ASSIGNMENT 7 – GPS POINT SOLUTION ANALYSIS

Assigned : 26 October 2020
Due : 6 November 2020, 10 PM

OBJECTIVES

This assignment completes the process of using GPS pseudorange measurements to form a solution. In HW6 we computed a single position solution (also called a point solution) at one specific time (or "epoch"), focusing on implementing all of the necessary pseudorange corrections, constructing the A-matrix (measurement connection matrix or measurement partials), and investigating how well this process converges to the correct answer given an a priori guess that is far from the truth. In this assignment we compute point solutions for a station over the course of an entire day using each of the measurement epochs given in a RINEX observation file. In addition to the mechanics of solving for position we also will look at the resulting position errors to see how they change over the day. To do this, we solve for the position correction (or relative position) with respect to the known receiver position, at each epoch. Corrections or relative positions like this are often expressed in East-North-Up components, which provide more meaningful interpretation of the position errors compared to the ECEF X, Y, Z errors.

We will look at data from NIST and USN8 (Naval Observatory) – the locations are given in attached text files.

ASSIGNMENT

Models and preparation for solution:

- Use the positions for each location given in the text files as your initial (*a priori*) guess for the station coordinates. You should assume that this position is correct.
- Based on these locations, compute the transformation matrix from ECEF to ENU for each of the two locations. You only need to compute this once – i.e. it doesn't change throughout the day.
- Set up your code to loop through the entire obs file, working with the data from one epoch at a time. (While you are debugging your code, just work with the first few epochs so you don't have to read everything and work with the large amount of data.)
- For each epoch, loop through the satellites computing the following for each one (these are all based on prior homeworks):
  - The satellite position, expected range, satellite clock correction, and relativity correction based on the parameters in the broadcast ephemeris file and the *a priori* receiver location.
  - To correct for the ionospheric delays use the dual frequency ionosphere-free pseudorange combination PIF which is computed using P1 (or C1) and P2.
  - To correct for tropospheric delays use zen_trop/sin(elevation angle). For NIST zen_trop = 2.0 m works pretty well. Decide what is a good value to use for USN8.
- Calculate and store the pre-fit residuals. Remove all satellites below 10 deg elevation and also remove any large measurement outliers in the pre-fit residuals before computing a least-squares solution.

Least Squares Point Solutions:

- At each epoch, use the position given in the class text file as your initial (*a priori*) guess for the station coordinates. This will be used to construct your A-matrix as well as the expected range.
- Compute the least squares position and clock solution: dx, dy, dz, b for each epoch of the day. This solution is an adjustment or correction to the *a priori* guess. Do not iterate this, just use the position given above as the *a priori* for each epoch, and solve for a position & clock correction. We will refer to this position correction as the "relative position" in the following.
- Compute the post-fit residuals: dpr_post = dpr_pre – A [dx dy dz b]'

- Rotate the *relative position* to East-North-Up (ENU also called ENV) coordinates based on transformation matrix you computed above for the NIST or USN8 locations. (Another option is to express the LOS vectors in the A matrix in ENU, then your relative position and DOPs will both automatically be in ENU coordinates.) You will now have a position correction for each time on the obs file (total of 2880 of them because the measurements are output every 30 seconds).

- Compute the East, North, and Up - **DOP** values for each epoch.
- Compute the standard deviation and RMS value of each of the relative position coordinates and of the pre and post-fit residuals over the entire day.
- See if you can find a good zen_tropo value for USN8 – explain your method.
- Compare the clock solutions (b) for NIST and USN8 over the day.

What to submit: All of your code, well-commented plus:

1. Print out your relative position solution in East, North, Up (vertical) coordinates to a precision of 1 cm, the clock bias (b), and the corresponding DOP values (EDOP, NDOP, VDOP, TDOP) **at time 01:00.**
2. Print out the standard deviation and RMS value of each of the relative position coordinates and the pre and post-fit residuals. These are computed over the entire day, so you should have a total of 5 standard deviations and 5 RMS values.
3. Plot the pre-fit residuals as a function of time (hours) and as a function of elevation (deg). (Do not include outliers.)
4. Plot the post-fit residuals as a function of time (hours) and as a function of elevation (deg).
5. Make a scatter plot of all the horizontal relative position solutions (horizontal relative positions, i.e. dNorth vs dEast (North on the y-axis, East on the x-axis)
6. Plot the ENU solutions (m) as a function of time (hours).
7. Plot the EDOP, NDOP, and VDOP values as a function of time (hours).
8. Plot the number of satellites used in each point solution as a function of time (hours).
9. Plot the clock solutions for NIST and USN8 vs time (hours) on the same graph.
10. Open-Ended Discussion (~1 page) - Discuss and explain the results. Use what you have learned from previous assignments to back up your analysis.