THE UNIVERSITY OF CALGARY
DEPARTMENT OF GEOMATICS ENGINEERING

ENGO 363: Estimation & Statistical Testing
Winter 2019
Due date: 11:59 pm on Tue, March 12, 2019

Lab # 3: Parametric Least Squares Adjustment

In C/C++:
Write a computer program to perform a parametric least squares adjustment:

- Populate the misclosure vector, the design matrix containing the partial derivatives with respect to the unknown parameters, and an appropriate weight matrix
- Estimate the solution vectors: the vector of corrections to the unknown parameters, the vector of unknown parameters, the vector of residuals, and the vector of adjusted observations
- Estimate the a-posteriori variance factor, and the scaled variance-covariance matrices of the solution vectors: the V-C matrix for the unknown parameters, the V-C matrix for the estimated residuals, and the V-C matrix for the adjusted observations; in addition, compute any relevant correlation coefficient matrices
- Make sure the program has the capability to perform the adjustment in an iterative manner in case the functional model is non-linear

In Matlab:
In this laboratory exercise, use Matlab to plot the given data/network (if applicable), the residuals from the adjustments, and/or anything else you may find helpful to have displayed graphically.

1. Figure 1 shows a diagram of a levelling network to be adjusted. The unknown parameters are the heights of points 1, 2, 3, 4, and5. Table 1 contains all the observation data necessary to carry out the adjustment. The observations are uncorrelated and their standard deviations are listed in Table 1. The known elevations above sea level for benchmarks BM A and BM B are 263.453 m and 294.837 m, respectively. *Note that this is the same scenario and data from Lab 2.*
    - Come up with all the observation equations, identify whether the functional model is linear or non-linear, and run your C/C++ program with this data set
    - Given your final results from Lab 2, comment of any of the similarities and/or differences in the final results (e.g., the values for the unknown parameters, the residuals, the adjusted observations, and their associated V-C and correlation

coefficients) between the two methods (i.e., conditional LSA in Lab 2, and parametric LSA in Lab 3)

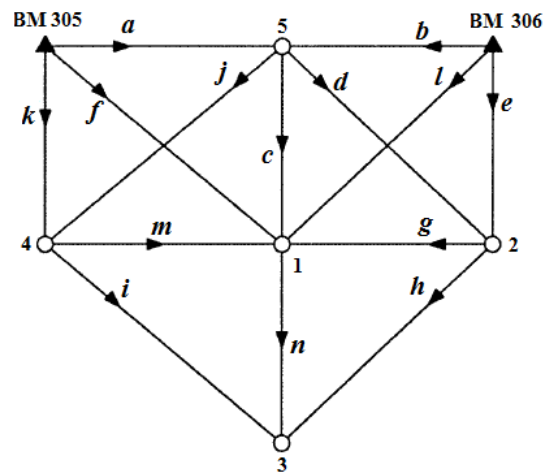

Figure 1. Levelling network

Table 1. Levelling network data

Obs.	From station	To station	Observed height differences (m)	σ(m)
a	305	5	25.102	± 0.018
b	306	5	-6.287	± 0.019
c	5	1	10.987	± 0.016
d	5	2	24.660	± 0.021
e	306	2	17.993	± 0.017
f	305	1	36.075	± 0.021
g	2	1	-13.295	± 0.018
h	2	3	-20.732	± 0.022
i	4	3	18.445	± 0.022
j	5	4	-14.906	± 0.021
k	305	4	10.218	± 0.017
l	306	1	4.693	± 0.020
m	4	1	25.893	± 0.018
n	1	3	-7.456	± 0.020

2. You are to adjust a trilateration network. You are given the easting and northing coordinates of control points A, B, C, and D in Table 2, and the observed distances/ranges between the control points and point E in Table 3. The coordinates of point E are unknown and to be determined. You may use Easting = 4,665.38 ft, and Northing = 4,309.49 ft as initial approximations.
   - Again, come up with all observation equations, identify whether the functional model is linear or non-linear, and run your C/C++ program with this data set.
   - What are the standard deviations for the Easting and Northing of point E? What are the standard deviations of the adjusted observations? Comment on any of the co-variances / correlation coefficients.

Table 2. Coordinates of control points

Point	Easting [ft]	Northing [ft]
A	2,643.15	2,213.07
B	3,093.92	7,422.48
C	6,515.54	7,544.40
D	6,451.84	2,061.87

Table 3. Distance/range observations

From	To	Distance [ft]	St. dev. [ft]
A	E	2,912.77	± 0.017
B	E	3,487.18	± 0.019
C	E	3,726.69	± 0.021
D	E	2,871.12	± 0.017

Write-up / Deliverables

The write-up should include the results for the required steps (presented in a tabular and/or graphical format) and the answers to any questions.

Program Source Code

- This is an individual lab assignment and as such all results presented in the write-up must be obtained from your own program(s).
- Computations must be performed in the C/C++ language using the Eigen library.
- Data visualization should be performed in Matlab.
- Source code will be evaluated on modularity, style, readability, and use of comments. The use of functions is mandatory. Do not underestimate the value of good, well documented code in terms of long term usefulness, and contribution to your grade.
- Data for the program(s) must come from external files. Hard coding of data should be avoided.