Lab 1: Analysis of Stationary and Moving GPS Data

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Stationary Data

A key observation made during the collection of stationary data was the eventual drift in the position over the data collection period of 10 minutes. Over this period, a total of 654 data points were recorded. The data was recorded in Centennial Commons in Northeastern University, which is an open space with no obstructions in the immediate vicinity.

In Figure 1, all the values converge into distinct points. Data for stationary GPS position has an overall change of 1.4m in Northing and 1m in Easting. However, there is a gradual drift in the position even when recording stationary data.

The LOWESS curve, (Locally Weighted Scatterplot Smoothing) creates a smooth line through the scatterplot which shows the gradual drift in the GPS position. This line is essentially the line of best fit.

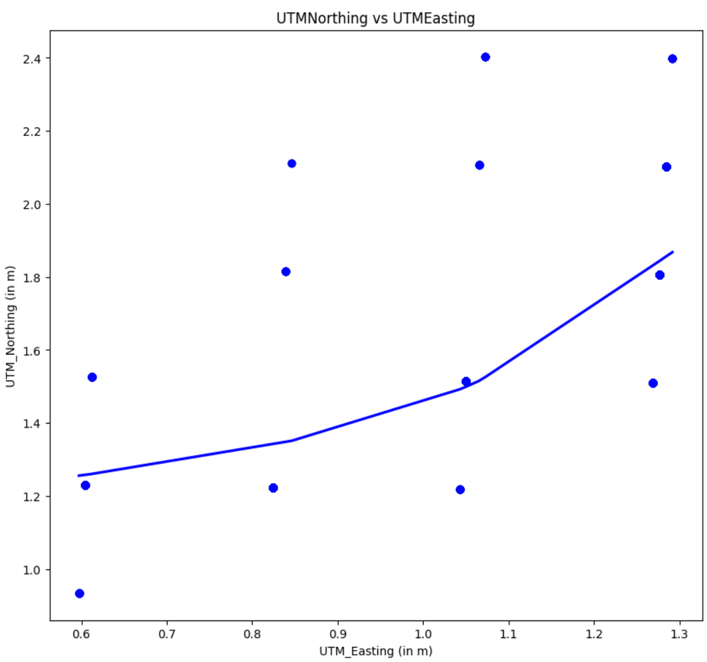

Fig. 1 – UTM Northing vs UTM Easting with LOWESS curve

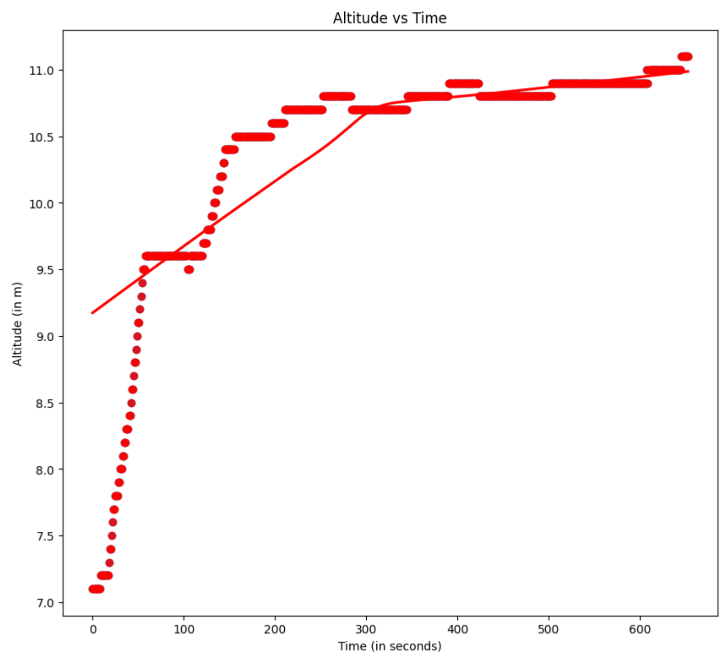

Fig. 2– Altitude vs Time with LOWESS curve

In Figure 2, it is observed that the altitude data is not constant or fixed. It changes with respect to time, from a value of 7m to 11m.

Analysis of Stationary Data

By observing this data that has been recorded, it can be said that based on the GPS data alone, from a single puck, the data is not precise. GPS navigation has a lot of sources of error which include multipath, atmospheric interference, device constraints.

The distribution of error in GPS cannot be approximated to a normal or gaussian distribution. For majority of cases, it *may* be approximated to a normal distribution, however, in cases like drift, multipath, the data that is obtained can be too erroneous, which deviates from a normal distribution. The error in GPS arises from many sources, which leads to the deduction that the error cannot be distributed uniformly.

A good error estimate could be done using many alternate methods, the best approximation to find the true GPS positional value is to find the mean. From further analysis, with the given data, the Root Square Mean for Easting is 0.27m and 0.352m for Northing.

In real-world cases, these errors cannot be bounded because GPS data depends on the environment and several sources of error. However, with the existing data that is collected, following are the error bounds observed.

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For UTM Easting,
upper bound: 0.29484364958538745
mean: 0.9968779384152677
lower bound: 0.3995992864010569

For UTM Northing,
upper bound: 0.8258524431807164
mean: 1.5771756268146273
lower bound: 0.6436738672706124
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The sources of these errors could be from:

- Atmospheric Interference – Atmosphere conditions are constantly changing which changes the refractive index, signal permeability, signal attenuation.
- Calculation and Rounding Errors – Algorithms used by the GPS puck to calculate and smoothen the data might affect the reading. Change in clock speeds of the satellite / device might also lead to errors.
- Ephemeris Data Errors – Orbital Path Errors
- Multipath – Interference of signal with surroundings like trees and buildings which lead to the reflected or altered signal that is being received.
- High Dilution of Precision – The angular separation between the satellites is too low, which leads to inaccurate readings.

Analysis of Moving Data

The moving data, however, is much more accurate and predictable, as seen in Figure 3.

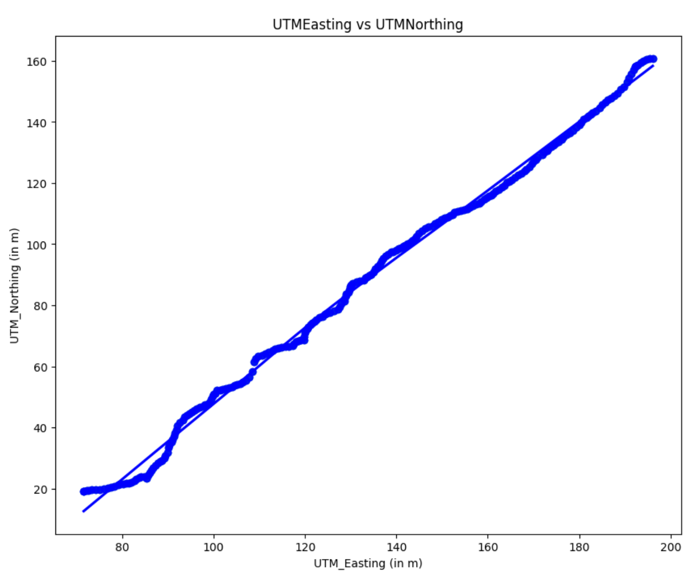

Fig. 3 – UTM Northing vs UTM Easting with LOWESS curve

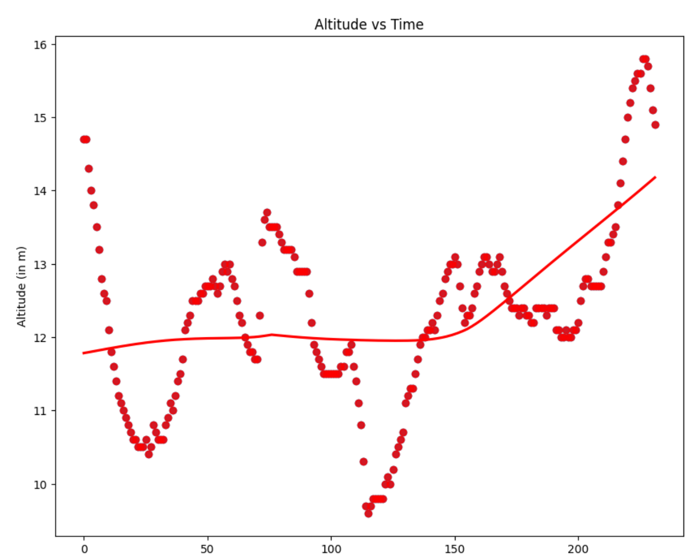

Fig. 4 – Altitude vs Time with LOWESS curve

This is because the GPS uses Extended Kalman Filtering to smooth the effects of the errors as listed out in the previous section. With the use of filtering, the GPS updates the noise estimate with each additional point added, which reduces the error when compared to raw data. The non-linear noises that the GPS is susceptible to is negated to an extent, although not completely, which gives us more true, real to world data.

The altitude vs time as seen in Figure 4, the Altitude data is being impacted a lot by noise. This erroneous data could be from the many sources of errors as listed above.

The data collected consists of 232 data points, collected over 150m by walking in a straight line over a period of 3 minutes.

The error estimate drastically decreases in moving data, and provides a more accurate measurement, which is helpful in GPS navigation during movement.

The distribution of noise is non-linear and non-uniform.