PURDUE ENGINEERING

CE597–Digital Photogrammetric Systems

Fall 2020

LYLES SCHOOL OF CIVIL ENGINEERING

LAB 3: SINGLE PHOTO RESECTION (USING PROJECTIVE TRANSFORMATION & QUATERNIONS)

Due date: November 16th 2020

Objective:

Determine the Exterior Orientation Parameters (EOPs) of a single photo using estimated projective transformation coefficients and quaternions

Given:

1. The image coordinates of the calibration targets as measured/provided in Lab 1 for images 65_09_20180803.jpg, 65_10_20180803.jpg, 65_14_20180803.jpg, and 65_18_20180803.jpg;
2. Estimated Interior Orientation Parameters from Lab 1 (principal point coordinates and distortion parameters); and
3. Estimated ground coordinates of the different targets in the calibration test field from Lab 1.

Single Photo Resection (SPR)

The objective of single photo resection is to determine the position of the perspective center and the orientation of the image coordinate system (i.e., the EOPs for a given image) relative to the ground coordinate system. In the previous lab, the SPR solution was determined using the Collinearity equations through *an iterative Least Squares Adjustment (LSA) procedure*. In this lab, the EOPs will be recovered according to the following procedure:

1. Using the corrected image coordinates for the Lens Distortion as well as the principal point coordinates and the corresponding ground coordinates (as derived from Lab 1), you can estimate the projective transformation coefficients through a single-step LSA procedure – note, you can ignore the Z-component of the ground coordinates of the control points from Lab 1 (i.e., assume these values to be zero).

$$x - dist_x - x_p = \frac{C_1X + C_2Y + C_3}{C_7X + C_8Y + 1}$$

$$y - dist_y - y_p = \frac{C_4X + C_5Y + C_6}{C_7X + C_8Y + 1}$$

2. Using the estimated projective transformation parameters, you can estimate the following parameters – please refer to the projective transformation slides for more details regarding the estimation of these parameters:
   a. The principal distance of the utilized camera (c),
   b. The position of the perspective center (X_o, Y_o, Z_o), and
   c. The Rotation matrix (R_c^m) and the rotation angles (ω, ϕ, κ).

Assumptions

For this lab, the following quantities are considered as known quantities:

- The parameters/coefficients describing the distortion parameters as derived from Lab 1,
- The principal point coordinates as derived from Lab 1, and
- The ground coordinates of the calibration targets (X, Y, Z) as derived from Lab 1, which represent a planar object space – you can ignore the Z-component of the derived coordinates from Lab 1.

Suggested Procedure:

For this lab, you can estimate the required parameters through the following procedure (refer to the class slides for more details regarding these steps):

- The projective transformation coefficients can be estimated through a linear LSA procedure given that the calibration targets define a planar object space,
- Using the estimated projective transformation coefficients, one can use closed forms to derive estimates of the principal distance (*c*) of the utilized camera as well as the position of the perspective center (X_o, Y_o, Z_o),
- Using the estimated principal distance and position of the perspective center, one can estimate the quaternion rotation relating the image and ground coordinate systems,
- Using the estimated quaternion from the previous step, derive the elements of the rotation matrix (R_c^m), and
- Given the elements of the rotation matrix, derive the rotation angles (ω, ϕ, κ)

Required Task

Develop a computer program using C/C++ or Mat lab to solve for the exterior orientation parameters using projective transformation and quaternion rotations. Implement your program to estimate the EOPs for images 65_09_20180803.jpg, 65_10_20180803.jpg, 65_14_20180803.jpg, and 65_18_20180803.jpg.

Deliverables and Report Preparation

Your lab report should include the following for images 65_09_20180803.jpg, 65_10_20180803.jpg, 65_14_20180803.jpg, and 65_18_20180803.jpg:

- The estimated principal distance and how does it compare to the estimated value from Lab 1 (Please, provide these values in a tabular form with the appropriate units),
- The estimated position of the perspective center and how does it compare to the estimated values from Labs 1 & 2 (Please, provide these values in a tabular form with the appropriate units),
- The estimated rotation angles and how do they compare to the estimated values from Labs 1 & 2 (Please, provide these values in a tabular form with the appropriate units),
- Using the estimated values for the principal distance and EOPs together with the principal point coordinates as well as the image and ground coordinates for the calibration targets, derive the image residuals for the different images – this should be done as part of your computer code (Please, provide these values in a tabular form with the appropriate units),
- Derive the Root Mean Square Error (RMSE) of the estimated residuals and compare this value with the square root of the variance component values in Labs 1 and 2,
- Explanation of your results and any problems encountered, and
- Well-documented computer code for the SPR procedure.