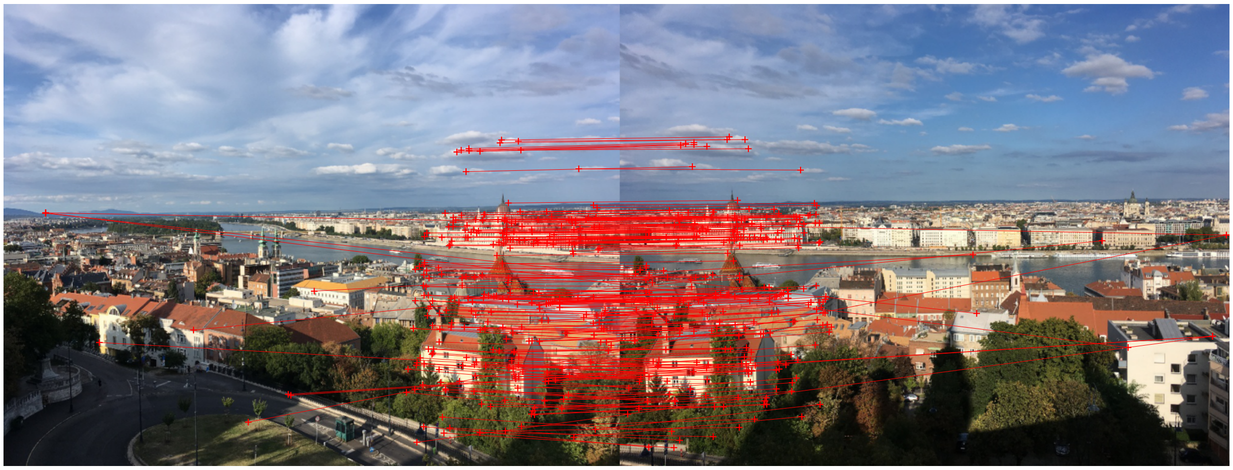
CS543 – Assignment 3

Pallaw Kumar (pallawk2)

Question 1.

1. Putative matches overlaid on the image pairs



2. Implementation details

1. First, the desired probability of finding at least one sample with no outliers p is specified. This is typically a high value such as 0.99.
2. The size of each sample s and the maximum allowed fraction of outliers e are also specified. The value of s is typically small, and the value of e is typically set to a relatively low value such as 0.1.
3. The number of iterations N required to achieve the desired probability p is calculated using the formula N = log (1 - p) / log(1 - (1 - e)^s).

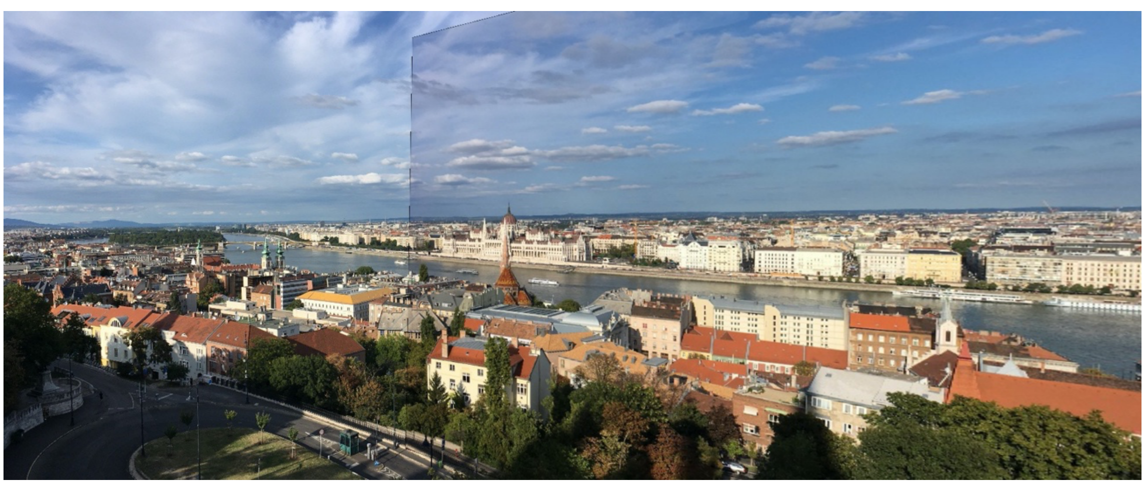
For each iteration:

4. Randomly select a subset of s matches from the dataset.
5. Compute the homography matrix h_mat using the selected matches.
6. Transform the source points using h_mat.
7. Calculate the residual distance between the transformed source points and their corresponding destination points.
8. Select the inliers whose residual distance is less than or equal to threshold.
9. If the fraction of outliers in the inliers is less than e, return the homography matrix, inliers, and residual distances of the inliers as the best model, inliers, and residuals, respectively.
10. Otherwise, update the best model, inliers, and residuals based on the mean residual distance of the inliers.
11. Return the best model, inliers, and residuals.

Hyperparameters:
distance_threshold=80, outlier_ratio=0.04, p = 0.99
Number of inliers: 158
Average residual for the inliers: 16.22942027555401

```
Best model: [[ 1.45772221e-03 2.42004160e-05 -9.63505400e-01]
             [ 3.23951959e-04 1.26834559e-03 -2.67681297e-01]
             [ 9.75224039e-07 -3.97951146e-09 4.77935232e-04]]
```

3. Stitched result:



4. Extra

Number of inliers: 78
Average residual for the inliers: `16.8820`

Number of inliers: 82
Average residual for the inliers: `4.6492`

Stitched result:

Question 2

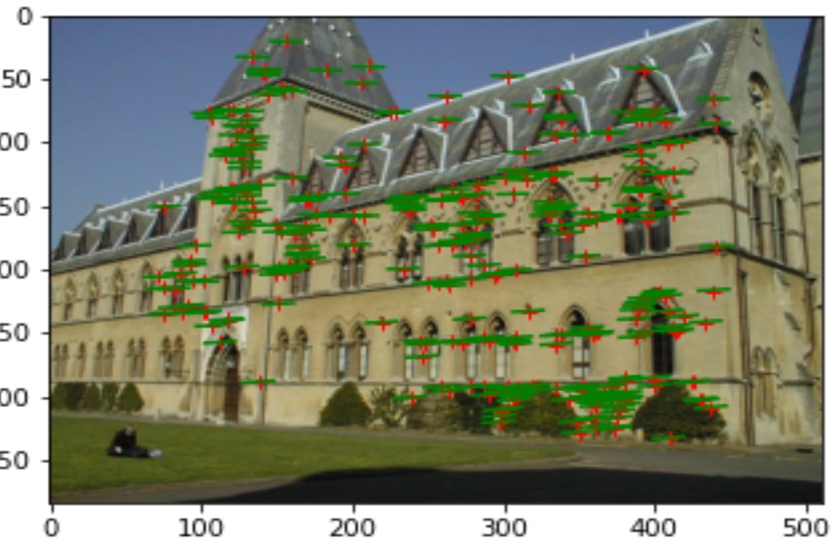
Part 1:

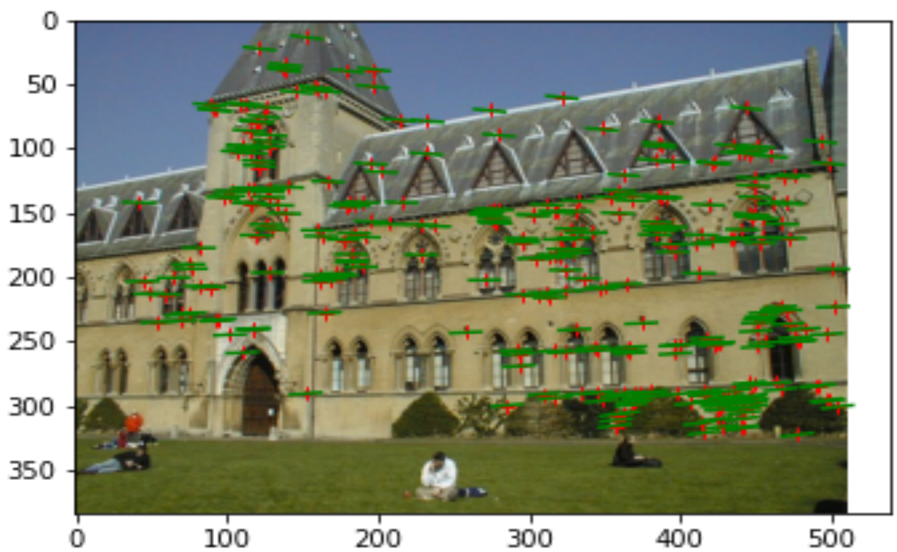
Non-normalized method

```
Fundamental Matrix: [[-1.32341616e-06 1.36640519e-05 -6.82803870e-04]
                      [-2.88178174e-05 2.66440807e-07 4.09069255e-02]
                      [ 5.62362952e-03 -3.72771609e-02 -9.98451273e-01]]

library: residual in frame 2 (non-normalized method) = 0.17921336682
library: residual in frame 1 (non-normalized method) = 0.14912309940
library: residual combined (non-normalized method) =  0.16416823311
```

visualization of epipolar lines and corresponding points:

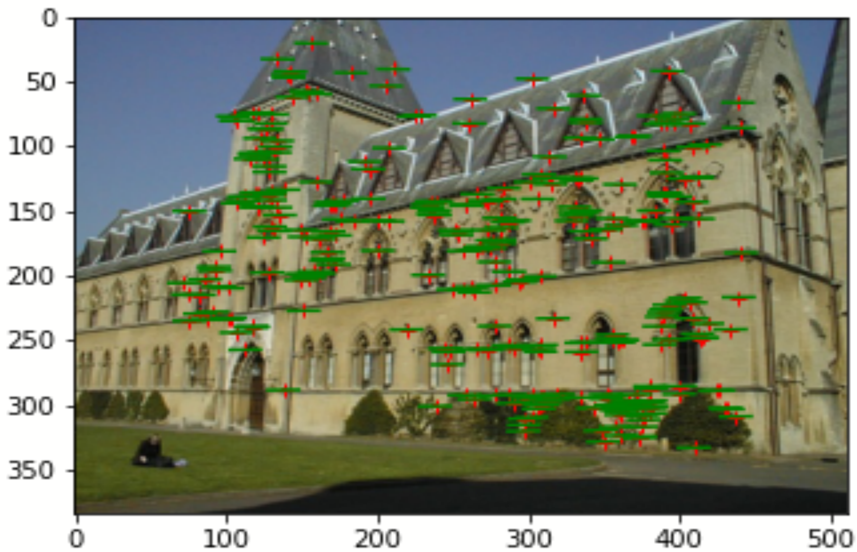


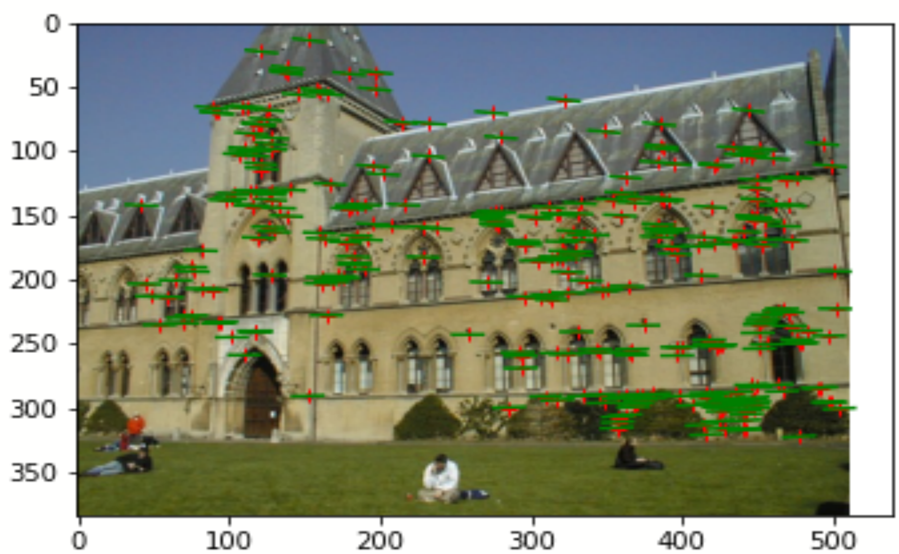


Normalized method:

```
Fundamental Matrix: [[-3.44725739e-08 7.27167745e-07 -1.09292791e-04]
                     [-4.37299224e-06 -4.44216115e-08 8.10999749e-03]
                     [ 1.04291060e-03 -7.28410119e-03 -1.97254324e-01]]
library: residual in frame 2 (normalized method) = 0.0602510525
library: residual in frame 1 (normalized method) = 0.0548136340
library: residual combined (normalized method) = 0.05753234333
```

visualization of epipolar lines and corresponding points:



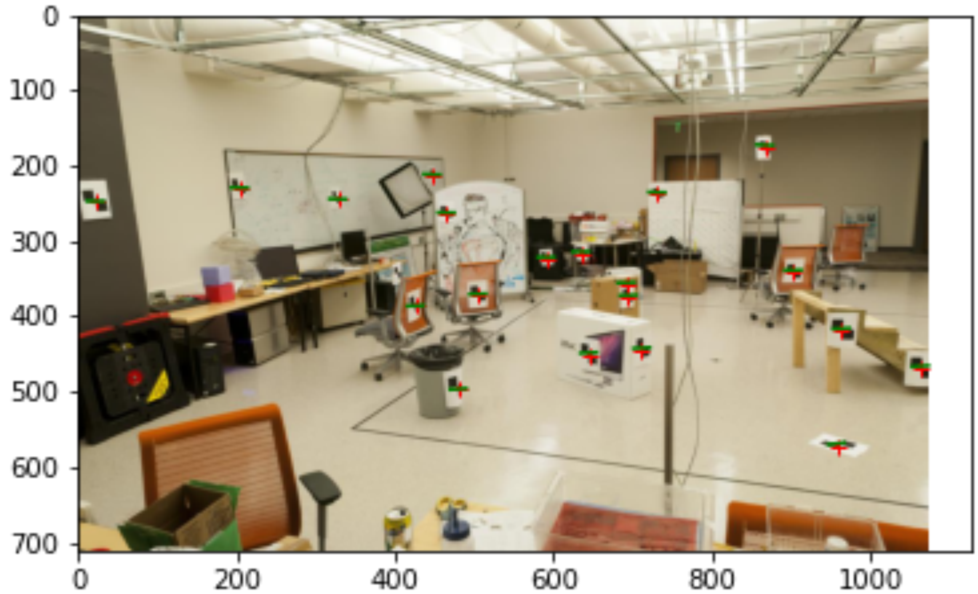


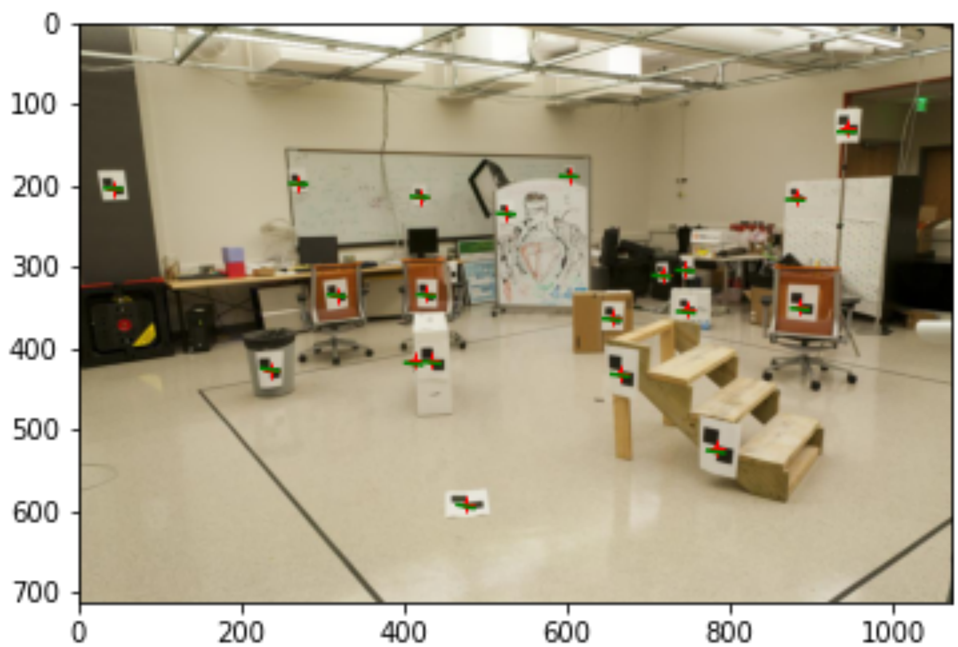
Lab Images:

```
Non-normalized method
Fundamental Matrix: [[-5.36264198e-07 7.90364771e-06 -1.88600204e-03]
                     [ 8.83539184e-06 1.21321685e-06  1.72332901e-02]
                     [-9.07382264e-04 -2.64234650e-02 9.99500092e-01]]
lab: residual in frame 2 (non-normalized method) = 6.567091502178205
```

```
lab: residual in frame 1 (non-normalized method) = 9.760655424957395
lab: residual combined (non-normalized method) =  8.1638734635678
```

visualization of epipolar lines and corresponding points:



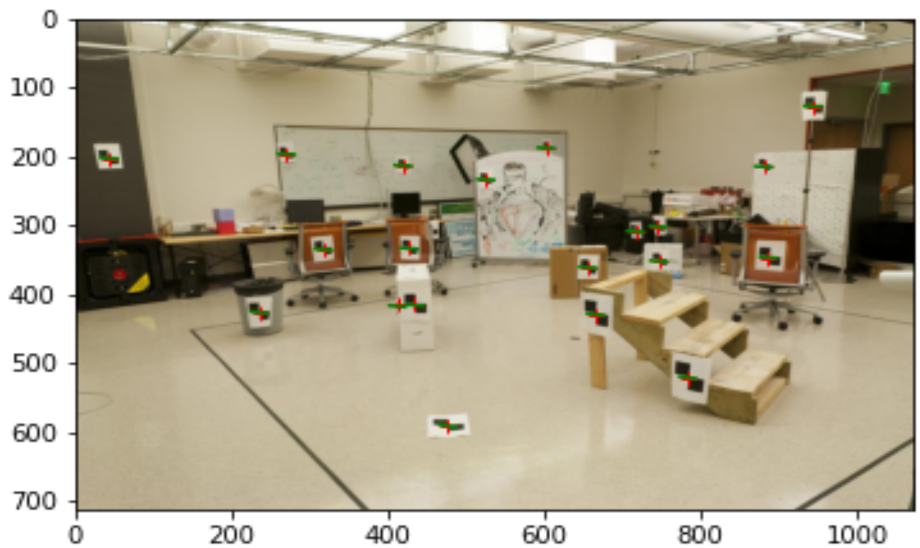


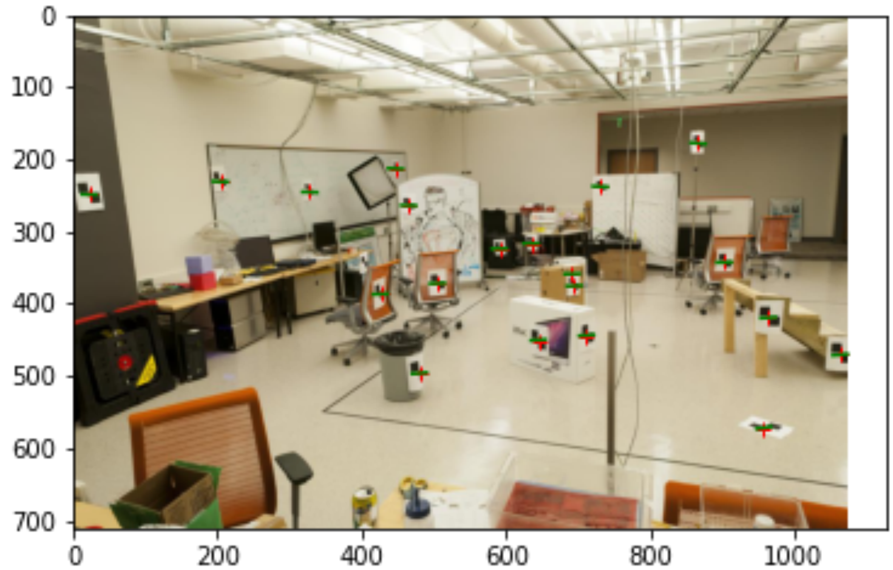
Normalized method:

```
Fundamental Matrix: [[-1.17248591e-07 1.60824663e-06 -4.01980786e-04]
                     [ 1.11212887e-06 -2.73443755e-07 3.23319884e-03]
                     [-2.36400817e-05 -4.44404958e-03 1.03455561e-01]]

lab: residual in frame 2 (normalized method) = 0.5473984648841871
lab: residual in frame 1 (normalized method) = 0.5792257462301152
lab: residual combined  (normalized method) =  0.5633121055571512
```

visualization of epipolar lines and corresponding points:





Part 2:

lab 1 camera projection:
```
[[ 3.09963996e-03 1.46204548e-04 -4.48497465e-04 -9.78930678e-01]
 [ 3.07018252e-04 6.37193664e-04 -2.77356178e-03 -2.04144405e-01]
 [ 1.67933533e-06 2.74767684e-06 -6.83964827e-07 -1.32882928e-03]]
```

lab 2 camera projection:
```
[[ 6.93154686e-03 -4.01684470e-03 -1.32602928e-03 -8.26700554e-01]
 [ 1.54768732e-03 1.02452760e-03 -7.27440714e-03 -5.62523256e-01]
 [ 7.60946050e-06 3.70953989e-06 -1.90203244e-06 -3.38807712e-03]]
```

```
residuals between the observed 2D points and the projected 3D points:
residual in lab1: 13.54583290508715
residual in lab2: 15.544953435941322

library1 camera projection:
[[-4.5250208e+01 4.8215478e+02 4.0948922e+02 3.4440464e+03]
 [ 4.8858466e+02 2.7346374e+02 -1.3977268e+02 4.8030231e+03]
 [-1.9787463e-01 8.8042214e-01 -4.3093212e-01 2.8032556e+01]]

library2 camera projection:
[[-5.9593834e+01 5.5643970e+02 2.3093716e+02 3.5683545e+03]
 [ 4.6419679e+02 2.2628430e+02 -1.9605278e+02 4.8734171e+03]
 [-1.9116708e-01 7.2057697e-01 -6.6650130e-01 2.8015392e+01]]
```

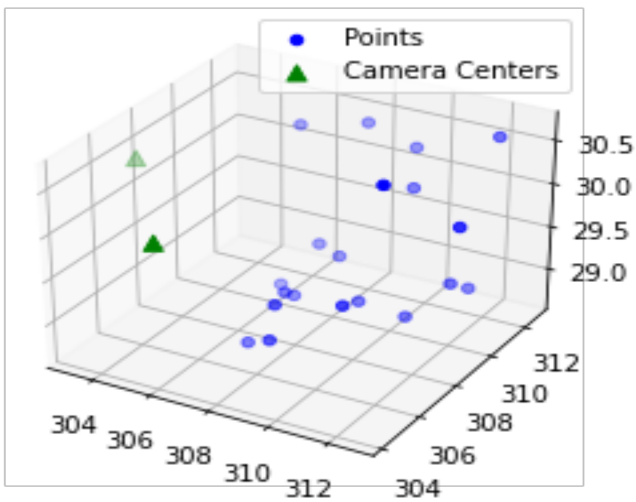
Part 3:

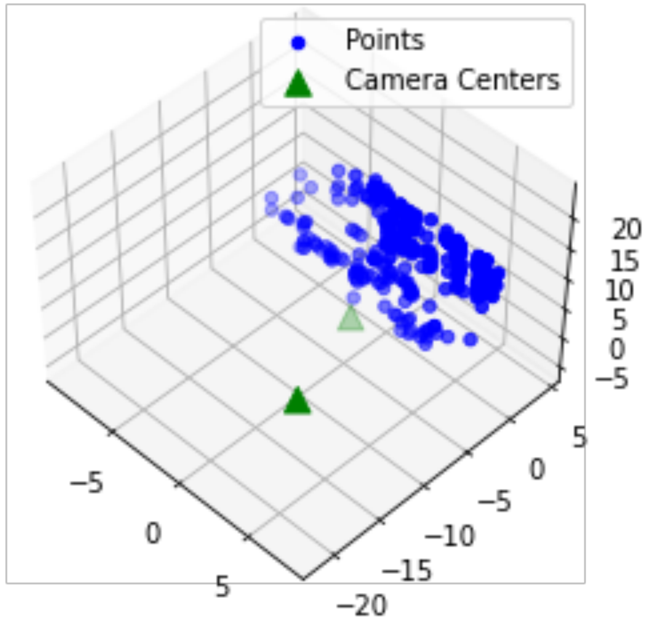
```
lab1 camera center [305.83276769 304.20103826 30.13699243]
lab2 camera center [303.10003925 307.18428016 30.42166874]
library1 camera center [ 7.28863053 -21.52118112 17.73503585]
library2 camera center [ 6.89405488 -15.39232716 23.41498687]
```

Part 4:

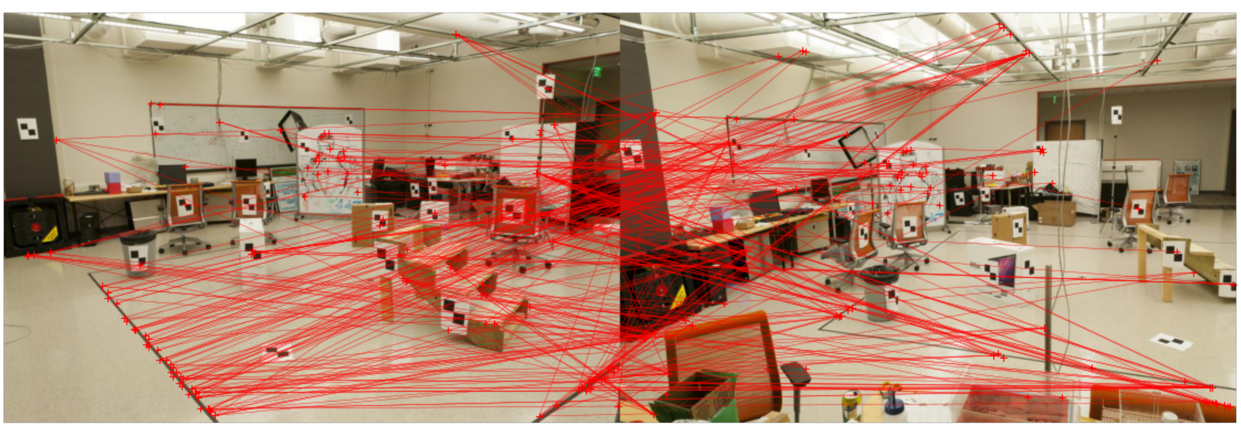
```
Mean 3D reconstruction error for the lab data:  0.00104
2D reprojection error for the lab 1 data:  10.899446002031738
2D reprojection error for the lab 2 data:  1.5485148152476724
2D reprojection error for the library 1 data:  24.662071196868382

2D reprojection error for the library 2 data:  28.64953773526143
```





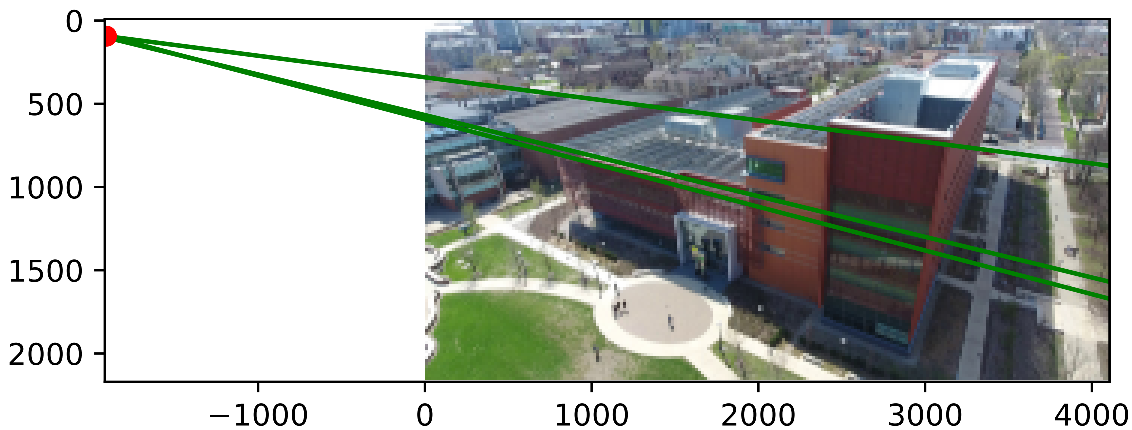
Extra credit:
Sift match

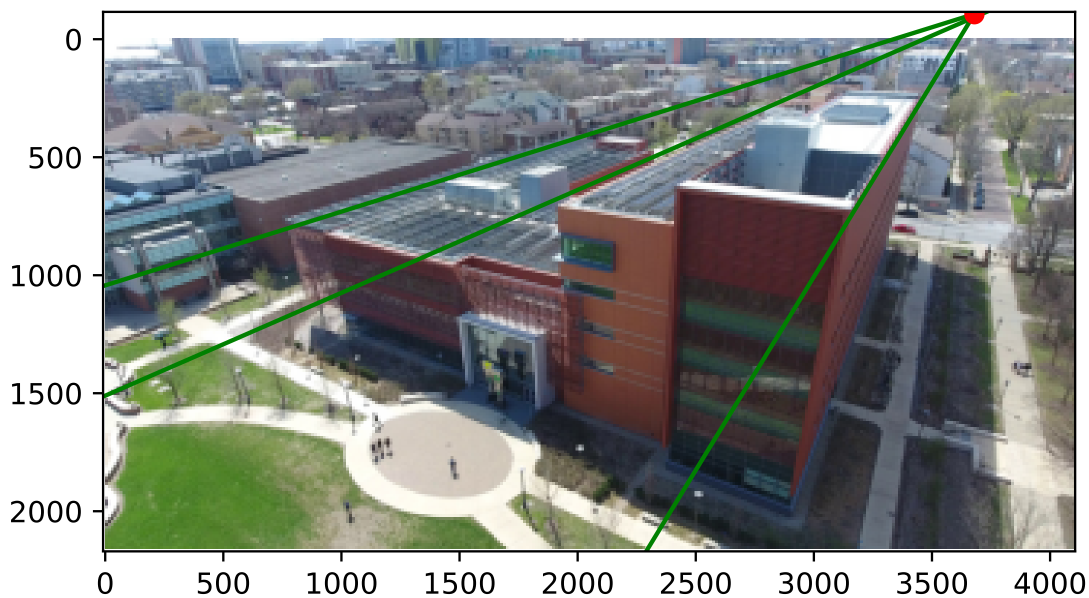


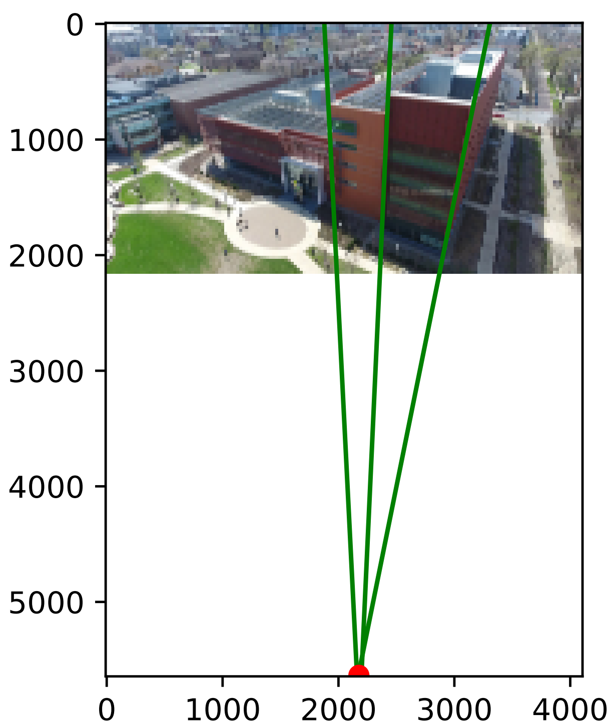
Ransac match:

Question 3

Part1

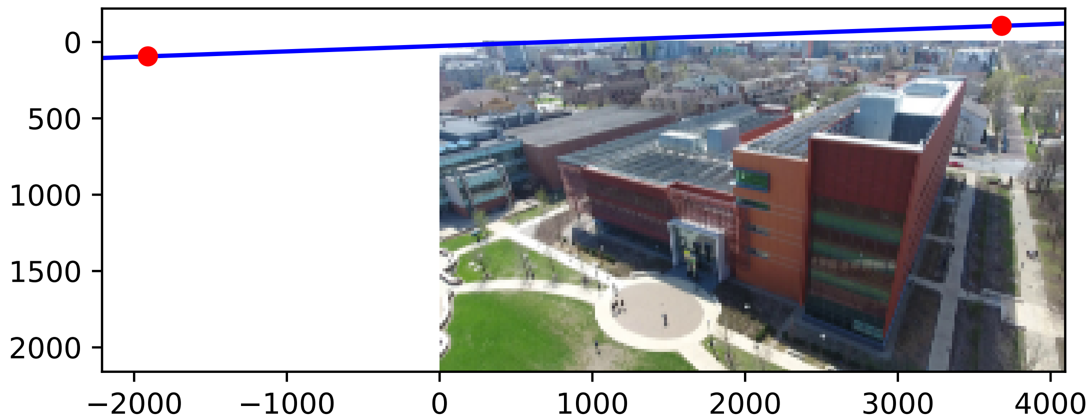







```
Vanishing point 1: [-1.90978090e+03 9.40147584e+01 1.00000000e+00]
Vanishing point 2: [ 3.67963040e+03 -1.05834448e+02 1.00000000e+00]
Vanishing point 3: [2.17609378e+03 5.63397782e+03 1.00000000e+00]
```

Part 2




```
Horizon line equation is:
0.03573213220408763x +0.9993614034613052y -25.714177462901553 = 0
```

Part 3

We use the sympy functions to calculate the camera parameters. We first write up three equations as there are three vanishing points:
vpt1.T*k_inverse.T*k_inverse*vpt2= 0
vpt1.T*k_inverse.T*k_inverse*vpt3= 0
vpt2.T*k_inverse.T*k_inverse*vpt3= 0

Based on three equations, we could solve the transformation matrix by sympy.solve().

The inputs to the function `get_camera_parameters` are the vanishing points. The function first creates symbolic variables for the focal length (f), and the x and y coordinates of the principal point (u and v). It then creates matrices for each vanishing point and for the camera matrix (K). The camera matrix is initialized as a symbolic matrix with the focal length and principal point as parameters. Next, the function computes three equations involving the vanishing points and the camera matrix. These equations represent the constraints that the vanishing points impose on the camera parameters. The function then solves these equations to obtain the values of f, u, and v that satisfy the constraints. Finally, the function creates a numpy array for the camera matrix using the computed values of f, u, and v, and returns all the camera parameters (f, u, v, K) as output.

```
U: 2014.769810487352 V: 1122.0458889828722 f: 2295.98139703213
K: [[-2.29598140e+03 0.00000000e+00 2.01476981e+03]
 [ 0.00000000e+00 -2.29598140e+03 1.12204589e+03]
 [ 0.00000000e+00 0.00000000e+00 1.00000000e+00]]
```

Part 4

```
R: [[ 0.84188993 -0.53870855 -0.0318502]
   [ 0.22053201 0.39731233 -0.89079097]
   [ 0.49253119 0.74292396 0.45329573]]
```