Assignment 4 FMAN95

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February 2024

1 Exercises

Exercise 1
The camera centers:

$$C_1 = -A_1^{-1}t_1$$
$$C_2 = -A_2^{-1}t_2$$

Same camera centers:

$$C_1 = C_2 \Leftrightarrow -A_1^{-1}t_1 = -A_2^{-1}t_2 \Leftrightarrow$$

$$A_2A_1^{-1}t_1 = A_2A_2^{-1}t_2 \Leftrightarrow A_2A_1^{-1}t_1 = t_2$$

If we multiply P with the homogenous 3D points

$$X_i = [X_i 1]$$

we will get:

$$\lambda_1 x_1 = A_1X_i + t_1 \Leftrightarrow X_i = A_1^{-1}(\lambda_1 x_1 - t_1)$$

using the Xi replacement:

$$\lambda_2 x_2 = A_2X_i + t_2 \Leftrightarrow \lambda_2 x_2 = A_2A_1^{-1}\lambda_1 x_1 - A_2A_1^{-1}t_1 + t_2$$

$$\lambda_2 x_2 = A_2A_1^{-1}\lambda_1 x_1 - t_2 + t_2$$
$$\lambda_2 x_2 = A_2A_1^{-1}\lambda_1 x_1$$

Therefore:

$$H = A_2A_1^{-1}$$

Exercise 3
5 Degrees of freedom, 5 minimal number of correspondences and 5 number or RANSAC iterations.

Exercise 2.

$$H = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix}$$ has 8 degrees of freedom as it's generalized with $h_{33} = 1$

Need 4 point correspondences as each gives two equations. → Solves for 8 unknowns. (4 random points)

10% is wrong. → Probability of selecting inlier = $0,9^4$

$$n \geq \frac{\log(1-0,98)}{\log(1-0,9^4)} \approx 3,66$$ so 4 iterations will be enough

2 Robust Homography Estimation and Stitching

Computer Exercise 1
Using the OpenCV SIFT feature I found 535 matches in total between the two images, see figure 1. With 100 iterations of the RANSAC algorithm the best solution got 279 inliers with the H matrix: $\begin{bmatrix} 0.6 & 0.8 & -67.4 \\ -0.8 & 0.6 & 167.5 \\ -7.1 & -1.1 & 1 \end{bmatrix}$

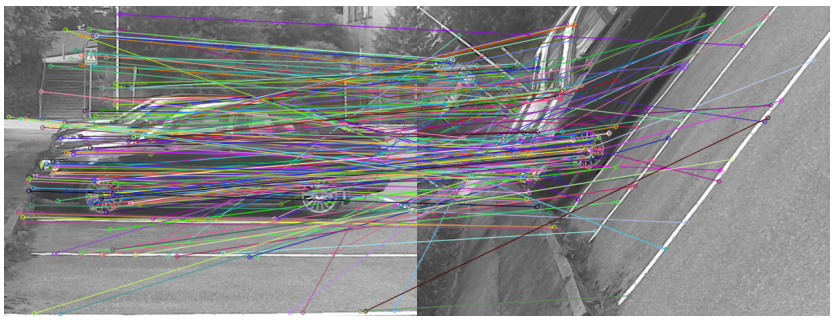

Figure 1: SIFT from the two images. Shows the 200 best matches.

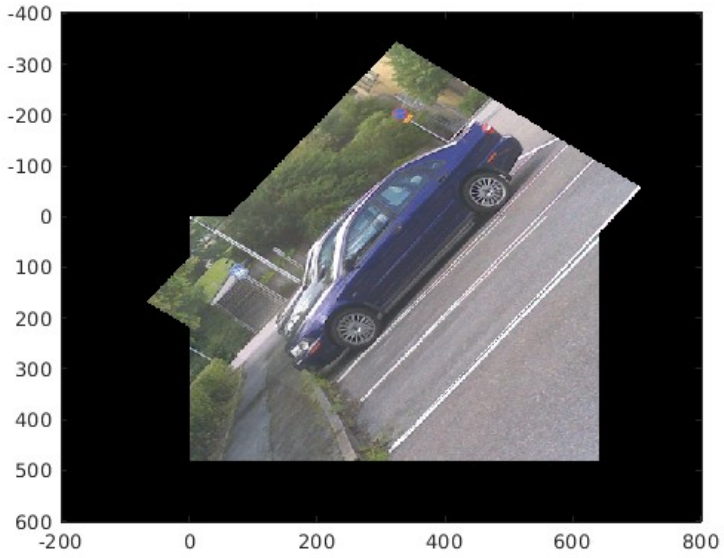

Figure 2: The panorama

3 Robust Essential Matrix Estimation

Computer Exercise 2
The maximum number of inliers I got was 1465. See figure 2 and 3 for the distances between the reprojected image points and the normalized image points. See figure 4 for reconstruction from the best 3D points found.

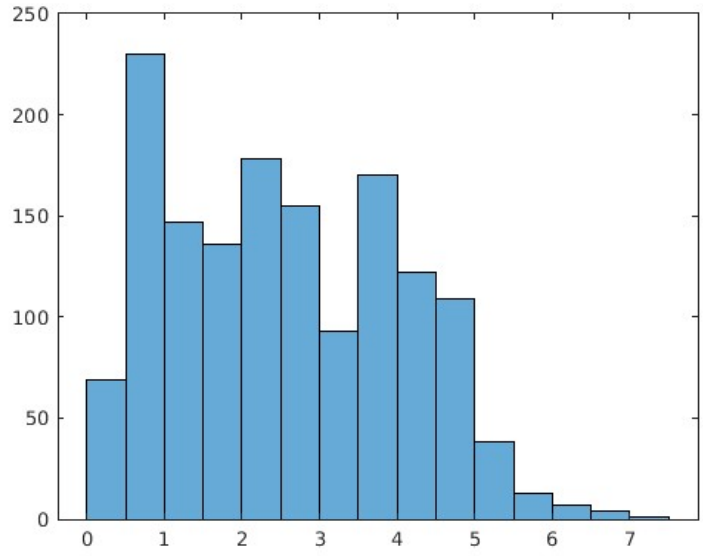

Figure 3: Histogram for the distances between image points and their projected image points for image1.

4 Calibrated Structure from Motion and Local Optimization

Computer Exercise 3
With the first value of gammak being 10^{-10} the individual residuals can be seen in figure 6 plotted in a histogram.
RMS = 0.34.

Computer Exercise 4
the individual residuals can be seen in figure 7 plotted in a histogram.
RMS = 0.24

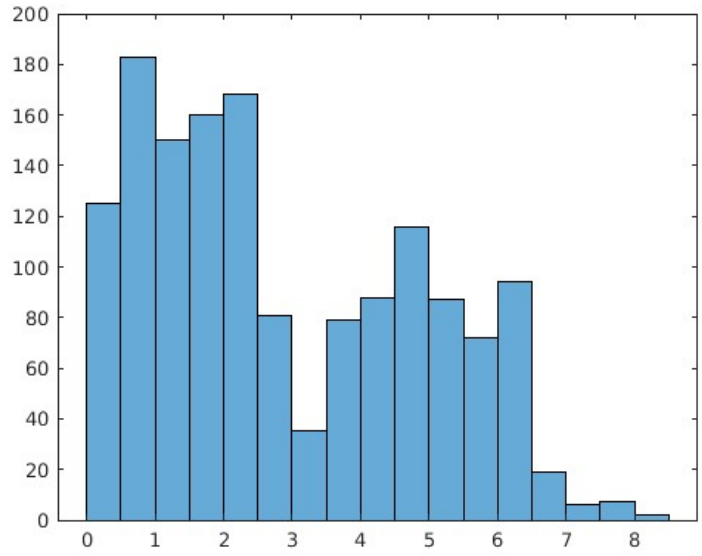

Figure 4: Histogram for the distances between image points and their projected image points for image1.

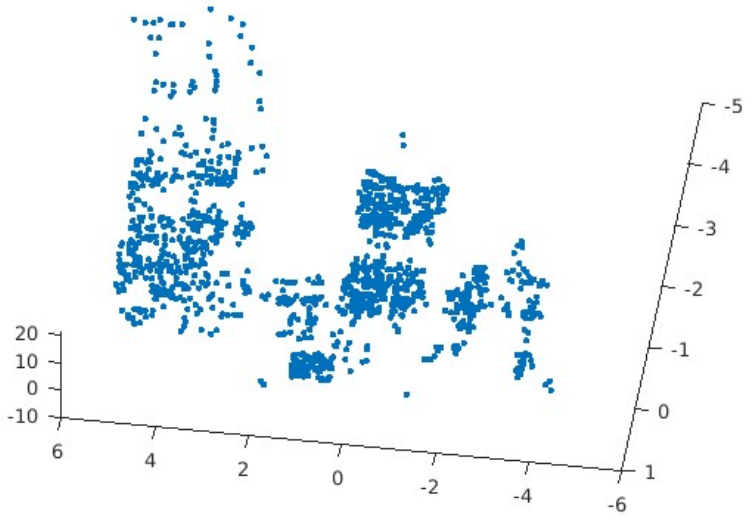

Figure 5: The reconstruction using the 3D points with the most inliers.

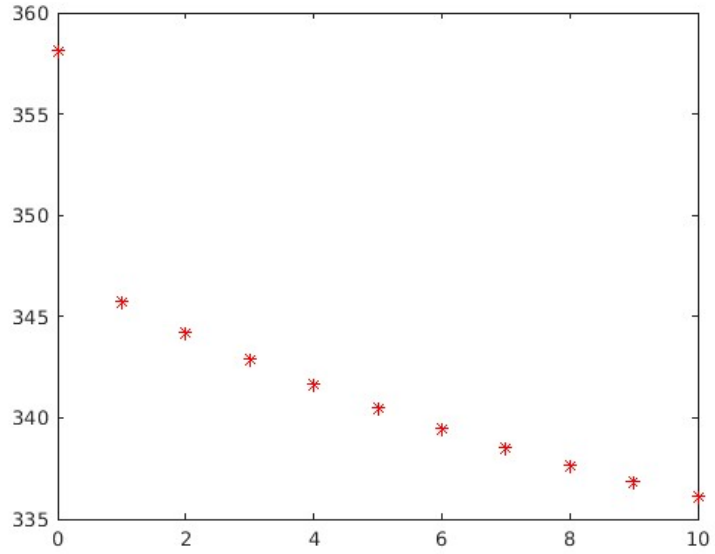

Figure 6: Error plotted against iterations. Computer exercise 3

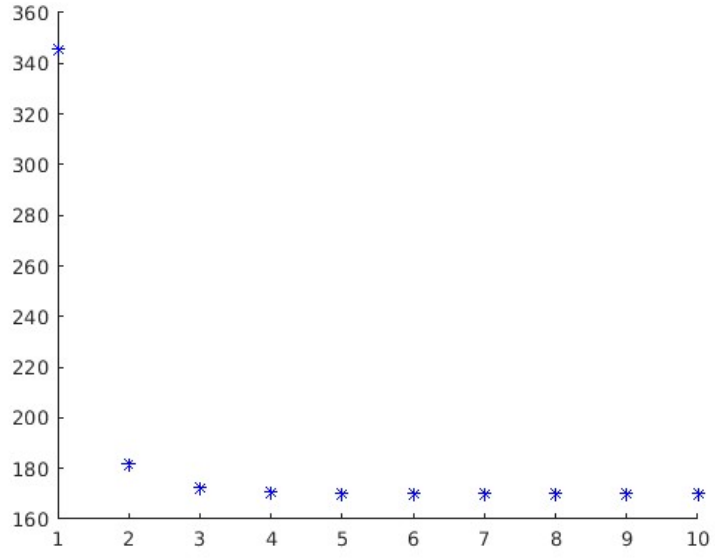

Figure 7: Error plotted against iterations. Computer exercise 4