Datorseende Assignment 4

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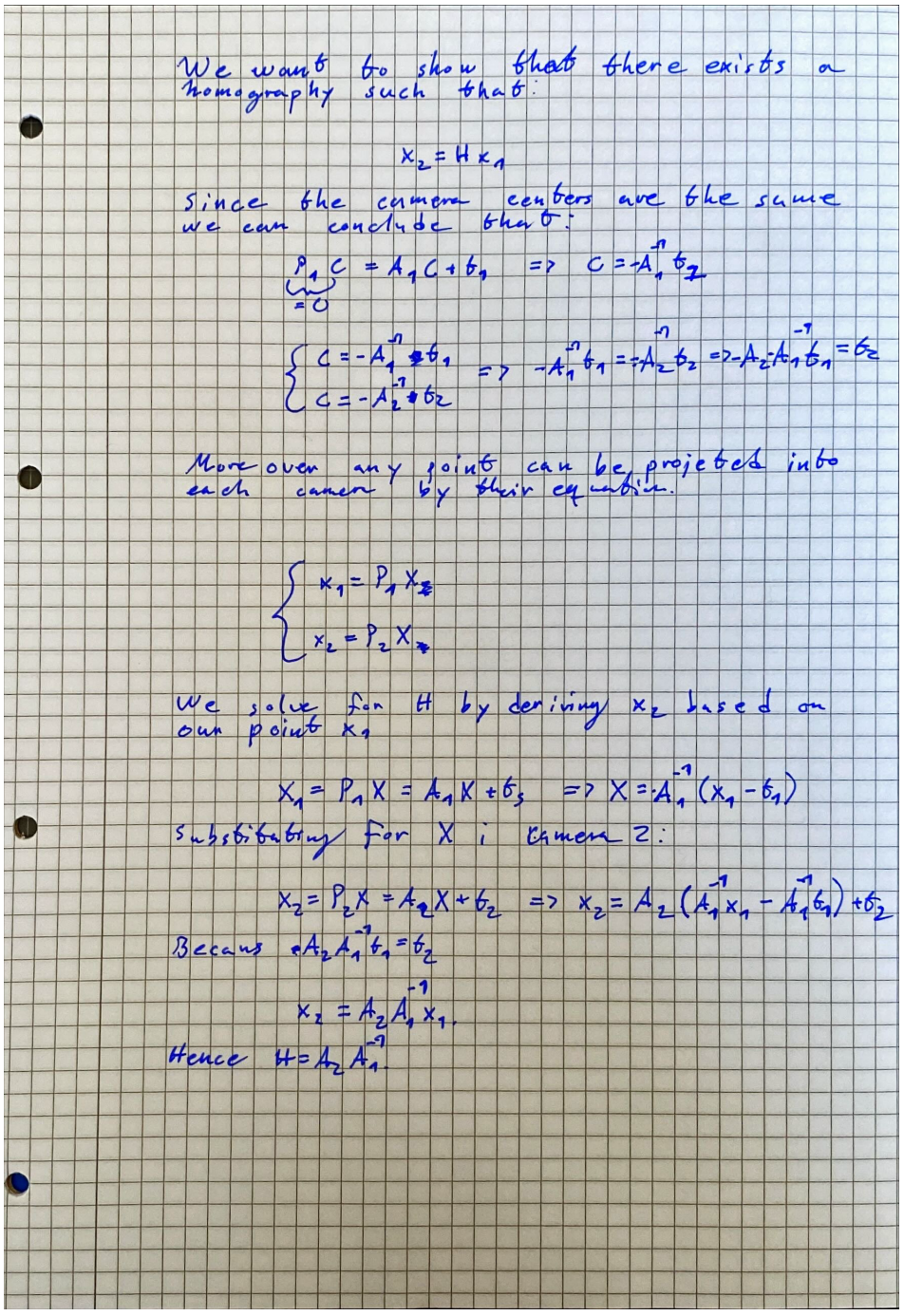
1 Introduction

Solution to the exercises in assignment three of spring term course in Computer Vision 2024.

2 Robust Homography Estimation and Stitching

2.1 Exercise 1



We want to show that there exists a homography such that:

$$x_2 = H x_1$$

Since the camera centers are the same we can conclude that:

$$\underbrace{P_1 C}_{=0} = A_1 C + b_1 \quad \Rightarrow \quad C = -A_1^{-1} b_2$$

$$\begin{cases} C = -A_1^{-1} b_1 \\ C = -A_2^{-1} b_2 \end{cases} \Rightarrow -A_1^{-1} b_1 = -A_2^{-1} b_2 \Rightarrow -A_2 A_1^{-1} b_1 = b_2$$

Moreover any point can be projected into each camera by their equation.

$$\begin{cases} x_1 = P_1 X \\ x_2 = P_2 X \end{cases}$$

We solve for H by deriving x_2 based on our point x_1

$$x_1 = P_1 X = A_1 X + b_1 \quad \Rightarrow X = A_1^{-1}(x_1 - b_1)$$

substituting for X in camera 2:

$$x_2 = P_2 X = A_2 X + b_2 \quad \Rightarrow x_2 = A_2\left(A_1^{-1} x_1 - A_1^{-1} b_1\right) + b_2$$

Because $-A_2 A_1^{-1} b_1 = b_2$

$$x_2 = A_2 A_1^{-1} x_1.$$

Hence $H = A_2 A_1^{-1}$.

2.2 Exercise 2

With a 3x3 homography, the degrees of freedom are 8. For a 3x3 homography I need 4 point correspondences to determine the homography.

$$(1 - 0.9^4)^n \leq 0.02 \quad \rightarrow \quad n \geq 3.66$$

I need at least 4 samples to produce an outlier free sample.

2.3 Computer Exercise 1

I found 204 matches between the two images(947 and 865 SIFT features in image a and b respectively). 139 inliners were identified.

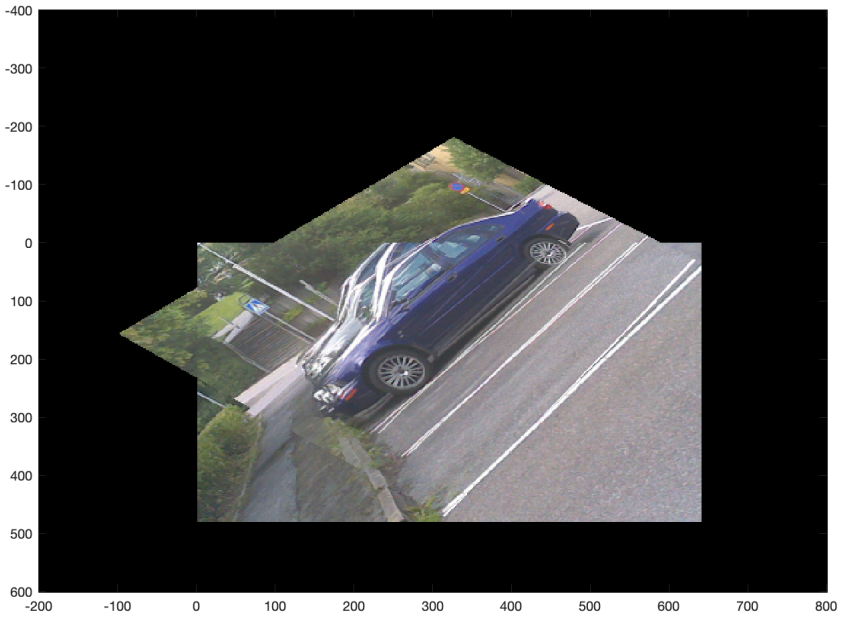


Figure 1: Images A and B transformed into a common coordinate system

3 Robust Essential Matrix Estimation

3.1 Exercise 3

For a 3x3 essential matrix consisting of a rotation (3 degrees of freedom) and a translation (2 degrees of freedom), the total degrees of freedom are 5. By using a minimum solver we can construct the essential matrix with 5 point correspondences.

$$(1 - 0.9^5)^n \leq 0.02 \quad \rightarrow \quad n \geq 4.38$$

I need at least 5 samples to produce an outlier free sample.

3.2 Computer Exercise 2

I found 1465 inliners, with an RMS of 10.3411.

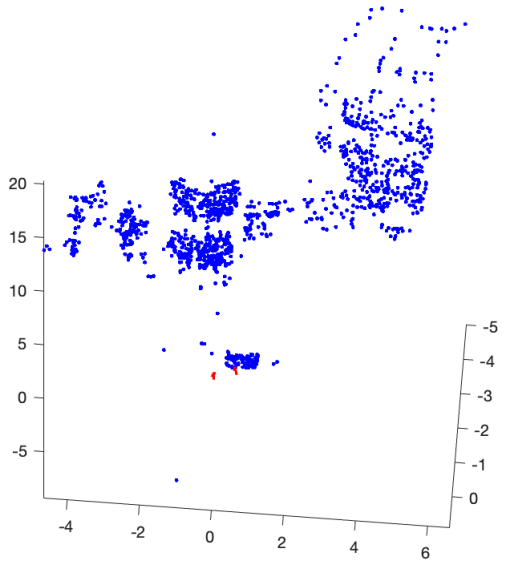


Figure 2: Reconstruction of Pictures

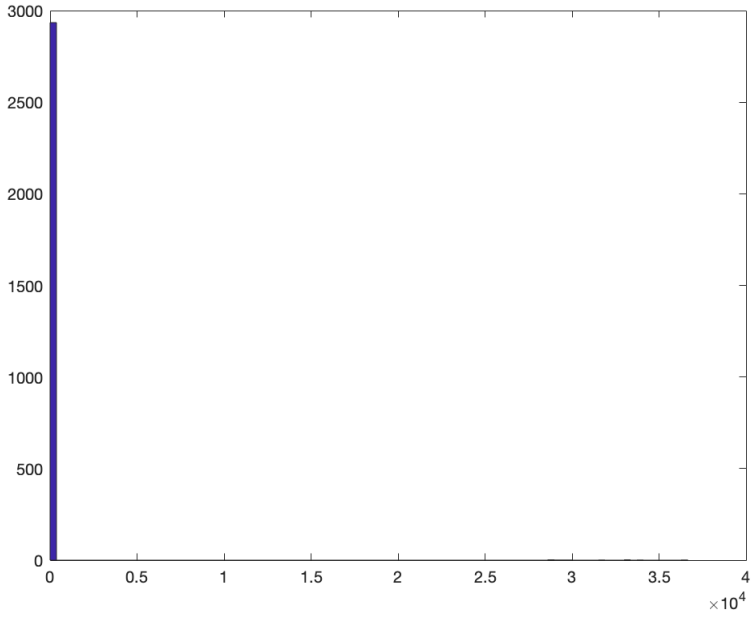


Figure 3: Histogram

4 Calibrated Structure from Motion and Local Optimization

4.1 Computer Exercise 3

I get an RMS of 0.6095.

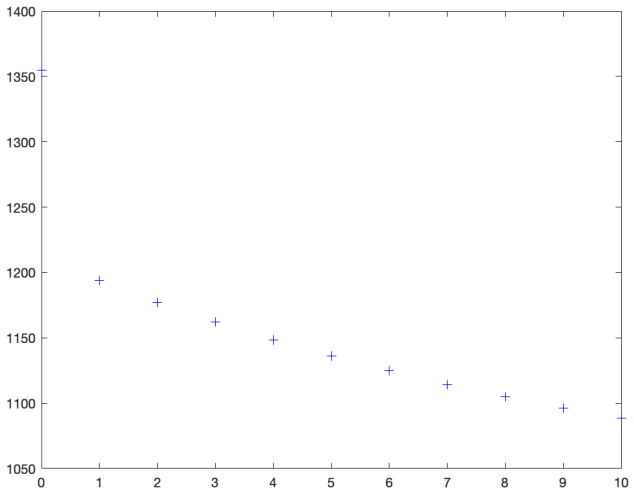


Figure 4: Objective value vs. iteration steepest descent

4.2 Computer Exercise 4

I get an RMS of 0.2556.

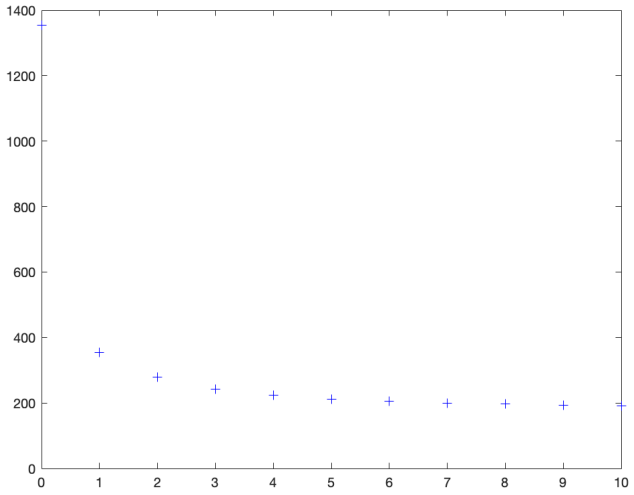


Figure 5: Objective value vs. iteration Levenberg-Marquardt