CS 4476 PS 3

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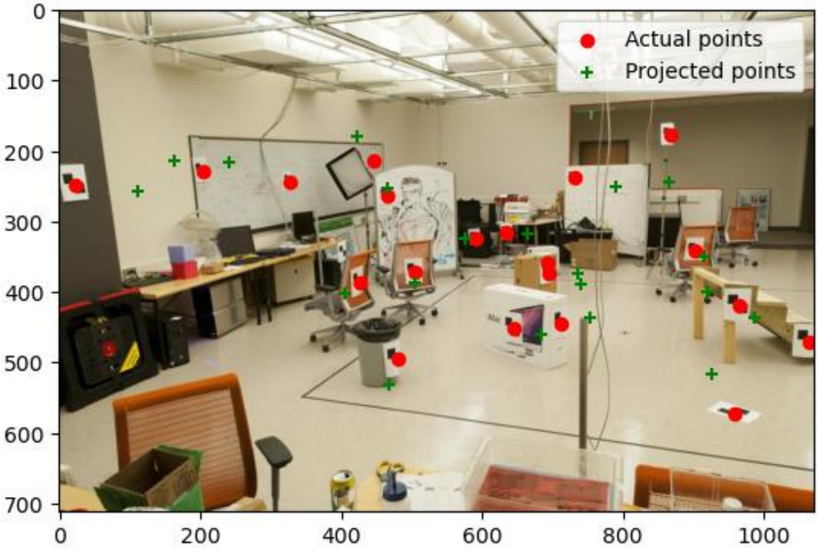
Part 1.5: Projection Matrix for provided image

<insert visualization of projected 3D points and actual 2D points for image provided by us here [1]>



<What is the minimum number of 3D-2D point correspondences needed to estimate the projection matrix? Why? [2]>

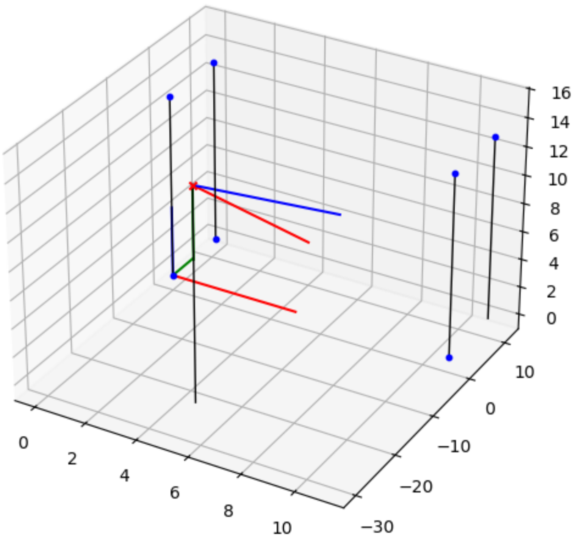
The 3x4 matrix has 11 degrees of freedom. Each point correspondence provides 2 linear equations. To solve for 11 unknowns, we need at least 11 equations. We need at least 6 points for that

Part 2.1: Projection Matrix for custom images

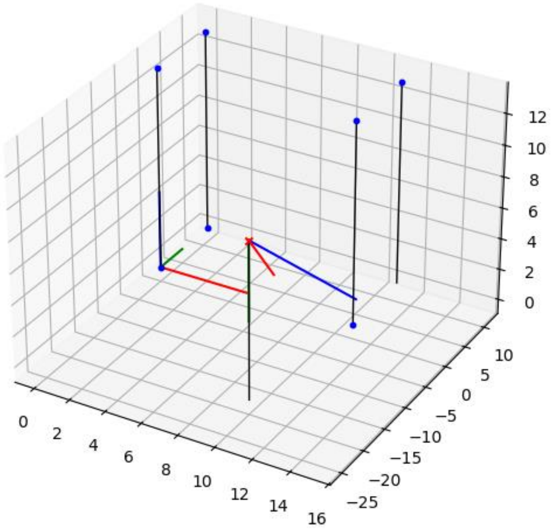
<Copy two [2]>

Part 2.2: Pose init for custom images

<Insert visualization for the initialized camera pose for 1st image> [1]

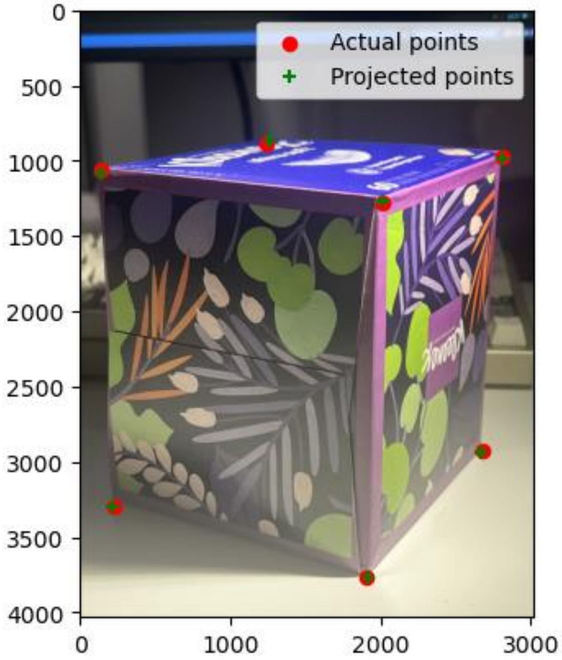


<Insert visualization for the initialized camera pose for 2nd image> [1]

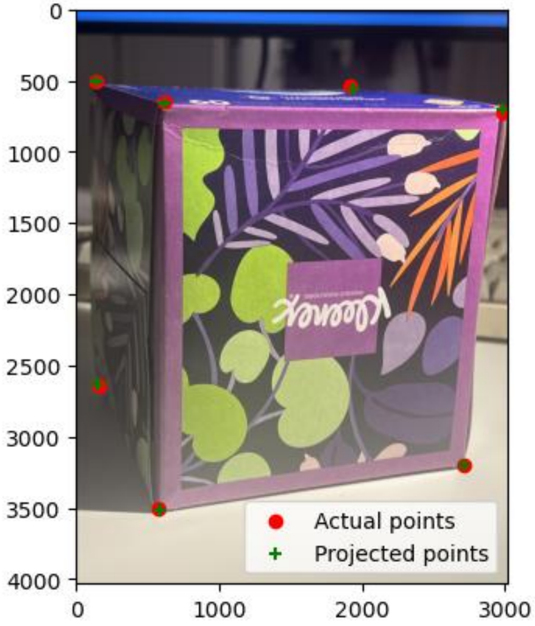


Part 2.2: Optimized results for custom images

<Insert visualization for projected 3D points and actual 2D points for 1st image> [1.5]

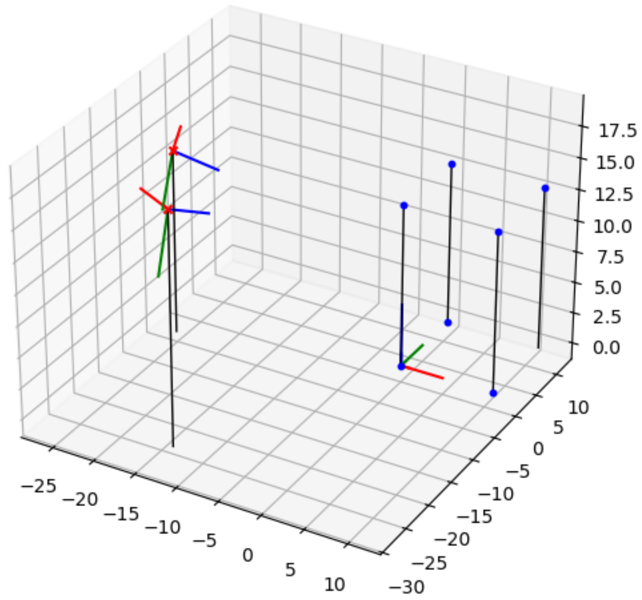


<Insert visualization for projected 3D points and actual 2D points for 2nd image> [1.5]



Part 2.3: Optimized Camera Poses

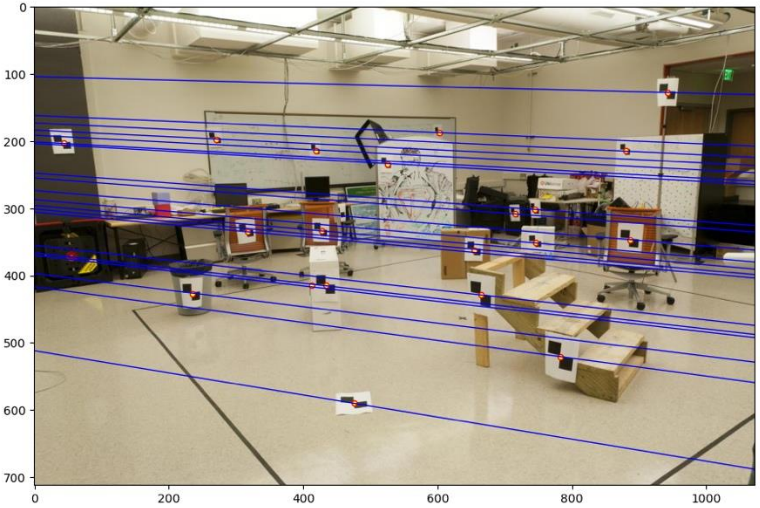
<Insert pose with world and optimized camera’s coordinate systems [1]>

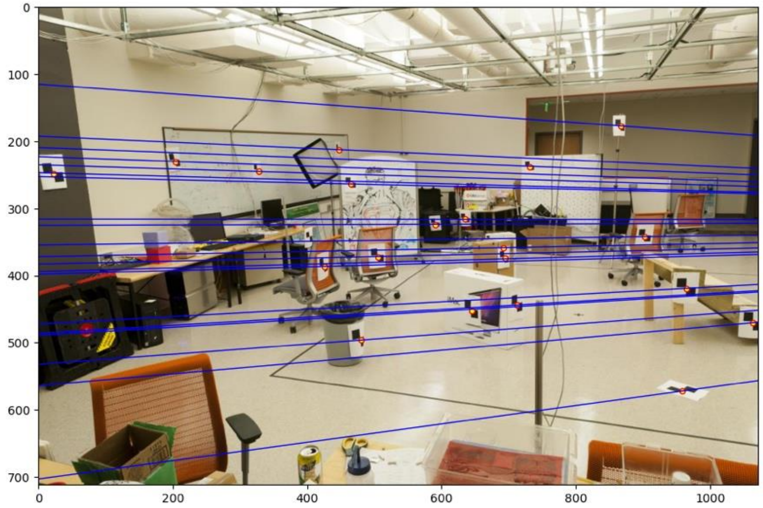


Part 3.2: Optimized Epipolar Lines (given images)

<Insert left image with epipolar lines> [1]

<Insert right image with epipolar lines> [1]

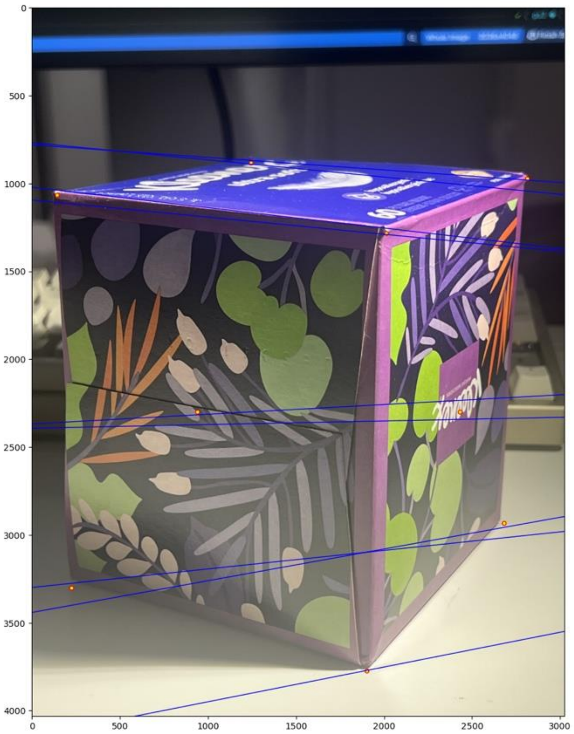




Part 3.3: Optimized Epipolar Lines (custom images)

<Insert left image with epipolar lines> [1.5]

<Insert right image with epipolar lines> [1.5]



Part 3.4: Reflection Questions [1x3]

1. Because without translation, the viewpoints stay the same so the information about the depth is lost and therefore we can’t properly estimate the fundamental matrix.

2. The fundamental matrix maps a point in the first image to the second image through an epipolar line and the corresponding point should be somewhere along that line.

3. If both camera centers are inside the images, the epipoles will appear along image boundaries and the corresponding epipolar lines will move out from them. This is because the epipole is a projection of the other camera’s center in each image.

Part 3.4: Reflection Questions [1x3]

4. Two cameras are dominantly related by horizontal translation

5. Fundamental matrix is calculated from homogeneous equations so multiplying it by any scalar number does not change the geometric relationships

6. Fundamental matrix is built using the cross-product matrix derived from the translation vector. The cross-product matrix has a rank of 2 so the fundamental matrix also has a rank of 2.

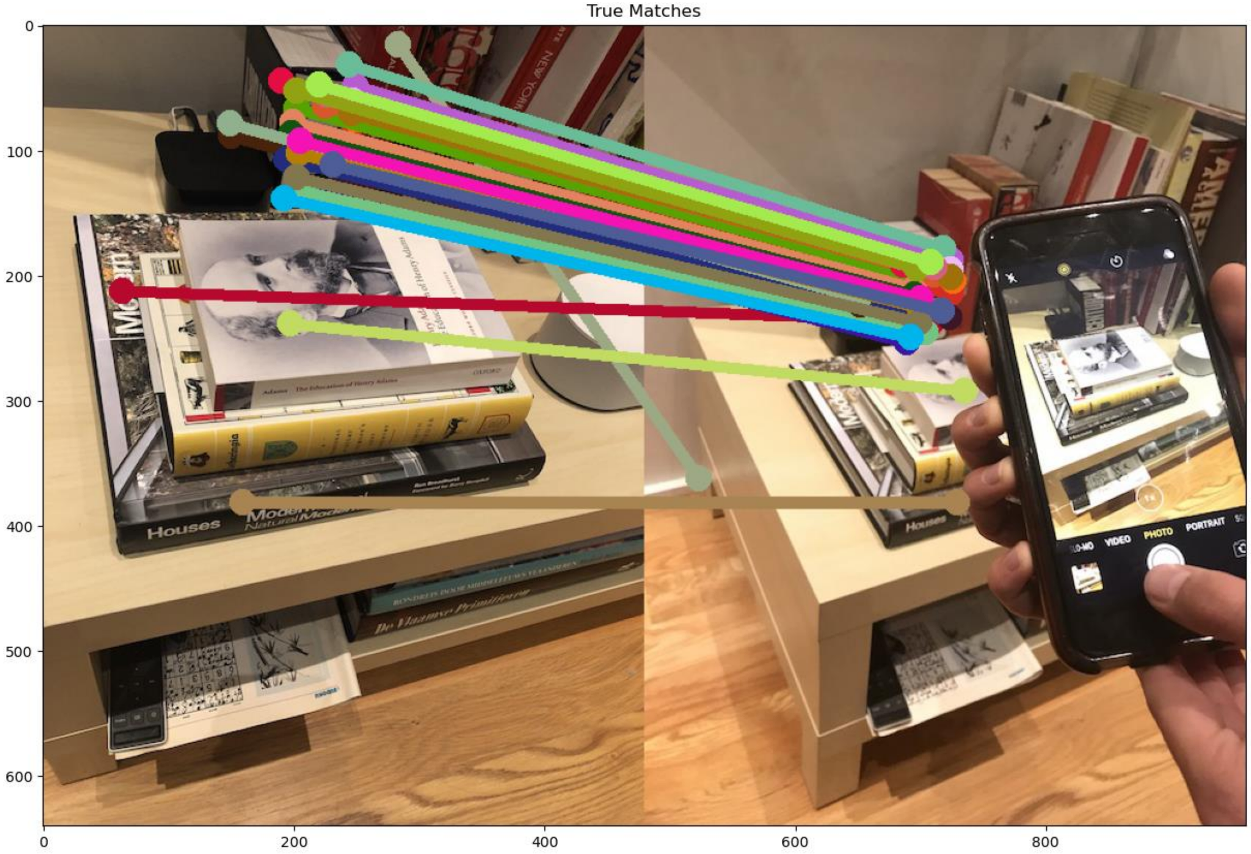
Part 4.2: RANSAC Iterations Questions [1x3]

Type your answers to the three RANSAC Iterations questions from the jupyter notebook below:

1. $S = \ln(1-0.999)/\ln(1-0.9^9) = 14.1 \Rightarrow 15$ iterations
2. $S = \ln(1-0.999)/\ln(1-0.9^{18}) = 42.5 \Rightarrow 43$ iterations
3. $S = \ln(1-0.999)/\ln(1-0.7^7) = 80.4 \Rightarrow 81$ iterations

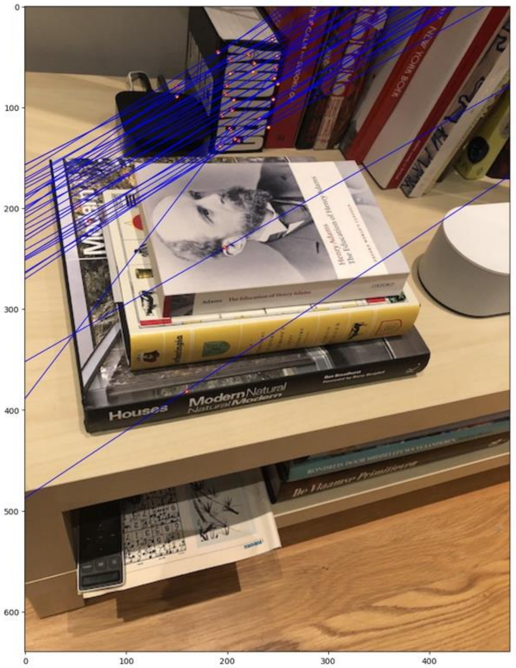
Part 4.4: RANSAC Inlier Matches

<Paste the

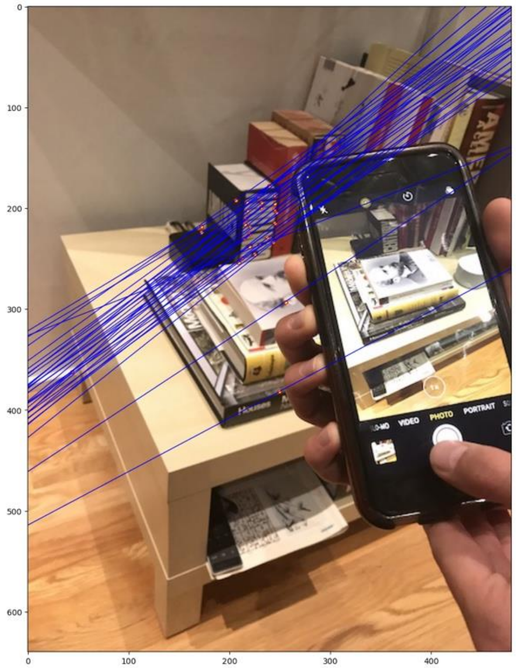


Part 4.4: RANSAC Epipolar Lines

<Paste the left image with epipolar lines> [1]



<Paste the right image with epipolar lines> [1]



Local Unit tests results

<Paste the screenshot when you run all provided unit tests using `pytest`> [1]

```
╭─  ~/Downloads/GT/CS4476/ps3_release/ps3_unit_tests   main ↑1 !19184 ?10 ─────────── ✔  ps3 
4:38:39 PM ⊙ ─╮
╰─ pytest ./
============================================= test session starts =============================================
================
platform darwin -- Python 3.9.24, pytest-8.4.2, pluggy-1.5.0
rootdir: /Users/dongkyunlim/Downloads/GT/CS4476/ps3_release
plugins: anyio-4.10.0
collected 20 items


part1_unit_test.py .....
         [ 25%]
test_essential_matrix_decomposition.py ..
         [ 35%]
test_fundamental_matrix.py .........
         [ 80%]
test_ransac.py ....
         [100%]

============================================= 20 passed in 0.62s =============================================
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```

Conclusions

<Describe what you have learned in this project. Feel free to include any challenges you ran into.> [2]

In this project, I learned how to estimate fundamental matrix and used it to come up with epipolar geometry between two different camera views. I implemented least-squares optimization, RANSAC for better estimation and many more. One of the biggest challenges I faced was trying to debug matrix decompositions.