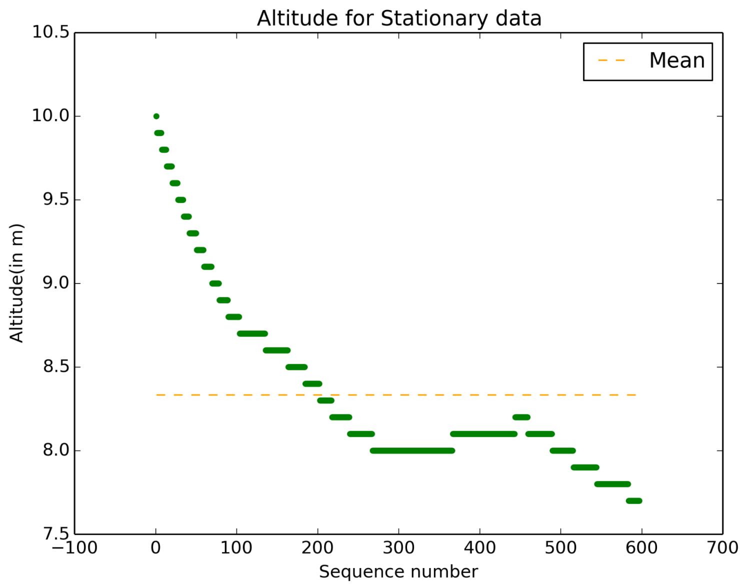
LAB1 Report

The data for this lab, both stationary and moving, was collected at Roberto Clemente Field, Boston, MA using GPS device BU353S4 on 8th February, 2022.

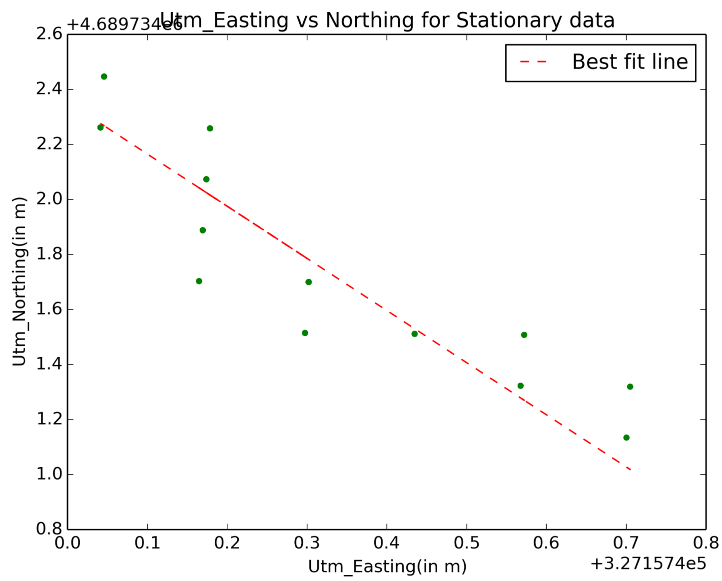
1. Stationary Data Analysis

Analysis for the **altitude data** collected gave the following values (wrt sequence number):
Mean: 8.333 m
Standard Deviation: 0.509 m



The error value is approximately around 1.7 m, if we consider the official elevation level as 5.8 m[1]. This error can be accounted for by considering the elevation of the post on which the laptop and the device were placed during measurement. The maximum altitude recorded is 10 m resulting in a 4.2 m maximum error, which is in accordance with gps.gov[2] where it is stated that the average measurement error is 4.8 m. The average measurement error, as mentioned on the website, is a consequence of satellite geometry, user range error (URE) and local factors such as signal blockage, atmospheric conditions and receiver design and quality, which evidently are contributing factors in the error in our data as well.

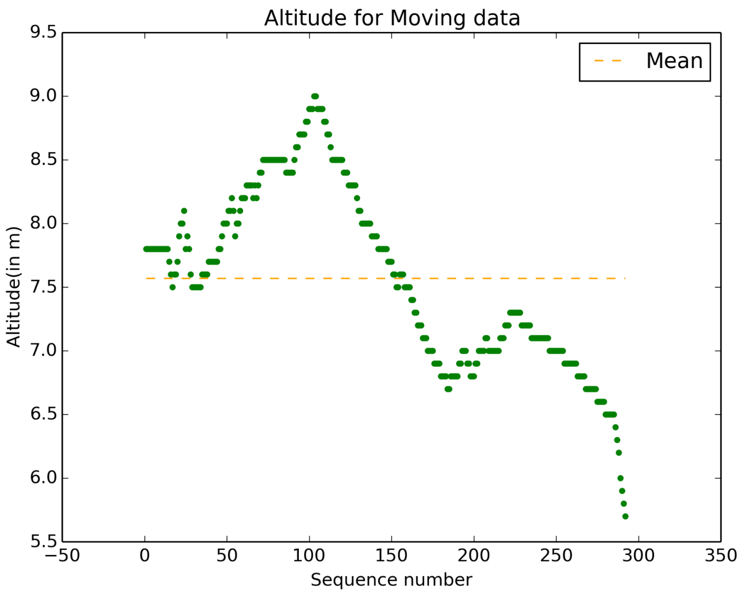
Analysis of **easting vs northing** collected gave the following values(wrt best fit line):
Maximum error: 0.339m
Minimum error: 0.0148m



The collected data shows a standard deviation of 0.156 m for the easting measurements and 0.341 m for northing measurements. This is quite different from the expected average error approximation of 4.8 m, as discussed above. This difference can be attributed to the horizontal dilution of precision value (HDOP) and the number of satellites communicating with the sensor at the time of measurement. These values are returned by the sensor to be 0.9 and 10 respectively. A low value of HDOP and higher value of the number of satellites would lead to a better accuracy and could be a possible explanation for the difference. Another possible factor could be avoidance of multipath error due to being in an open space, at a distance from buildings and trees which significantly reduced signal reflection. In an effort to make sure that the sensor was picking up accurate data, we confirmed our geographical location using the latitude and longitude data record on google earth. We can put a bound on these errors using real time differential correction and post processed differential correction.[3]

2. Moving Data Analysis

Analysis for the **altitude data** collected gave the following values (wrt sequence numbers):
Mean: 7.570m
Standard Deviation: 0.7m



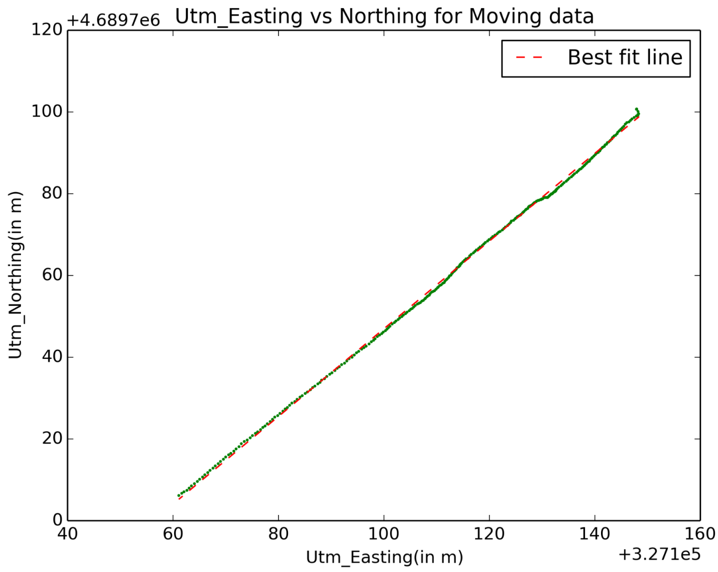
The maximum altitude recorded was 8.9 m and the minimum was 5.6 m. Assuming the standard altitude to be 5.8 m, the maximum variance is observed to be 3.1 m. This falls under the standard average error of 4.8m as discussed above[2]. The vertical error could have occurred due to multiple satellites communication with the sensor at various angles of signal approach. As was discussed in the lecture, if the vertical angle is not significantly large, there is a higher magnitude of error and hence could act as a contributing factor to the errors seen in our data, in addition to the stationary data errors discussed above.

Analysis of **easting vs northing** collected gave the following values(wrt best fit line):
Maximum error: 2.316
Minimum error: 0.004

As we can see from the graph below, our data and the best line fit are significantly similar. If we compare the actual maximum variation from best line fit value for northing measurements, we see a maximum error of 2.316 m and hence we can see that the error propagation is quite more while moving, and can be validated from the stationary data collected. We could account for this error, to some extent, by deviation from a straight line while walking during data collection. Another contributing factor could be the noise in the sensor and signal.

Even though it is expected that the stationary error would be more than the moving error, the measurements are not in sync with this expectation.

Apart from assuming that our stars (satellites) were aligned during the data collection, we could further substantiate our results by collecting multiple sets of data in varying locations, environmental conditions and different sensors. We could then derive the repeatability, precision and accuracy based upon these multiple sets of data to support or counter this initial data set.



3. Additional Data

Stationary

Analysis of the Easting data collected gave the following values(wrt sequence number):
Mean: 327157.65m
Standard Deviation: 0.156m

Analysis of the Northing data collected gave the following values(wrt sequence number):
Mean: 4689735.881m
Standard Deviation: 0.341m

Moving

Analysis of the Easting data collected gave the following values(wrt sequence number):
Mean: 327213.853 m
Standard Deviation: 24.734 m

Analysis of the Northing data collected gave the following values(wrt sequence number):
Mean: 4689761.837 m
Standard Deviation: 26.545 m

4. Citations

1. https://en-us.topographic-map.com/maps/f02f/Boston/
2. gps.gov
3. https://www.e-education.psu.edu/natureofgeoinfo/c5_p24.html