<u>Lab 2</u>

RTK GNSS

Real time Kinematic GPS is a technology that is used to provide highly accurate positioning and data to navigate. The RTK GPS uses a combination of GPS signals and local base station to provide positioning date with high accuracy.

Differences between RTK GNSS and GNSS

Standard GNSS positioning determines the user's position by measuring the time of flight of signals to the receiver. The accuracy of this method is influenced by factors such as satellite clock errors, atmospheric delays and multipath errors. RTK improves the accuracy of the GNSS positioning by using a network of fixed reference stations with known positions. These stations continuously observe satellite signals and compute corrections for errors. A mobile RTK receiver applies these corrections in real time to enhance its positional accuracy.

The main difference between RTK and standard GNSS is that RTK achieves a higher level of accuracy by using real time corrections from reference stations, while standard GNSS positioning depends only on satellite signals and provides less accurate information.

Sources of error in RTK GNSS

- **Ionospheric Error:**

When the GNSS signal passes through the ionosphere, the path of the signal will bend, and the propagation speed will also change. At this time, the distance between the propagation time of the signal by the speed of light in vacuum is not equal to the geometric distance between the satellite and the receiver. This deviation is called the ionospheric refraction error. For suck an RTK error, we can select a more powerful RTK GNSS receiver to guarantee the RTK accuracy.

- **Baseline Distance Error:**

When the distance between the rover and the base increase by 1km, the RTK error will increase by 1mm. Such error is caused by the increase of the baseline distance. This error is an objective error and its better to keep the distance between the rover and the base station within 20km to ensure surveying accuracy.

- **Multipath Error:**

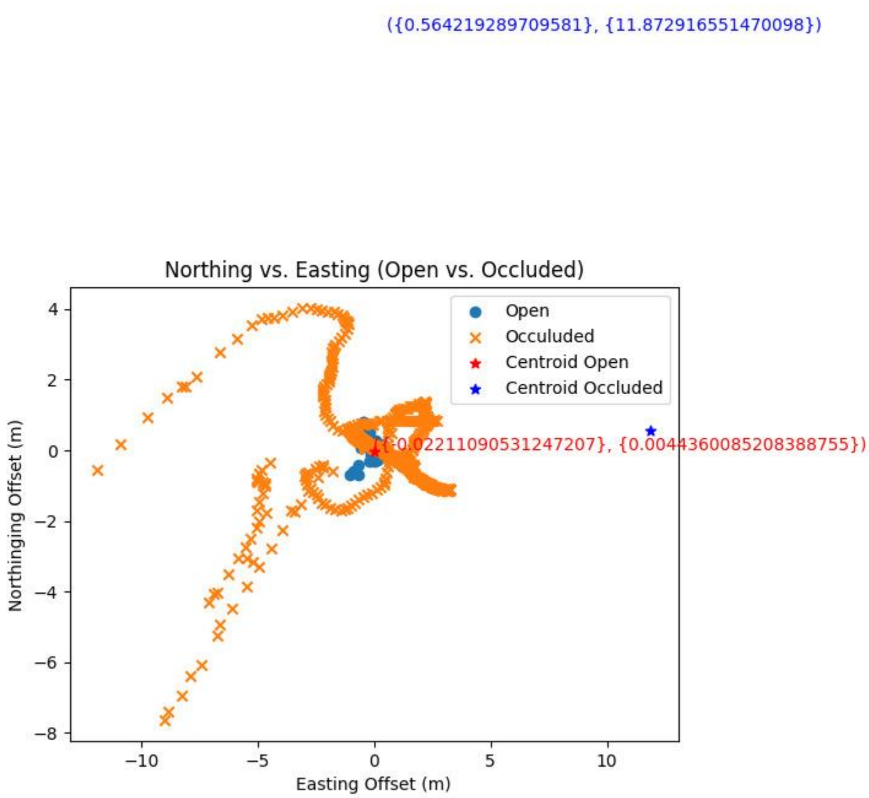
Multipath interference occurs when the satellite signal is reflected off a surface such as a building or a vehicle and arrives at the receiver at different times, causing errors in the GNSS measurements. Avoiding large reflective surfaces like water surfaces, glass buildings during measurement or usage of choke ring antenna can eliminate multipath errors.

- **Satellite Signal Quality Error:**

Poor satellite quality will also lead to large RTK errors. They are usually caused by severe occlusion or signal interference like dense forests, buildings, electric towers, etc. To fix this error, surveyors can select full constellation RTK receivers, which can track more satellites even in harsh environments.

1. **What do the error (if you used a "true" position) or deviation (if you didn't) tell you about the accuracy of RTK GNSS navigation, as compared to standalone GNSS without RTK?**

   The deviation reveals that the RTK GNSS plot has the points that appear closely clustered, indicating much smaller deviations from the reference positions. The centroids (blue for open and red for occluded) also stay closer to the origin, highlighting high precision.



2. **What can you say about the ranges and shapes of your position in Easting and Northing from RTK GPS?**

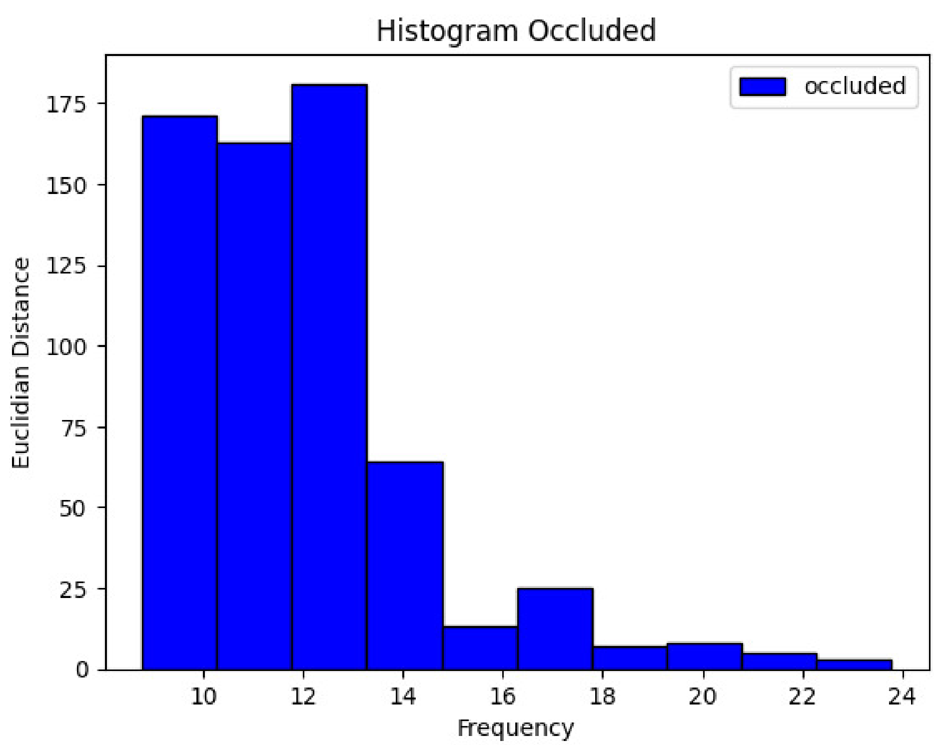
The easting and northing range suggests that the robot being tracked covers a significant area along both the Easting and Northing axes during its motion.

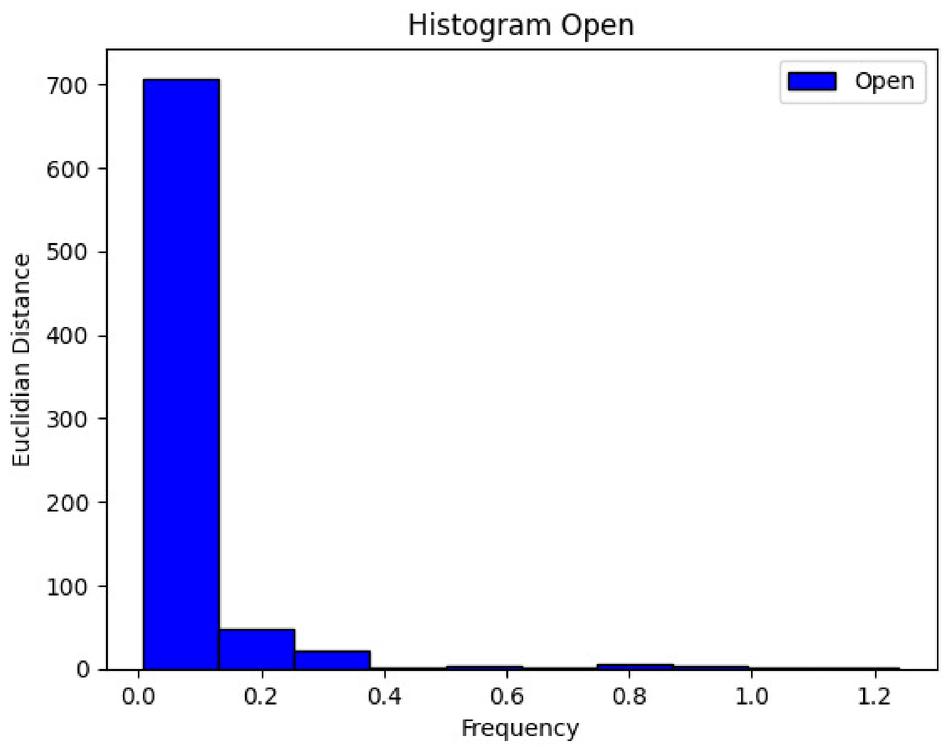
Easting offset: -10m to +12m

Northing offset: -8m to +4m

3. **Is the shape or range of your histogram different than your dataset collected in Lab 1?**

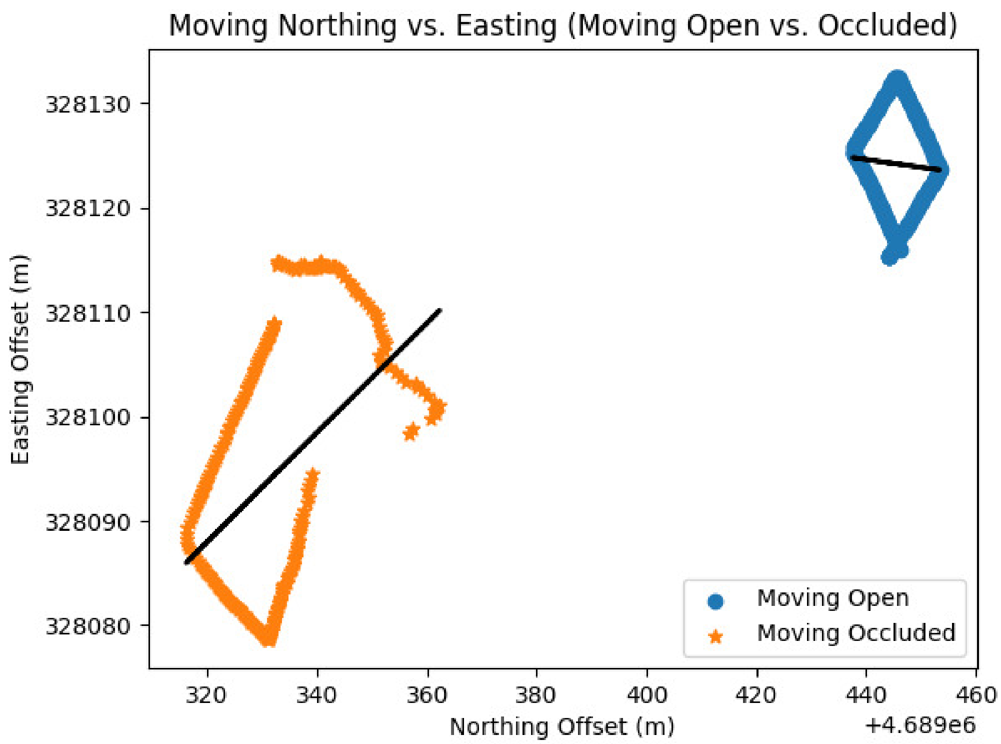
The RTK GNSS histogram (presumably the last one) shows much tighter clustering around certain distance values, especially around 10 to 14 meters. RTK GNSS provides centimeter-level accuracy by using a base station and correction data, which corrects satellite signal errors, leading to significantly higher precision. RTK readings, as shown in the histogram, are less affected by occlusions. While there are still some outliers, the data is much more concentrated, reflecting RTK's ability to maintain accuracy even in somewhat challenging environments by leveraging correction data. The RTK GNSS data appears to maintain tighter groupings with fewer extreme deviations, suggesting that the positioning errors are smaller and more consistent.





4. Give quantitative comparisons for how your moving data differ in the open and occluded cases, including error/deviation estimates? Does this have anything to do with GNSS fix quality?

In occluded data, Error is Minimal, with deviations well below 0.1 meters due to the high precision of RTK. Deviations are generally within **1-2 meters**, significantly smaller than those seen in GNSS data.

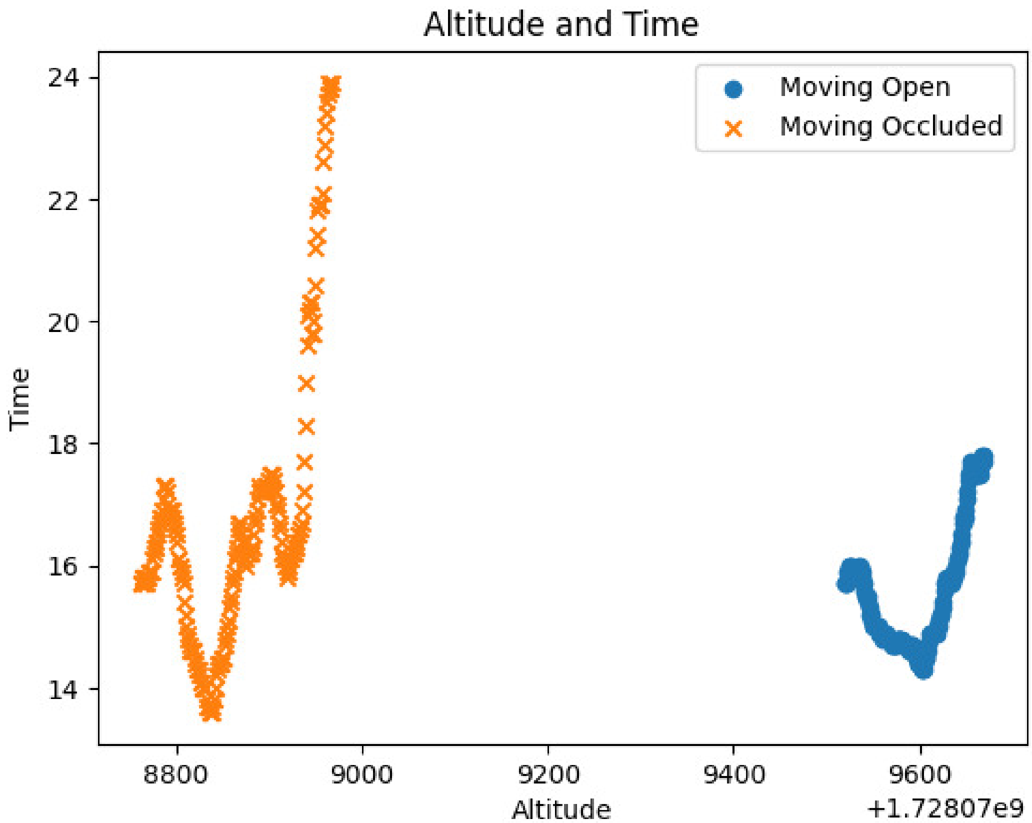


5. How are your stationary data different in the open and occluded cases, including numerical error/deviation estimates? Does this have anything to do with GNSS fix quality?

For GNSS data, the accuracy of location and altitude measurements is highly dependent on satellite visibility. In the open case (blue), the error should generally be lower, resulting in tighter clustering of data points.

In the occluded case (orange), the deviation from the mean altitude might be much larger. This likely relates to GNSS fix quality. In open environments, the receiver has a clearer line of sight to multiple satellites, improving the quality of the location fix and reducing error.

In occluded environments, the signal is obstructed or reflected, reducing fix quality and increasing errors in both the horizontal and vertical positions.


Altitude and Time
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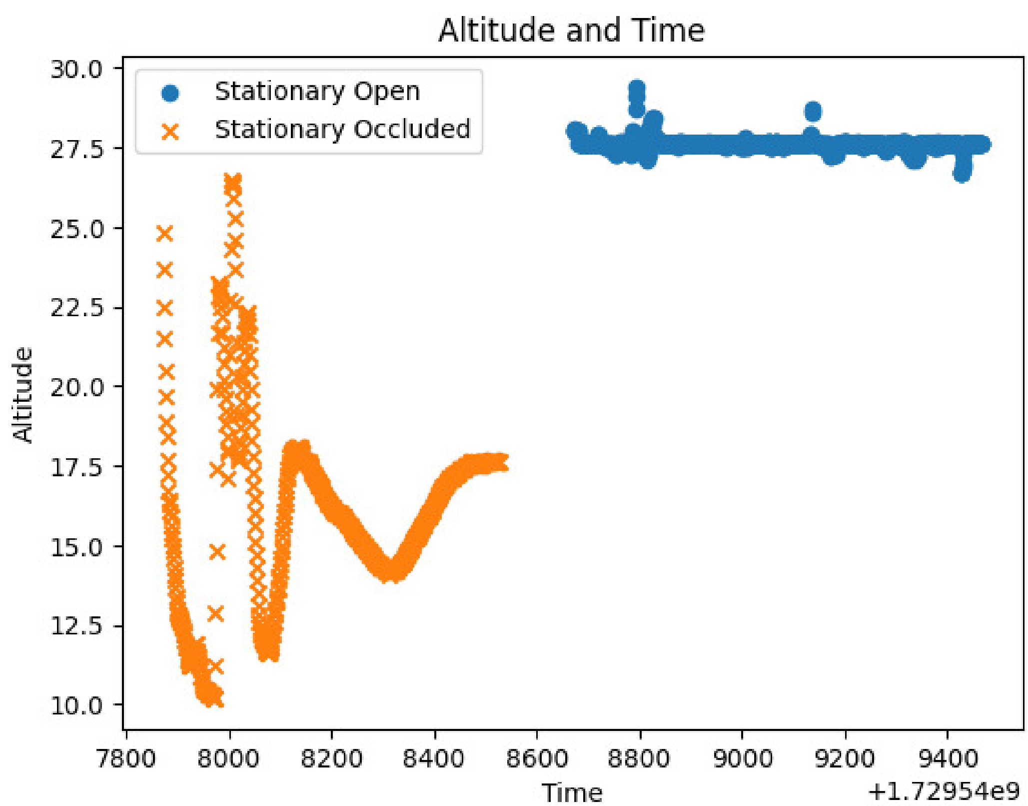
Altitude and Time
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