Computer Vision
Assignment 6: Fundamental Matrix Estimation With RANSAC
MSEE 18005

Part 1: To estimate camera projection matrix first of all set up linear equations and then set last element m34 to equal to 1 to solve the system by pseudo inverse. Using all points improve the results. Camera center is estimated by the fact that center is projected to zero at camera co-ordinates. Camera center is estimated by taking inverse of first three columns and multiplying by fourth column.

Results:

The projection matrix is

```
[[ 0.76785834 -0.49384797 -0.02339781  0.00674445]
 [-0.0852134  -0.09146818 -0.90652332 -0.08775678]
 [ 0.18265016  0.29882917 -0.07419242  1.        ]]
```

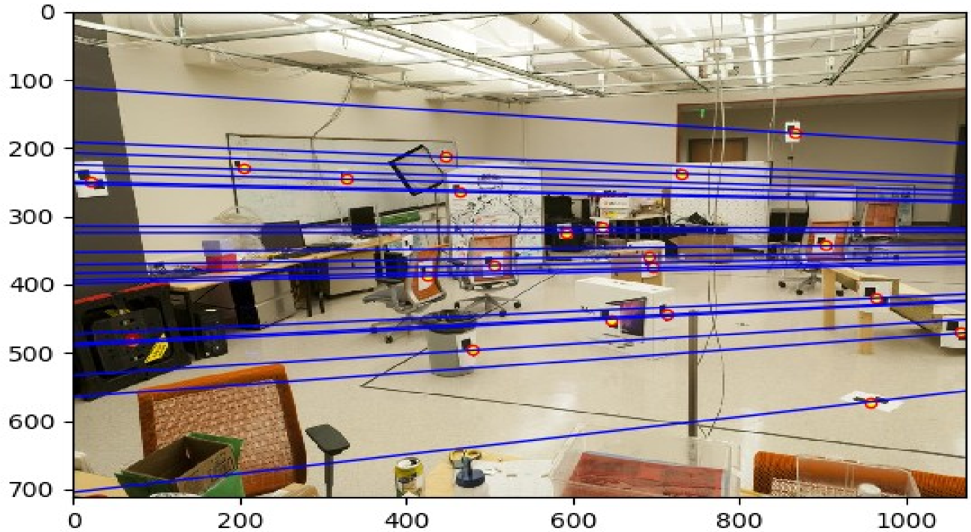
The total residual is 0.044535.

The estimated location of the camera is <-1.5126, -2.3517, 0.2827>

Part 2:

In this part fundamental matrix is estimated given the correspondences in pics taking by two cameras. depending on the translation and rotation, location of epipole can be at infinity or at finite distance. Fundamental matrix is found by setting up linear equations as described in assignment and then setting smallest singular value to zero to make the rank of the equation equal to 2.
After taking SVD, set smallest singular value to zero and then again multiply US'V to get the estimated fundamental matrix.
Normalization: Subtracting mean and then normalizing the points improves estimate.Two kind of normalization is used.
1. Normalizing by standard deviation
2. Normalization by making average norm of points equal to 2.
Standard deviation works better.
Fundamental Matrix is given by:

**[[7.29032987e-06, -9.61523855e-05, 2.42411761e-02],
[-6.07038629e-05, 1.84301264e-05, -1.91300631e-01],
[-5.42660556e-04, 2.59217380e-01, -5.20302725e+00]]**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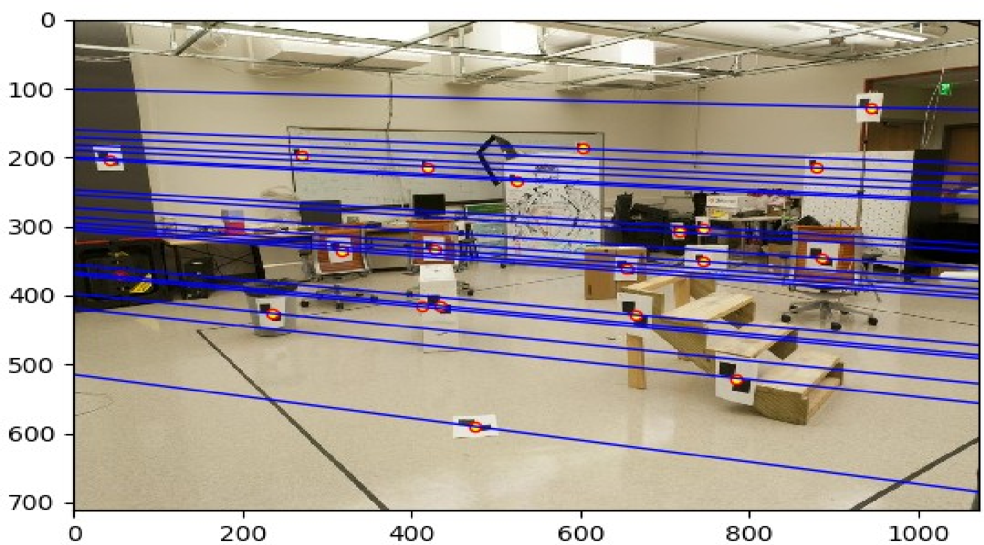
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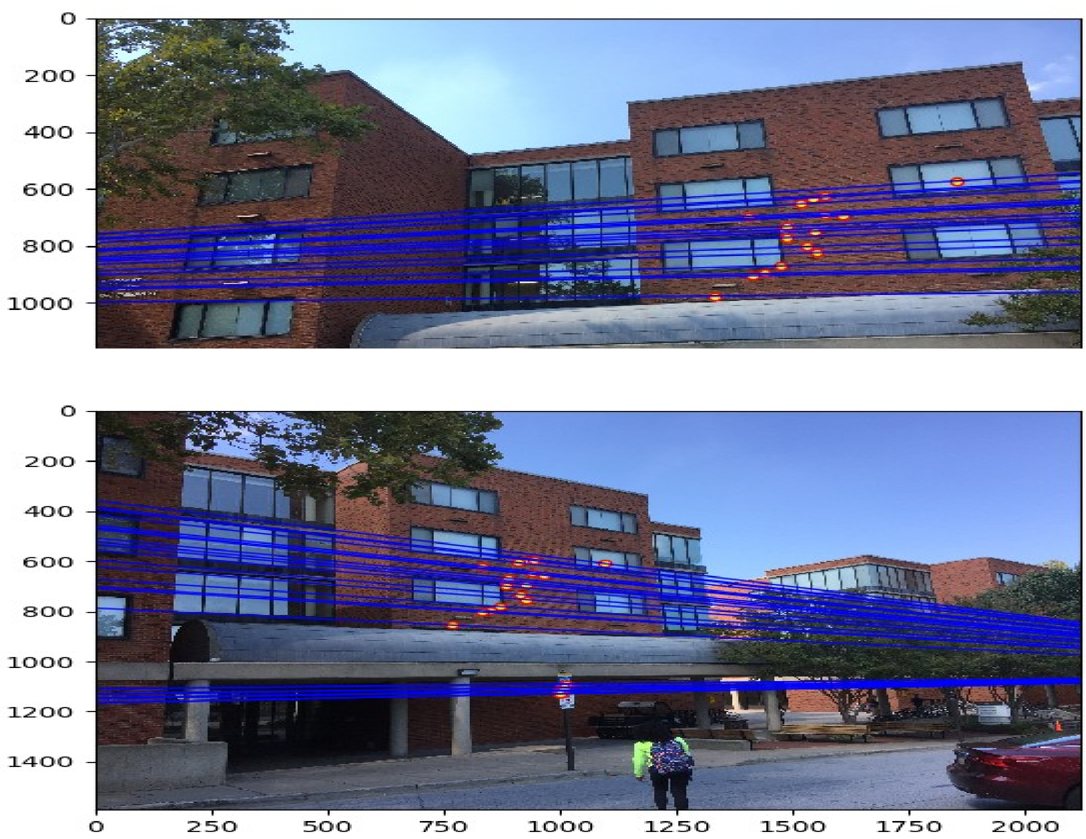
Part 3: RANSAC

In most scenarios we don't have exact correspondences, matching algorithms like SIFT and ORB are used to find the correspondences which may return false correspondences, to remove the outliers and find the better approximation.
RANSAC required to compute number of inliers to find the better solution. We know the property of Fundamental matrix that a point in one image makes a line in other image whose equation is given by fundamental matrix. This property can be written as $bFa=0$ mathematically. This definition is used to find inliers.
Normalization: Although slight improvement can be observed in part2 by using normalization but in this part normalization helps a lot to find the better fundamental matrix.

Since ground truth is not provided, so results are checked on the basis of guess about the change in the camera position which roughly gives the idea about the epipolar lines.

Results:

Visualization of Epipolar lines:

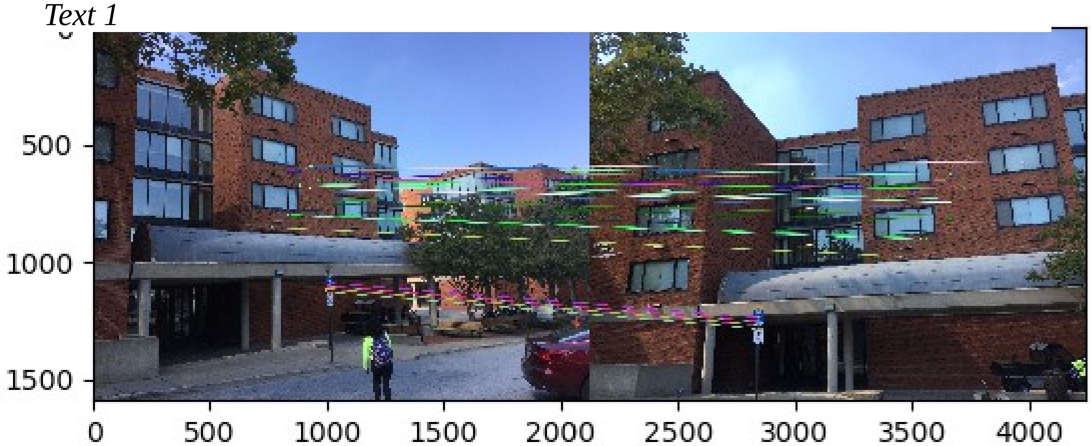


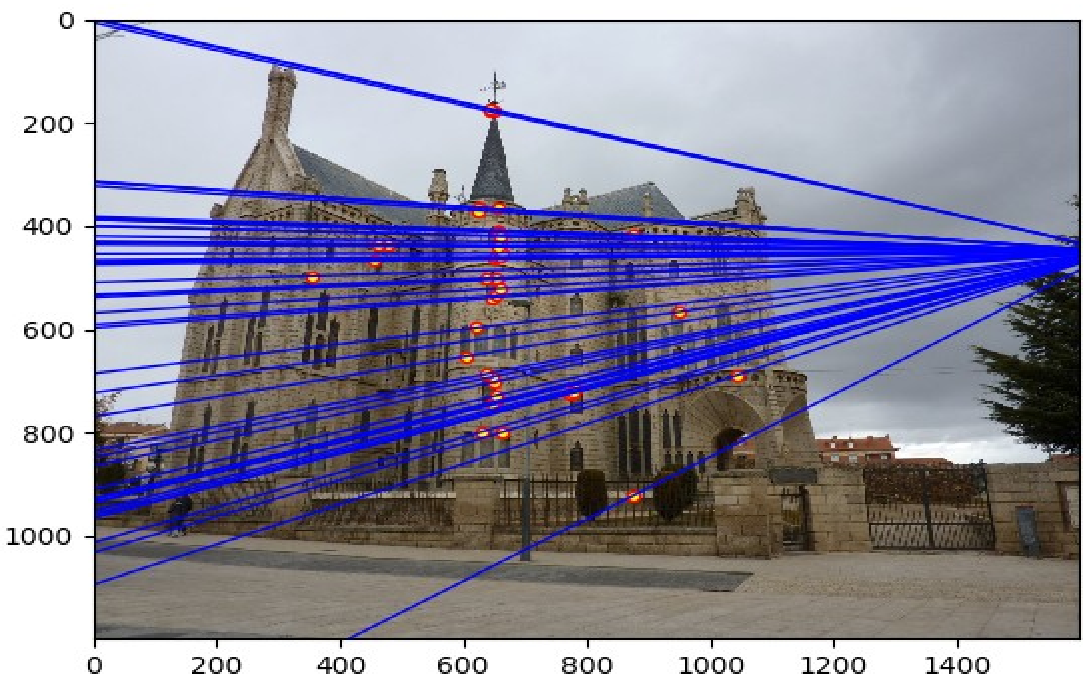
Inliers

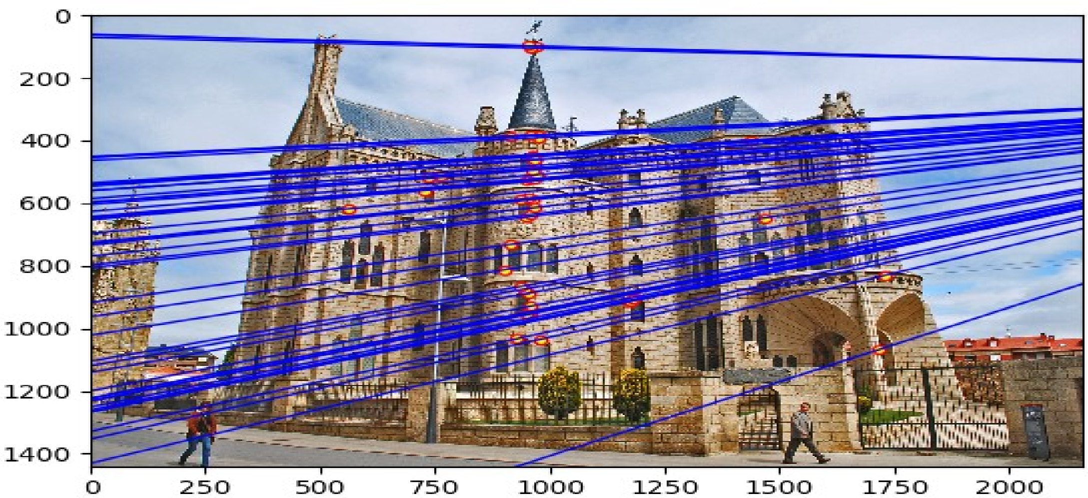
```
array([[ 5.36931321e-05, -6.92165732e-05, -1.42570419e-02],
       [-3.05545967e-05,  5.91579215e-05,  1.01925767e-02],
       [-2.04541583e-02,  2.36712732e-02,  5.14752700e+00]])
```

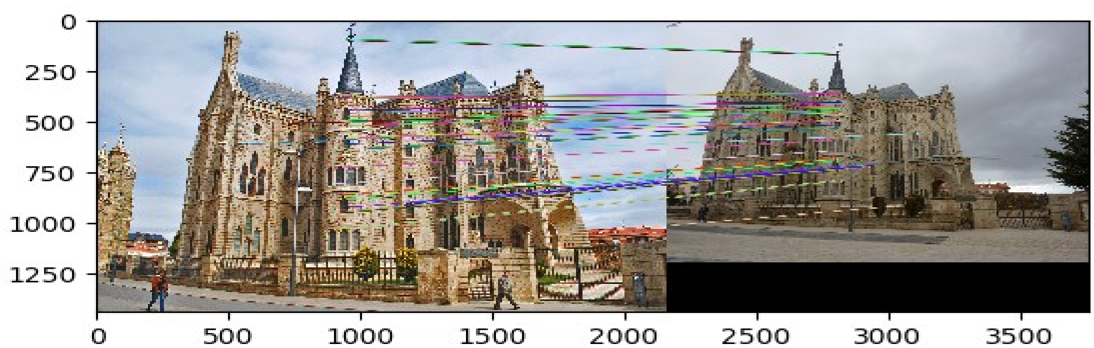
Illustration 1: Fundamental Matrix

Text 1



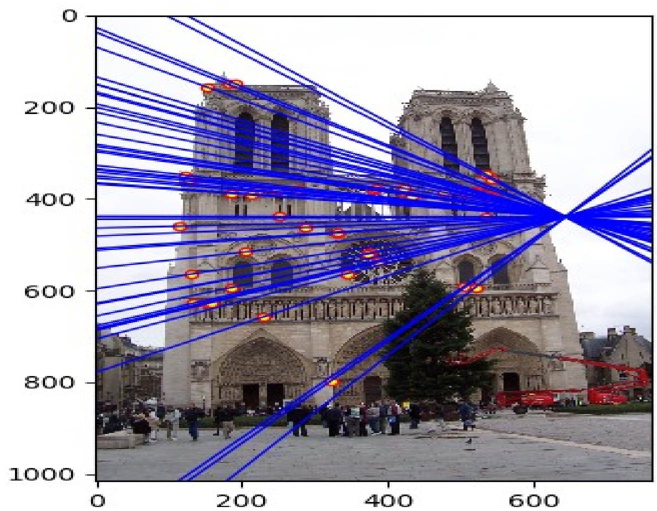







```
: array([[ 2.31252180e-06,  4.96713979e-05, -5.58442046e-02],
         [-4.84521086e-05, -1.97913822e-05,  5.83905435e-02],
         [ 4.04549099e-02, -1.51415724e-02, -1.42723426e+01]])
```

Illustration 2: Fundamental Matrix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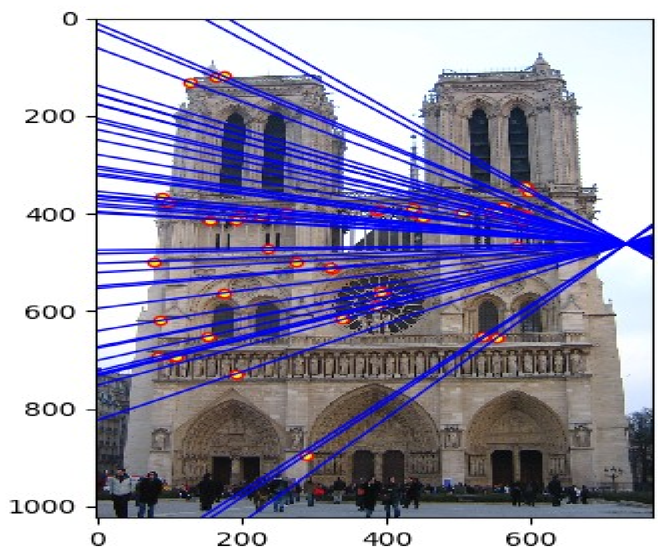
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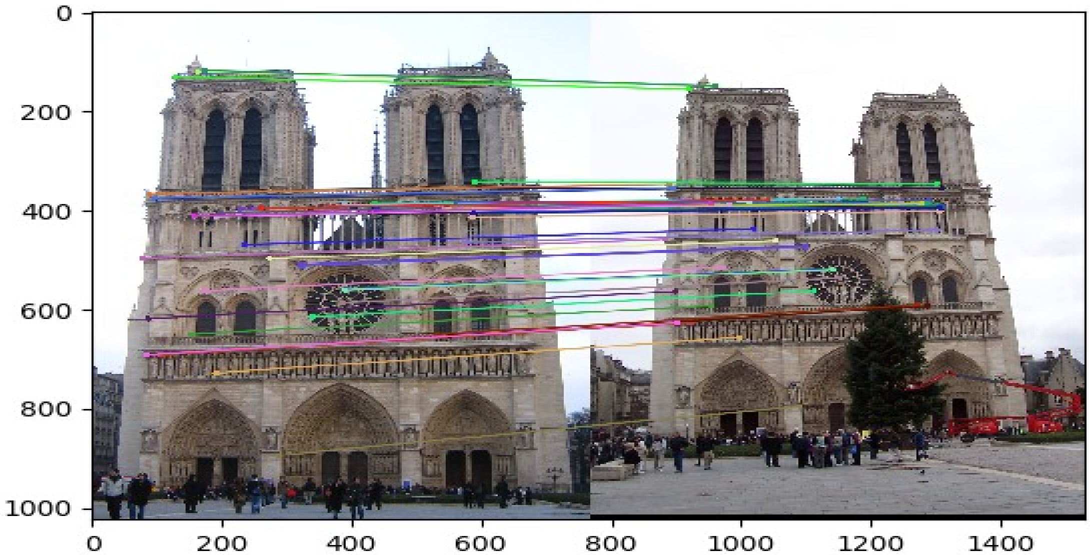
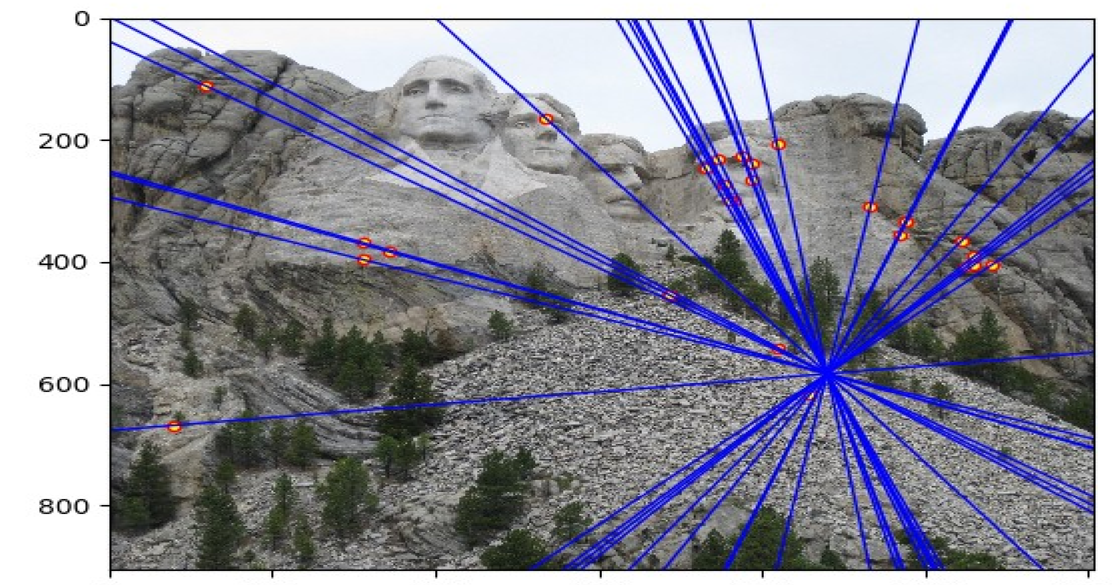
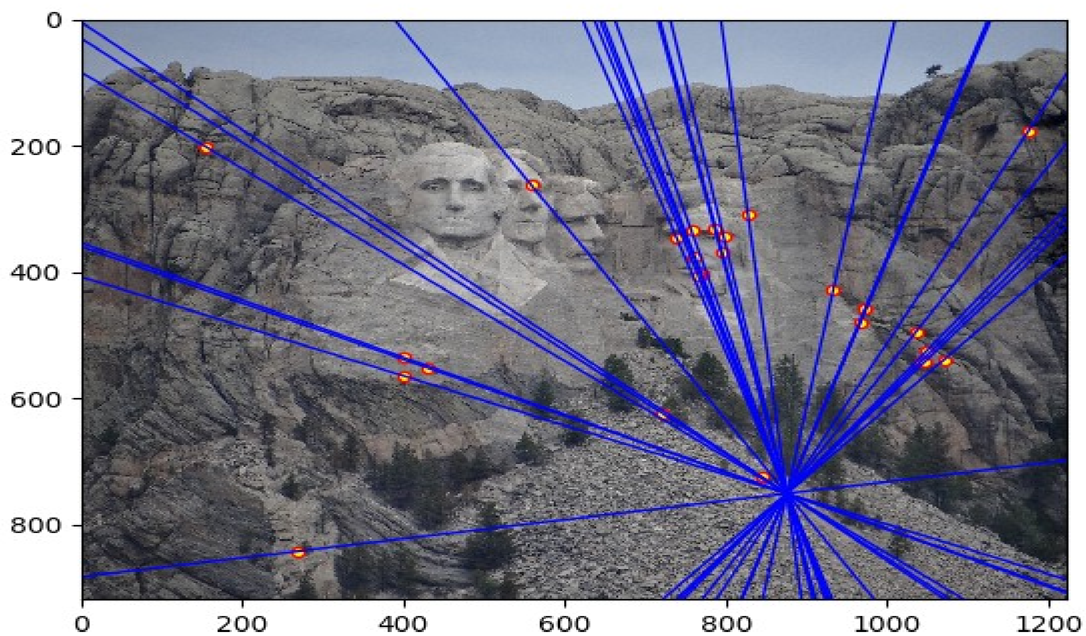
Inliers



Fundamental Matrix:

[[-7.75490918e-05, 7.453371304e-03, -5.47795281e+00],
[-7.66262992e-03, -3.98526343e-04, 1.58020521e+00],
[5.10379877e+00, -1.29661839e+00, 9.82171530e+01]])




0
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600
800
0
200
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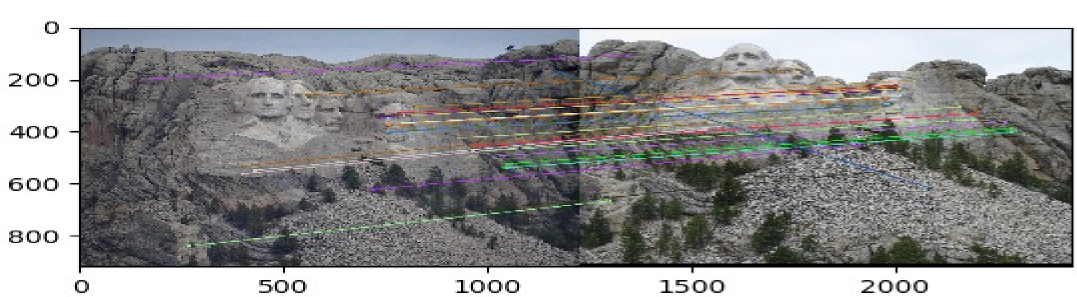
600
800
1000
1200

Inliers


0
200
400
600
800
0
500
1000
1500
2000

Fundamental Matrix:

```
[[ 1.96225030e-06,  1.01073116e-04, -7.75505408e-02],
 [-1.25123566e-04, -2.95854630e-06,  1.11740220e-01],
 [ 7.12745311e-02, -8.72172846e-02,  3.05075363e+00]]
```