GPS Data Analysis

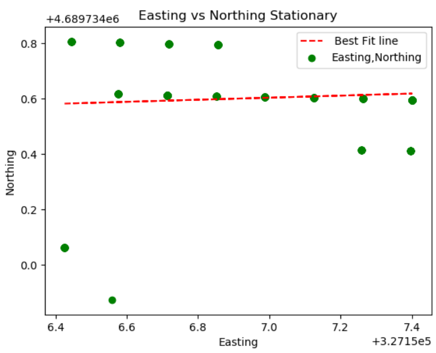
Errors in GPS

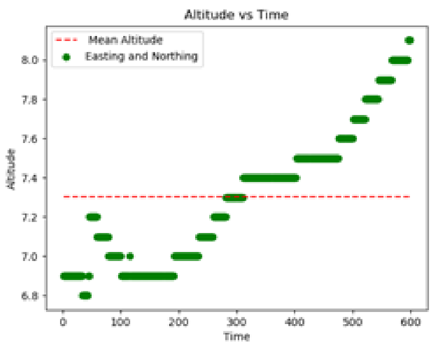
The sources of error occur due to various reasons as are mentioned below

1. Satellite clock: GPS position calculations depend on measuring signal transmission time from satellite to receiver; this, in turn, depends on knowing the time on both ends. NAVSTAR satellites use atomic clocks, which are very accurate but can drift up to a millisecond (enough to make an accuracy difference).
2. Upper atmosphere (ionosphere): As GPS signals pass through the upper atmosphere, signals are delayed and deflected. The ionosphere density varies; thus, signals are delayed more in some places than others. The delay also depends on how close the satellite is to being overhead (where distance that the signal travels through the ionosphere is least).
3. Receiver clock: GPS receivers are equipped with quartz crystal clocks that are less stable than the atomic clocks used in NAVSTAR satellites.
4. Satellite orbit: GPS receivers calculate coordinates relative to the known locations of satellites in space, a complex task that involves knowing the shapes of satellite orbits as well as their velocities, neither of which is constant. The GPS Control Segment monitors satellite locations at all times, calculates orbit eccentricities, and compiles these deviations in documents called ephemerides
5. Multipath: Ideally, GPS signals travel from satellites through the atmosphere directly to GPS receivers. In reality, GPS receivers must discriminate between signals received directly from satellites and other signals that have been reflected from surrounding objects, such as buildings, trees, and even the ground. Antennas are designed to minimize interference from signals reflected from below, but signals reflected from above are more difficult to eliminate. One technique for minimizing multipath errors is to track only those satellites that are at least 15° above the horizon, a threshold called the "mask angle."

   Cited :- GPS Error Sources

Stationary Data

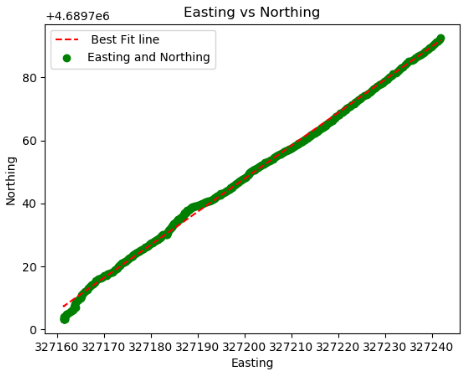


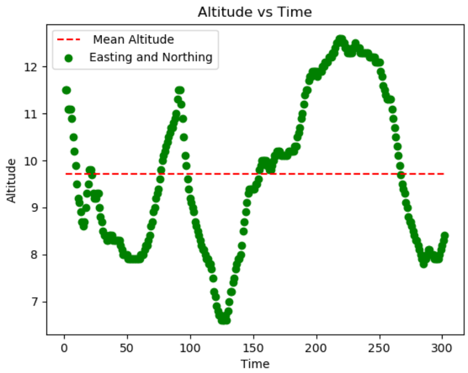


The stationary data was collected on a clear sunny day on Clemente Field in Boston. From the above Easting vs northing Stationary Data Graph, we can see that the max deviation is of 0.8 meters. The standard deviation from the easting mean measurement is about 0.320m so on an average the error in easting data is 30cm and similarly the average error in northing data is 18cm. This is strange as the stationary GPS must have more error according to Gps.gov the standard error must be in range of 5 meters but they mention that for a standard android phone and not the sensor hence our data may vary depending on the sensor accuracy. Another thing to be considered is the hdop and the number of satellite our sensor is talking to at the time of recording data. A low value of hdop is better for accuracy and according to data on clemente field the hdop the time the data was collected was 0.9, the number of satellites it is talking to was reported by the sensor to be about 10. We were in an open field hence we can eliminate the Multipath error. Another hypothesis could be that the day the measurements were taken, the satellite orbits were in our favor and we had multiple satellites with varying angle of transmission of data leading to better accuracy. Hence from this we can say that our data accurate. The latitude and longitude when input on this website gives us the location we were at and hence we can validate our hypothesis.

The Altitude data has a standard deviation of 0.34m and the mean is 7.3m but according to this website: The city's official elevation, as measured at Logan International Airport, is 19 ft (5.8 m) above sea level. Hence due to vdop, The wall we kept the gps and laptop on and the other noisy data we can accommodate the error value to be about 1.5m which is in coherent with the data we have collected

Moving Data





The moving data was collected in the same conditions mentioned above. The above Northing vs Easting graph gives us a max error from the line of best fit to be about 5 metres and the min error about the line of best fir to be about 0.003m. This is also very accurate data set as we can see from the graph of Easting vs Northing and the best fit line. The error can be assigned to the data not being collected in an exact straight line as well as also not walking in the straight line at a constant velocity.

The altitude data in this graph seems to be very messy but when statistically calculated the mean altitude comes out to be 9.7m and from the stationary data we know that the avg altitude was 7.3. This error can be assigned to me holding the sensor above the head and my height is 1.7m. The remaining 0.9 meters can be accounted for noise by the sensor and other GPS sources of error as mentioned above. The lowest value of altitude is 6.8m and the highest value of altitude is 12.8m which is off from the new mean (considering my height) by 3.8m. The avg error in vertical distance according to Gps.gov is about 5 meters hence we can validate our collected data.