EECE 5554
Robotics Sensing & Navigation

Lab 1:
GNSS Drivers and Data

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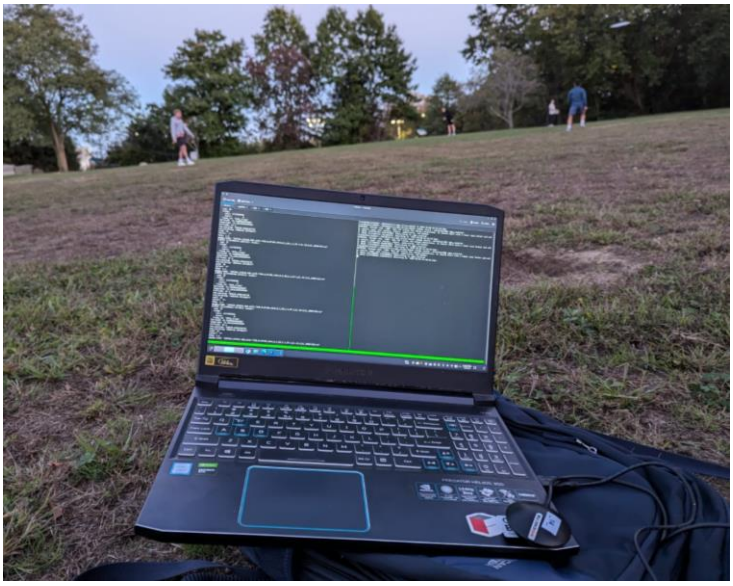
Introduction:

The data was collected in a park along **‘Parker Hill Avenue’** road. The **‘Open’** data set was collected on a plain grass field, & the area’s coordinates are (42.3289, -71.1042).
The GPS device was placed on the ground during data collection.
The **‘Occluded’** dataset was collected in the woods at the coordinates: (42.3285, -71.1045), which was a few meters away from the ‘Open’ dataset location. The GPS was kept on an approximately 1m elevated brick wall.
Walking data set was collected while walking along **'Parker Hill Avenue'** Road.

Six datasets were collected: 2 open, 2 occluded and 2 walking.
Here, we are using the 2nd dataset from each pair of open, occluded & walking data collected.
Both Open and Occluded contain 300 rows.
(Sampling time: 1sec * Sampling Duration: 5 mins = 300 sec)



Open area data collection

Occluded area data collection

Graph analysis:

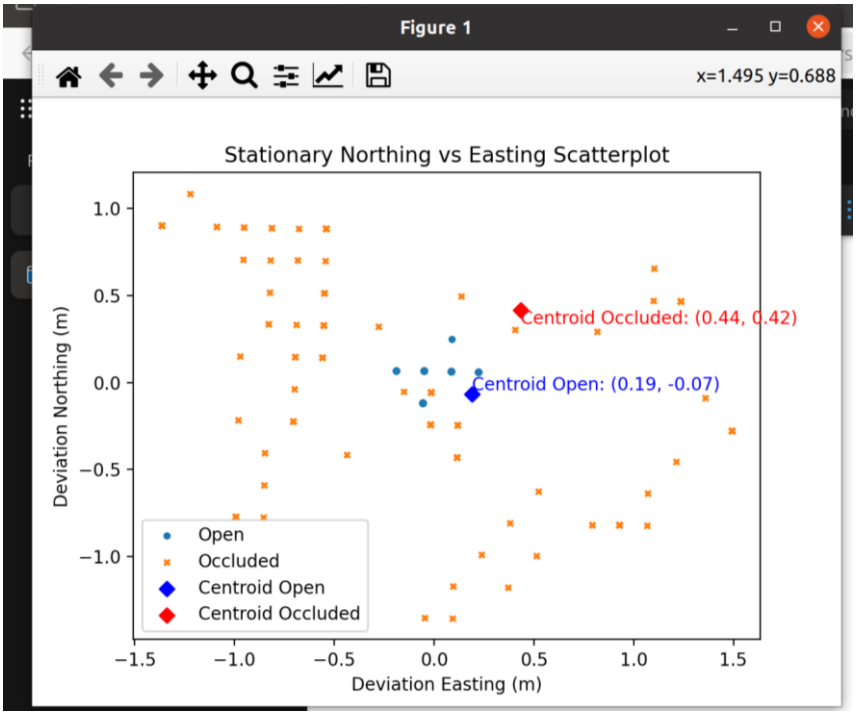


Fig1: Stationary Northing vs. Easting scatterplot

Fig1 displays the deviations in Northing vs. Easting values while we were collecting data in both open & occluded areas. Even though the data collected was in stationary state, we see high deviations in Occluded Northing vs. Easting data compared to Open data.
The graph shows Occluded scatterplots (Orange) are highly scattered (more deviations) compared to Open(Blue), because in Occluded area the GPS didn't receive proper signals for the dense trees. There were higher errors in Occluded GPS data compared to Open data collected in an area with little to no signal obstruction.
Centroid is the average point of all the given points.
Since Open areas points have less deviations, its centroid is closer to the set of points. (0.19, 0.07)
Whereas, Occluded areas points have high deviations, its centroid is further from the set of points. (0.44, 0.42)

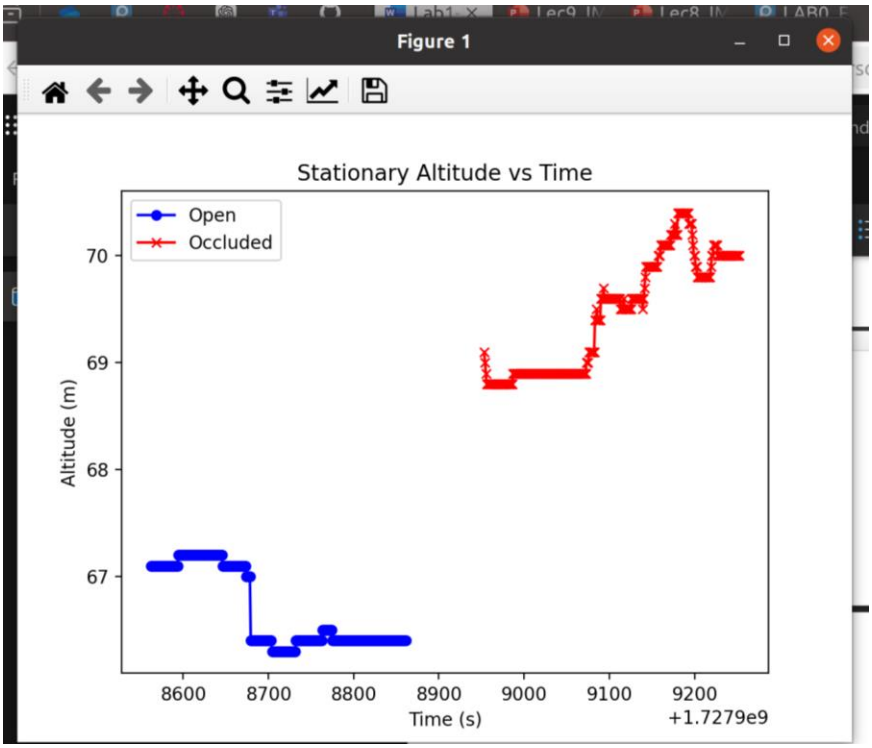


Fig2: Stationary Altitude vs. Time

Fig2 displays the change in altitude of the GPS against time while we were collecting data in both open & occluded areas.

While taking data for both Open & Occluded space, the device was kept stationary. But we see slight change in altitude (approx. 1m) in Open space & high change in altitude (approx. 2m, 69 to 71m) in Occluded space.

The altitude change in Open is a slight GPS data anomaly, but the error is less compared to the error (high deviation in values) in Occluded data. This means even though the GPS was in a stable place in Occluded area, the GPS received higher errors in its altitude value collected compared to Open area's data, which is due to high obstruction due to trees.

In Occluded area, the device was kept on 2m high brick wall, hence the change in initial height between Open & Occluded. Or else, both initial altitudes should be same.

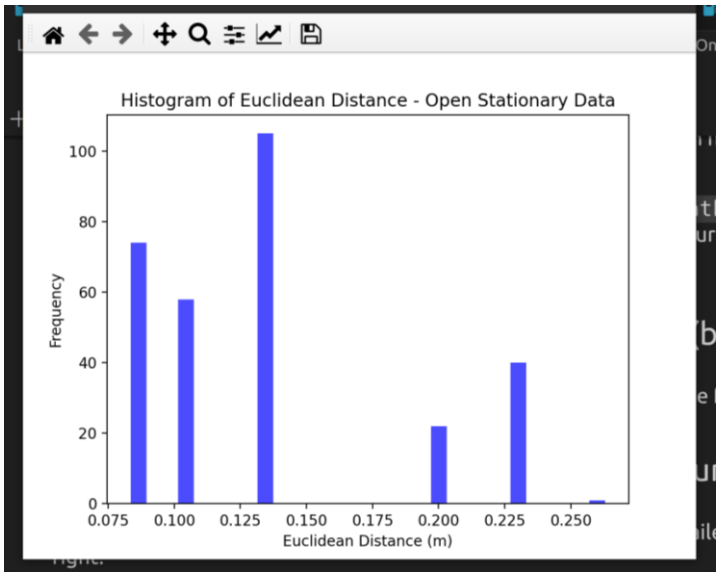


Fig3: Histogram of Euclidean Distance- Open Stationary data

Fig3 displays the histogram which gives the distribution of Euclidean distances between the GPS values collected in a Stationary Open area.
Highest frequency: 0.135m
Other peaks: 0.090, 0.105, 0.200, 0.230 m
Here, the GPS values of Open stationary data are taken over a set period of time. Then, Euclidean distance between each GPS data point is calculated. A frequency range table of each Euclidean distance is made & plotted in a graph.
This graph shows the position accuracy of the collected GPS data (precision of GPS puck) is mostly within ±0.135m. The GPS can give data with errors within a range of ± (0.090 to 0.230m). Hence, when analyzing data from GPS in Stationary Open space, it's preferrable to consider a ±0.135m error range. There are only specific Euclidean distance values, so GPS puck values have less deviation & more stable.
The frequency decreases as Euclidean distance increases.

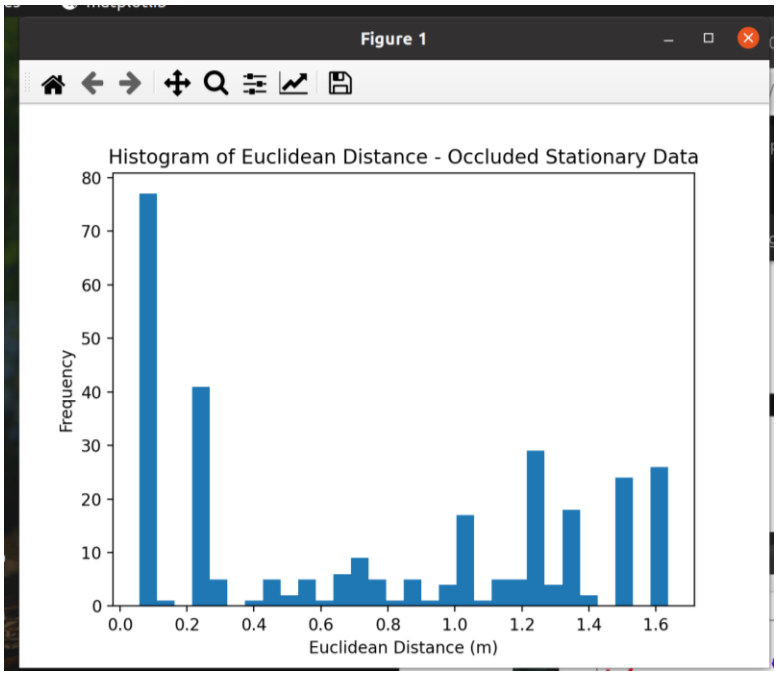


Fig4: Histogram of Euclidean Distance- Occluded Stationary data

Fig4 displays the histogram which gives the distribution of Euclidean distances between the GPS values collected in a Stationary Occluded area.

1. The highest frequency occurs at the smallest Euclidean distance (0.0-0.2 m)
2. There's a second high peak around 0.2-0.4 m
3. The frequency generally decreases as the Euclidean distance increases, but there are some smaller peaks at larger distances.
4. There's a noticeable increase in frequency for distances between 1.2-1.6 m, showing three moderate peaks.

Here, the GPS values of Occluded stationary data are taken over a set period of time. Then, Euclidean distance between each GPS data point is calculated. A frequency range table of each Euclidean distance is made & plotted in a graph.

This histogram shows that in this Occluded stationary data set, the GPS device most frequently recorded small errors (0-0.4 m) between two points. However, there's an error range up to 1.6 m, with some increased occurrence of larger errors in the 1.2-1.6 m range.

The graph illustrates the accuracy and precision of the GPS device under occluded stationary conditions, showing that while small errors are most common (0-0.4m), larger errors (1.2-1.6m) do occur more regularly. It shows that most errors fall within 0-0.4 meters, with some larger errors up to 1.6 meters. So, we should consider an error range of 0.4 to 1.6m while analyzing data from GPS in Stationary Occluded space.

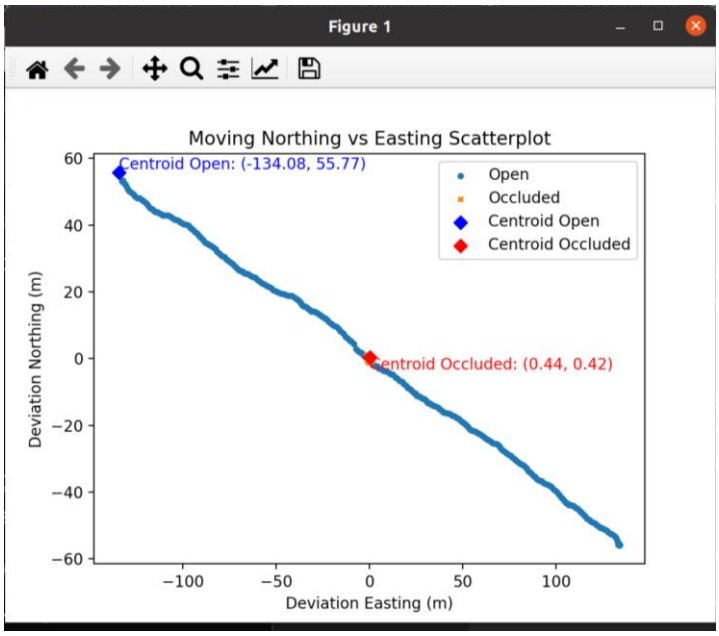


Fig5: Moving Northing vs. Easting scatterplot

Fig5 displays the deviations in Northing vs. Easting values while we were collecting data while we were moving in both open & occluded areas.
There is a single blue line that dominates the graph, representing the path of the moving object. So Open data is collected continuously & more accurately than Occluded data. The scattered orange points in the middle show less accurate or more scattered readings when the GPS signal was partially blocked or occluded.
The graph shows, the Northing is decreasing (we are moving towards South) & Easting is increasing (also moving towards East). It shows we are moving South-East.

- Centroid Open: (-134.08, 55.77); Centroid Occluded: (0.44, 0.42)
- These centroids represent the average positions of GPS points in open and occluded spaces.

The huge difference between the Centroid Open and Centroid Occluded positions suggests that the GPS accuracy was significantly lower in occluded areas.
This graph illustrates the difference in GPS accuracy and consistency between open areas (where a clear path can be seen) and occluded areas (where the readings are more clustered and potentially less accurate).

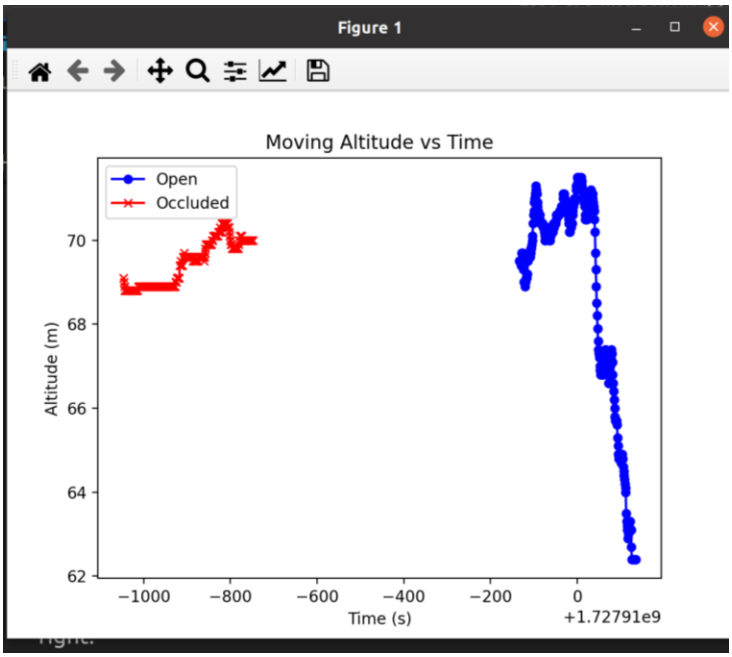


Fig 6: Moving Altitude vs. Time

Fig6 displays the change in altitude of the GPS against time while we were collecting data walking in both open & occluded areas.

We were walking over a small high bump (approx. 2m from flat ground), not flat ground, while collecting the data. Hence there's a slight change in altitude (2m).

Occluded data has higher deviation (62 to 71m) in data compared to Open data, whereas the altitude change should be within 2m against time. The GPS received higher errors in its altitude value collected compared to Open area's data, which is due to high obstruction due to trees.