Exercise 2

Deadline: December 09, 2016

Please send your solutions to threedcv@dfki.uni-kl.de

Theory

A homography is a projective mapping between two planes that preserves lines. The exercises involve some computations in Matlab. You find the needed intrinsic parameters of the camera $(\alpha_x, \alpha_y, x_0, y_0, s)$ and the homographies H_i in the file homography.m.

1. Homography definition

In the lecture a homography was introduced as $h : \mathbb{P}^2 \mapsto \mathbb{P}^2$. Define it for $h : \mathbb{P}^n \mapsto \mathbb{P}^n$. How many degrees of freedom has the homography?

2. Relative rotation estimation from a homography

A homography between two images taken with the same camera can be used to compute the relative rotation R_{rel} (in case the camera has only undergone a rotation between the shots). The relative rotation tells how the camera was placed between the two shots. For the following tasks assume a camera with given intrinsic parameters $(\alpha_x, \alpha_y, x_0, y_0, s)$. Use Matlab as a calculator and explain your intermediate steps.

1. A homography H_1 was computed from arbitrary feature matches between 2 images. The camera has undergone a perfect rotation. Compute R_{rel}.

2. A homography H_2 was computed from arbitrary feature matches between 2 images. The camera was rotated manually. Compute R_{rel}. Check, if R_{rel} fulfills the properties of a rotation matrix. What is causing this problem? Provide a correct R_{rel}.

3. Camera pose estimation from a homography

A homography between a plane in the world coordinate system and a camera image can be used to compute rotation R and translation t of the camera. Assume a camera with given $(\alpha_x, \alpha_y, x_0, y_0, s)$ and a homography H_3, that was computed from the corners of a (fully visible) chessboard. The chessboard lies in the xy-plane of the world coordinate system centered around the origin. Compute R and t. Use Matlab as a calculator and explain your intermediate steps.

4. Camera pose estimation from a homography

1. Illustrate the meaning of $t = -RC$ in a camera pose $[R|t]$, i.e. from where to where does this vector point? Hint: What is linked by $[R|t]$? Try applying $[R|t]$ to the origin of the world.

2. The third element of t in exercise 3 might be negative. What does this mean in this particular case (consider the location of the chessboard corners)? Why can this happen?

5. Line preservation of homographies

Let x_1, x_2, $x_3 \in \mathbf{P}^2$ be three points on a line. Show that a homography H preservers this property. Hint: Use the implicit definition of a line $ax + by + c = 0$, thus $lx_i = 0$ with $l = (a, b, c)$.

Good Luck!