Laboratory Session 5: Omnidirectional Vision

In this laboratory session we will implement a non-linear projection model which is able to deal with any radially symmetric system. In particular we are going to implement the Kannala-Brandt empirical model in order to perform stereo 3D reconstruction through linear triangulation of rays and bundle adjustment.

Goals of the assignment:

1. Understand the non-linear Kannala-Brandt projection and unprojection model
2. Triangulate 3D points from a fish-eye stereo using planes.
3. Adapt classical algorithms using rays for taking advantage of calibrated non-linear projection models.

Evaluation of the assignment:

The resulting work will be shown by presenting the obtained results in the following Laboratory session, and the code will be submitted through the ADD (Moodle).

1. Provided data

Two acquisitions of the stereo fisheye system Realsense T265 in two different poses.

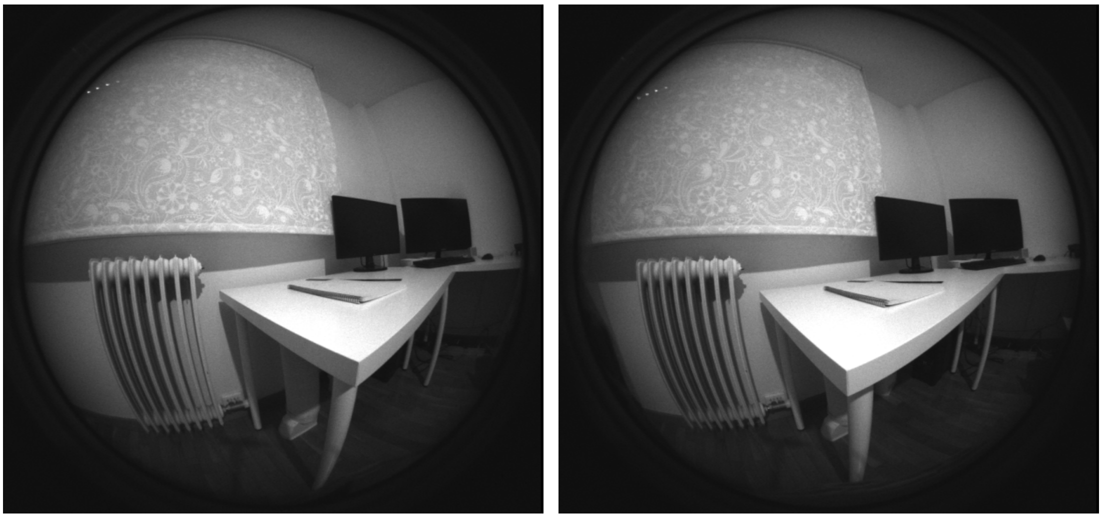

Fig 1. Left and right views in pose A

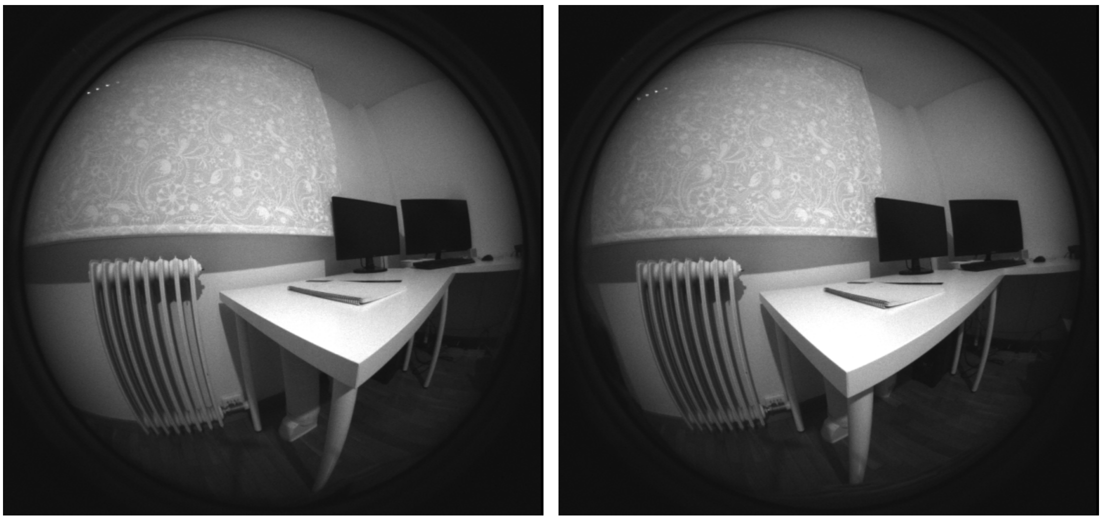

Fig 2. Left and right views in pose B

The intrinsic calibration of both cameras: `K_1.txt`, `K_2.txt`, `D1_k_array.txt`, `D2_k_array.txt;`
K matrix for the focal length and principal point and D for the polynomial coefficients such that [k1,k2,k3,k4] = D[0:4] and $d(\theta) = \theta + k_1\theta^3 + k_2\theta^5 + k_3\theta^7 + k_4\theta^9$.

The extrinsic calibration of the stereo system: i.e. the rotation and the translation of the cameras with respect to a reference system W located between the two cameras. `T_wc1.txt`, `T_wc2.txt`

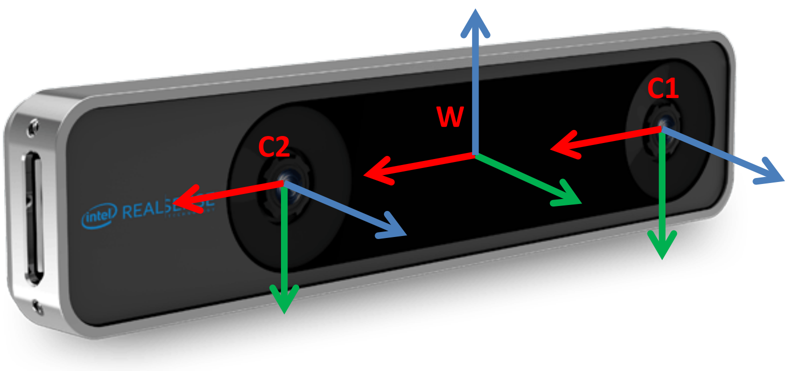

Fig 3. References of the stereo system

The ground truth data for the pose transformation `T_wAwB_gt.txt.`

A rough estimation of the pose transformation `T_wAwB_seed.txt` for using as seed in the bundle adjustment.

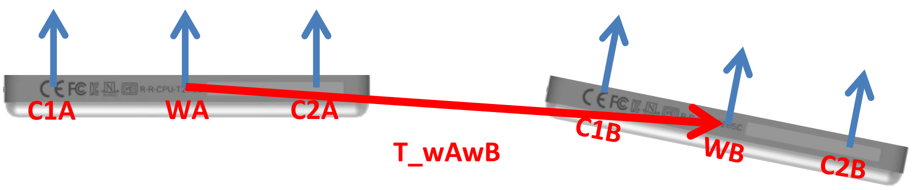

Fig 4. Pose transformation scheme

The point matches of each image are given in files (1 column per point, 3 rows defining the point coordinates in pixels): `x1.txt` , `x2.txt` for pose A and `x3.txt`, `x4.txt` for pose B.

2. 3D reconstruction from 3D calibrated stereo using fish-eyes.

3.1 Implement the Kannala-Brandt projection and unprojection model.
Solution: For verifying that the implementation is correct you can check both models on these virtual points:

$$\mathbf{X}_1 = \begin{pmatrix} 3 \\ 2 \\ 10 \\ 1 \end{pmatrix}, \quad \mathbf{X}_2 = \begin{pmatrix} -5 \\ 6 \\ 7 \\ 1 \end{pmatrix}, \quad \mathbf{X}_3 = \begin{pmatrix} 1 \\ 5 \\ 14 \\ 1 \end{pmatrix}$$

$$\mathbf{u}_1 = \begin{pmatrix} 503.387 \\ 450.1594 \\ 1 \end{pmatrix}, \quad \mathbf{u}_2 = \begin{pmatrix} 267.9465 \\ 580.4671 \\ 1 \end{pmatrix}, \quad \mathbf{u}_3 = \begin{pmatrix} 441.0609 \\ 493.0671 \\ 1 \end{pmatrix}$$

3.2 Implement the triangulation algorithm based on planes and compute the 3D points by triangulation for pose A (`x1.txt`, `x2.txt`,`T_wc1.txt`, `T_wc2.txt`). Notice that, since we have a calibrated stereo system, the pose of the cameras with respect the center of the camera system is known and scaled.

3. Bundle adjustment using calibrated stereo with fish-eyes (optional)

3.1. Modify the `resBundleAdjustment` function from laboratory session 3 for computing the residuals on 4 fish-eye lenses. Consider as optimization parameters, the pose transformation `T_wAwB` and the 3D coordinates of the points. Consider as calibration know parameters `K_1`, `K_2`, `D_1k`, `D2k` and also the extrinsic parameters of the stereo system `T_wc1` and `T_wc2`.

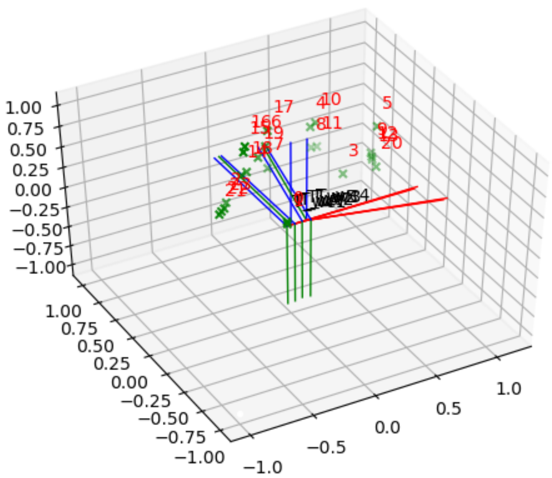

Fig 5. 3D reconstruction after bundle adjustment.