Robotics Sensing and Navigation
EECE 5554 LAB-2

Overview :

Each RTK GNS Receiver was connected with a 915 Mhz telemetry radio and a GNSS antenna. One was considered to be RTK Base and another was considered as a RTK rover. The data was collected in two regions: open space and partially occluded space. Open space data was collected near the Howland street playground and partially occluded space data was collected near the curry center at Northeastern University premises. Below are the observations, plots, statistical calculations, and analysis for the collected data.

Note

We struggled to collect data with the given kit. Hence, we decided to replace the kit on the last submission. After updating the firmware and respective configuration files, we were able to collect data in partially occluded space but with fix mode as : float. Last sunday on 26th Feb, we were successfully able to collect open data with fix mode as Fix.

Unfortunately, there is a significant delay in our submission as we were not able to configure the RTK kit properly. Hence, we requested TA Skanda for a new pair of rover and base. Please consider our delayed submission and I kindly request you not to give us late marks for this.

Introduction :

Real Time Kinematic (RTK) is a technique used to improve the accuracy of a standalone GNSS receiver. Traditional GNSS receivers like the one which we use in mobile phones or a GPS puck could only determine the position with 2-4 meters accuracy, but the GNSS RTK receivers provide centimeter level accuracy.

GNSS RTK receivers measure distance by comparing a code generated by a satellite with the same code generated internally in the receiver. The time difference between the two codes multiplied by the speed of light gives the distance.

There are 2 receivers used in the RTK:

1. Base Station - It is a GNSS receiver installed at a location whose precise position is computed by other independent precision methods of survey. It computes its location also using the GNSS and computes error in this measurement by comparing it to its precise location. These errors are transmitted in real time to the rover.
2. Rover - It uses the correction data to improve its own computed position from the GNSS and thus is able to achieve centimeter precision. RTK is mainly used for applications that require higher accuracy such as cadastral surveying,

construction activities and drones navigation. It also saves time, energy and cost, allowing more work to get done with accurate results.

Analysis :

For occluded space : Status of Fix mode was Float.
(We think this is mostly because of cloudy weather.)
For open space - Status of fix mode was Fix as expected.
While collecting the data for open space, we initially received the fixed mode status as “float” only but once the sky was clear. We started receiving the “fix” value. Also, the survey in setting was : 10 seconds and 50 meters of accuracy.

1.Stationary data open space :

mean_easting -15.519797211519933   median_easting -15.51976678398205
mean_northing 26.892091492446138   median_northing 26.89202020689845

Figure : scatterplot for open space stationary

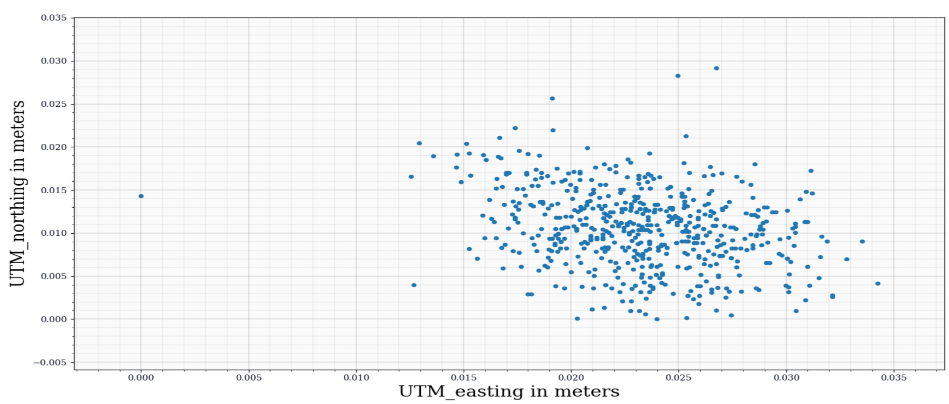
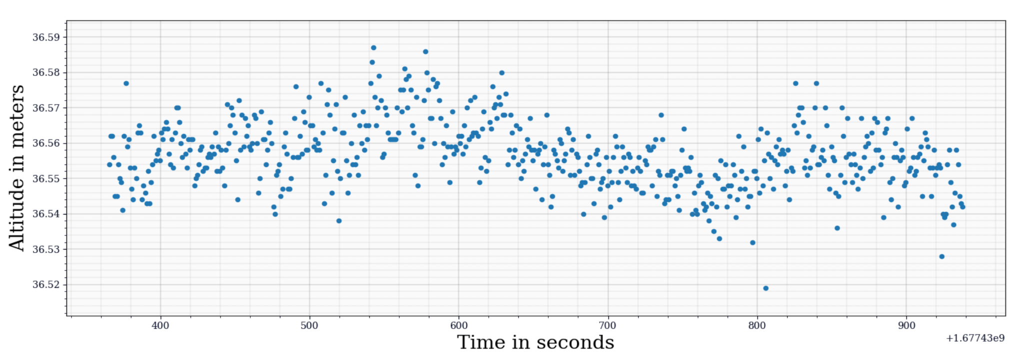


Figure : Altitude plot for open space walking



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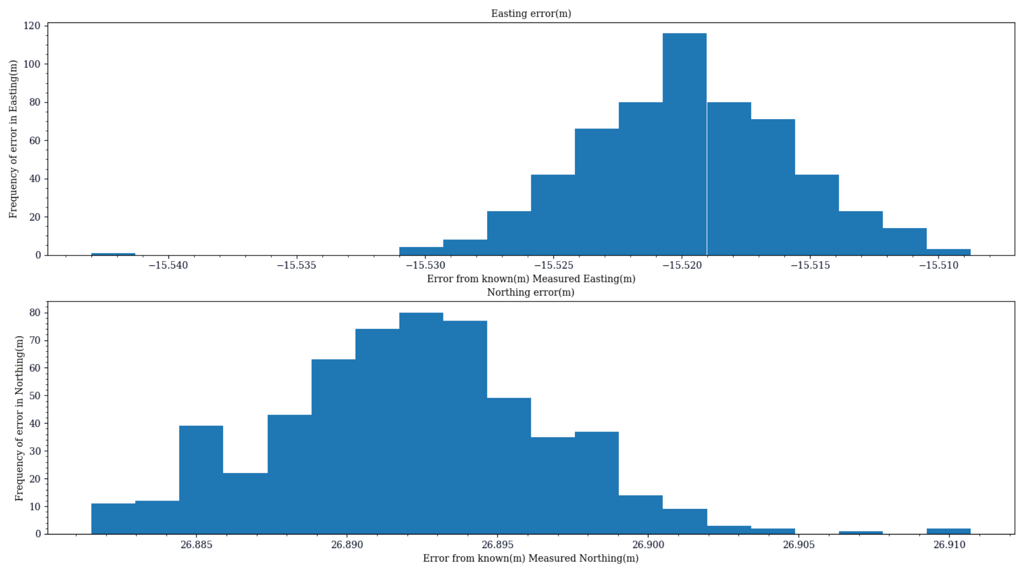
Open stationary Altitude variation = 6 cm.
All stationary points are clustered between 25 cm range.
This deviation could be caused by multipath effect or human error while placing the rover RTK gnss.

Histogram Figure : Error plot for open space stationary



2. Walking data open space :

Mean Easting Value 327878.2737399799
Mean Northing Value 4686848.044456808
Standard Deviation of UTM_Easting: 7.769775880262213
Standard Deviation of UTM_Northing 7.869597464205227

The Root Mean Square Error(RMSE) of easting vs northing is 0.2542404218080672 m which is approximately 25.42 cm and is a good accuracy.
This deviation could be caused by multipath effect or human error while placing the rover RTK gnss.

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Figure : scatterplot for open space walking

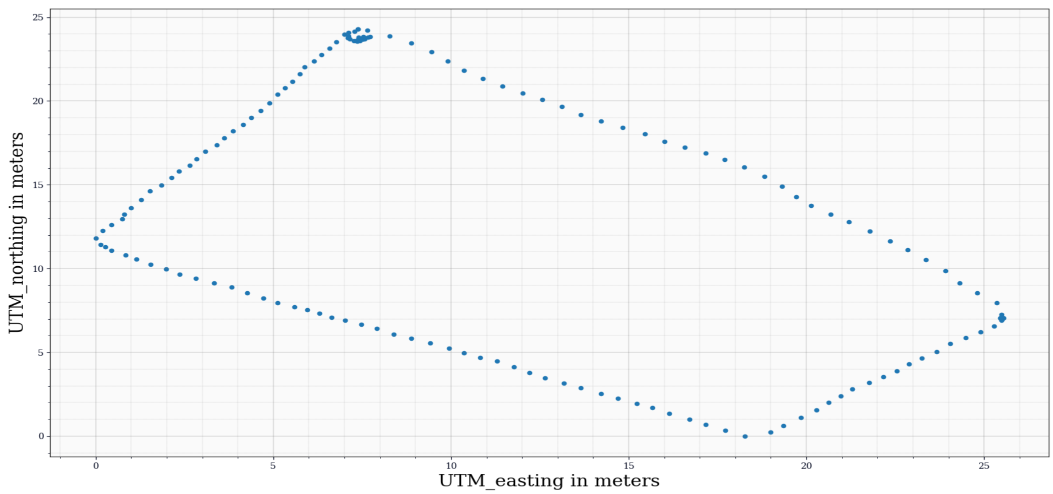

Figure : best fit line for open space walking

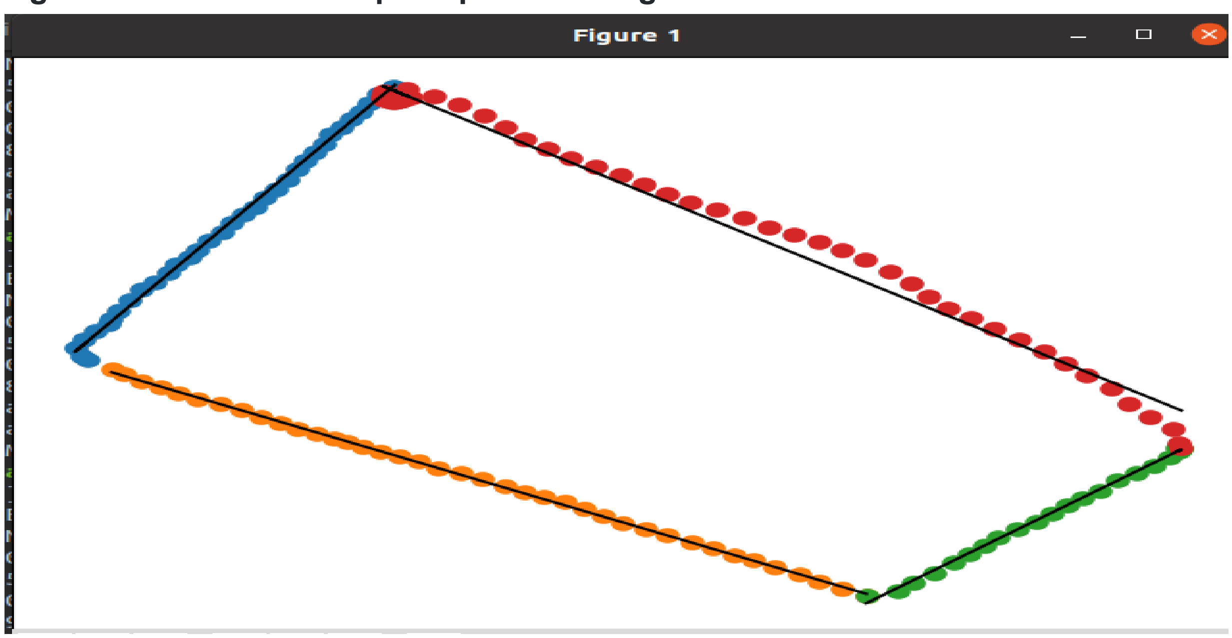

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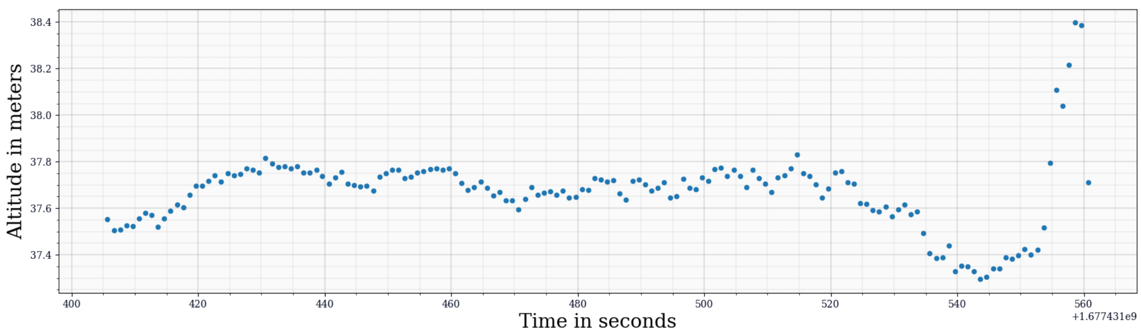
Figure : Altitude plot for open space walking



Altitude variation : 1 meters

<u>3. Stationary data occluded space :</u>

mean_easting -3.71407367734795   median_easting -3.356444949982688
mean_northing 60.0158074815644   median_northing 60.5287815602496

Figure : scatterplot for occluded space stationary

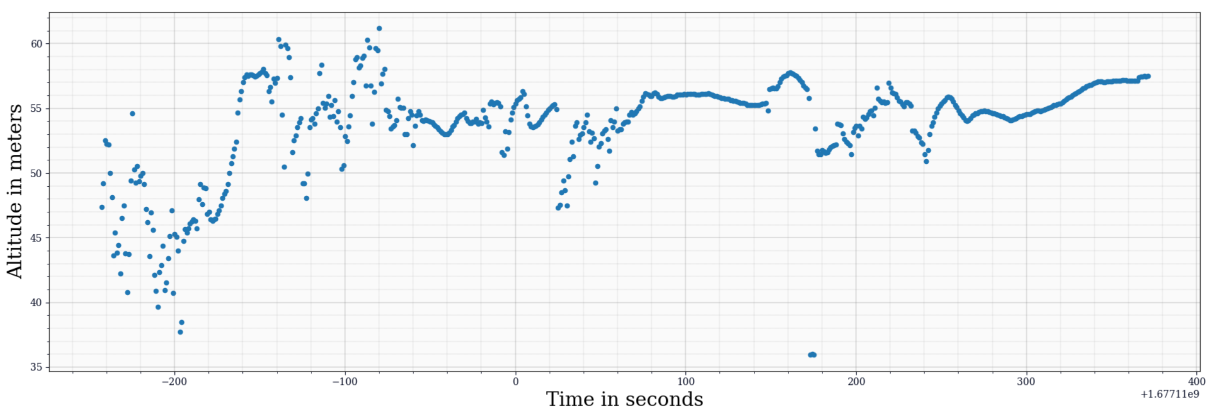
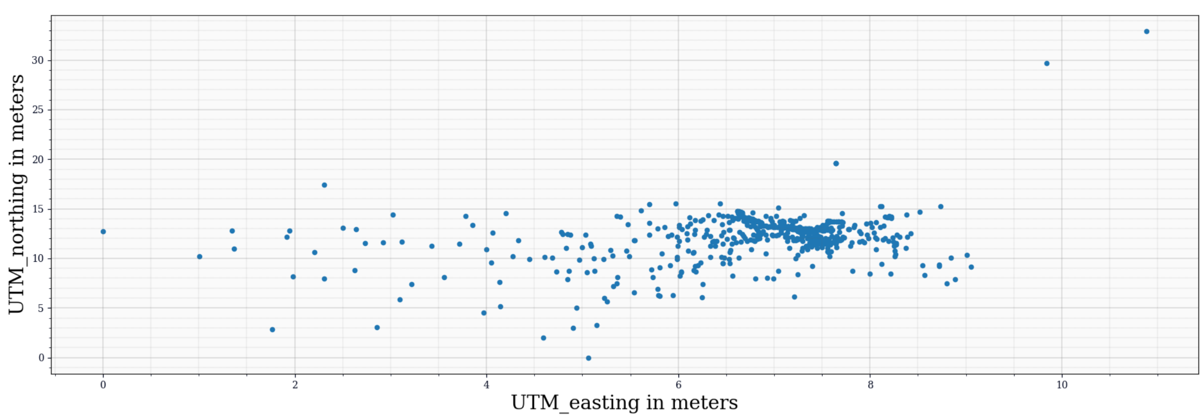
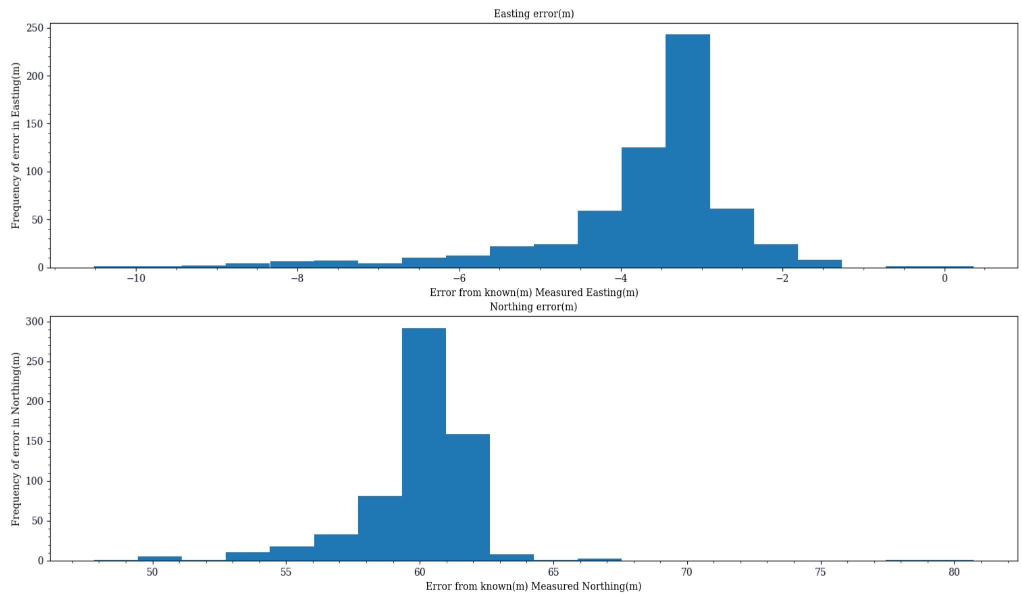


Figure : Altitude plot for occluded space walking



Histogram Figure : Error plot for occluded space stationary



Occluded stationary Altitude variation = 20 meters.
All stationary points are clustered between 15 cm range. With some outliers ranging above 30 cm.

<u>4. Walking data occluded space :</u>

Mean Easting Value 328069.1659049603
Mean Northing Value 4689600.411021503

Standard Deviation of UTM_Easting: 11.107424455872309
Standard Deviation of UTM_Northing 18.400222487647625

The Root Mean Square Error(RMSE) of easting vs northing is 2.686365369801207 m which is approximately 2.68 meters and is a bad accuracy.

Unfortunately, we could not walk straight as there was an obstacle. Hence, you could see a small bulge in the walking scatter plot.

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Figure : scatterplot for occluded space walking

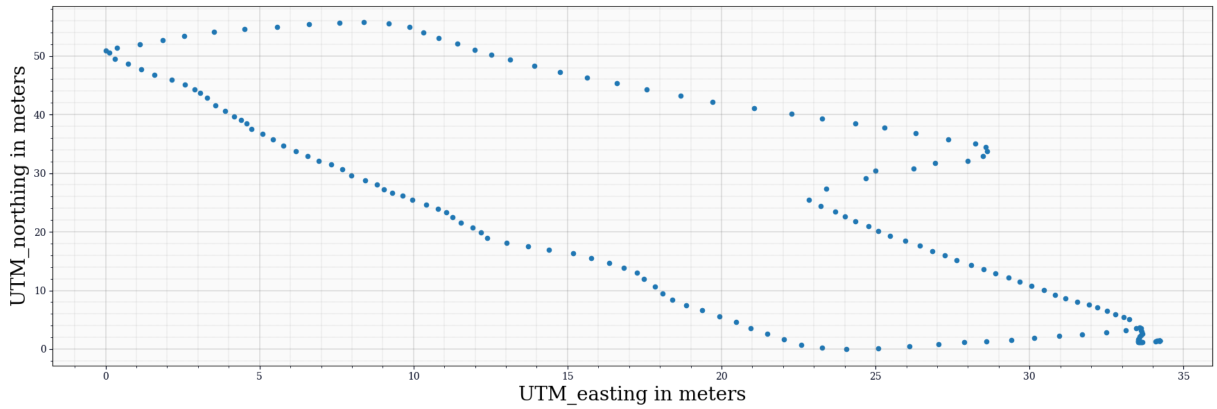


Figure : Altitude plot for occluded space walking

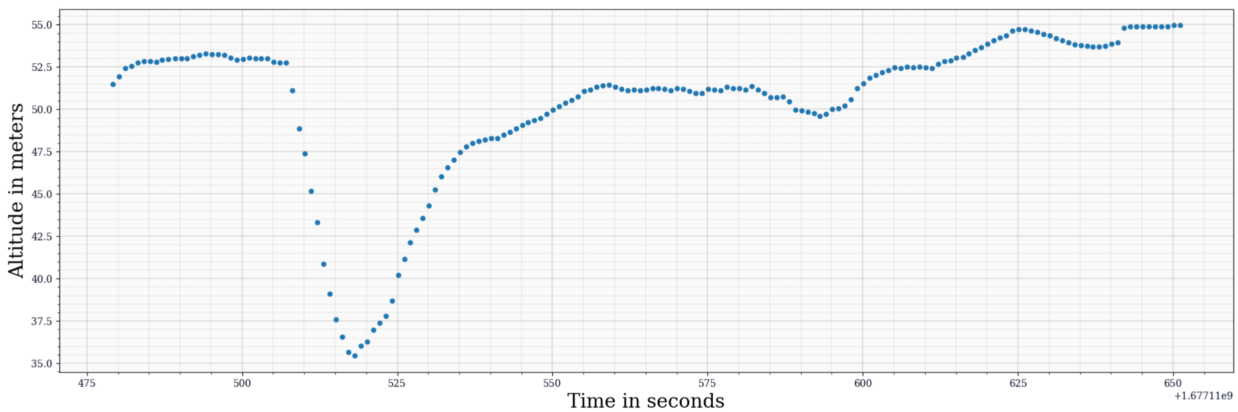
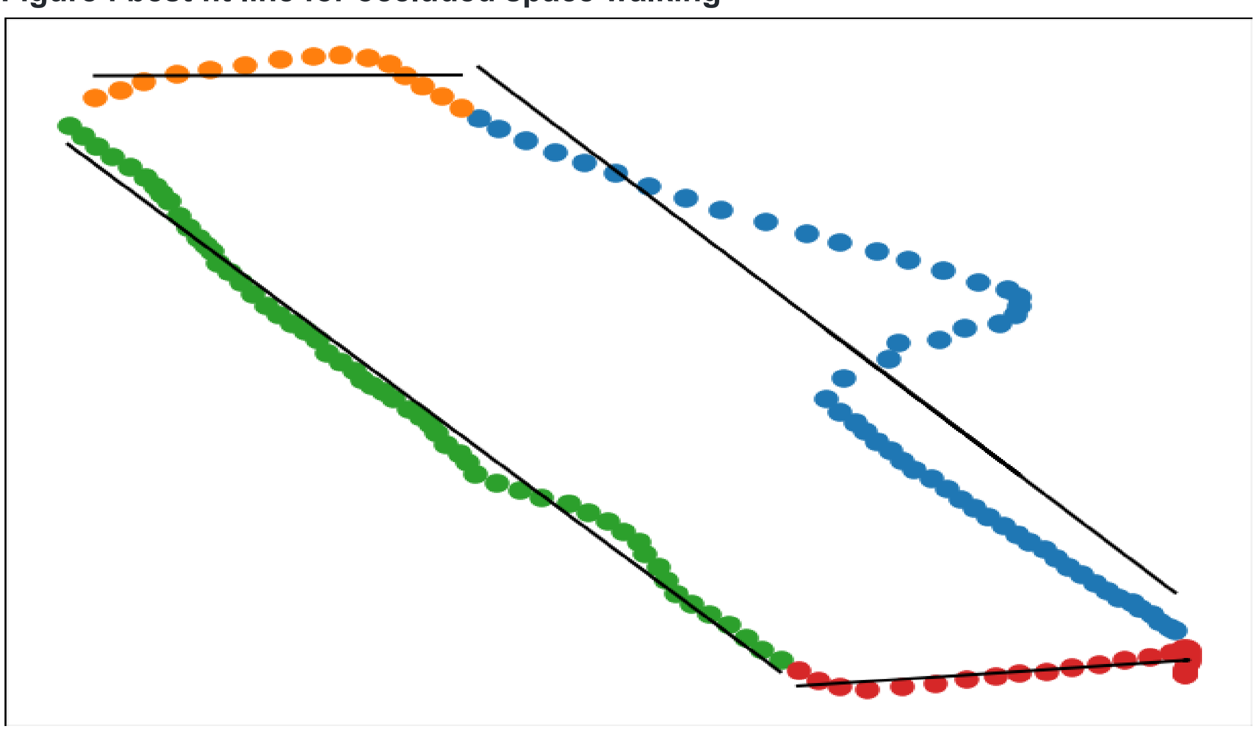


Figure : best fit line for occluded space walking



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Conclusion :

Overall, RTK GNSS accuracy still depends on signal strength, multipath effect, Ionosphere delays, clock - related errors, human errors while calculating and other factors. But it is definitely better than the GPS puck sensor used in the previous lab. Because we have a RTK GNSS base that keeps sending correction values to the RTK GNSS rover which reduces the calculation errors and gives centimeter level accuracy. We should also note that GNSS is not only using all available satellites for global positioning but satellite constellation systems as well. Also, comparing the above data, plots and statistics we can come to the conclusion that data collected in an open space has more accuracy compared to the data collected in partially occluded space.

a. What does the error (if you used a “true” position) or deviation (if you didn’t) tell you about RTK GNSS navigation, as compared to GNSS without RTK?

Without RTK, GNSS can typically provide positioning information with an accuracy of several meters. In contrast, RTK GNSS can provide positioning information with centimeter-level accuracy. The deviation aka error in RTK GNSS navigation tells you about the level of accuracy. When using a "true" position as a reference, the error tells you how much the RTK GNSS receiver's calculated position differs from the actual position.

b. What can you say about the distribution of noise in the signal? It may be useful to make a scatter plot and plot something from there?

In order to analyze the noise distribution statistically, we can do this by calculating the standard deviation of the measured positions relative to the true position. A smaller standard deviation indicates that the noise in the signal is more tightly distributed around the true position, indicating higher accuracy. We can see the std of open space is 7 meters while occluded is around 11-12. Hence, this deviation could be caused by multipath effect or human error while placing the rover RTK gnss. I have used mean values to plot the histograms and we can see the bell-curve distribution. To sum up, RTK signals are expected to have less noise as the receiver uses additional information from the nearest base station to correct errors in signals.

c. Why is this distribution different from GNSS data collected in Lab 1?

This distribution is more accurate than data collected in Lab1 using Gps puck. RTK GNSS base keeps sending correction values to the RTK GNSS rover which reduces the calculation errors and gives centimeter level accuracy. RTK GNSS is a high-precision positioning technology that uses signals from multiple GNSS satellites and a nearby base station to determine an object's precise location. This setup was not available for puck hence, the distribution is better in terms of accuracy and precision.

d. How are your moving data different in the open and occluded cases? Does this have anything to do with GNSS fix quality?

The quality of the GNSS fix is determined by the number of visible satellites, their geometry, and the signal strength.
RTK fixed: RTK z with the highest accuracy within the 1-2 cm range
RTK float: if we can not accomplish the RTK fixed state because of the conditions or calculation. The RTK float accuracy is in the range of 0.2-0.5m.
In an open space with a clear sky, the GNSS receiver can typically receive signals from a sufficient number of satellites to obtain a high-quality GNSS fix. But in occluded space, due to signal obstruction the accuracy will be lower. We see that the Kalman filter helps track the data to give an approximate shape of the field. In the open space structure motion data, the points are quite accurate and precise in terms of tracing the field path. Hence, the RMSE error is 25 cm in open space while 2 meters in occluded space. The signal quality may be degraded in occlusion, leading to a lower GNSS fix quality.

e. How are your stationary data different in the open and occluded cases? Does this have anything to do with GNSS fix quality?

The GNSS receiver can typically receive signals from a sufficient number of satellites to obtain a high-quality GNSS fix. In an occluded or obstructed environment, the number of visible satellites may be reduced, and the signal quality may be degraded, leading to a lower GNSS fix quality. Hence, we were getting a Float as fix mode instead of fix status. In occluded areas, with a lower-quality GNSS fix, the stationary data may be less accurate and more prone to errors and noise.