# EECE 5554 LAB 1 Analysis Report

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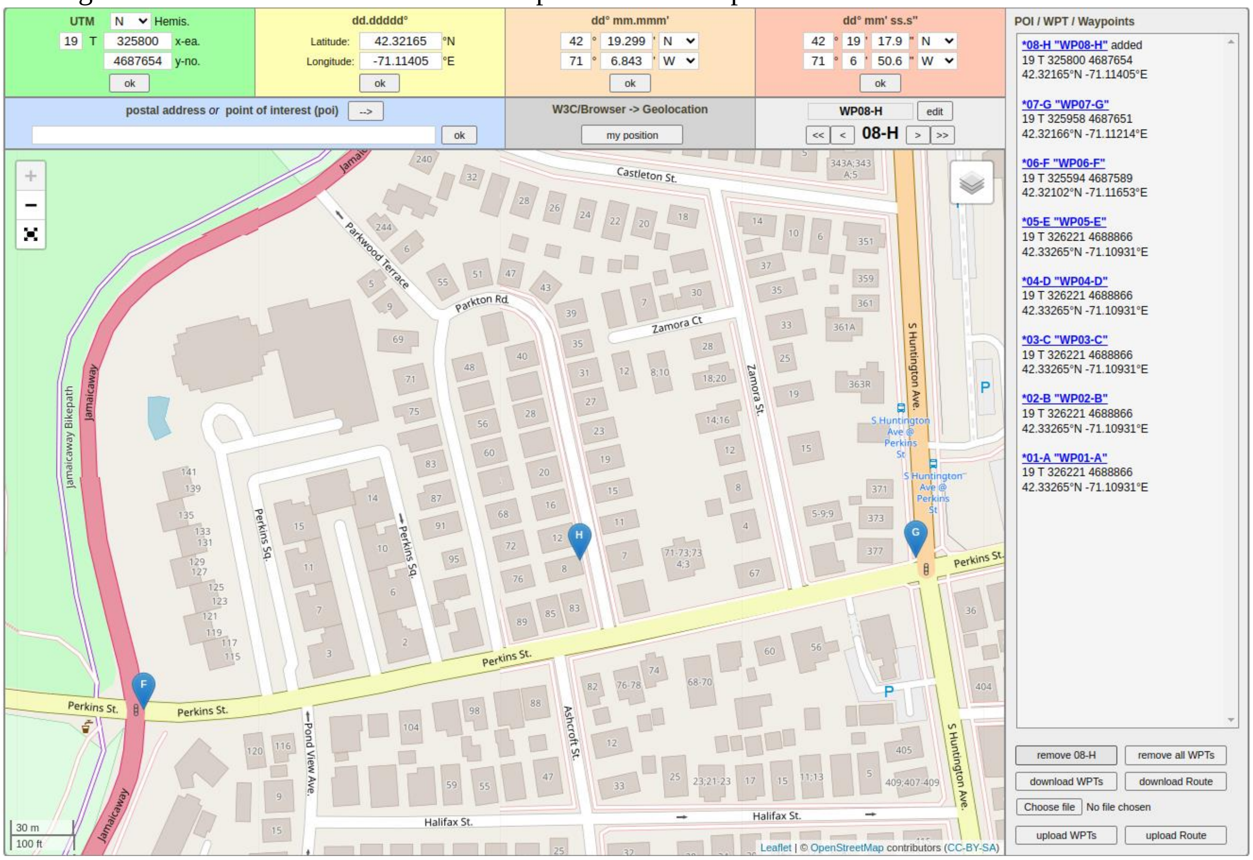
The region where the data was collected is depicted in this map.




Static data collection (Marker **H**) was done on an open apartment porch with some tall buildings nearby.

Motion data was collected (between markers **F** and **G**) by walking on the sidewalk alongside a residential area with 2-storied houses and some apartments.

Since the grid origin did not change for this experiment, all the UTM values have been stripped to accommodate simply the offset from the UTM gridlines in meters, to improve the plot readability

Data samples are collected at the rate of 1 sample.s$^{-1}$ using a GNSS gps puck[1]

[1]*BU353-s4 position accuracy: Position Horizontal: <2.5m 2D RMS SBAS Enable*

# **Static Data collection**

*Table 1. Readouts for static case*

<table>
<tr><td rowspan="2"><u>Reference Data</u></td><td colspan="2">Reference Latitude (Decimal degrees)</td><td colspan="2">Reference Longitude (Decimal degrees)</td><td colspan="2">Reference Altitude (m)</td><td colspan="2">Reference UTM Easting (m)</td><td colspan="2">Reference UTM Northing (m)</td><td>Zone</td></tr>
<tr><td colspan="2">42.32164°N</td><td colspan="2">-71.11408°E</td><td colspan="2">25m (base elevation)+ ~5m (self-assessed)</td><td colspan="2">325797</td><td colspan="2">4687653</td><td>19T</td></tr>
<tr><td rowspan="6"><u>Collected Data</u></td><td colspan="2">Latitude (Decimal degrees)</td><td colspan="2">Longitude (Decimal degrees)</td><td colspan="2">Altitude (m)</td><td colspan="2">UTM Easting (m)</td><td colspan="2">UTM Northing (m)</td><td rowspan="3"></td></tr>
<tr><td>Mean</td><td>Std. Dev</td><td>Mean</td><td>Std. Dev</td><td>Mean</td><td>Std. Dev</td><td>Mean</td><td>Std. Dev</td><td>Mean</td><td>Std. Dev</td></tr>
<tr><td>42.321629</td><td>1.03197e-05</td><td>-71.113972</td><td>4.143387e-05</td><td>41.24703</td><td>3.87866</td><td>806.4430845</td><td>3.38786</td><td>651.54214</td><td>1.22525</td></tr>
<tr><td colspan="11">Variance</td></tr>
<tr><td colspan="2">Latitude</td><td colspan="2">Longitude</td><td colspan="2">Altitude</td><td colspan="2">UTME</td><td colspan="3">UTMN</td></tr>
<tr><td colspan="2">1.064977e-10</td><td colspan="2">1.7167659e-10</td><td colspan="2">15.04404</td><td colspan="2">11.477657</td><td colspan="3">1.501241</td></tr>
</table>

Table 1 shows the readouts for static data collection scenario. Reference positions are manually determined with utmost care through pins on google maps. Data is collected at a base elevation of 25m on a first-floor porch which is approximately 5 meters above ground level.

Focusing on the UTM values after they have been pre-truncated to remove the redundant grid line number, we record a variance of 11.477657 in the easting direction and 1.501241 in the northing direction. In this case there is a certain drift of the data points in a certain direction even though the recording device was held static. Most of the recorded data is concentrated towards the east of the true location. The altitude value shows a significant error and drift towards the 40meter mark, which puts it around 10 meters above the reference altitude

Figure 1. shows the 2D distribution of UTM data, with the true position highlighted by the green point, and the mean position highlighted by the pink marker. The mean norm error recorded between the mean position and the recorded positions is 9.56 meters. The RMS error is recorded between the true positions and the recorded data points and is observed to be significantly high value of 145 meters, which is in line with how GPS errors are observed in handheld devices indoors.

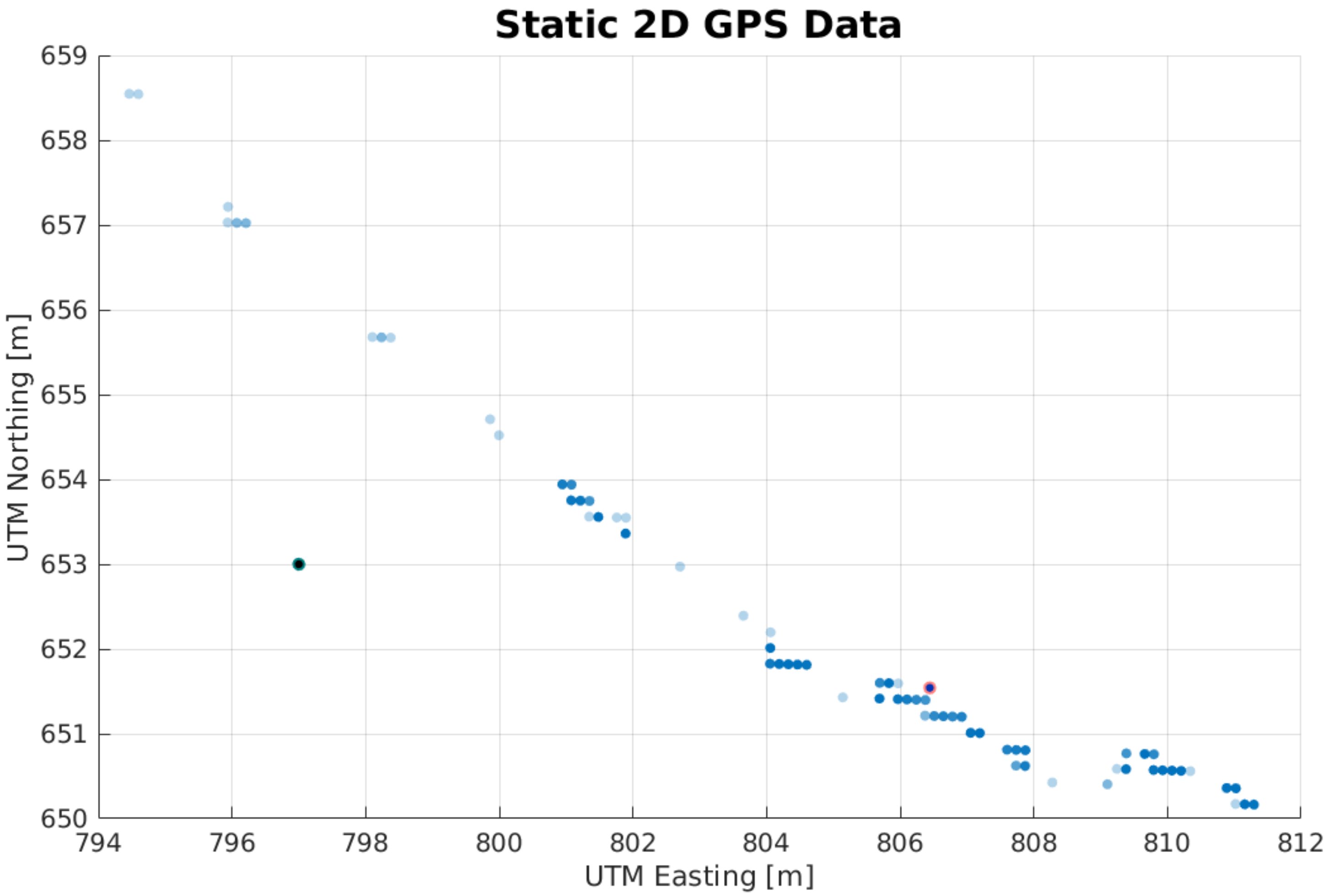



*Figure 1. 2D distribution of the UTM easting and UTM northing (static case)*

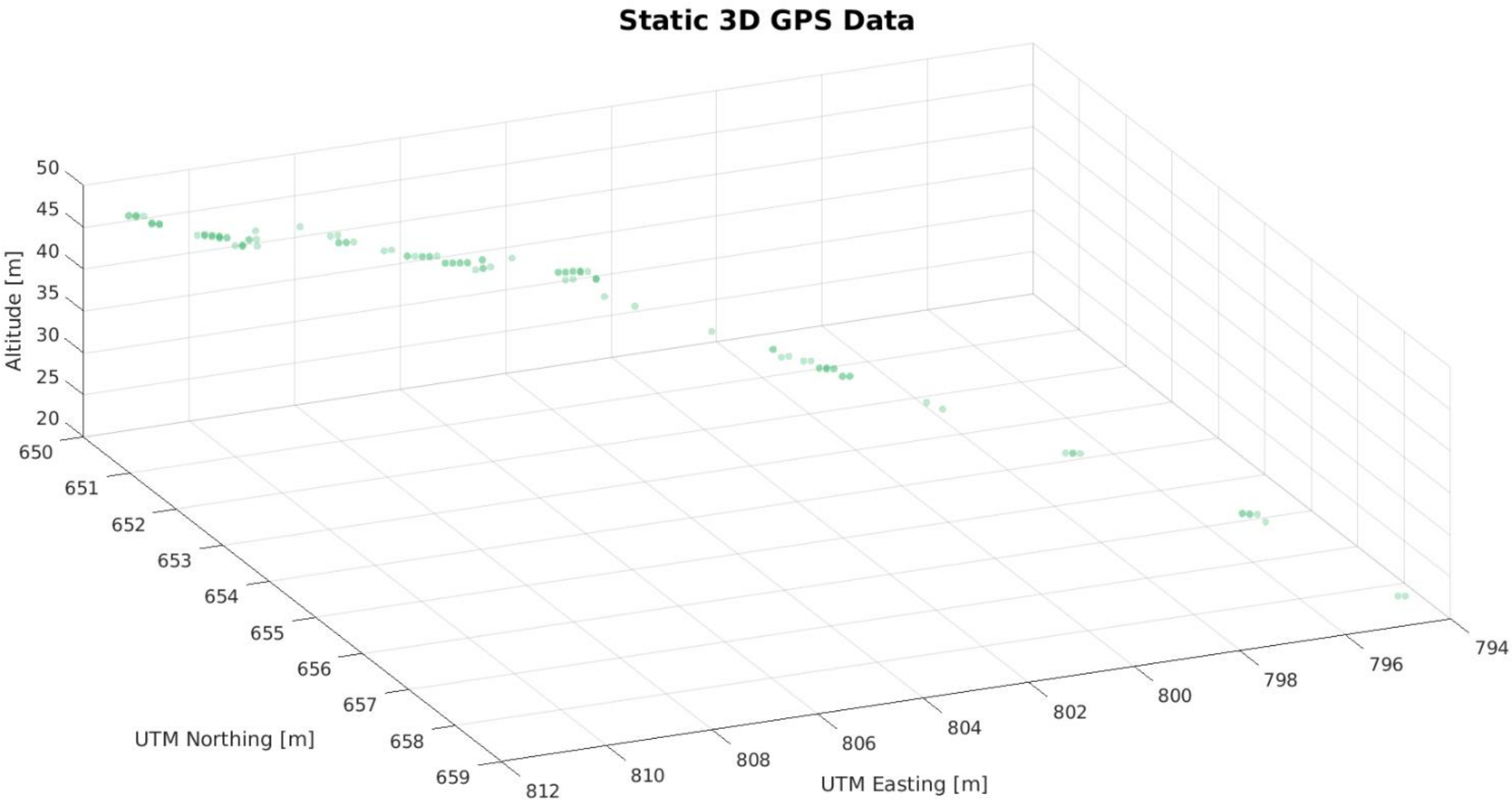



*Figure 2. 3D distribution of static data*

# Non-Static Data collection

*Table 2. Setup for motional data collection*

| Landmark type | Reference Latitude (Decimal degrees) | Reference Longitude (Decimal degrees) | Reference Altitude | Reference UTM Easting Value | Reference UTM Northing Value | Zone |
|---|---|---|---|---|---|---|
| **Start Position (approx.)** | 42.32102°N | -71.11653°E | [25m (base elevation)]() | 325594 | 4687589 | 19T |
| **Stop Position (approx.)** | 42.32166 | -71.11214 | | 325958 | 4687651 | 19T |

Table 2 shows the readouts for non-static data collection scenario. Reference positions are manually determined through pins on google maps. Data is collected at a base elevation of [25m]() by walking along a sidewalk for roughly 300 meters.

There is a curve at the start of the recording but has been considered a valid part of this recording as the curve was not sharp.

Figure 3. shows the recorded data points in blue and a best fit straight line passing through the start and end points in red.

Taking each data point and recording the average L2 norm error over all these data points with respect to the best fit line, we observe an average norm error of 6.3556 meters. The RMS value is observed to be a small value of 7.3323 meters, which is in line with what we see while driving and navigating through google maps

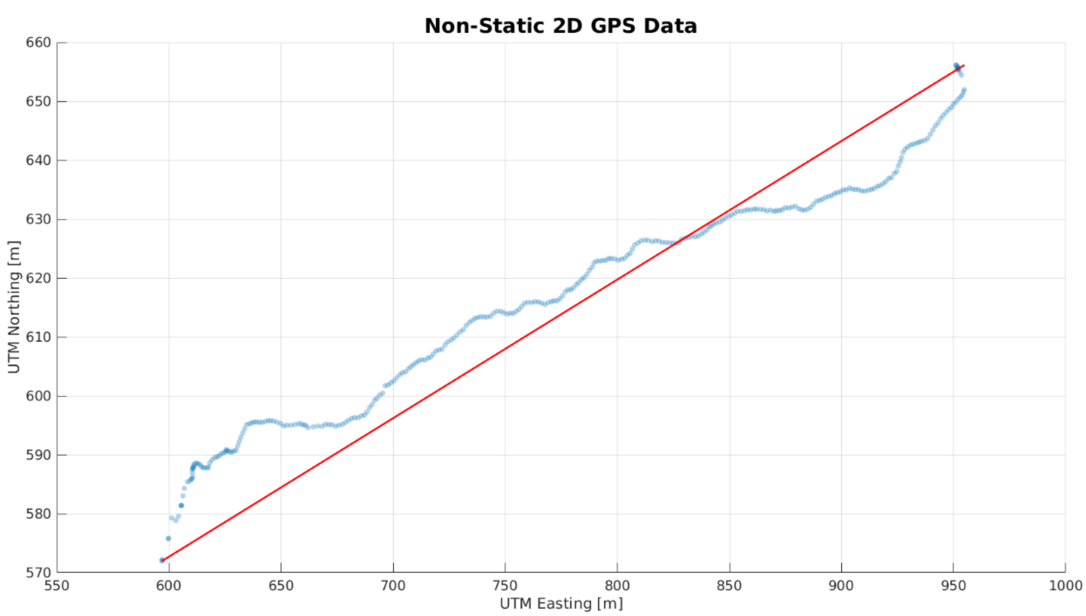



*Figure 3. 2D distribution of the UTM easting and UTM northing (non-static case)*

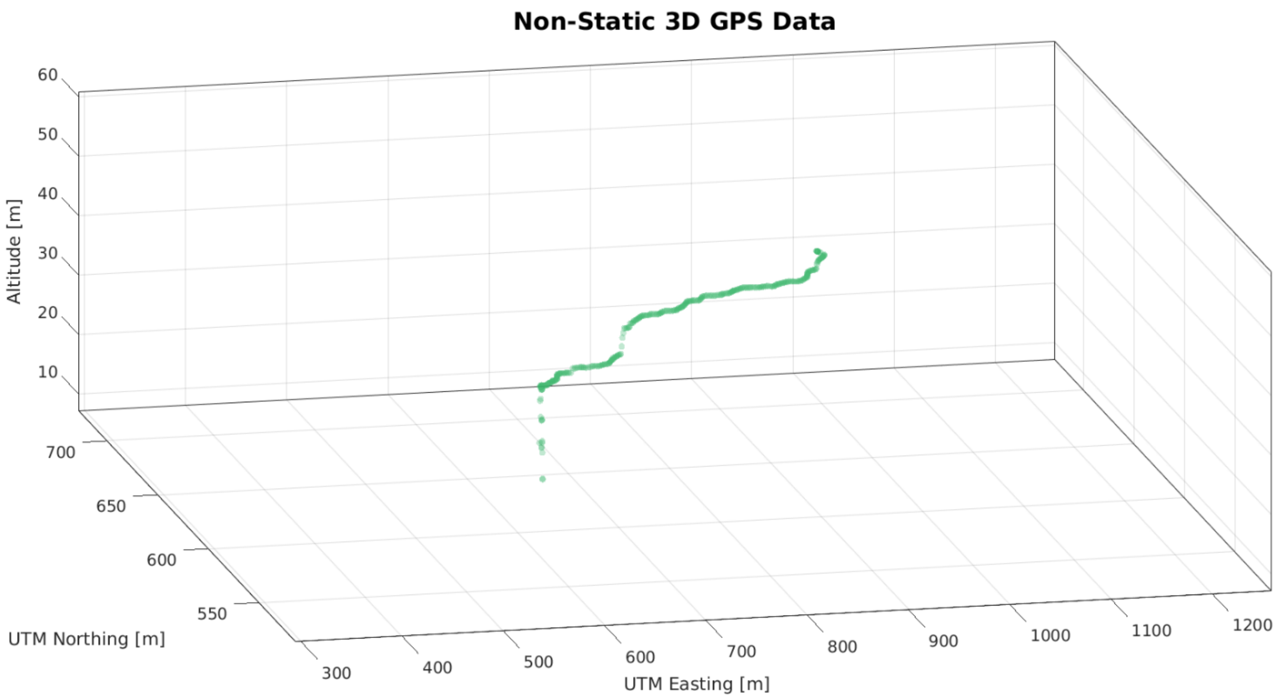



*Figure 4. 3D representation of non-static data*

## Concluding remarks:

The nature of GPS errors is observed to be **non-uniform/non-gaussian**. The distribution can represent gaussian data with some resemblance if a large amount of data is collected over time[2].These can be attributed to transmitter errors, receiver errors, and signal propagation errors. In our case the conditions were extremely sunny so atmospheric interferences with GPS signal values can be neglected to a large extent. Most of the error source can be attributed to the recording being done in a residential area, which might cause temporary LOS or add some multipath effects (which can be seen as the spikes in position error while crossing a building in Figure 3. The altitude variation remains on the high end in both the static and non-static cases.

The gross errors for static data collection are worse than that for non-static data collection as we see that the mean UTM error for the static case comes out to be around 9.55 meters and for the non-static case around 6.3 meters.

Good error metrics for GNSS data can be the rms error, and the twice rms error.

This can be attributed to better reckoning of the receiver velocity when in motion and subsequent correction. A GPS receiver typically locks on to 4 or more satellites. When static, there is supposedly no change in the receiver operator distance, and as such a rate of change cannot be calculated. In motion, some change of distance can be accounted by the fact that the satellites are moving in a precisely-defined geometry with respect to the receiver. Any shift in the signal strength can then be accounted for through the receiver motion. Once this signal shift is estimated, it can be used to interpolate the actual position on the basis of the initial position.

The question is, *what if the initial guess is incorrect?* This could be rectified through subsequent corrections in the position estimate as and when a signal of higher quality is received while in motion. This is a gross oversimplification of my perspective on positional correction while in motion.

[2]https://www.gpsworld.com/gps-accuracy-lies-damn-lies-and-statistics/