CSE 573
Homography and fundamental matrix estimation
Project Report

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1 Introduction

The purpose of this project was to write code that estimates Homography and Fundamental matrix using RANSAC on Putative matches. This document is a write up of the project and contains implementation details, results and also Running Instructions.

2 Homography Estimation

In this part the Homography was estimated so that images could be stitched together to create a Panorama. The following steps were taken

1. Feature Selection - In this features were extracted from the images using one of the two methods
    - Harris Corner Detection - Harris corner detection code that was provided was used and a Neighborhood of 9X9 was used for capturing the feature.
    - SIFT - For calculating SIFT features, first blobs were detected using blob detection code from the previous homework and the detected blobs were passed to the find_sift function provided.
2. Putative Matches - The dist2 function that was provided was used to calculate pairwise distance between all the features from the images and top 200 were selected to be passed to RANSAC for homography estimation.
3. RANSAC for Homography Estimation - Homography estimation was done by running RANSAC in epochs of 200 iterations until the inlier ratio was greater than 0.3. A match was deemed an inlier if the distance was less than 10 between estimated matched and calculated matches.
4. Image Warping and Stitching - on receiving the best homography matrix from RANSAC the first image was warped so that it would be in the same

coordinate system as the second image and the two images were merged and the intensities at overlapped locations was averaged.[1]

2.1 Results For Homography Estimation

This section includes the warped images on figure 1 on page 5 along with the details of the inliers,residuals and the ratio given in table 1.

Name	Inliers	Inlier Ratio	Residual
Hill	151	0.75	2.131
Pier	94	0.45	16.11
Ledge	199	0.99	17.81
Uttower	109	0.54	11.41

Table 1: Result of running RANSAC for the given images.

Panaromas of multiple images is also included on figure 2 on 6. These were created by running the code twice.

3 Fundamental Matrix Estimation

3.1 Fitting Fundamental Matrix using Ground Truth

Two Algorithms were used to fit the fundamental matrix. The result for both images are in table 2 and 3 repectively and the epipolar lines can be seen in figure 3 on 7 .

- Unnoramlized Approach - Eight Point algo was used to estimate matrix.
- Noramlized Approach - Here before applying the Eight point algo, the points were scaled by a const value(2/size(image)) and translated and after calculating the Fundamental matrix it was denoramlized. This approach is more stable and produces better results.

House	Normalized Residual	Unnormalized Residual
Camera1	.0685	76.43
Camera2	0.0701	284.46

Table 2: Residual for House, Ground Truth.

[1]Referred - https://www.mathworks.com/matlabcentral/answers/2946-aligning-overlapping-images-and-averaging-the-overlap

Library	Normalized Residual	Unnormalized Residual
Camera1	0.0568	504.337
Camera2	0.0633	107.97

Table 3: Residual for Library, Ground Truth.

3.2 Fundamental Matrix Estimation using RANSAC

In this section putative matches were selected using Harris corned detector as used in Homography estimation and these points were passed to RANSAC from which 8 matches were chosen and a fundamental matrix was fit using the normalized method and the matrix with the best ratio was selected. The results are given in table 4 and the resulting images are in figure 4 on page 8. The neighborhood size was 25X25 and a treshhold of 5 was used for RANSAC. While the residual is greater than in the case with ground truth it is acceptable and can be attributed to the feature matches not being perfect.

Name	Inliers	Inlier Ratio	Residual
House Camera2	40	0.57	5.191
Library Camera2	37	0.52	3.17

Table 4: Result of running RANSAC for the given images for fundamental matrix.

3.3 Plotting Points in 3D

- House - Table 5 contains the camera coordinates for the house pair, the residual was .0282. The visualization is in figure 5 on page 8

House	X	Y	Z
Camera1	-4.8225	1.4807	-3.6490
Camera2	-5.0495	1.9317	-4.6628

Table 5: Camera Coordinated for House Stereo.

- Library - Table 6 contains the camera coordinates for the house pair, the residual was .0141. The visualization is on 6 on 9.

Library	X	Y	Z
Camera1	7.2886	-21.5212	17.7350
Camera2	6.8941	-15.3923	23.4150

Table 6: Camera Coordinated for Library Stereo.

4 Running Instructions

The code is present in the code directory and contains the following files in addition to the given helper functions

1. run_stitching.m - helper function runs code for the panorama
2. run_fundamental.m - Helper function runs both methods for all images in the data folder.

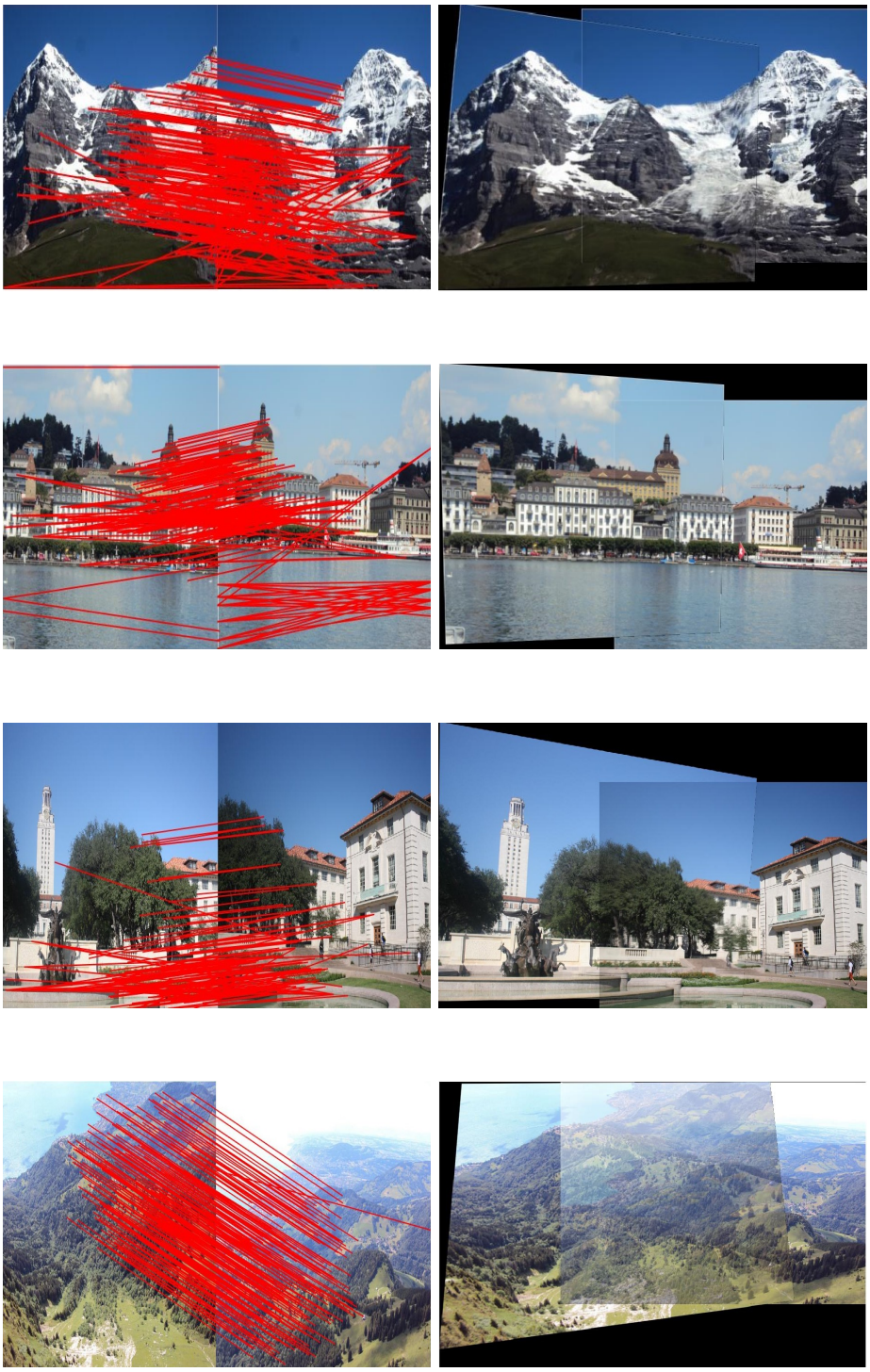

Figure 1: First Column: Feature Point Matches. Second Column: Stitched Image.

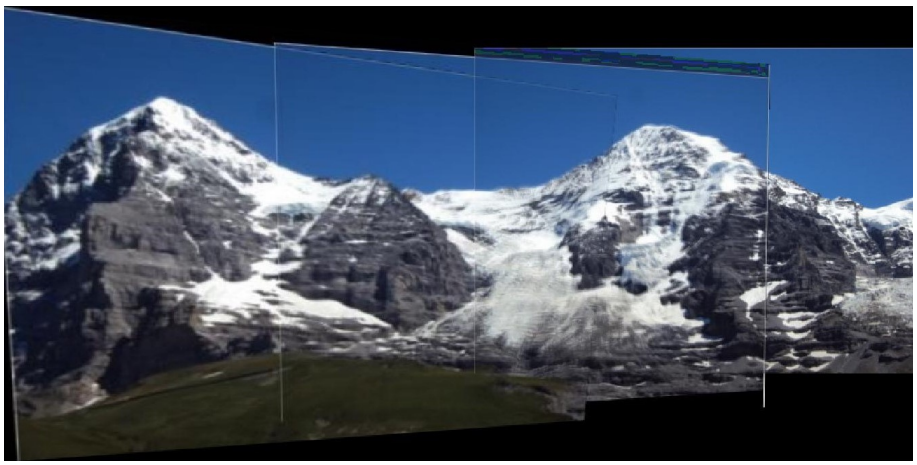

Figure 2: Panorama for Multiple Images

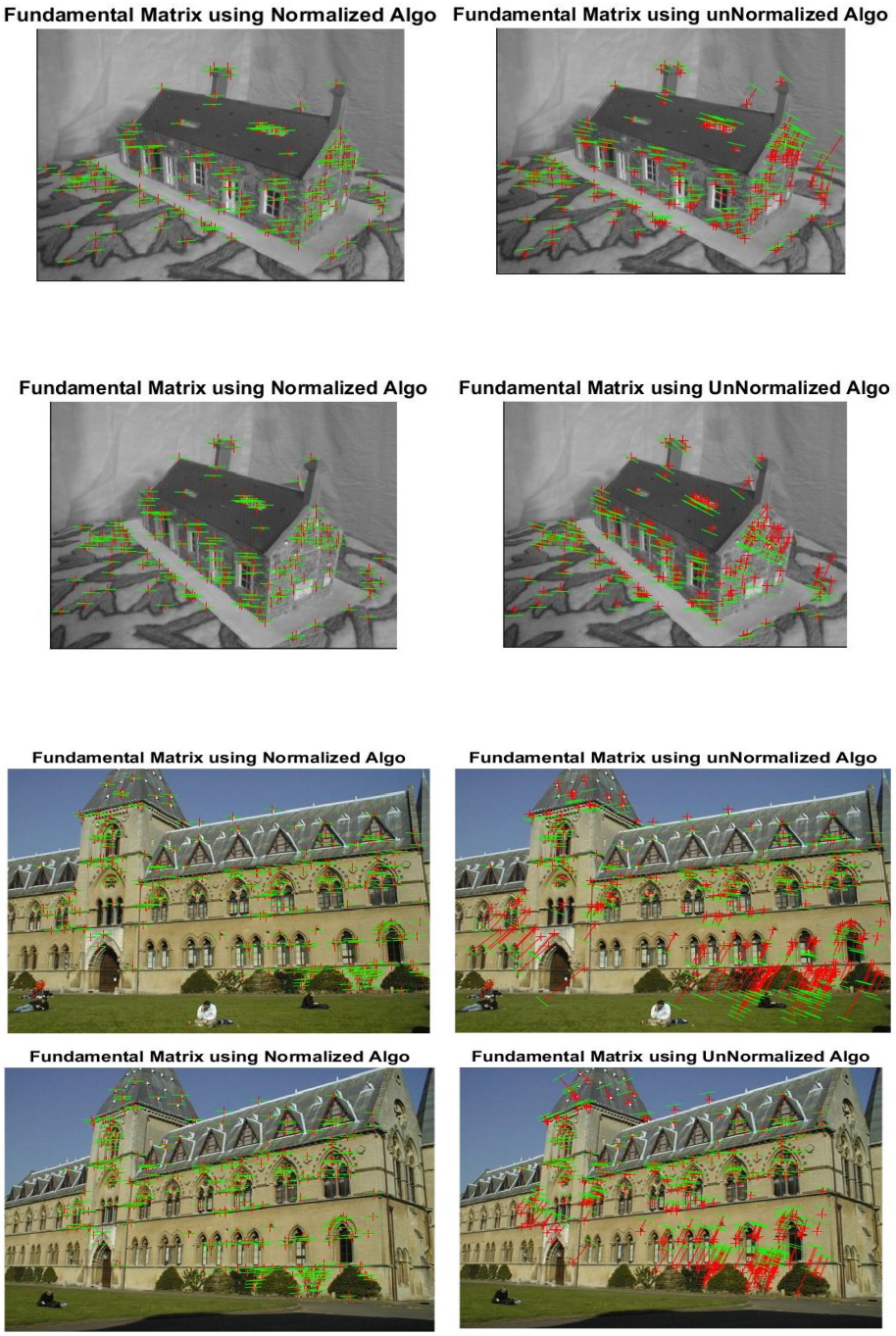

Figure 3: Epipolar lines from ground truth: First Column: Normalized Algo. Second Column: Unnormalized algo. First Row: First Camera, Second Row: Second Camera

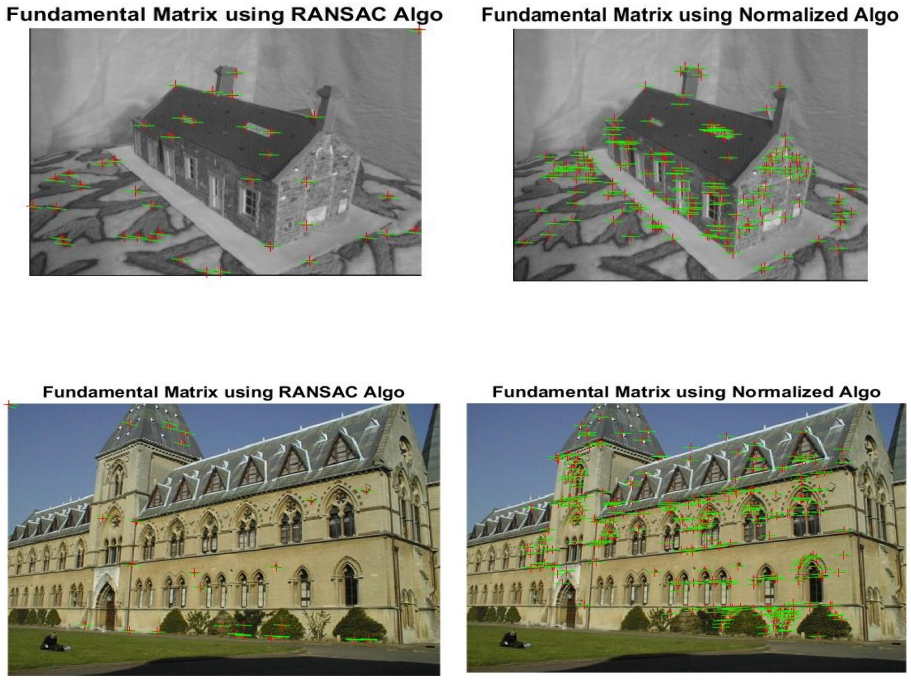

Figure 4: Epipolar lines from RANSAC and Ground Truth: First Column: RANSAC. Second Column: normalized algo.

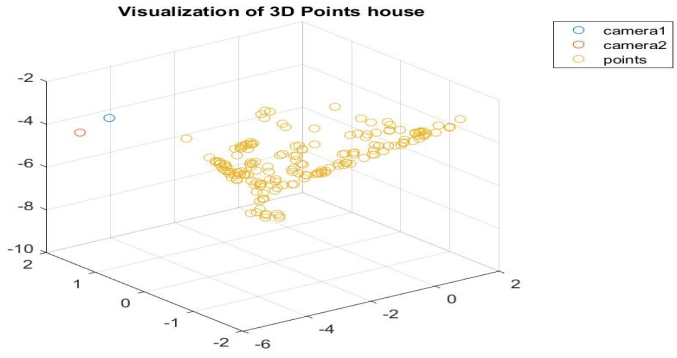

Figure 5: Visualization for House stereo pair.

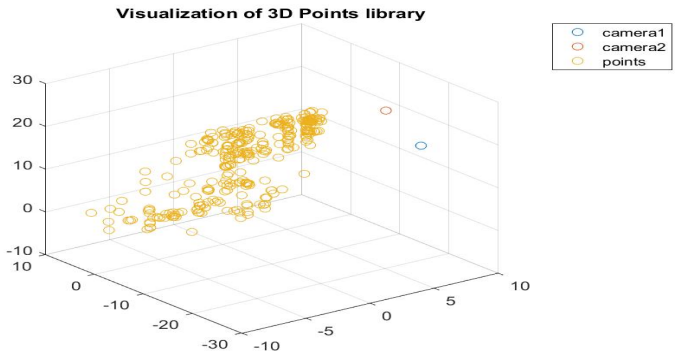

Figure 6: Visualization for Library stereo pair.