CMP5550 Computer Vision

Homework 2, Eren ATAS 1334129

Output parameters K, R, and T :

R:
[array([0.76612027, 0.02548563, 0.64219173]),
[0.5415398224747381, 0.5385856582803972, -0.6454921450867551],
array([-0.36232603, 0.84229701, 0.3988199])]

T:
[119.17065669 10.27060777 10.05724902]

Alpha:
1.0056888391248568

f:
98.7973578292012

K:
[[98.79735783 0. 0.]
[0. 98.79735783 0.]
[0. 0. 1.]]

Performance Results:

Results are very very close to the exact solution.
Compared to the exact solution, R is very close to the exact solution.
T_z was supposed to be 13 but it is 10.05 but it should be a negligible result. Other than that both T_x and T_y resulted as very very similar. Alpha should have been 1 but it resulted as 1.005 which is also very close. F should have been 100 but it is 98.797 which is also very close. I can say that this is a good result, everything looks very close to the exact solution.

Code Instructions:

Required Tools

1. Python 3.7 - https://conda.io/miniconda.html

Required Libraries to Install

Type in cmd or terminal:
conda install numpy

You can simply run by writing:
python HW2.py

Example Output

```
/Users/erenatas/anaconda3/envs/ComputerVisionHW2/bin/python /Users/erenatas/Documents/
Homeworks/ComputerVisionHW2/HW2.py
X:  [[75.1267 25.5095 50.5957]
 [69.9077 89.0903 95.9291]
 [54.7216 13.8624 14.9294]
 [25.7508 84.0717 25.4282]
 [81.4285 24.3525 92.9264]
 [34.9984 19.6595 25.1084]
 [61.6045 47.3289 35.166 ]
 [83.0829 58.5264 54.9724]
 [91.7194 28.5839 75.72  ]
 [75.3729 38.0446 56.7822]
 [ 7.5854  5.395  53.0798]
 [77.9167 93.4011 12.9906]
 [56.8824 46.9391  1.1902]
 [33.7123 16.2182 79.4285]
 [31.1215 52.8533 16.5649]
 [60.1982 26.2971 65.4079]
 [68.9215 74.8152 45.0542]
 [ 8.3821 22.8977 91.3337]
 [15.2378 82.5817 53.8342]
 [99.6135  7.8176 44.2678]]


x:  [[   847.    129.]
 [   245.     35.]
 [  1846.    405.]
 [   191.     64.]
 [   646.     20.]
 [   638.     92.]
 [   450.    109.]
 [   431.    100.]
 [   782.     86.]
 [   572.     93.]
 [   461.    -49.]
 [   287.    142.]
 [   533.    211.]
 [   451.    -32.]
 [   302.     87.]
 [   567.     40.]
 [   307.     89.]
 [   293.    -50.]
 [   176.     29.]
 [-12160.  -2150.]]
A:  [[ 6.36323149e+04  2.16065465e+04  4.28545579e+04  8.47000000e+02
  -9.69134430e+03 -3.29072550e+03 -6.52684530e+03 -1.29000000e+02]
 [ 1.71273865e+04  2.18271235e+04  2.35026295e+04  2.45000000e+02
  -2.44676950e+03 -3.11816050e+03 -3.35751850e+03 -3.50000000e+01]
 [ 1.01016074e+05  2.55899904e+04  2.75596724e+04  1.84600000e+03
  -2.21622480e+04 -5.61427200e+03 -6.04640700e+03 -4.05000000e+02]
 [ 4.91840280e+03  1.60576947e+04  4.85678620e+03  1.91000000e+02
  -1.64805120e+03 -5.38058880e+03 -1.62740480e+03 -6.40000000e+01]
 [ 5.26028110e+04  1.57317150e+04  6.00304544e+04  6.46000000e+02
  -1.62857000e+03 -4.87050000e+02 -1.85852800e+03 -2.00000000e+01]
 [ 2.23289792e+04  1.25427610e+04  1.60191592e+04  6.38000000e+02
  -3.21985280e+03 -1.80867400e+03 -2.30997280e+03 -9.20000000e+01]
 [ 2.77220250e+04  2.12980050e+04  1.58247000e+04  4.50000000e+02
```

```
  -6.71489050e+03 -5.15885010e+03 -3.83309400e+03 -1.09000000e+02]
 [ 3.58087299e+04  2.52248784e+04  2.36931044e+04  4.31000000e+02
  -8.30829000e+03 -5.85264000e+03 -5.49724000e+03 -1.00000000e+02]
 [ 7.17245708e+04  2.23526098e+04  5.92130400e+04  7.82000000e+02
  -7.88786840e+03 -2.45821540e+03 -6.51192000e+03 -8.60000000e+01]
 [ 4.31132988e+04  2.17615112e+04  3.24794184e+04  5.72000000e+02
  -7.00967970e+03 -3.53814780e+03 -5.28074460e+03 -9.30000000e+01]
 [ 3.49686940e+03  2.48709500e+03  2.44697878e+04  4.61000000e+02
   3.71684600e+02  2.64355000e+02  2.60091020e+03  4.90000000e+01]
 [ 2.23620929e+04  2.68061157e+04  3.72830220e+03  2.87000000e+02
  -1.10641714e+04 -1.32629562e+04 -1.84466520e+03 -1.42000000e+02]
 [ 3.03183192e+04  2.50185403e+04  6.34376600e+02  5.33000000e+02
  -1.20021864e+04 -9.90415010e+03 -2.51132200e+02 -2.11000000e+02]
 [ 1.52042473e+04  7.31440820e+03  3.58222535e+04  4.51000000e+02
   1.07879360e+03  5.18982400e+02  2.54171200e+03  3.20000000e+01]
 [ 9.39869300e+03  1.59616966e+04  5.00259980e+03  3.02000000e+02
  -2.70757050e+03 -4.59823710e+03 -1.44114630e+03 -8.70000000e+01]
 [ 3.41323794e+04  1.49104557e+04  3.70862793e+04  5.67000000e+02
  -2.40792800e+03 -1.05188400e+03 -2.61631600e+03 -4.00000000e+01]
 [ 2.11589005e+04  2.29682664e+04  1.38316394e+04  3.07000000e+02
  -6.13401350e+03 -6.65855280e+03 -4.00982380e+03 -8.90000000e+01]
 [ 2.45595530e+03  6.70902610e+03  2.67607741e+04  2.93000000e+02
   4.19105000e+02  1.14488500e+03  4.56668500e+03  5.00000000e+01]
 [ 2.68185280e+03  1.45343792e+04  9.47481920e+03  1.76000000e+02
  -4.41896200e+02 -2.39486930e+03 -1.56119180e+03 -2.90000000e+01]
 [-1.21130016e+06 -9.50620160e+04 -5.38296448e+05 -1.21600000e+04
   2.14169025e+05  1.68078400e+04  9.51757700e+04  2.15000000e+03]]
Eigenvalues:  [1.86643532e+12 6.96335505e+09 3.76581469e+09 9.78534084e+07
 4.02755565e+07 1.54910286e+07 3.21854601e+05 2.80728981e+00]

Eigenvectors:  [[ 8.95488390e-01 -3.15601673e-01 -1.83292148e-01  5.74090863e-02
/Users/erenatas/Documents/Homeworks/ComputerVisionHW2/HW2.py:124: FutureWarning:
`rcond` parameter will change to the default of machine precision times ``max(M, N)`` where M and
N are the input matrix dimensions.
   1.58381412e-01 -1.90174109e-01  1.82533067e-02  4.50171889e-03]
To use the future default and silence this warning we advise to pass `rcond=None`, to keep using
the old, explicitly pass `rcond=-1`.
  np.linalg.lstsq(AA.conj().T, b)
 [ 7.68865673e-02  7.09438607e-01 -6.27507509e-01  1.27470451e-01
   2.75175972e-01  6.07673375e-02  3.65567804e-02  4.47716148e-03]
 [ 4.02448507e-01  6.07123954e-01  6.51112683e-01 -9.61626145e-02
  -1.66926329e-01  9.07666646e-02 -1.04379321e-02 -5.36585503e-03]
 [ 9.09387759e-03  5.35164788e-03 -7.00689130e-03 -3.43373836e-02
   1.07675973e-01  2.70524458e-02 -9.89467139e-01  8.53776344e-02]
 [-1.58115837e-01  1.03876940e-01  2.56610108e-01  4.68120371e-01
   3.13568108e-01 -7.62122952e-01 -5.11462094e-03  6.40484399e-03]
 [-1.36863452e-02 -1.30785446e-01  2.78010201e-01  3.30859694e-01
   6.87067372e-01  5.64024854e-01  7.59235598e-02  2.13062499e-04]
 [-7.03632692e-02  2.38532953e-02  7.39674001e-02 -8.00884736e-01
   5.37638101e-01 -2.28456920e-01  7.94756521e-02  5.36878871e-03]
 [-1.60498745e-03  2.80838504e-04  5.64770928e-03  2.82807729e-03
  -1.71388017e-02  4.76679280e-03  8.40792738e-02  9.96278909e-01]]
0 th column of A @ eigenvec:  [   77934.55801553    27142.26589744   107541.52018814
8044.17274671
    72874.77834315    28108.94882523    34237.22146918    45325.66790865
    91523.62573663    54885.60697341    12929.17752733    25650.05108604
    31384.73998515    28241.74860316    12252.28192985    47221.32194325
    27626.11843753    13084.26796972     7546.33883354 -1349555.2872501 ]
```

```
1 th column of A @ eigenvec:  [20536.56351509 24423.44214707  1303.47982017
13283.0570725
 30858.72537284 11427.23880732 15856.18991399 20752.41034341
 28522.02604704 21162.52591605 15585.5745292  14766.10511202
  8611.12248948 22246.42309188 11682.1427733  22149.8437305
 18153.93983284 20235.95913033 15448.24760878 10289.81062646]

2 th column of A @ eigenvec:  [ -1209.61704987  -3278.14671098 -24339.25283229
-9856.3533707
  18877.71639414  -3038.0548249  -11586.83914515 -11134.6649882
   8186.22955352  -3587.61157427  14089.27022161 -25157.96347243
 -26700.22015888  16553.79454257 -10563.88698721   7426.67268598
 -13009.50960487  13526.00930212  -4338.88712744  -2049.76872007]

3 th column of A @ eigenvec:  [ 1858.58101625  2008.92398321 -1043.19523402   607.11925795
  -204.76113614  1062.43197098   988.49169433  1554.67313077
  1955.26458753  1883.09833327 -3672.55826117 -3758.18217731
 -3844.45432292 -3013.82708322   447.88787798   894.39660739
   938.51179232 -4669.50914067  1340.52615421   123.48216108]

4 th column of A @ eigenvec:  [  154.70942267   107.987296    4588.55893412  -679.9453014
   865.01628706   889.96287672   -50.75453719  -876.06151004
    48.80122369    -9.98278388 -1101.09857865 -3244.55434306
   938.13327409   550.52804507   296.67564448   495.59918951
 -1256.93077646  1172.00972255   238.76145776   378.26373364]

5 th column of A @ eigenvec:  [ 1.44865211e+02  1.08197452e+03 -9.85994317e-01
-9.20849570e+02
 -2.19051778e+03 -5.18610722e+01  5.53770247e+02  1.17146897e+03
 -7.73808424e+02  6.39492194e+02  9.91503384e+02 -9.05213530e+02
 -5.56128052e+02 -2.93283502e+02 -5.56392381e+02 -3.64116248e+02
  4.70533171e+02  1.66082472e+03  5.80495788e+02 -8.34721184e+01]

6 th column of A @ eigenvec:  [ -63.87324973  128.81120686 -162.35555613  -97.69272342
91.44815382
 -244.56079456    3.03133027   54.83654888   63.46213152   17.21097118
 -327.81005338  -43.69243985  205.72797841  -36.66079885  -53.0876804
  -58.86861762  -22.60864685  172.77309862    1.15714876   -9.12791248]

7 th column of A @ eigenvec:  [-0.77960848  0.40094419 -0.05437959  0.07952116 -0.16239902
0.12176752
  0.37780396  0.19899616  0.31139122 -0.58498471  0.15311427  0.11566338
  0.05344133  0.02824793 -0.02056642  0.27629079 -0.82638566 -0.22562742
  0.71733707 -0.03356794]

Last column is the closest to 0 which is our v.
Gamma:  0.008312812286417455
1.0
r2:
 [0.5415398224747381, 0.5385856582803972, -0.6454921450867551]

r3:
 [-0.36232603  0.84229701  0.3988199 ]

Determinant of R:  0.9998017222762016
/Users/erenatas/Documents/Homeworks/ComputerVisionHW2/HW2.py:127: FutureWarning:
`rcond` parameter will change to the default of machine precision times ``max(M, N)`` where M and
N are the input matrix dimensions.
To use the future default and silence this warning we advise to pass `rcond=None`, to keep using
the old, explicitly pass `rcond=-1`.
```

```
 solving_for_Tz_fx= np.linalg.lstsq(AA.conj().T,b)

R:
[array([0.76612027, 0.02548563, 0.64219173]), [0.5415398224747381, 0.5385856582803972,
-0.6454921450867551], array([-0.36232603,  0.84229701,  0.3988199 ])]

T:
[119.17065669  10.27060777  10.05724902]

Alpha:
1.0056888391248568

f:
98.7973578292012

K:
[[98.79735783  0.          0.        ]
[ 0.         98.79735783  0.        ]
[ 0.          0.          1.        ]]

Process finished with exit code 0
```