



Multiple View Geometry: Exercise Sheet 6

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<http://vision.in.tum.de/teaching/ss2018/mvg2018>

Exercise: June 6th, 2018

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. The essential matrix $E = \hat{T}R$ has the singular value decomposition $E = U\Sigma V^T$. Let $R_Z(\pm\frac{\pi}{2})$ be the rotation by $\pm\frac{\pi}{2}$ around the z -axis.

Show the following properties:

- (a) $\hat{T} \in so(3)$ (i.e. \hat{T} is a skew-symmetric matrix)
- (b) $R \in SO(3)$ (i.e. R is a rotation matrix)

Hint: Use the equalities: $\hat{T} = UR_Z(\pm\frac{\pi}{2})\Sigma U^T$ and $R = UR_Z(\pm\frac{\pi}{2})^T V^T$.
(see Chapter 5, Slide 9)

2. Consider the matrices $E = \hat{T}R$ and $H = R + Tu^T$ with $R \in \mathbb{R}^{3 \times 3}$ and $T, u \in \mathbb{R}^3$. Show that the following holds:

- (a) $E = \hat{T}H$
- (b) $H^T E + E^T H = 0$

3. Let $F \in \mathbb{R}^{3 \times 3}$ be the fundamental matrix for the cameras C_1 and C_2 . Show that the following holds for the epipoles e_1 and e_2 :

$$Fe_1 = 0 \quad \text{and} \quad e_2^T F = 0$$

Part II: Practical Exercises

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

1. Download the package `ex6.zip` from the website and extract the images `batinria0.tif` and `batinria1.tif`.
2. **Get the 2D coordinates of corresponding point pairs:** Show the first image and mark at least 8 points. You can retrieve the pixel coordinates of mouse clicks with the command `[x, y] = ginput(gcf)`. Then show the second image and click at the corresponding points in the same order. Again you can get the pixel coordinates with `ginput`. Now you should have the 2D coordinates of corresponding point pairs.
3. **Implement the 8-point algorithm** from the lecture and run it with these point pairs. To this end, you have to transform the coordinates. The intrinsic camera matrices are:

$$K1 = \begin{pmatrix} 844.310547 & 0 & 243.413315 \\ 0 & 1202.508301 & 281.529236 \\ 0 & 0 & 1 \end{pmatrix}$$

$$K2 = \begin{pmatrix} 852.721008 & 0 & 252.021805 \\ 0 & 1215.657349 & 288.587189 \\ 0 & 0 & 1 \end{pmatrix}$$

4. Reconstruct the depths of the points as described in Chapter 5 on Slides 17 and 18.

Hints:

- The file `additional_information.txt` provides $K1$ and $K2$
- Use `kron` and `reshape`
- It might occur that one of the matrices U or V of the SVD of E has a determinant less than zero. In this case, determine the SVD of $-E$.