ENGO 625 – Advanced GNSS Theory and Applications (F2020)

Lab #2 – Float and Fixed Ambiguity Resolution
(Instructor: Kyle O'Keefe)

Due Date

Insert Date Here 2020 via D2L dropbox. Please submit your written report and source code.

Objectives

1. To become familiar with phase processing and ambiguity resolution.
2. To understand the abilities of carrier phase differential processing using a float and fixed solution in L1 only mode.
3. To improve programming skills with regards to Geomatics Engineering (C/C++, MATLAB or Python, please).

Data Description

Use the data you were provided from Lab 1.

Special Notes

For each task, you will be required to make several assumptions both theoretically and empirically. State all assumptions clearly (a list is preferred) and justify each assumption.

Tasks

1. Implement the phase rate method for cycle slip detection on L1
   a. Plot any cycle slips as a function of time.
   b. Identify a data set of approximately 20-30 minutes with the following characteristics:
      - No cycle slips.
      - No blunders (refer to Lab 1).
      - No satellites dropping in and out (so that you can choose one and only one base satellite).
      - Adequate geometry and number of satellites for ambiguity resolution.

   It will likely be necessary to remove an entire sequence of observations from one or more satellites in order to meet the above criteria. Justify the data set you have chosen.
2. From the data set you have selected, use double-differenced L1 phase observations and pseudoranges to perform either a sequential least-squares (SLSQ) solution or a Kalman filter (KF) solution – the choice is yours. If you select a KF, justify the dynamics model that you use. Estimate the remote station position and the **float** ambiguities.
   a. Using the true position given to you, determine the position errors in the East-North- Up (ENU) frame.
   b. Plot the time series of each of these error components (East, North, Up) **on separate plots** (use the subplot function in Matlab). On the same graphs, plot the time series of the estimated standard deviations. You must plot both the standard deviation (which is always positive) and

the standard deviation multiplied by negative one (which will then be always negative) in order to get the estimated accuracy “envelope”.

   c. Discuss the differences between the true and estimated accuracy. Comment on which assumptions you made may influence any discrepancies between the two. Justify your assumptions if necessary.
   d. Comment on the differences in accuracy between this solution and the differential pseudorange-only solution from Lab 1.
3. Modify your code to resolve the L1 ambiguities after the solution has converged. Justify your criteria for sufficient convergence. Use a sum-of-squares search method (nothing fancy, a brute force search over the search volume is sufficient) where you keep track of the ambiguity set with the smallest and second smallest sum-of-squares of residuals.
   a. List the estimated integer values of the ambiguities and the corresponding ratio test value.
   b. For each ambiguity, list the search space used for the ambiguity search.
   c. Plot the fixed ambiguities on top of the float ambiguities (from Task 2) at each epoch. Centre the accuracy envelope on the (changing) float ambiguity value. Comment on the behavior of the float ambiguities over time, and on the agreement between the float and fixed ambiguities.
4. Use the L1 fixed integer ambiguities to determine the position of the rover receiver. Then:
   a. Repeat all four subtasks in Task 2.
   b. Comment on the change in accuracy that fixed ambiguities provide compared to float ambiguities from (from Task 2).
5. Choose one of the ambiguities at random, and add exactly **one cycle** to its fixed value. Use this incorrect fixed-integer ambiguity and the other correct fixed-integer ambiguities to determine the position of the rover receiver.
   a. Repeat subtasks 2a, 2b and 2c.
   b. Plot the phase residuals (if using SLSQ) or innovations (if using KF) over time.
   c. Comment on the effect of a single incorrect cycle on the accuracy and how the phase residuals/innovations can be used to detect such an occurrence.

Report Format

Each report must be professionally written. Be concise but thorough. Explanations should accompany all plots. Assumptions must be clearly documented and justified.

Grading Criteria (10% of Final Grade)

Technical Accuracy (7/10)

- Correct solution/plots
- Correct analysis of results
- Correct justification and assumptions
- Insight into results
- Graphs correctly labeled (each axis with out a unit or title will be -1 point)

Source Code (2/10)

- Methodical and logical procession of algorithms
- Commented source code
- If you share software with other classmates, you must acknowledge their contribution both in the comments and in the text of the report.

Report Quality, Neatness and Readability (1/10)

- Title Page
- Neat, clear and effective use scales on plots
- Logical organization of lab

References

ENGO 625 Course Lecture Notes - Advanced GNSS Theory and Applications
ENGO 421 Course Lecture Notes (might be useful for coordinate systems)
ENGO 363 Course Lecture Notes or Text (for a detailed explanation of Least Squares)