Jkilver3

CV Assignment 4

GEOMETRY

JACOB KILVER

1. Question 1 – Calibration

a. Finding Projections

The M matrix that was output for the set of normalized points was:

$$M = \begin{bmatrix} 0.7678 & -0.4938 & -0.0233 & 0.0067 \\ -0.0852 & -0.0914 & -0.9065 & -0.0877 \\ 0.1826 & 0.2988 & -0.0741 & 1 \end{bmatrix}$$

The projection of the last 3D point to the normalized 2D coordinates was

$$\langle u, v \rangle = \begin{bmatrix} 0.1419 & -0.4518 \end{bmatrix}$$

Finally, L2 distance between the final projected coordinated and the actual coordinate was 0.001563 or $1.569*10^{-3}$.

b. Camera Calibration

Table 1: Average L2 error for various sizes of constraining points

Iteration	K=8	K=12	K=16
1	0.9491	2.1337	1.5922
2	2.0937	1.3393	1.2362
3	6.3917	0.5525	0.6622
4	2.4446	1.2759	1.1603
5	1.3047	1.0214	1.3820
6	2.6850	1.9794	0.9188
7	2.0407	1.2996	1.1568
8	1.5077	1.4639	1.9969
9	1.6526	1.2504	1.2734
10	1.5828	0.2649	0.8545
Sum	22.6526	12.581	12.2333

There is a significant drop in the error between the k=8 case and the k=12 and k=16 cases. It seems that over constraining the equation reduces the error. However, once the equation is over constrained, the gains in error are not as pronounced. While there is a decrease in the error going from 12 to 16 points, it is only a fraction of that from going from 8 to 12 points.

The best M was

$$M = \begin{bmatrix} -2.0445 & 1.1838 & 0.3911 & 244.1 \\ -0.4562 & -0.3039 & 2.1509 & 166.2 \\ -0.0022 & -0.0010 & 0.0005 & 1 \end{bmatrix}$$

c. Camera Center

The camera center was computed to be

$$C = \begin{bmatrix} 303.1 & 307.1 & 30.41 \end{bmatrix}$$

2. Fundamental Matrix Estimation

a. Computing fundamental matrix

The fundamental matrix output using least squares was

$$F = \begin{bmatrix} -6.60 * 10^{-7} & 7.90 * 10^{-6} & -1.88 * 10^{-3} \\ 8.83 * 10^{-6} & 1.21 * 10^{-6} & 1.72 * 10^{-2} \\ -9.08 * 10^{-4} & -2.64 * 10^{-2} & 1.0 \end{bmatrix}$$

b. Reducing Rank

Using singular value decomposition to reduce the rank resulted in the fundamental matrix below. It is not very different from the original.

$$F = \begin{bmatrix} -5.35 * 10^{-7} & 7.89 * 10^{-6} & -1.88 * 10^{-3} \\ 8.83 * 10^{-6} & 1.21 * 10^{-6} & 1.72 * 10^{-2} \\ -9.08 * 10^{-4} & -2.64 * 10^{-2} & 1.0 \end{bmatrix}$$

c. Drawing Epipolar lines

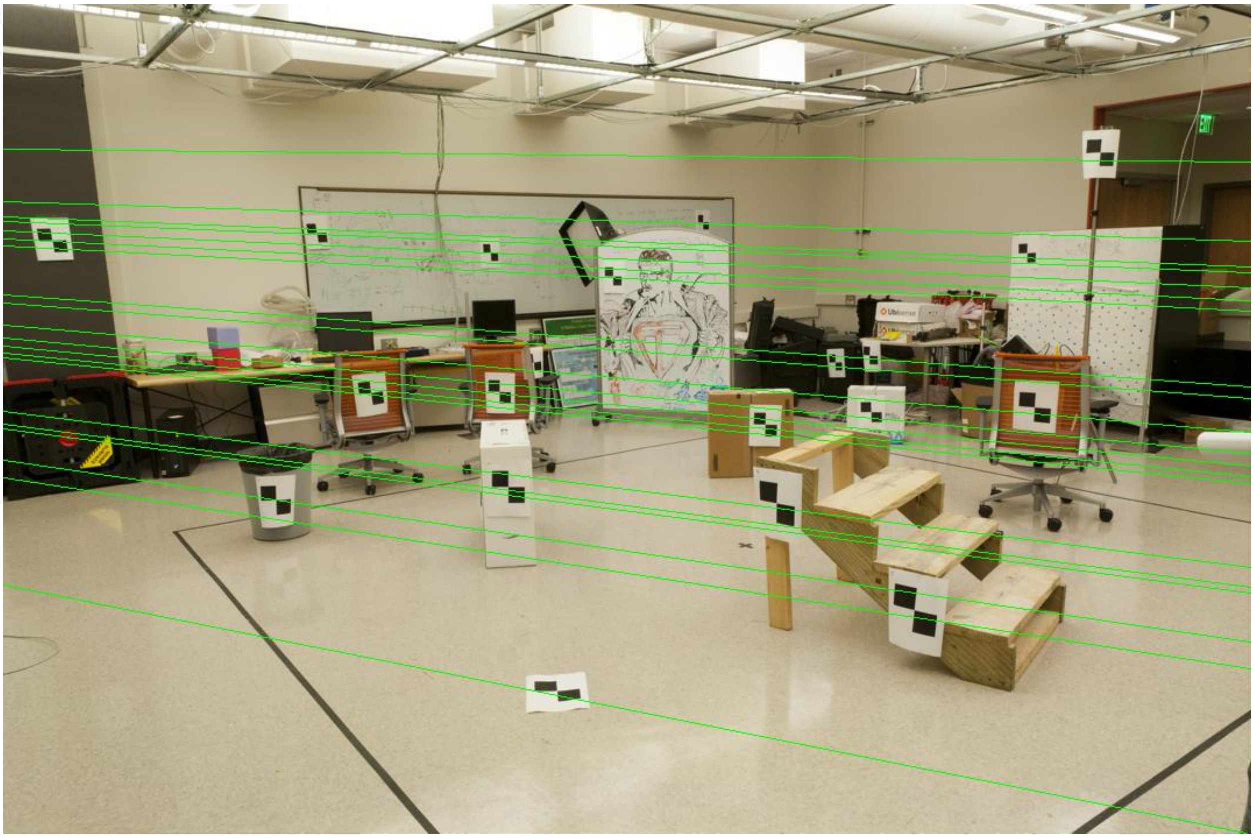

Figure 1: ps4-2-c-1.png

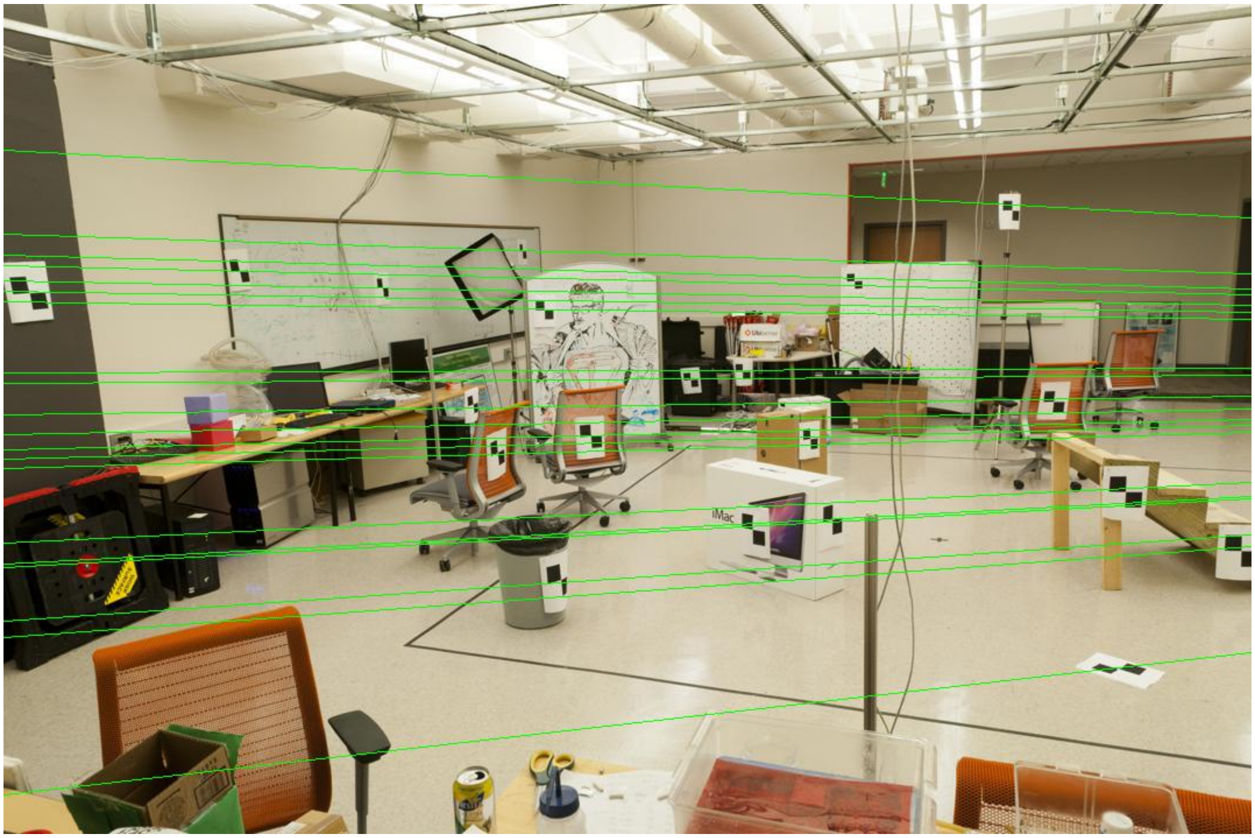

Figure 2: ps4-2-c-2.png

d. Transformation matrices

The transformation matrices were, respectively,

$$T_a = \begin{bmatrix} 0.001 & 0.0 & -0.592 \\ 0.0 & 0.001 & -0.345 \\ 0.0 & 0.0 & 1.0 \end{bmatrix}$$

$$T_b = \begin{bmatrix} 9.39 * 10^{-4} & 0.0 & -5.79 * 10^{-1} \\ 0.0 & 9.39 * 10^{-4} & -3.26 * 10^{-1} \\ 0.0 & 0.0 & 1.0 \end{bmatrix}$$

The fundamental matrix after normalizing the points was found to be

$$F = \begin{bmatrix} 5.73 & -97.0 & -3.15 \\ -60.7 & 18.5 & -233 \\ -16.1 & 194 & 1.0 \end{bmatrix}$$

After reducing the rank of the fundamental matrix using SVD, the result was

$$F = \begin{bmatrix} 6.97 & -96.9 & -3.47 \\ -60.8 & 18.5 & -233 \\ -15.5 & 194 & 0.843 \end{bmatrix}$$

e. Better epipolar lines

Using the equation in the problem write-up, the best fundamental matrix was found to be

$$F = \begin{bmatrix} 6.95 * 10^{-6} & -9.65 * 10^{-5} & 2.43 * 10^{-2} \\ -6.06 * 10^{-5} & 1.84 * 10^{-5} & -1.91 * 10^{-1} \\ 2.38 * 10^{-4} & 2.59 * 10^{-1} & 5.72 \end{bmatrix}$$

Using this fundamental matrix, the epipolar lines were recomputed as below.

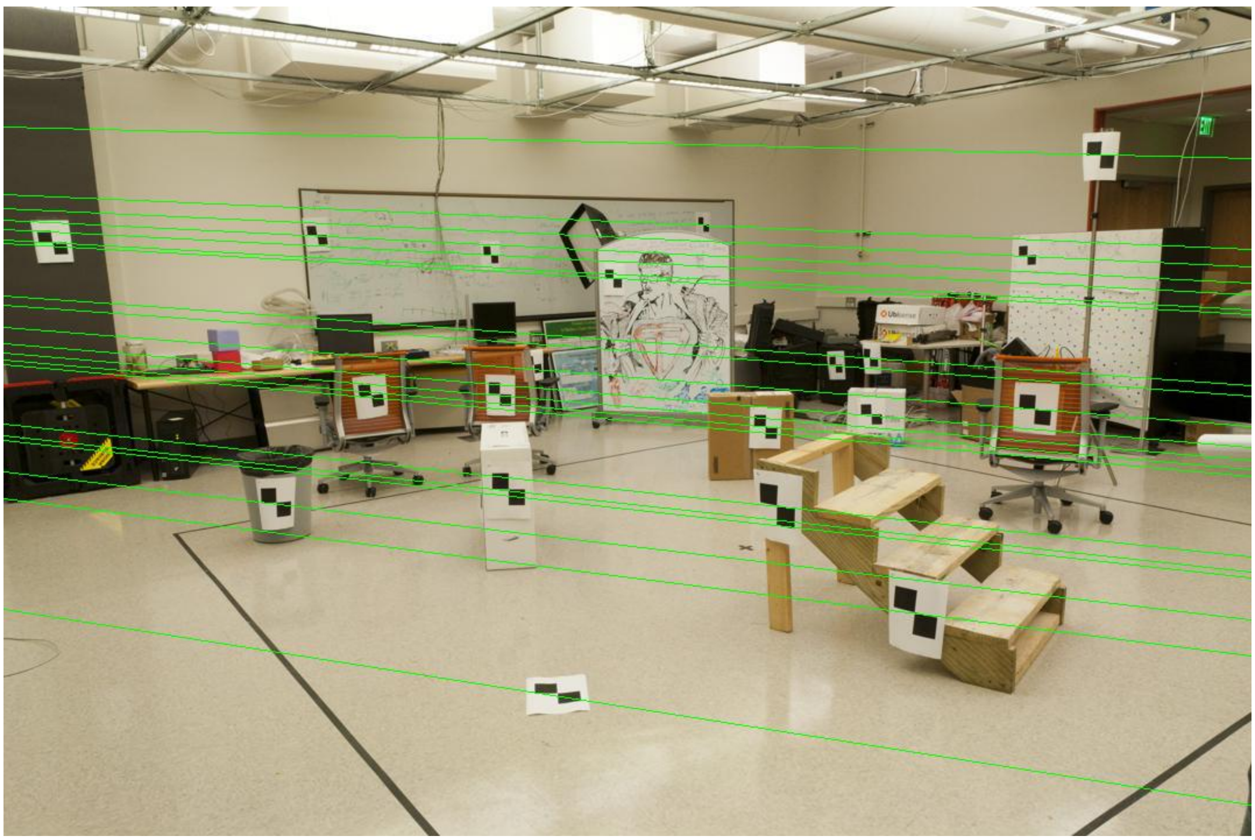

Figure 3: ps4-2-e-1.png

Figure 4: ps4-2-e-2.png