LAB 4: LINEAR APPROACH FOR PHOTOGRAMMETRIC INTERSECTION

Due date: December 11th 2020

Objective:

Given the Interior Orientation Parameters (IOP) of a utilized camera and the Exterior Orientation Parameters (EOP) of a stereo-pair or multiple images, this lab aims at implementing a linear intersection procedure for the estimation of the ground coordinates of tie points through two-light-ray and multiple-light-ray intersection.

Given:

1. The image coordinates of the calibration targets as measured/provided in Lab 1 for images 65_04_20180803.jpg, 65_05_20180803.jpg, 65_11_20180803.jpg, and 65_12_20180803.jpg;
2. Estimated Interior Orientation Parameters (IOP) from Lab 1 (principal distance, principal point coordinates, and distortion parameters); and
3. Estimated Exterior Orientation Parameters (EOP) for the different images from Lab 1.

Photogrammetric Intersection

The objective of the photogrammetric intersection is to determine the ground coordinates of tie points that can be identified in overlapping images given the IOP of the utilized cameras and the EOP of the used images. There are different approaches for implementing the photogrammetric intersection procedure:

1. **Non-Linear Multiple-Light-Ray Intersection:** Using the collinearity model, we can write a non-linear system of equations for every tie point. Each tie point would produce $2n$ equations, where n is the number of images the tie point can be identified in. Using Least Squares Adjustment (LSA), one can produce an estimate of the ground coordinates of the tie points. Since we are dealing with non-linear system of equations, we have to start from approximate values, derive partial derivatives with respect to the unknowns, and perform an iterative solution to estimate the ground coordinates.
2. **Linear two-light Intersection:** Rather than directly solving for the ground coordinates of a tie point using the collinearity model, this approach starts with the estimation of the scale factors for the light rays connecting the perspective centers of a stereo-pair to the respective image points (λ, μ). The estimation of the scale factors is based on a linear model (refer to Slides 55 – 58 in Chapter 9 or Slides 63 – 66 in Chapter 10). Then, the scale factors are used to derive the ground coordinates of the tie point as can be seen in Slide 59 in Chapter 9 or Slide 67 in Chapter 10. This procedure can be done for only one stereo-pair at a time.
3. **Linear Multiple-Light-Ray Intersection:** In contrast to estimating the scale factor and then deriving the ground coordinates of a tie point in one stereo-pair at a time, this approach is a based on a linear model that can be used to directly estimate the ground coordinates of a tie point that appears in <u>two or more images</u> (refer to Slides 68 – 69 in Chapter 10).

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 and principal distance as derived from Lab 1, and
- The Exterior Orientation Parameters (EOP) of the different images as derived from Lab 1.

Suggested Procedure:

For this lab, you need to estimate the ground coordinates of tie points for stereo and multiple images as follows:

- Using the linear approach in Slides 55 – 59 in Chapter 9 or Slides 63 – 67 in Chapter 10, estimate the ground coordinates for the tie points in the following stereo-pairs: 1) 65_04_20180803.jpg and 65_05_20180803.jpg;

and 2) 65_11_20180803.jpg and 65_12_20180803.jpg. In other words, you should use the linear two-light-ray intersection to derive the ground coordinates of tie points.

- Using the linear approach in Slides 68 – 69 in Chapter 10, estimate the ground coordinates of the tie points in images 65_04_20180803.jpg, 65_05_20180803.jpg, 65_11_20180803.jpg, and 65_12_20180803.jpg. In other words, you should use the linear multiple-light-ray intersection to derive the ground coordinates of tie points.

Required Task

Develop a computer program using C/C++ or Mat lab to solve for the ground coordinates using a linear approach for a) two-light ray intersection, and b) multiple-light ray intersection.

Deliverables and Report Preparation

Your lab report should include the following:

- The estimated ground coordinates of the tie points that are visible in the stereo-pair 65_04_20180803.jpg and 65_05_20180803.jpg through the two-light-ray intersection;
- The estimated ground coordinates of the tie points that are visible in the stereo-pair 65_11_20180803.jpg and 65_12_20180803.jpg through the two-light-ray intersection;
- The estimated ground coordinates of the visible light rays in images 65_04_20180803.jpg, 65_05_20180803.jpg, 65_11_20180803.jpg, and 65_12_20180803.jpg through the multiple-light-ray intersection;
- Comparison between the derived coordinates in the above three tasks with the outcome from the bundle adjustment with self-calibration in lab 1 (this comparison should include the differences in the X, Y, and Z coordinates as well as the Root Mean Square Error in the X, Y, and Z for the different intersection procedures in this lab and BASC output in Lab 1. Please, provide these values in a tabular form with the appropriate units);
- Explanation of your results and any problems encountered, and
- Well-documented computer code for the two-light-ray and multiple-light-ray intersection procedures.