COSC 342 Assignment 1 – Image Mosaicing

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Introduction

The aim of this report is to perform experiments on parts of the image stitching process specifcally the feature matching and homography estimation. First experiment we will compare two feature matchers used by OpenCV and second experiment vary the choice of RANSAC threshold used in homogrpahy estimation. Both experiemtn will be measuring the accuracy of the homography via the reprojection error.

Reprojection Error, calculates the euclidean distance between transformed points in source image to points in destination image. It measures how well the homography aligns the source and destination points. The same reprojection error used by OpenCV findHomography() for filtering by the ransacThreshold.

$\mathbf{d}$ point in the image we want to align to

$\mathbf{s}$ point in the image we want to transform using homography H

Projection error = $||\mathbf{d} - H\mathbf{s}||$

Image Dataset:

Both experiments used the same image dataset, it contains a mix of 3 scene types: Outdoor/Natural greenery, Exteriror of buildings, Interior of buildings. Image pairs differ by camera rotations or translation of camera for planar scenes

Image Number	Resolution/Image type	Source
1-40	1000x750 / JPG	https://github.com/tlliao/Single-perspective-warps/tree/master [1]
41-59	3000x4000 / JPG	Myself
60-104	1500x2000 / JPG	Myself

Images 1-40 scene type is all Exterior of buildings with a mix of Outdoor/Natural greenery

Images 41-104 scene types: Interior scenes 40, Exterior scenes 16, Greenery scenes 8.

Experiment Process:

For each image pair:

1. Generate SIFT features from both images.
2. Use a feature matcher like Brute-Force or FLANN to find corresponding features between the images.
3. Apply Lowe's ratio test to remove unreliable matches.
4. Use RANSAC to estimate the homography between the images.
5. Compute the reprojection error for either inlier points or for both inlier and outlier points.

Notes:

Inlier/Outlier points refer to the points that are consistent/inconsistent with the homography model.

Insert example of stitched image

Experiment 1: Feature Matching

Hypothesis/Question:

Which OpenCV feature matcher results in a more accurate homography

Experimental Design:

We will follow the Experiment Process above, but vary the feature matcher between experiements between Brute-Force and FLANN.

Results:

Boxplot below shows the distributions for the reprojection error for inlier points for the Brute-Force and FLANN feature matcher. The median, standard deviation, and spread are nearly identical, indicating similar performance in accurately estimating homography for inlier points.

BF first then FLANN add if needed..

[94302 rows x 1 columns]

count 98006.000000

mean 1.018591

std 0.664731

min 0.005340

25% 0.515630

50% 0.874329

75% 1.386900

max 8.361810

Name: 0, dtype: float64

count 94302.000000

mean 1.016181

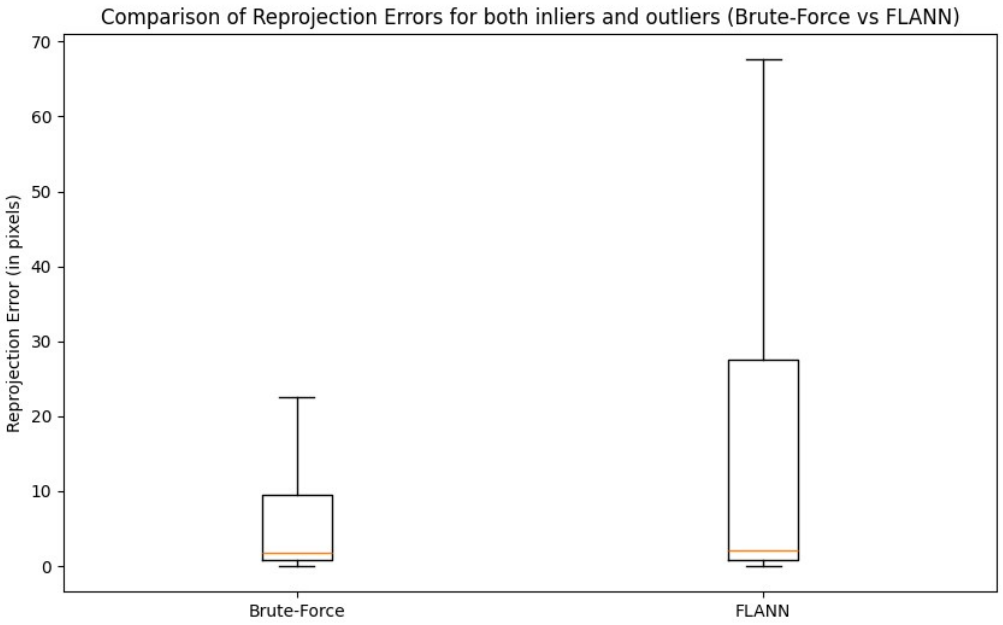
std 0.671404

min 0.001365

25% 0.505144

50%	0.866665
75%	1.392410
max	5.402230

Below boxplot shows the distributions for the Reprojection error for both inlier and outlier points for the Brute-Force and FLANN feature matcher.



Below is the summary statistics for reprojection errors for both inliers and outliers

	Brute-Force	FLANN
Count	172242	181106
Mean	145.01	239.15
Standard Deviation	480.27	616.62
Min	0.01	0
Lower Quartile (25%)	0.77	0.82
Median (50%)	1.73	2.16
Upper Quartle (75%)	9.48	27.56
Max	5869.18	9623.1

Count: Brute-Force has 172,242 data points, while FLANN has 181,106 data points.

Mean: The average reprojection error is 145.01 for Brute-Force and 239.15 for FLANN, indicating that Brute-Force generally produces lower average errors.

Standard Deviation: Brute-Force has a standard deviation of 480.27, while FLANN's standard deviation is slightly higher at 616.62, suggesting that FLANN exhibits more variability in reprojection errors.

Minimum and Maximum: The minimum reprojection error is 0.01 for Brute-Force and 0 for FLANN, while the maximum reprojection error is 5869.18 for Brute-Force and 9623.1 for FLANN.

Quartiles (25%, 50%, 75%): Brute-Force has lower quartile values compared to FLANN, with a median (50th percentile) reprojection error of 1.73 for Brute-Force and 2.16 for FLANN. Additionally, the upper quartile (75th percentile) is 9.48 for Brute-Force and 27.56 for FLANN, indicating that FLANN tends to have higher reprojection errors at the higher end of the distribution.

Overall, Brute-Force generally exhibits lower average reprojection errors and less variability compared to FLANN. However, FLANN may have a slightly higher maximum error and higher reprojection errors at the upper quartile range, indicating potential outliers with larger errors.

Discussion/Conclusions:

What do the results of the experiment tell us about the hypothesis or question. It is OK if they don't answer the question clearly, or if the results are not what you would expect. The important thing is to interpret the results honestly and to explain what you have observed as clearly as possible.

Experiment 2: RANSAC for Homography Estimation

Hypothesis/Question:

How does the choice of RANSAC threshold affect the accuracy of the homography?

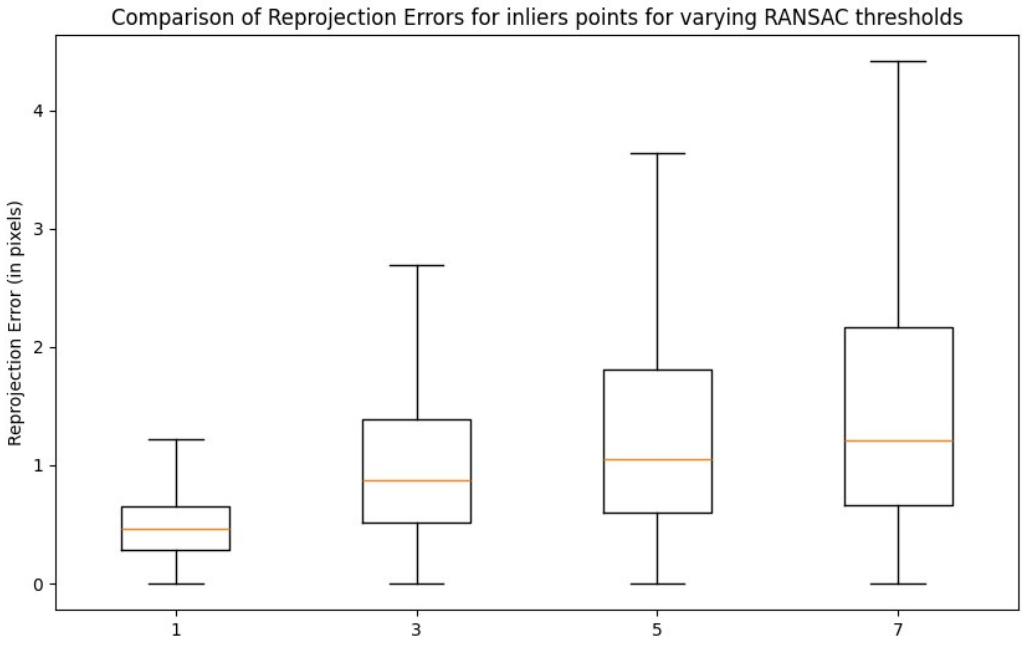
Experimental Design:

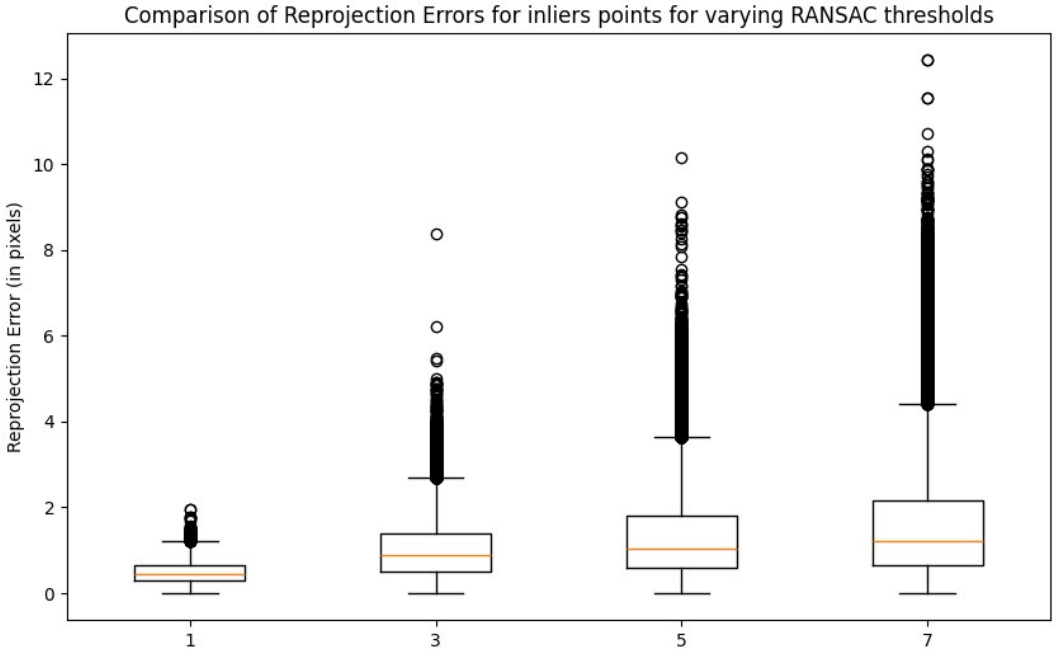
Explain what your experiment is, what data you are going to be using, what you will measure, and how this will answer your question or test your hypothesis. If there are

some parts of your design (e.g. your set of test data) that are common to both of the experiments, then you can move that out to the front of the report.

Results:

Danmn look at that lower threshold results in better estimation very wowww hmm upper 50 increases alot ..





Discussion/Conclusions:

What do the results of the experiment tell us about the hypothesis or question. It is OK if they don't answer the question clearly, or if the results are not what you would expect. The important thing is to interpret the results honestly and to explain what you have observed as clearly as possible.

Final Remarks

Draw together the two experiments and tell us what you've found from them in general. This is also a good place to suggest what the next steps will be. It is good to be honest about the limitations of your work, especially if you can see how to improve things in the future.

Only 3 scene types although due to time constraints and not balalnced and not balanced within the pixel reoslutions.

Also I resized alot of images to smaller reoslutiosn since the processing time was rather long with the 3000x4000 images with some images returning 100,000+ features

Would be interesting to see the distributions for just the outliers

References:

[1] Liao, T., & Li, N. (2020). Single-Perspective Warps in Natural Image Stitching. *IEEE Transactions on Image Processing*, *29*, 724–735. https://doi.org/10.1109/TIP.2019.2934344