



Multiple View Geometry: Exercise Sheet 7

Prof. Dr. Daniel Cremers, David Schubert, Mohammed Brahimi
Computer Vision Group, TU Munich

<http://vision.in.tum.de/teaching/ss2019/mvg2019>

Exercise: June 26th, 2019

Part I: Theory

The following exercises should be **solved at home**. Writing down your answer will help you present and discuss the answer during the tutorial.

1. Coimages of Points and Lines

Suppose p_1, p_2 are two points on the line L . Let x_1, x_2 be the images of the points p_1, p_2 , respectively, and let l be the coimage of the line L .

Furthermore suppose L_1, L_2 are two lines intersecting in the point p . Let x be the image of the point p and let l_1, l_2 be the coimages of the lines L_1, L_2 , respectively.

Draw a picture and convince yourself of the following relationships:

(a) Show that

$$l \sim \hat{x}_1 x_2, \quad x \sim \hat{l}_1 l_2,$$

(b) Show that for some $r, s, u, v \in \mathbb{R}^3$,

$$l_1 \sim \hat{x}u, \quad l_2 \sim \hat{x}v, \quad x_1 \sim \hat{l}r, \quad x_2 \sim \hat{l}s$$

where \sim means equivalence in the sense of homogeneous coordinates.

2. Rank Constraints

Let x_1 and x_2 be two image points with projection matrices Π_1, Π_2 . Show that the rank constraint

$$\text{rank} \begin{pmatrix} \hat{x}_1 \Pi_1 \\ \hat{x}_2 \Pi_2 \end{pmatrix} \leq 3$$

ensures that x_1 and x_2 are images ($/$ projections) of the same three-dimensional point X .

3. Projection and Essential Matrix

Suppose two projection matrices $\Pi = [R, T]$ and $\Pi' = [R', T'] \in \mathbb{R}^{3 \times 4}$ are related by a common transformation H of the form

$$H = \begin{bmatrix} I & 0 \\ v^\top & v_4 \end{bmatrix} \in \mathbb{R}^{4 \times 4} \quad \text{where } v = \begin{pmatrix} v_1 \\ v_2 \\ v_3 \end{pmatrix}.$$

That is, $[R, T]H \sim [R', T']$ are equal up to scale.

Show that Π and Π' give the same essential matrices ($E = \hat{T}R$ and $E' = \hat{T}'R'$) up to a scale factor.

Part II: Practical Exercises

This exercise is to be solved **during the tutorial**.

Epipolar lines

1. Download the package `ex7.zip` from the website. Extract the images `batinria0.pgm` and `batinria1.pgm`. Their corresponding camera calibration matrices can be found in the file `calibration.txt`.
2. Show the two images with matlab and select a point in the first image. You can use the command `[x,y]=ginput(n)` to retrieve the image coordinates of a mouse click.
3. Think about where the corresponding epipolar line l_2 in the second image could be.
4. Now compute the epipolar line $l_2 = Fx_1$ in the second image corresponding to the point x_1 in the first image. To this end you will need to compute the fundamental matrix F between the two images.
(Use the calibration data from the file `calibration.txt`.)
Visualize the epipolar line in the second image.
5. Test your program for different points x_1 . What do you observe?
6. *Bonus: Determine the best matching point on the epipolar line via normalized cross correlation.*