EECE5554 LAB 1 Project Report

Introduction

- The main objective of the lab was to develop a driver that retrieves Latitude and Longitude coordinates from raw GPS data. The collected data was then plotted and analyzed to evaluate the scatter plot for any errors or noise.
- The initial step was to write the driver and gather the raw data. Since the data was in various formats, the driver was designed to only collect the GPGGA format. Along with the UTM values, the processed data was published on the " /gps " rostopic. After the driver was completed, a launch file was created to launch the GPS driver.

Collecting the data

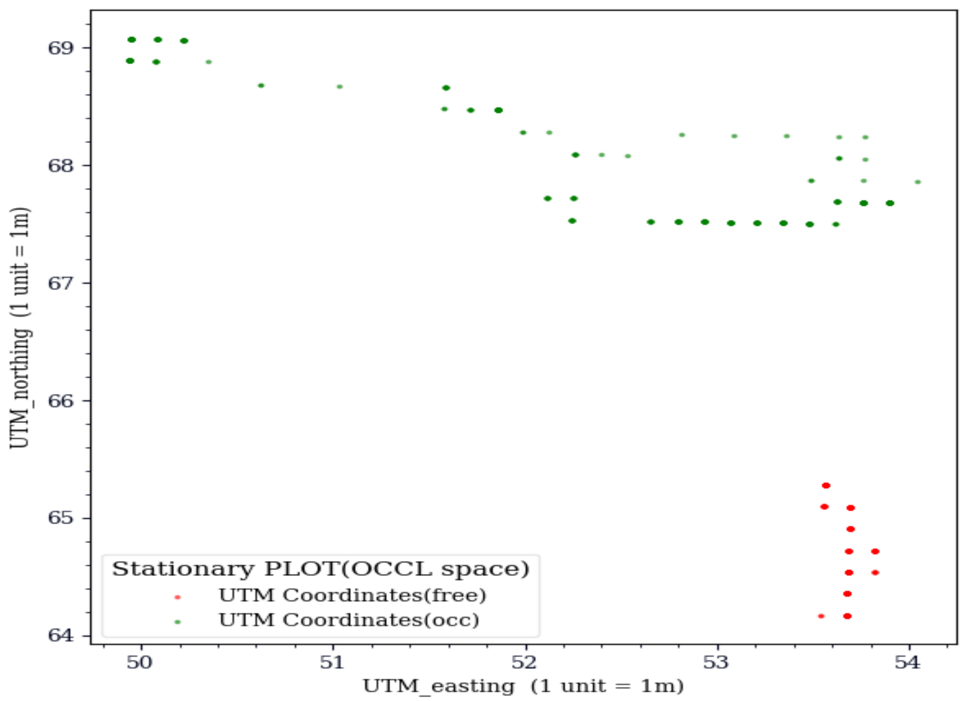
- The data from the collection bag file was transformed into CSV files, and then visualized as graphs using Pyplot. The graphs plotted were UTM_northing vs UTM_easting for both stationary and walking data, as well as latitude vs longitude for both cases. The altitude data was not plotted as it was not relevant to the analysis of errors in the scatter plot of GPS coordinates. The focus was solely on evaluating the accuracy of the collected GPS data.

Data analysis:

- The collected bag file's data was converted to CSV files and then using pyplot, graphs were plotted for that data. As shown in the below figures UTM_northing vs UTM_easting graphs were drawn for both stationary and walking data. Additionally, the latitude vs longitude graph was also plotted for both cases. The altitude graphs weren't plotted since there is no inference being taken from it. We are only analyzing the error in scattered data while collecting the GPS coordinates.

Figure 1: Plot of Stationary Data (UTM_Easting vs UTM_Northing)

Both Free space and Occl.



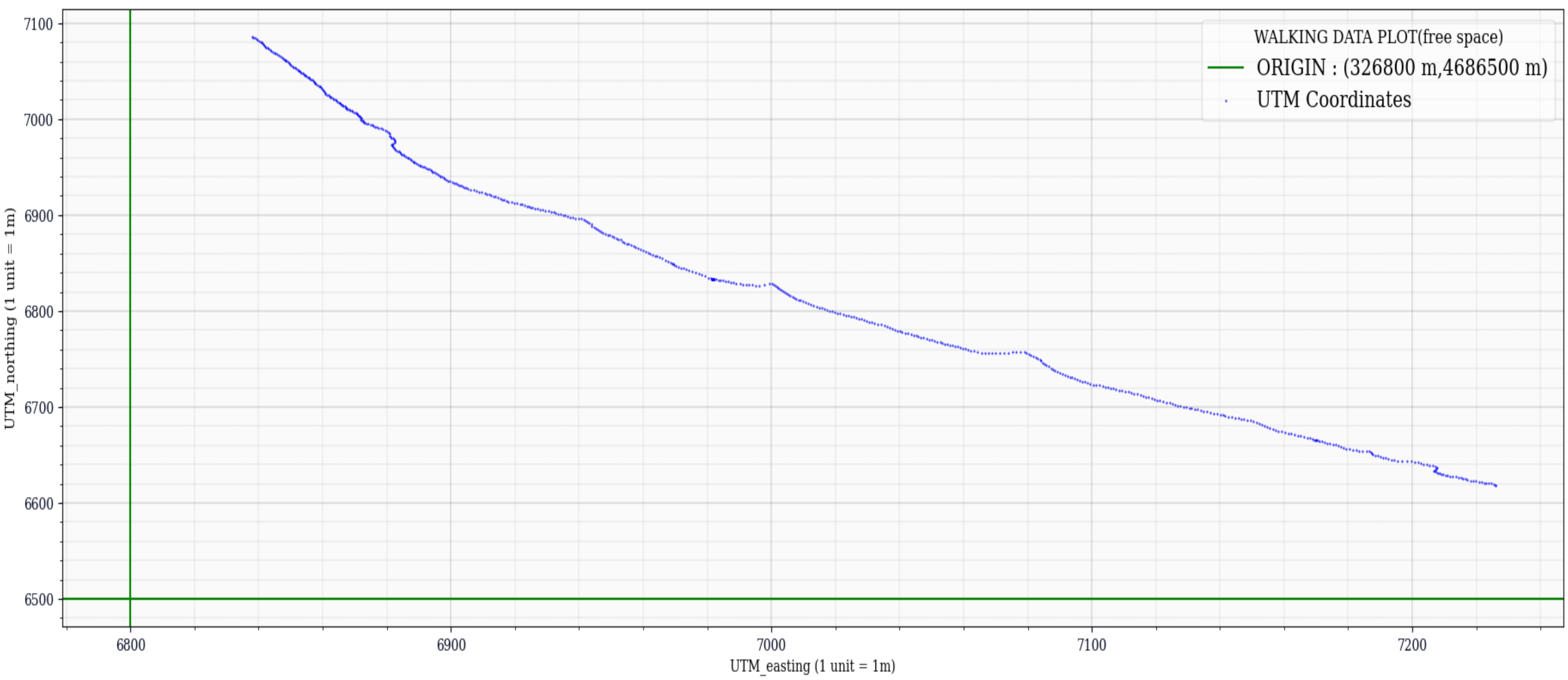
- Stationary data sets were gathered at different places to test the GPS accuracy and credibility in the stationary position
- The table below shows the no of satellites, HDOP values, and the time at which the dataset was captured. All the datasets were taken at the same position in a stationary state at a single point for 5 minutes

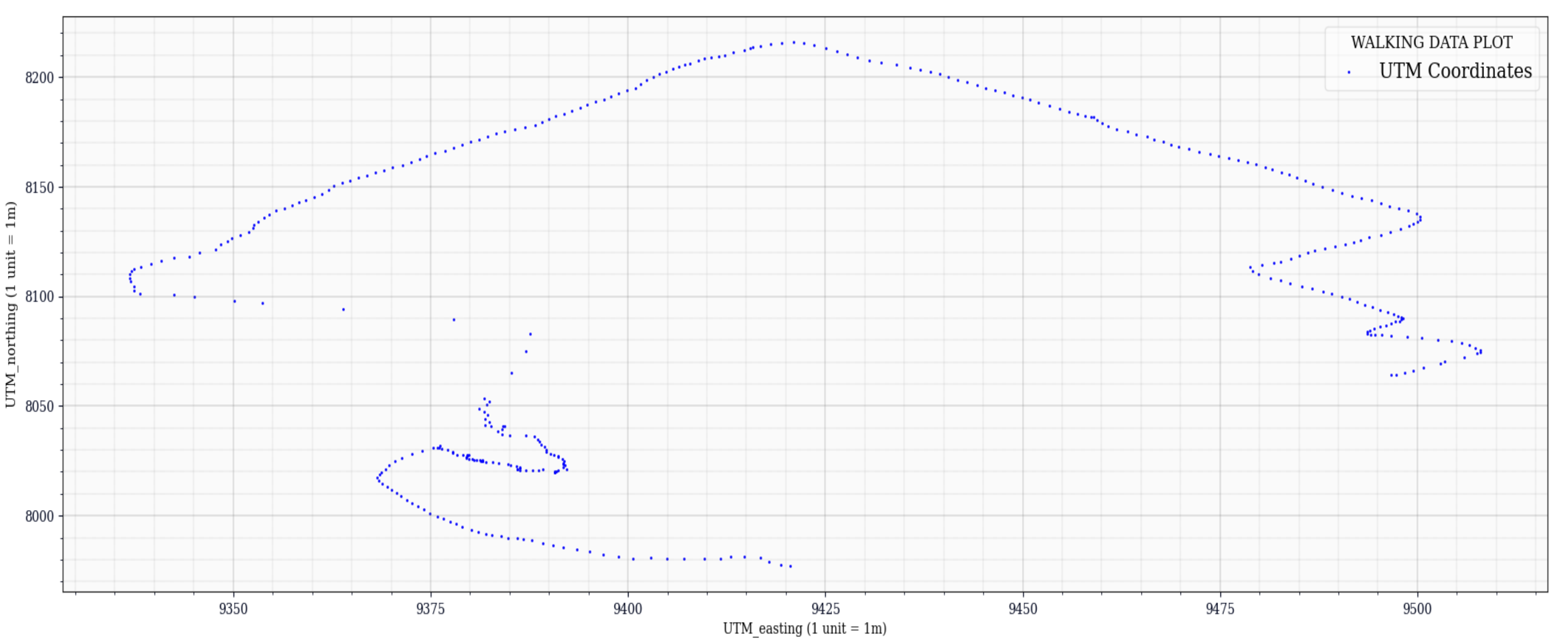
DATASET	TIME	HDOP	No of satellites
Stationary(free space)	1:20 pm	1-1.3	7-8
Stationary(Occluded space)	3:30 pm	1-1.1	5-6

UTM northing defines the distance from the equator and the UTM easting defines the distance from the prime meridian. As observable from the plot, instead of showing a single stationary point, the data seems to be scattered around a region which is because of various reasons which will be discussed in later sections. Also, one inference made from the data is that the data would best fit in Gaussian error distribution.

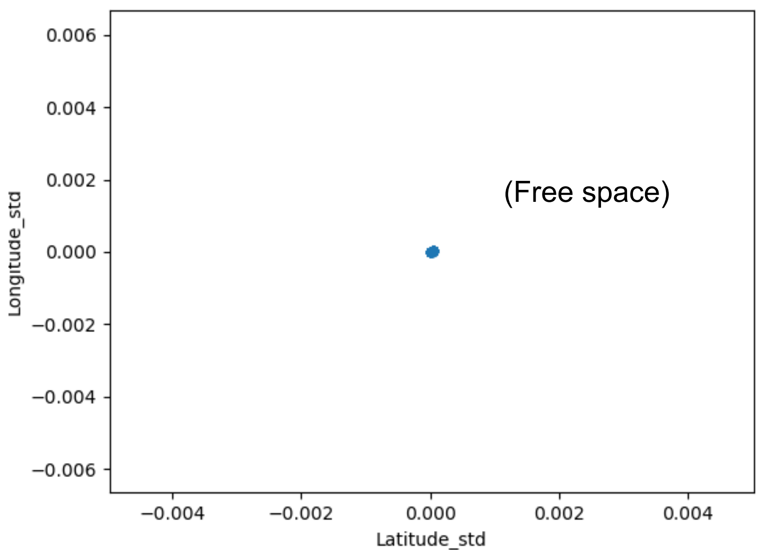
As you can for the occluded data the Hdop value is low and hence the accuracy of the spread for a stationary point is less as compared to the normal stationary data in the free space and also as the no of satellites visible in the free space is more as compared with the occluded space and also it depends on the distribution of the satellite in the sky

Figure 2: Plot of Walking Data (UTM_Easting vs UTM_Northing) in free space and occl





In Figure above UTM northing vs UTM easting of the data collected while walking (from the snell library through soccer ground to curry student center) was plotted. It had straight paths around the soccer ground, curvy paths from the snell library to the ISEC building, and also an indoor environment inside the ISEC building. The data which had lesser density and scattered data is collected inside the ISEC building which obviously shows the loss in GPS signal due to various reasons which include obstructions, electromagnetic influence, etc. The plot with solid points depicts the data collected in open areas which shows an important observation that the UTM data seems to be more scattered in the case of stationary data but not while walking. The reasons for this same are discussed in further sections.



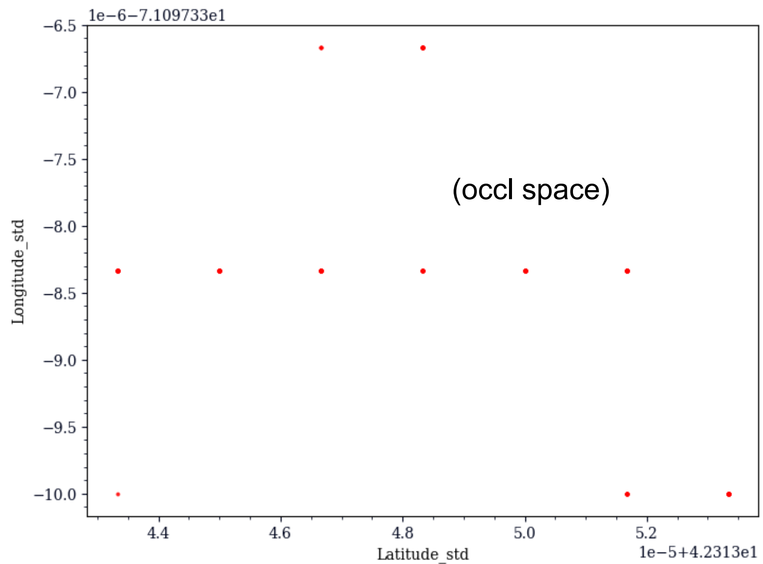
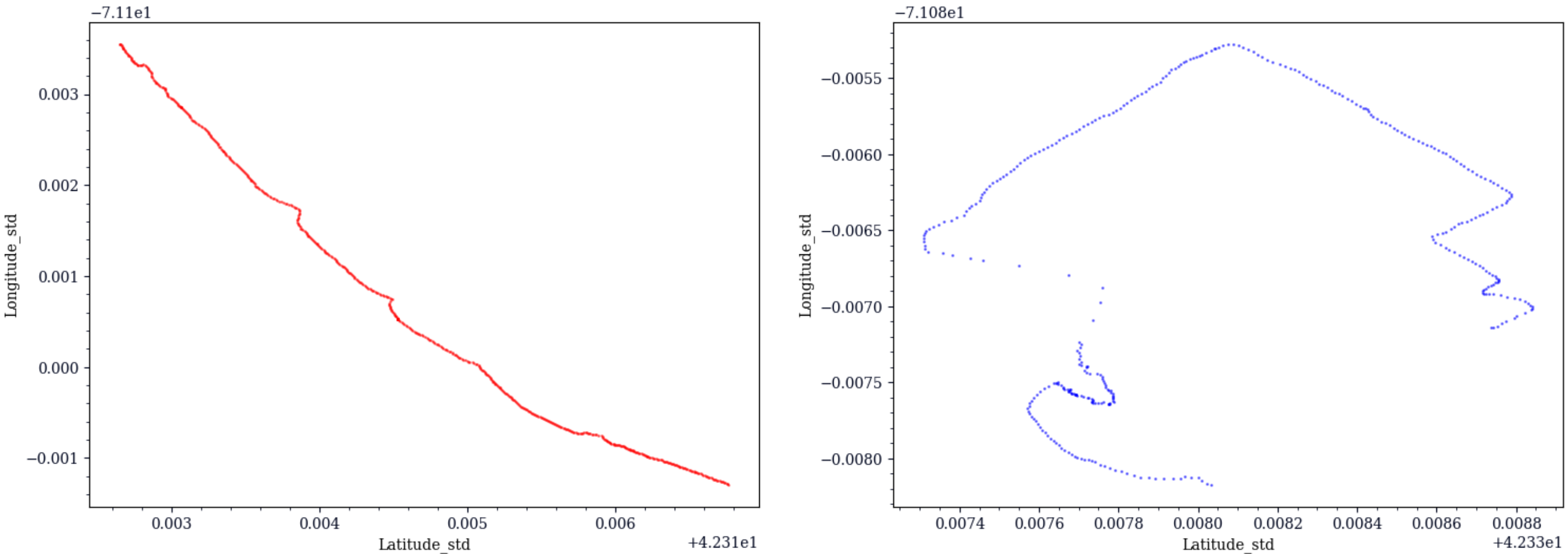


Figure-2: Latitude vs Longitude for Stationary Data(free space and occluded space)

Figure-2 Latitude vs Longitude for the stationary data was plotted which seems to be a single point with a small error which makes the point blurry/multi-point overlap

And for the occluded part of the data the deviation is much more as compared to the free space and hence which makes the point move deviated from the actual position and you can see the spread in the data over the space

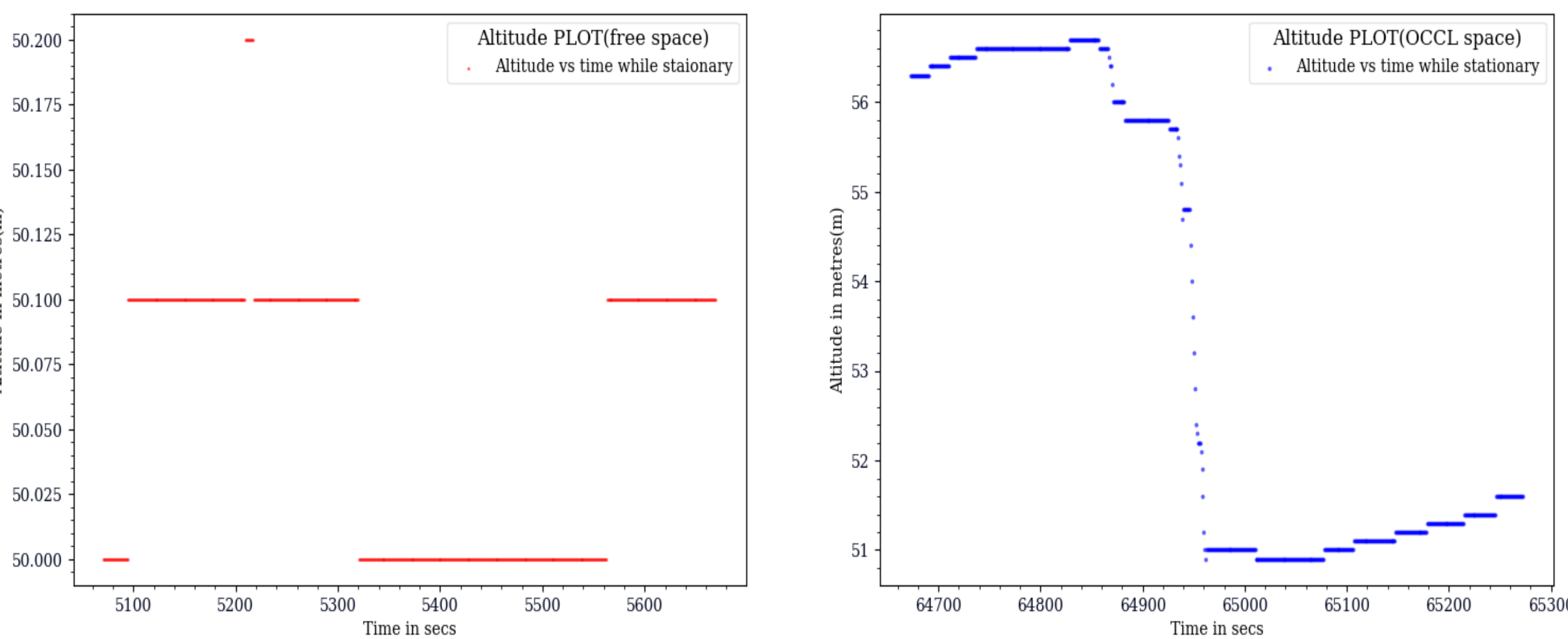
Figure-4: Latitude vs Longitude for Stationary Data(free space and occluded space)



The Firgure-4 shows the plot of Latitude vs Longitude of the data collected while walking in the path mentioned in previous sections which seem similar to the UTM graph and we can deduce similar points like the graph seems distorted in the indoor environments and the GPS signal seemed pretty strong in open.

Figure 5: Plot of Altitude of stationary data

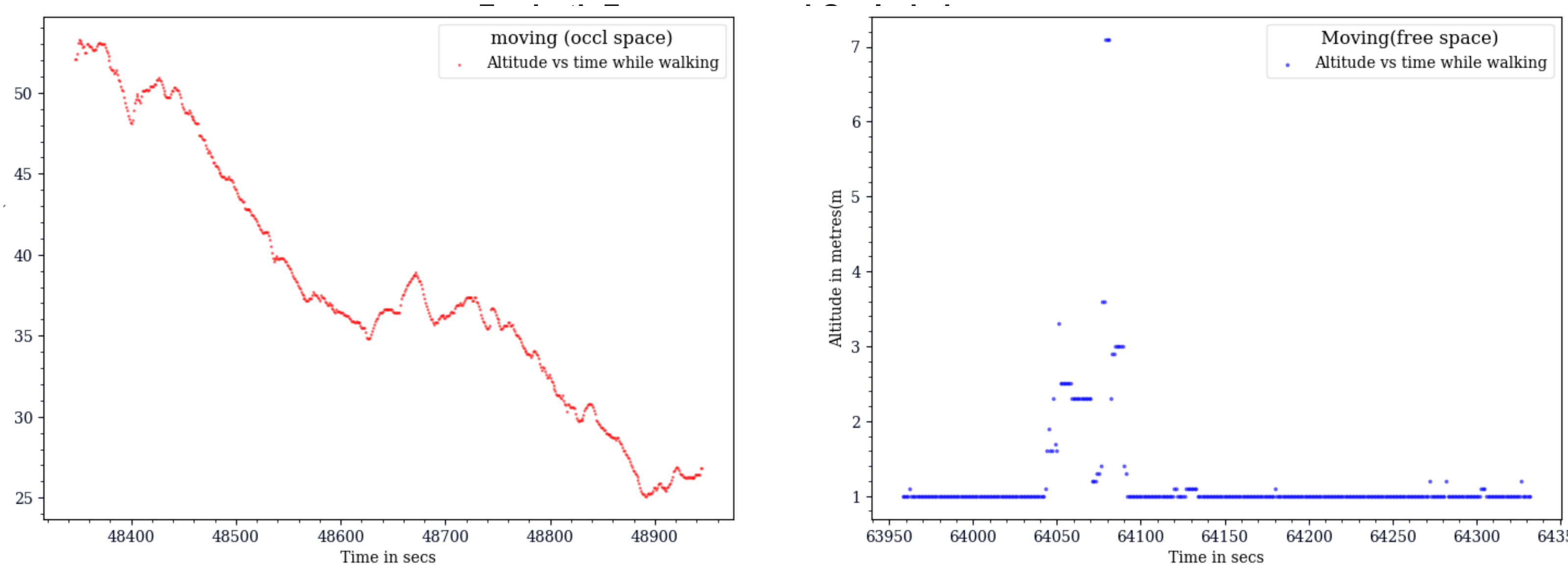
For both Free space and Occluded space



Firgure-5 shows the plot of Altitude and the time (in seconds) for a stationary position in the free and as well as in Occluded space in the environment as we can observe the free space the deviation in altitude is very less as there is no or less diffraction and reflection or interference of the GPS signal from the building and atmosphere and hence the change in altitude is negligible also the minute change in altitude is maybe due to the change in my posture as I sat down for collecting data.

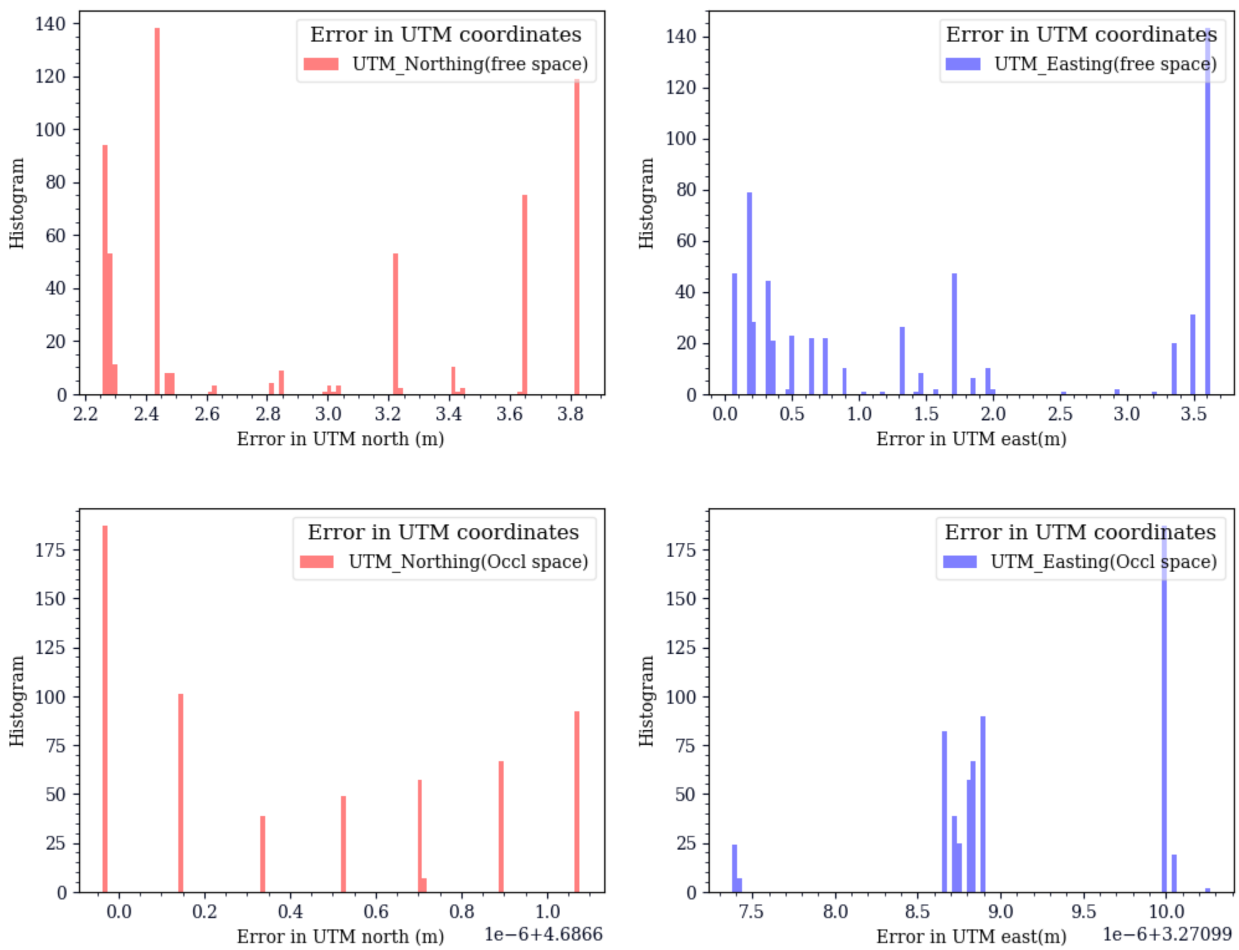
For the second graph, the altitude varied much because it's in the occluded space and the data that I got from the GPS was not very accurate due to high interference with buildings and reflecting of the data signal from void points we see the change in altitude but even the difference is of 4m only which is not very much as compared to the scale as you can see in between of the graph there is a sudden drop in altitude as the module took some time to correct itself after some readings so the correction the error took some time after the start of the module

Figure 6: Plot of Altitude of Walking data



Firgure-5 shows the plot of Altitude and the time (in seconds) for a moving position in the free and as well as in Occluded space in the environment as we can observe for the free space the deviation in altitude is very less as there is no or less diffraction and reflection or interference of the GPS signal from the building and atmosphere as discussed above and also these two dta are collected at different location for the occluded dataset i was walking down a slope near my(around my house) so there is a drastic change in the altitude in the occluded graph .

Figure 7 Error Analysis of stationary position for both free and occluded space



From the above figure we can analyze the error of the histogram plot for each of the category Stationary(free and occluded environment) from the graph we see that the error for the UTM

NORTH for a stationary position in the free space in low as compared with the occluded Environment same is true for the UTM EAST coordinates for the free space as well as for occluded space

- average Eroor in UTM EAST in stationary(free space) 1.6179666263145434 m
- average Eroor in UTM North in stationary(free space) 2.9354480400510754 m
- average Eroor in UTM EAST in stationary(Occl space) 3.2709991350973424 m
- average Eroor in UTM North in stationary(Occl space) 4.686600419088528 m

For Moving Data I tried to fit an ideal using my known current position or the known UTM coordinates through a linear regression model and tried to predict the deviation through it and also found the RMSE error using the linear regression model used

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} (Predicted_i - Actual_i)^2}{N}}$$

The value of the axes are in meters for the UTM coordinates the average error that i got from it for the moving data is around **4.809320480329198m (for free space walking)** in a straight line of about 300m