Computer Vision, fall 2019

Exercise 1, 11.9.2019

EX 1.1

a) Use homogeneous coordinates and give the matrix representations of the following transformation groups: translation, Euclidean transformation (rotation + translation),similarity transformation (scaling + rotation + translation), affine transformation, projective transformation.
b) What is the number of degrees of freedom in these transformations?
c) Why is the number of degrees of freedom in a projective transformation less than the number of elements in a 3×3matrix?
d) Find the point where the homogenous lines l_1 and l_2 join when

    a. l1 = [3,1,1] and l2 = [-1,0,1]
    b. l1 = [1,0,1] and l2 = [3,0,1]

    Hint: the (3x1) homogenous point vector x must satisfy both l_1'x = 0 and l'_2x = 0. In other words, it should be orthogonal to both l_1 and l_2.

Ex 1.2.

In this exercise we'll start learning how to use Matlab for computer vision tasks. If you haven't used Matlab before, please watch the tutorial from https://youtu.be/NSSTkkKRabI

1. Read image GOPR1515 06102.jpg into Matlab. Find out the size of the image. The images are presented with a 3-dimensional matrix. What does each of the three 2-dimensional matrices contain? What do you see when you show them?
2. Image has been taken with and wide-angle lens camera (GoPro 3). File Calib_Results.m contains its calibration parameters in a form easily read into Matlab and Calib_Results.m the data in text form. Image has been taken with and wide-angle lens camera (GoPro 3). Define the calibration matrix K for this image.

Ex 1.3.

Using the calibration file Calib_Results.m, and equations given in slide 42 (Forsyth, Ponce p. 18) form the camera matrix P and compute image coordinates (x,y) for an object point X (0, 0, 1, 1) when the origin of the world coordinate frame is

- exactly 3 meters away from the camera center, i.e. t = (0, 0, 3), and the camera is completely aligned with the world coordinate axis
- exactly 5 meters away from the camera center, i.e. t = (0, 0, 5), and the camera is completely aligned with the world coordinate axis

- t = (0.5, 1, 3) and the camera otherwise aligned with the world coordinate axis but it has only turned 20 degrees to the left
- t = (15, 1, 3) and the camera otherwise aligned with the world coordinate axis but it has only turned 20 degrees to the left

Discuss the phenomena behind the results.

Ex 1.4.

Singular value decomposition (SVD) is one of the most useful matrix decomposition methods, especially for overdetermined systems of equations. Two good tutorials are provided in http://16720.courses.cs.cmu.edu/lec/svd.pdf and http://web.mit.edu/be.400/www/SVD/Singular_Value_Decomposition.htm. Go through the computations. The tutorials explain the method well and correctly, but there are some erroneous mechanical computations in the latter one, so please go it through carefully.

Please note that there are e.g. the following two errors in the MIT tutorial:

1) erroneous characteristics, a square root character has been replaced by a letter "Ö"
2) an error in the sign of the eigenvector values when using the second eigenvalue, they should be x1=0.82, x2 = -0.58 for the first eigenvalue and x1 = 0.58, x2 = 0.82 for the second

Decompose the matrix A following the SVD procedure

$$A=\begin{bmatrix} 5 & 1 & 0 & 0 \\ 7 & 0 & 1 & 0 \\ 0 & 0 & 12 & 1 \end{bmatrix}.$$

Report the U, V and S matrices.