Lab3: Camera Calibration

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A. Compute the projection matrix from a set of 2D-3D point correspondences by using the least-squares (eigenvector) method for each image.

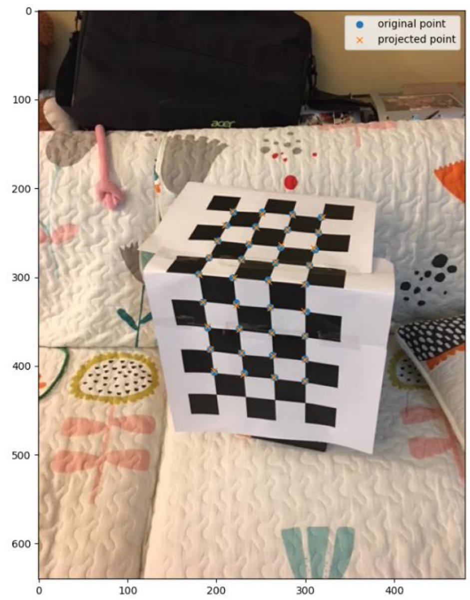
```
Projection Matrix of chessboard1:
 [[ 3.69740581e+01 -1.90846173e+01 -1.16387874e+01  1.80441840e+02]
 [ 9.48201494e-01  8.04695185e+00 -4.24853737e+01  2.97421016e+02]
 [-8.07322748e-03 -4.42700286e-02 -3.81588137e-02  1.00000000e+00]]
Projection Matrix of chessboard2:
 [[ 3.31131840e+01  3.89075129e+00 -1.11825662e+01  2.41258799e+02]
 [-3.05543797e+00  2.97120693e+00 -3.53360055e+01  2.83144884e+02]
 [ 2.31183611e-02 -3.97563075e-02 -3.71148667e-02  1.00000000e+00]]
```

B. Decompose the two computed projection matrices from (A) into the camera intrinsic matrices K, rotation matrices R and translation vectors t by using the Gram-Schmidt process. Any QR decomposition functions are allowed. The bottom right corner of intrinsic matrix K should be normalized to 1. Also, the focal length in K should be positive.

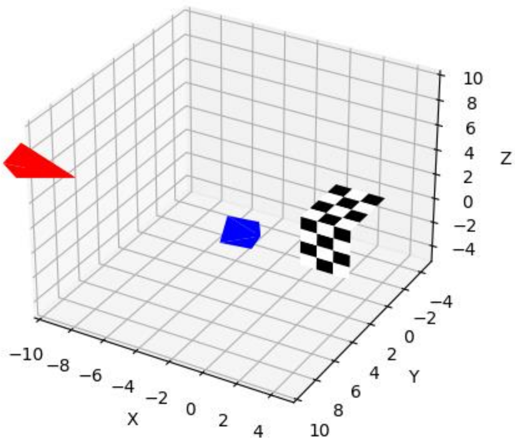
```
intrinsic matrices K, rotation matrices R, translation vectors t of chessboard_1

K:[[674.7060519    8.20409212 284.53556578]
 [  0.         637.90723826 361.17747714]
 [  0.           0.           1.        ]]

R:[[ 0.98525963 -0.17075218 -0.01035203]
 [ 0.10266648  0.63863273 -0.76263217]
 [-0.13683225 -0.75032788 -0.64674957]]

t:[[-2.59427884]
 [-1.69397874]
 [16.94889085]]
```

```
intrinsic matrices K, rotation matrices R, translation vectors t of chessboard_2

K:[[517.32333531 -13.63516056 293.73501436]
 [  0.         509.28911272 321.46561071]
 [  0.           0.           1.        ]]

R:[[ 0.85179967  0.52302648 -0.02967515]
 [-0.34843723  0.52334355 -0.77762653]
 [ 0.39118897 -0.67272195 -0.62802577]]

t:[[-1.7500035 ]
 [-1.27320666]
 [16.92113764]]
```

C. Re-project 2D points on each of the chessboard images by using the computed intrinsic matrix, rotation matrix and translation vector. Show the results (2 images) and compute the point re-projection root-mean-squared errors.

<table>
<tr><td></td><td></td></tr>
<tr><td>RMSE: 1.21</td><td>RMSE:1.25</td></tr>
</table>

D. Plot camera poses for the computed extrinsic parameters (R, t) and then compute the angle between the two camera pose vectors.



E. Print out two “chessboard.png” in the attached file and paste them on a box. Take two pictures from different angles. For each image, perform the steps above (A ~ D).

A

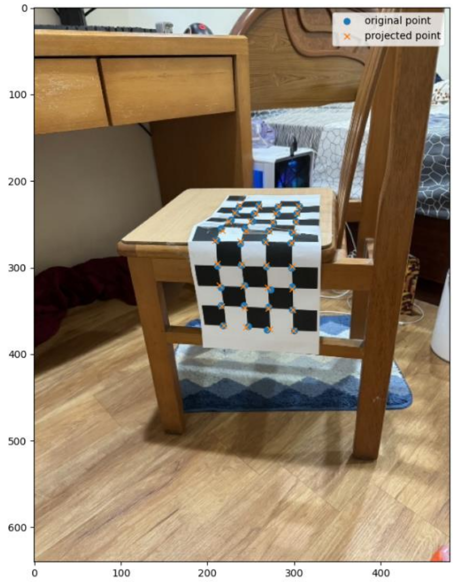
```
Projection Matrix of chessboard1:
 [[ 2.56580908e+01 -2.45281525e+01 -7.39156512e+00  2.08974211e+02]
 [-2.52162769e+00 -6.63541331e+00 -3.28436985e+01  2.69161773e+02]
 [-1.20422549e-02 -7.37634423e-02 -2.27751328e-02  1.00000000e+00]]
Projection Matrix of chessboard2:
 [[ 7.80073970e+01 -1.35564846e+01 -3.00627051e+01  1.44420783e+02]
 [-1.78034617e+00  2.83284039e+01 -9.39877951e+01  2.88434923e+02]
 [ 1.83194949e-02 -9.47476366e-02 -1.34017920e-01  1.00000000e+00]]
```

B

```
intrinsic matrices K, rotation matrices R, translation vectors t of chessboard_1

K:[[374.99661026  -2.48926072 273.33447687]
 [  0.         376.59293789 207.67973564]
 [  0.           0.           1.        ]]

R:[[ 9.88051099e-01 -1.47055217e-01 -4.61496402e-02]
 [-7.03341901e-04  2.95121604e-01 -9.55459441e-01]
 [-1.54125052e-01 -9.44075210e-01 -2.91491795e-01]]

t:[[-2.18275465]
 [ 2.08949579]
 [12.79868699]]
```

```
intrinsic matrices K, rotation matrices R, translation vectors t of chessboard_2

K:[[449.17433557 -10.86779663 247.21568121]
 [  0.         471.40244652 362.23354857]
 [  0.           0.           1.        ]]

R:[[ 0.98793094  0.15248013  0.0272446 ]
 [-0.108108    0.80473507 -0.58370723]
 [ 0.11092844 -0.57371708 -0.81150699]]

t:[[-1.40868933]
 [-0.94795088]
 [ 6.05521254]]
```

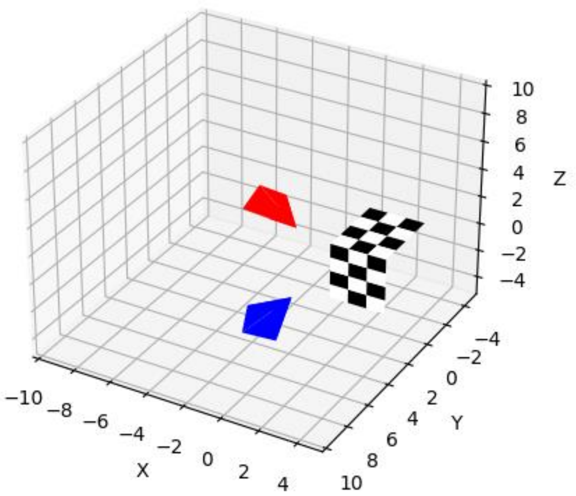
C



RMSE:1.93

RMSE:2.98

D



F. Instead of mark the 2D points by hand, you can find the 2D points in your images automatically by using corner detection, houghtransform, etc.

<table>
<tr><td></td><td></td></tr>
<tr><td>Corner detection of image 1</td><td>Corner detection of image 2</td></tr>
<tr><td colspan="2">Please run exc_corner_detection.py to generate corner detection results.</td></tr>
</table>