Exercise 2

Deadline: December 15, 2017

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

Theory

1. Homography definition

In the lecture a planar 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 does it have?

2. Line preservation

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

Implementation

For the following tasks, you find the required intrinsic parameters of the camera $(\alpha_x, \alpha_y, x_0, y_0, s)$ and the homographies H_i in the file `data/ex2.mat`.

3. 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} when the camera has undergone a pure rotation, i.e. no translation between the shots. The relative rotation tells how the camera was placed between the two shots. Homography H_1 (from `ex2.mat`) was obtained after a pure rotation whereas H_2 was computed after manually rotating the camera. Write a function `compute_relative_rotation` that:

1. loads a homography from `ex2.mat`
2. computes R_{rel} and prints it to the console
3. checks wheter R_{rel} fulfills the properties of a rotation matrix
4. if necessary, corrects R_{rel} and prints the new rotation matrix to the console

Apply `compute_relative_rotation` to H_1 and H_2. Why does the rotation matrix computed from H_2 need correction?

4. Camera pose estimation from a homography

1. 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. Homography H_3 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. Write a function `compute_pose` to determine R and t from H_3 and print them to the console.
2. In your report, 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.

3. The third element of t in exercise 4.1 might be negative. What does this mean in this particular case (consider the location of the chessboard corners)? Why can this happen?

Remark:

1. Make sure your code executes the tasks above sequentially by simply calling `python main.py` (include `ex2.mat` alongside `main.py` in your `.zip` file).

Good Luck!