Assignment 7

Paolo Deidda (paolo.deidda@usi.ch)
Raffaele Perri (raffaele.perri@usi.ch)
`https://github.com/USI-Projects-Collection/Computer_Vision.git`

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1 Problem 1 [10 points]

1.1 Image Point Selection and Coordinates

We manually selected the ten image coordinates (u_i, v_i) corresponding to the cardinal points of the house in `house1.png` and `house2.png`. Table 1 lists the points for `house1.png`, and the points for `house2.png`.

i	u_i	v_i
1	285.0	408.0
2	414.0	267.0
3	483.0	274.0
4	609.0	61.0
5	750.0	215.0
6	575.0	482.0
7	411.0	58.0
8	680.0	337.0
9	277.0	245.0
10	734.0	393.0

i	u_i	v_i
1	286.0	444.0
2	343.0	287.0
3	377.0	292.0
4	689.0	73.0
5	807.0	249.0
6	384.0	536.0
7	340.0	57.0
8	662.0	392.0
9	283.0	269.0
10	793.0	480.0

Table 1: Image coordinates for `house1.png` and `house2.png`

1.2 Projection Matrix Estimation via DLT

Following the Direct Linear Transform (DLT) algorithm, we assembled the homogeneous system $A\mathbf{p} = 0$ from the world coordinates $\mathbf{X}_i$ (given in `coords.tex`) and the image points. Solving by SVD gave the projection matrices:

Note that although the coefficient matrix A can be of full rank (rank 12), per the assignment instructions we still take the last column of V (corresponding to the smallest singular value) as the solution vector $\mathbf{p}$, ensuring we correctly extract the nullspace direction.

$$P_1 = \begin{pmatrix} -0.137859 & -0.203597 & 0.013123 & -0.742593 \\ 0.006457 & -0.010256 & 0.235090 & -0.576638 \\ 0.000099 & -0.000136 & 0.00002853 & -0.001440 \end{pmatrix}$$

$$P_2 = \begin{pmatrix} -0.022210 & -0.265996 & 0.003833 & -0.696883 \\ 0.033914 & -0.015285 & 0.251539 & -0.615171 \\ 0.000169 & -0.000077 & 0.00000740 & -0.001334 \end{pmatrix}.$$

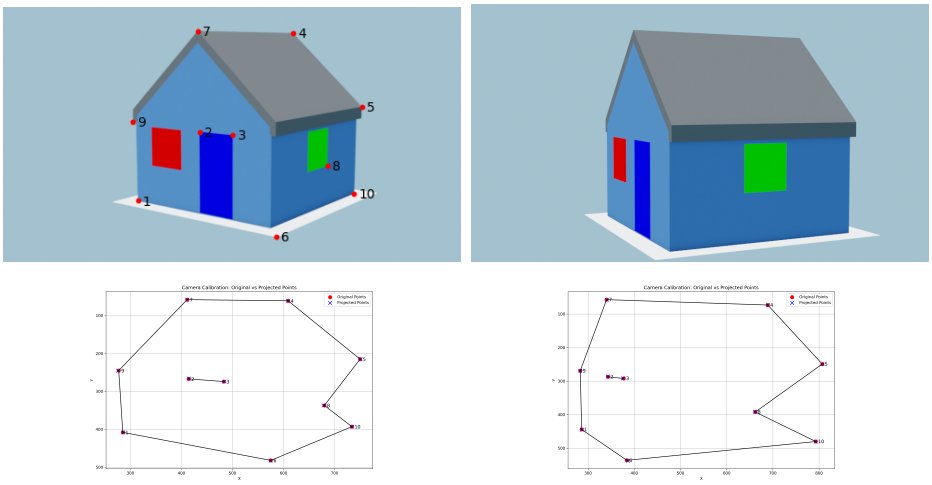

Figure 1: Reprojection of the points using the estimated projection matrices for house1 and house2.

1.3 Intrinsic and Extrinsic Parameter Recovery

Decomposing each P_j by RQ decomposition of its left 3×3 submatrix yields the intrinsic matrix K_j, rotation matrix R_j, and camera center $\tilde{C}_j$. The results are:

$$K_1 = \begin{pmatrix} 1356.21 & 0.561 & 492.43 \\ 0 & 1346.33 & 300.18 \\ 0 & 0 & 1 \end{pmatrix}, \quad R_1 = \begin{pmatrix} -0.8069 & -0.5906 & 0.0036 \\ -0.1016 & 0.1328 & -0.9859 \\ 0.5818 & -0.7959 & -0.1672 \end{pmatrix},$$

$$\tilde{C}_1 = (4.7285,\ -6.7183,\ 2.0299)^T.$$

$$K_2 = \begin{pmatrix} 1351.75 & -0.4345 & 485.33 \\ 0 & 1344.28 & 253.88 \\ 0 & 0 & 1 \end{pmatrix}, \quad R_2 = \begin{pmatrix} -0.4148 & -0.9099 & -0.0006 \\ -0.0360 & 0.0171 & -0.9992 \\ 0.9092 & -0.4145 & -0.0398 \end{pmatrix},$$

$$\tilde{C}_2 = (6.4066,\ -3.1348,\ 1.3914)^T.$$

The average reprojection errors are 0.79 px for image 1 and 0.93 px for image 2, indicating subpixel accuracy.