top 20 matches between src_1 and dst_1
Total number of matches: 42479
Number of good features: 473



Top 20 matches between src_2 and dst_0
Total number of matches: 13005
Number of good features: 905

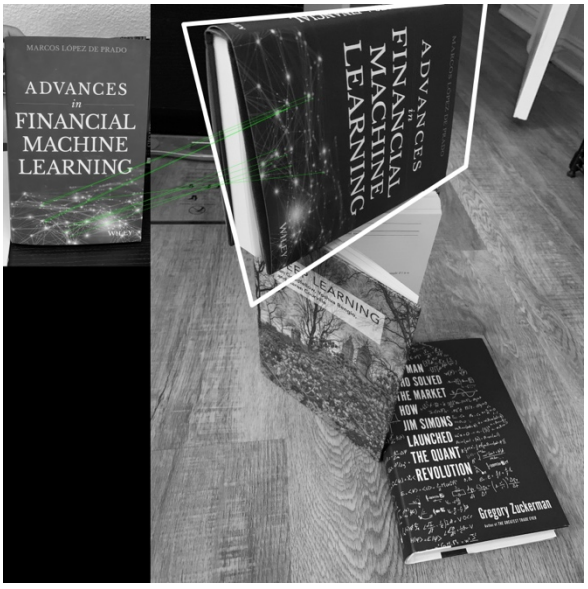


Top 20 matches between src_2 and dst_1
Total number of matches: 13005
Number of good features: 794

The table below shows the statistics of the matches found for each pair. The columns include the total number of matches found, number of good matches found, and number of Inliers found.

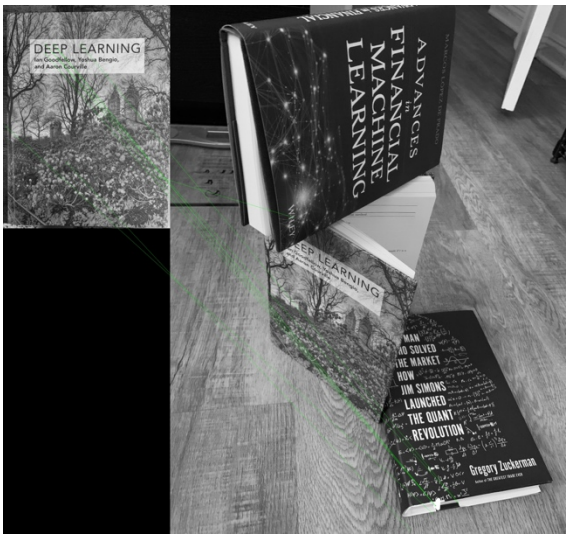
Source, Destination	Matches	Good matches	Inliers (Mask = 1)
src_0, dst_0	5258	132	30
src_0, dst_1	5258	393	217
src_1, dst_0	42479	56	8
src_1, dst_1	42479	473	391
src_2, dst_0	13005	905	579
src_2, dst_1	13005	794	372

4. Top 10 matches that have minimum error between projected source keypoint and the destination keypoint after applying RANSAC.



Top 10 matches between src_0 and dst_0

Top 10 matches between src_0 and dst_1



Top 10 matches between src_1 and dst_0

Top 10 matches between src_1 and dst_1

Top 10 matches between src_2 and dst_0

Top 10 matches between src_2 and dst_1

The top 10 matches that have minimum error between the projected source key point and destination key point are shown in the images. The detected objects are also highlighted in the destination images.

5. Homography matrices

The homography matrices calculated are shown below for each pair.

	dst_0	dst_1
src_0	Homography matrix: [[3.92295656e-01 -1.22174641e+00 2.34115374e+03] [1.41289782e+00 5.94337840e-02 -4.09313582e+01] [2.40608046e-04 -2.86382021e-04 1.00000000e+00]]	Homography matrix: [[3.40823099e-01 6.42442124e-03 4.59950949e+02] [-2.19241575e-01 2.92831895e-01 2.00867614e+02] [-6.16022278e-05 -1.68686890e-04 1.00000000e+00]]
src_1	Homography matrix: [[2.01339705e-01 -1.72558291e+00 2.02818530e+03] [3.52871661e-01 -3.22789630e+00 3.82167348e+03] [9.77436318e-05 -8.47908473e-04 1.00000000e+00]]	Homography matrix: [[4.52948825e-01 -8.87361246e-02 8.84475815e+02] [1.47539288e-02 3.94339478e-01 7.53485275e+01] [1.37716219e-05 -6.91187146e-05 1.00000000e+00]]
src_2	Homography matrix: [[8.26010612e-01 -1.42902894e-01 1.42182430e+03] [5.05256786e-02 1.59885165e-01 2.37052056e+03] [4.62908621e-05 -1.83143213e-04 1.00000000e+00]]	Homography matrix: [[2.11866276e-01 -3.92524254e-01 1.48583984e+03] [3.10327818e-01 2.58149350e-01 9.00961645e+01] [-6.69829414e-05 -3.49487195e-05 1.00000000e+00]]

6. QUALITATIVE ANALYSIS

Overall SIFT with RANSAC performed good. It performed well on images that did not have much change in orientation. All the books were detected with good accuracy by the RANSAC algorithm. Src_1 and dst_0 did not have a good match but it is still a good approximation. It could because the object is occluded. In all the other cases the desired object was located.