

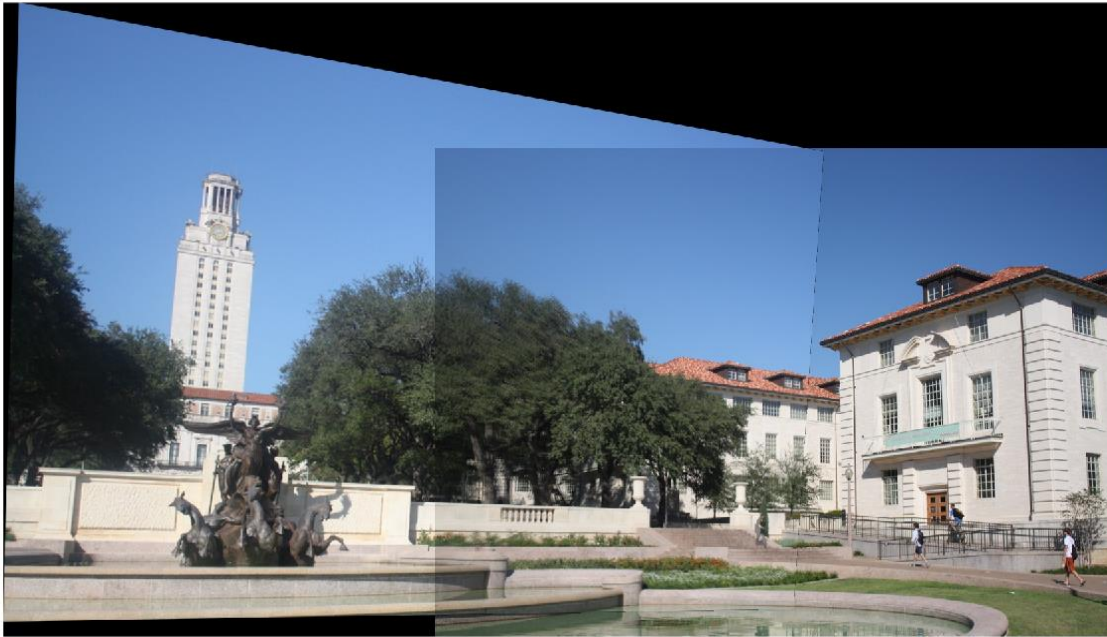
CSE 573: Computer Vision and Image Processing

Homework 3_ Homography and fundamental matrix estimation

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- **Stitching pairs of images**
 - a. For stitching pairs of images, I performed the following steps:
 - i. First, I calculated features (corners) in both the images using Harris detector (The script 'harris.m' was provided with the initial code).
 - ii. For these feature points, I extracted a neighborhood of all the points. To calculate the neighborhood, I basically setting the boundaries to 1 (for left) and width of imaged (for right). So, while calculating any position whose left neighbor cannot be calculated will be kept as zero. For extracting the neighborhoods, I have written the 'extractNeighborhood.m'.
 - iii. After calculating the neighborhoods, using the dist() function, I got the distance between the descriptors. I then selected the points where the descriptors from both the images have a lower distance than threshold (0.7). These are the point pairs.
 - iv. I then sent these points (from both images) to RANSAC function which computes the homography matrix and also return inlier indices and residual. In the RANSAC function for each iteration I calculated homography matrix and number of inliers obtained after projecting this homography matrix onto the points from image1. I have considered the maximum value of inliers and return the homography matrix and inlier indices corresponding to this number of inliers. Based on these indices the corresponding points can be fetched from both the images. The inliers between both the images can be viewed as:



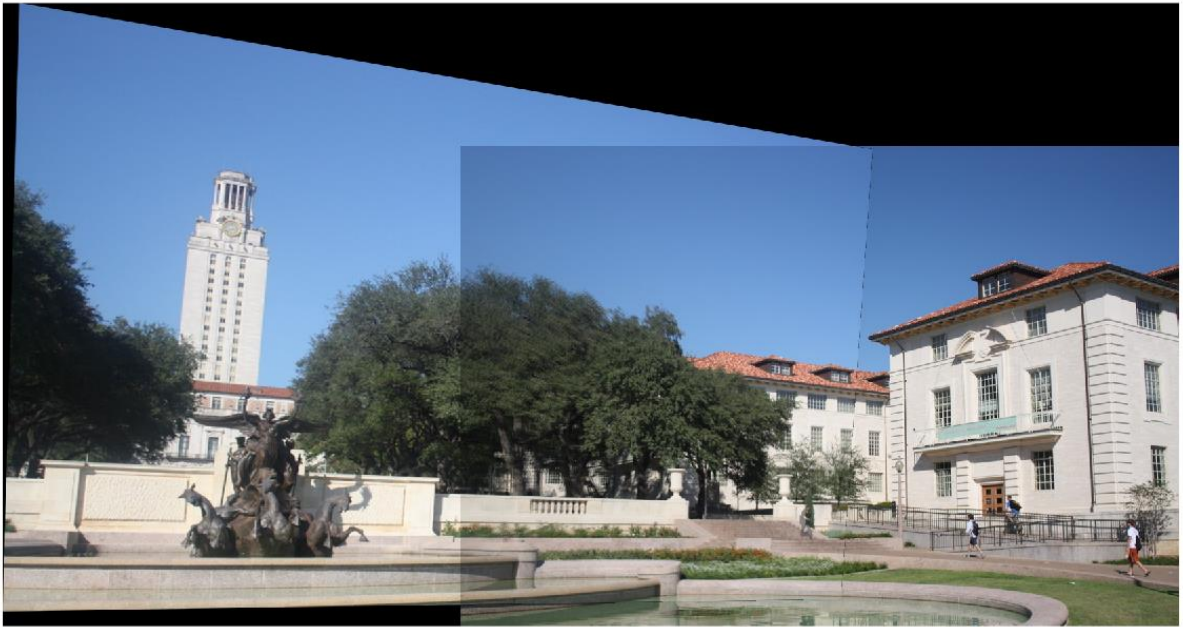
- v. After computing the homography matrix, we can stitch the images. I have transformed the first image, according to the homography matrix, using 'imtransform'. The transformation is 'maketform' and projective transformation is applied. After This I have added the two images, by calculating the bounds and transforming both the images based on the bounds calculated. For overlapping region, I have simply calculated the average values of the pixels and set them in the overlapped pixel region.
- b. Parameters used:
iterations - 10000
Minimum Threshold Distance - 15
Using these parameters, the number of inliers I got is 25. The average residual error is 510.0988.

The indices of the inliers and the corresponding point co-ordinates in both the images is given in the below table.

| Inlier indices | img1_x | img1_y | img2_x | img2_y |
|----------------|--------|--------|--------|--------|
| 15 | 623 | 535 | 166 | 498 |
| 20 | 748 | 537 | 293 | 503 |
| 24 | 783 | 562 | 326 | 529 |
| 27 | 829 | 482 | 376 | 451 |
| 28 | 840 | 543 | 384 | 511 |

| | | | | |
|----|------|-----|-----|-----|
| 29 | 854 | 548 | 397 | 516 |
| 31 | 879 | 547 | 420 | 515 |
| 34 | 893 | 469 | 438 | 441 |
| 35 | 905 | 554 | 443 | 523 |
| 36 | 905 | 540 | 444 | 509 |
| 38 | 905 | 547 | 444 | 516 |
| 43 | 910 | 412 | 457 | 387 |
| 44 | 906 | 339 | 458 | 317 |
| 46 | 923 | 433 | 468 | 408 |
| 47 | 933 | 496 | 472 | 468 |
| 49 | 931 | 391 | 478 | 368 |
| 55 | 947 | 377 | 493 | 356 |
| 64 | 970 | 540 | 503 | 511 |
| 66 | 973 | 573 | 504 | 542 |
| 71 | 998 | 539 | 528 | 511 |
| 72 | 1001 | 549 | 531 | 520 |
| 79 | 994 | 342 | 538 | 326 |
| 80 | 995 | 350 | 538 | 333 |
| 84 | 1021 | 477 | 553 | 453 |
| 86 | 1015 | 338 | 557 | 323 |

c. Final Stitched image



- Fundamental Matrix estimation

a.

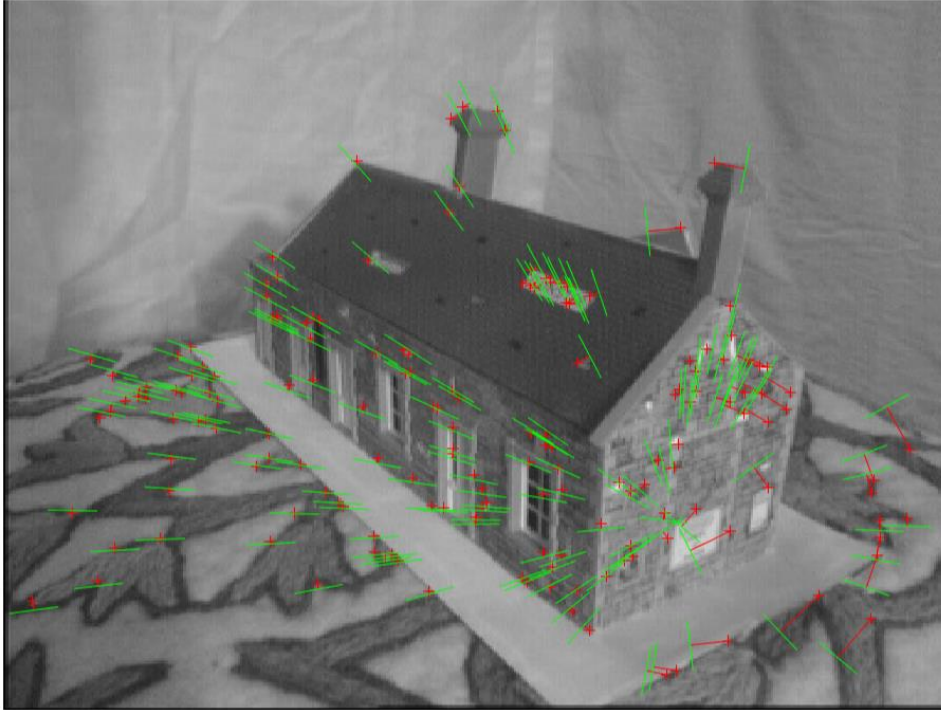


Figure 1 Un-normalized output for image 2



Figure 2 Un-normalized output for image 1

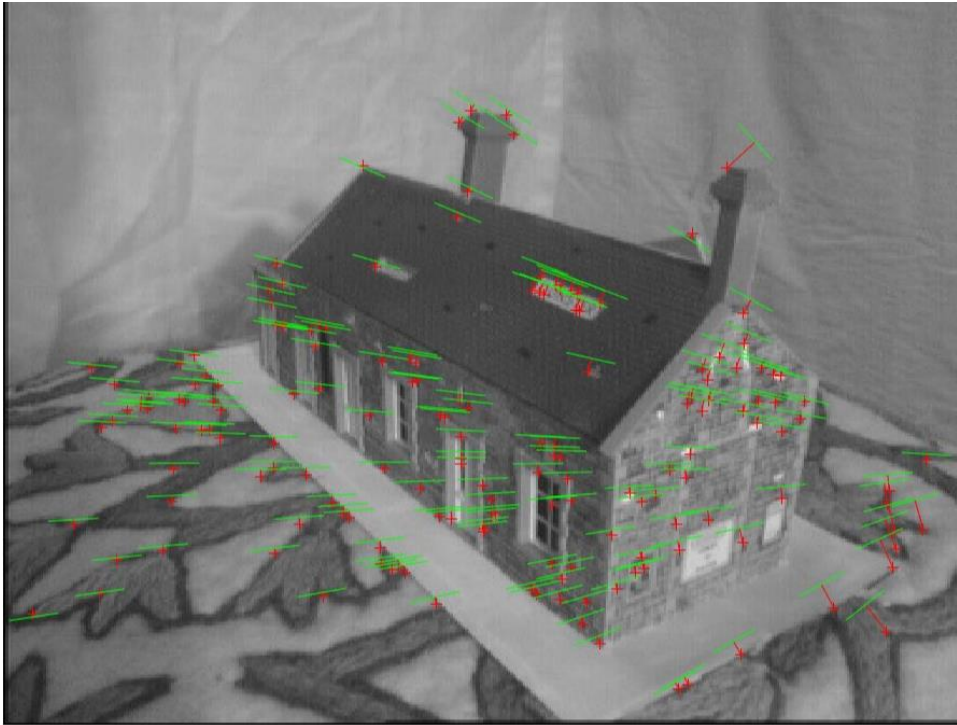


Figure 3 Normalized output for image 2

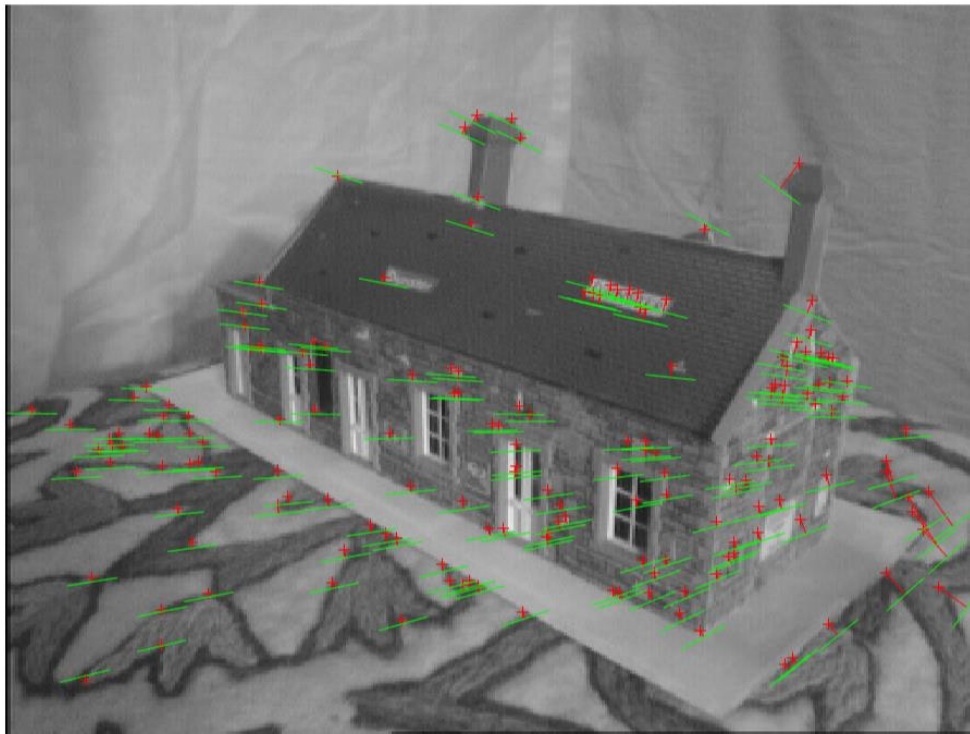


Figure 4 Normalized output for image 1

Residual Estimation for both the images using normalized and un-normalized approach of calculation of Fundamental Matrix

| Residual | Un-normalized | Normalized |
|----------|---------------|------------|
| Img1 | 18.0501 | 16.0765 |
| Img2 | 26.4013 | 16.4980 |

b.

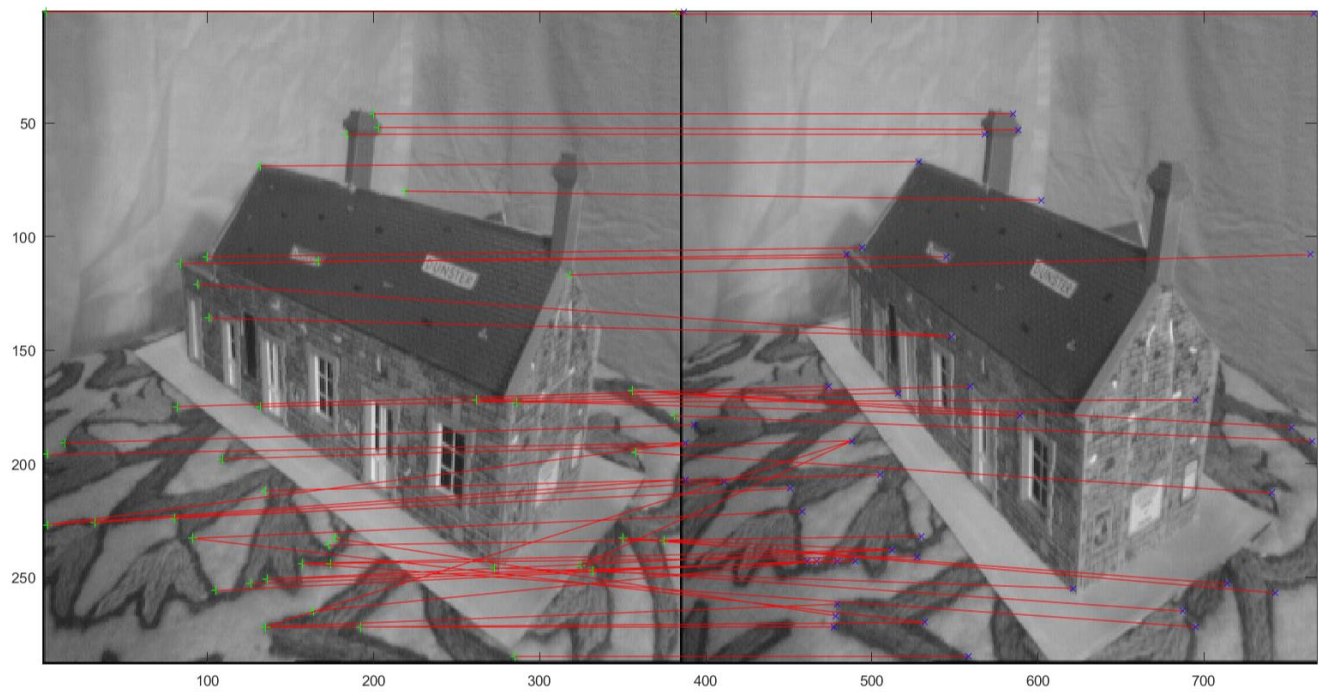


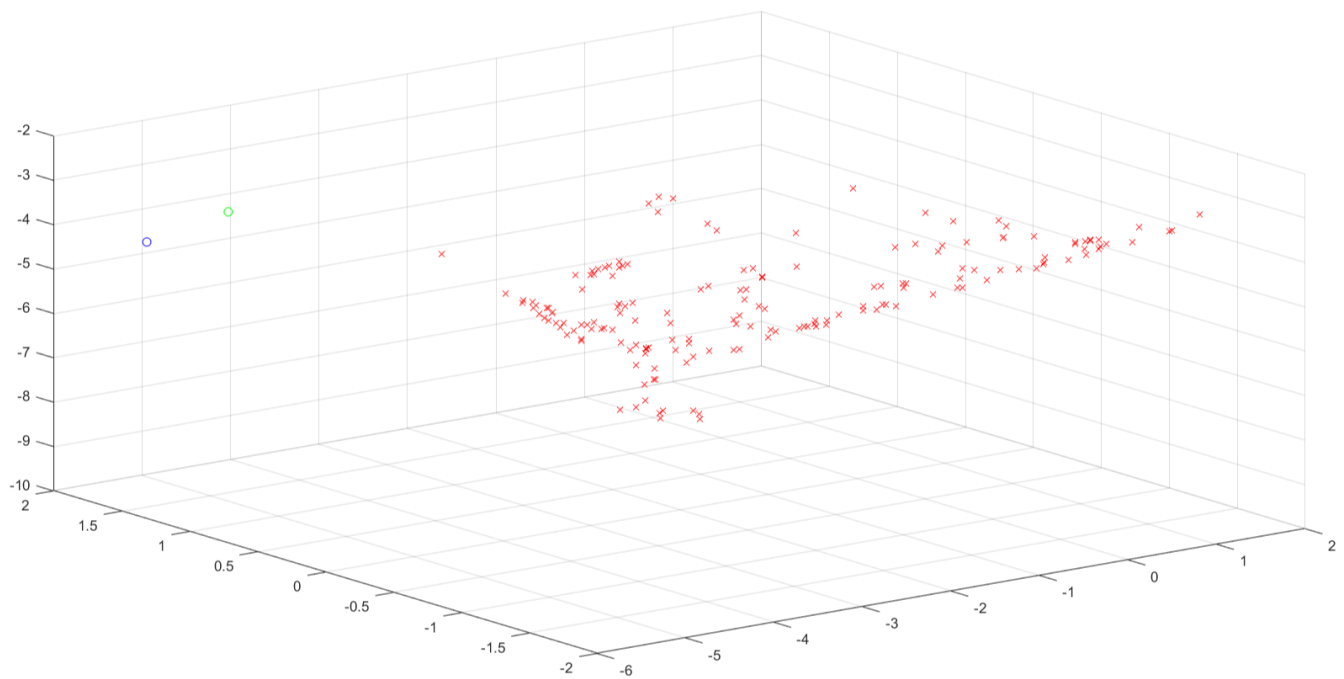
Figure 5 Inlier matches between 2 images

Number of inliers: 53

Residual Estimation: $1.7724e+03$

(Number of inliers obtained using ground truth correspondences provided was 168 and residual is 16.0765)

c.



- Scripts in the '**code**' directory

Part1

- **main.m** – main function to call for part1 image stitching
- **extracNeighborHood.m**- returns the distance calculated between the feature descriptors of both the images
- **ransac.m**- calculates the homography matrix using RANSAC implementation and also returns inlier indices and residual
- **solveH.m** – calculates Homography matrix when passed a set of points from 2 images
- **harris.m** – sample Harris detector (already given)
- **find_sift.m** – (already given)
- **dist2.m** – (already given)

Part2

- **main_part2.m** – main function to call for part2 to obtain inliers between both images
- **sample_code.m** – (already given)
- **fit_fundamental.m** – calculates the fundamental matrix (un-normalized)
- **fit_normalized.m** – calculates normalized fundamental matrix
- **fransac.m** – implements RANSAC for calculating fundamental matrix
- **triangulate1.m** – to calculate the corresponding 3 D points and calculate triangulation.

- References:

- <https://inside.mines.edu/~whoff/courses/EENG512/lectures/24-EpipolarAndEssential.pdf>
- http://www.cs.cmu.edu/~16385/Slides/11.4_Triangulation.pdf
- <http://www.cse.psu.edu/~rtc12/CSE486/lecture20.pdf>
- <http://www.cse.psu.edu/~rtc12/CSE486/lecture19.pdf>