Lab 2 Report: Real Time Kinematic GPS

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Introduction

A sophisticated satellite positioning technique called real-time kinematic (RTK) GNSS incorporates corrections from ground-based reference stations to greatly increase GPS accuracy. This method is extremely useful for applications needing great accuracy, like construction and surveying, because it allows for centimeter-level precision in real time. For activities requiring exact measurements, the RTK system can provide consistent and extremely dependable positional data by connecting to a base station and receiving real-time adjustments.

RTK-GNSS vs GNSS

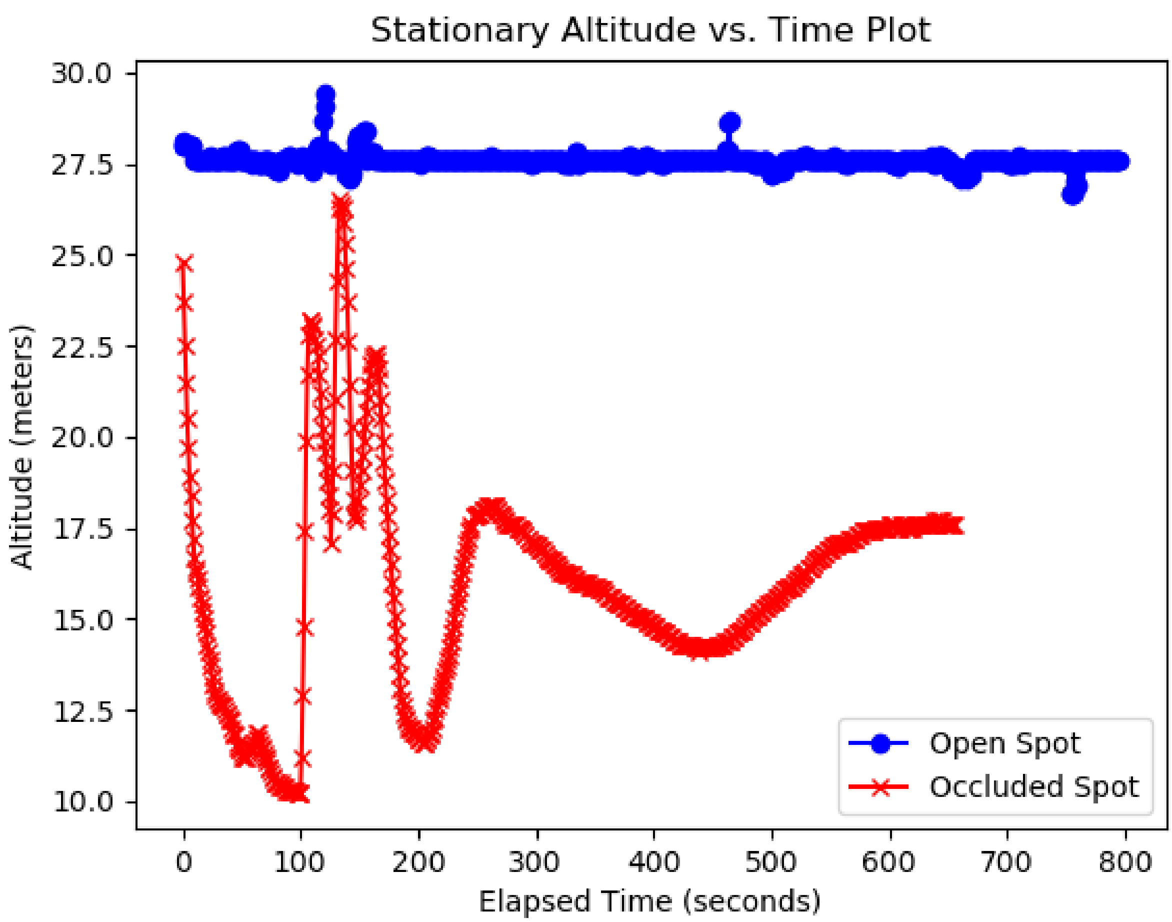
Using real-time corrections from a nearby base station, RTK GPS provides centimeter-level precision, which makes it perfect for applications like land surveying and precision agriculture. However, ordinary GPS, which does not use these corrections, is often accurate within 5 to 10 meters, which makes it appropriate for general navigation. Similar to this, RTK GNSS uses real-time kinematic techniques to improve accuracy to a few centimeters, whereas regular GNSS systems that solely rely on satellite signals typically attain accuracy of a few meters. This means that while regular GPS and GNSS are better suited for routine locating operations, RTK systems are necessary for applications where high precision is crucial.

The "Fix Quality" feature in GNGGA data shows the kind of GPS fix and the data's correctness and dependability. Fix quality values range from 0 (no fix, invalid), 1 (standard GPS, 5–10 m accuracy), 2 (differential GPS, DGPS, 1-3 m accuracy), 4 (fixed RTK, yielding centimeter-level accuracy), and 5 (RTK float, yielding decimeter-level accuracy). For applications requiring a high degree of precision, such as engineering projects or surveying, these fix types are essential for evaluating the quality of GPS data.

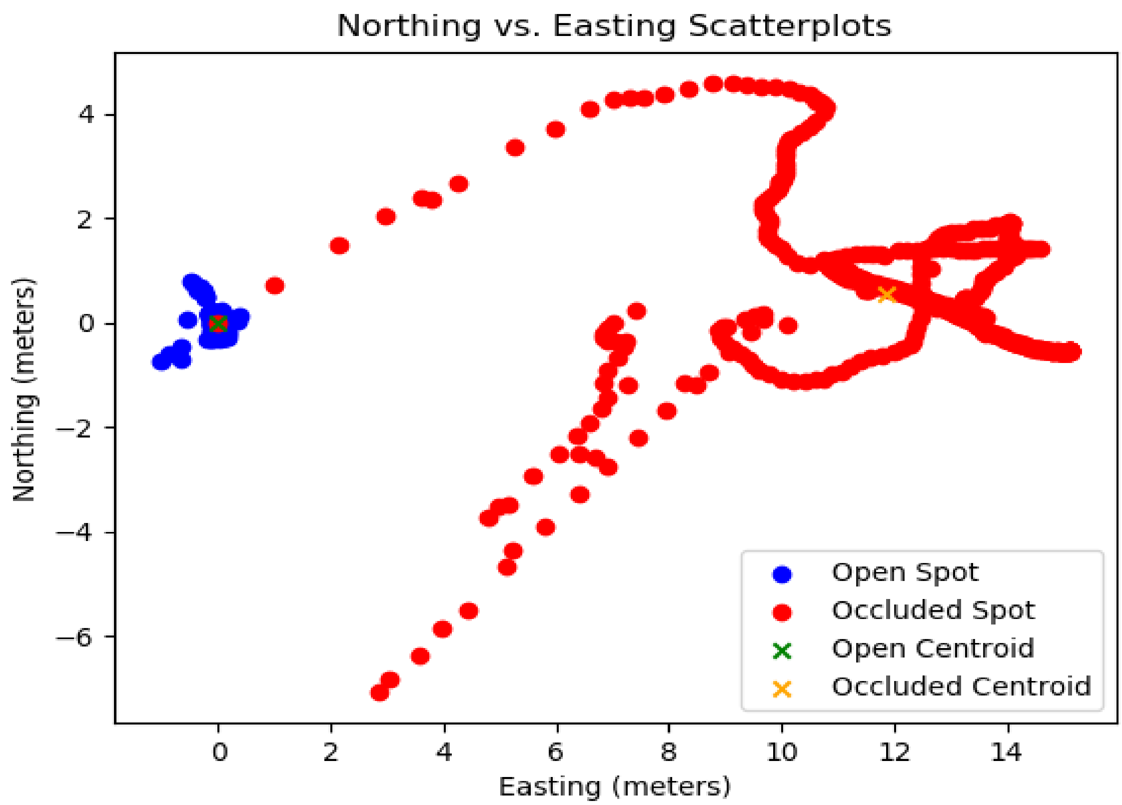
Source of Error in RTK GNSS

The accuracy of RTK GNSS location can be greatly impacted by a number of factors. Positioning errors can be increased by poor satellite geometry, which occurs when satellites are grouped together rather than dispersed equally. Accuracy can be further distorted by multipath effects, in which GNSS signals bounce off adjacent surfaces like buildings or water before reaching the receiver. Additional interference is introduced by atmospheric circumstances, such as tropospheric and ionospheric delays. Performance can also be harmed by network delay, receiver quality fluctuations, and mistakes in the base station's reference position. The accuracy of RTK GNSS measurements is also impacted by physical obstacles that interfere with satellite signals, such as tall buildings, trees, or terrain. Resolving these issues is essential to raising the general dependability of the system.

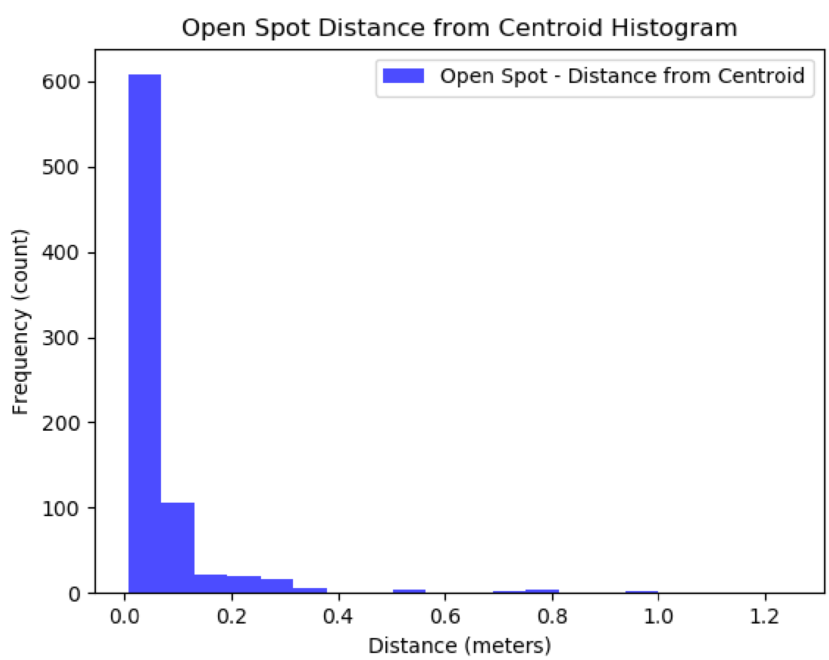
Stationary Analysis



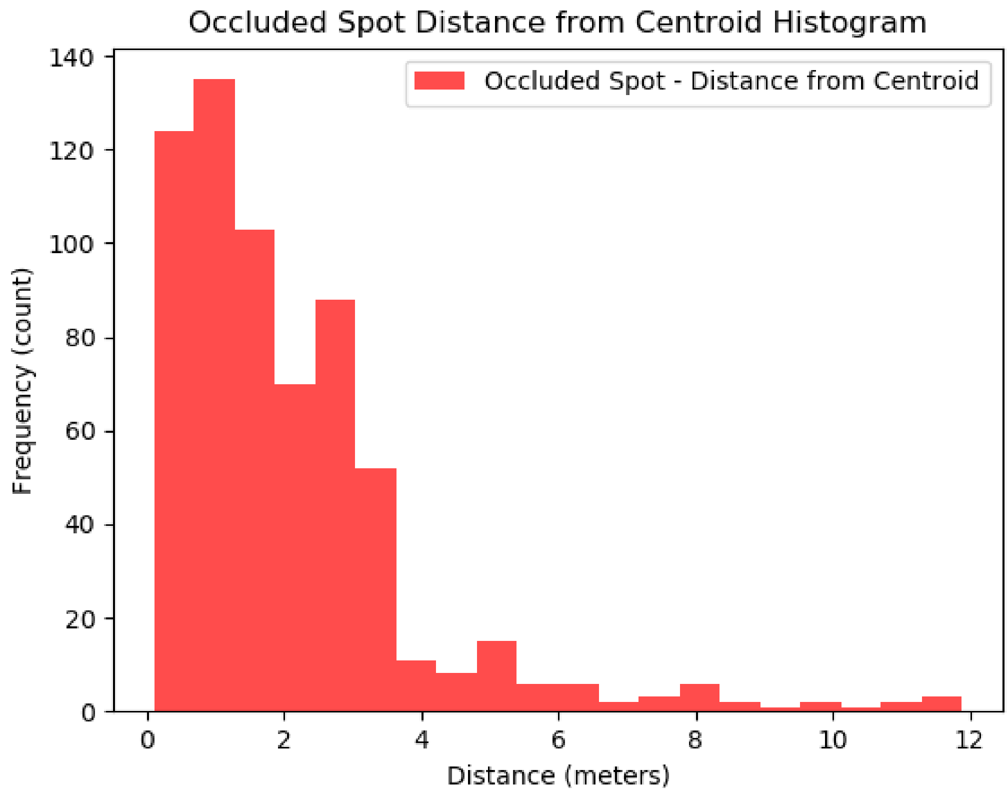
This plot describes that the accuracy of RTK to detect the altitude is better in open environment than the partially occluded one cause of the disturbance created due to the building and other elements.



This graph also represents the same derivation that the open environment reading are more accurate and precise than the partially occluded one.



The histogram shows that most open spots are concentrated near the centroid, with fewer spots further away.



The histogram shows that most occluded spots are concentrated near the centroid, with fewer spots further away.

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Open Spot Centroid Coordinates: Easting = 0.00 meters, Northing = -0.02 meters
Occluded Spot Centroid Coordinates: Easting = 11.87 meters, Northing = 0.56 meters
Error for Open data (mean distance from centroid): 0.06 meters
Error for Occluded data (mean distance from centroid): 2.08 meters
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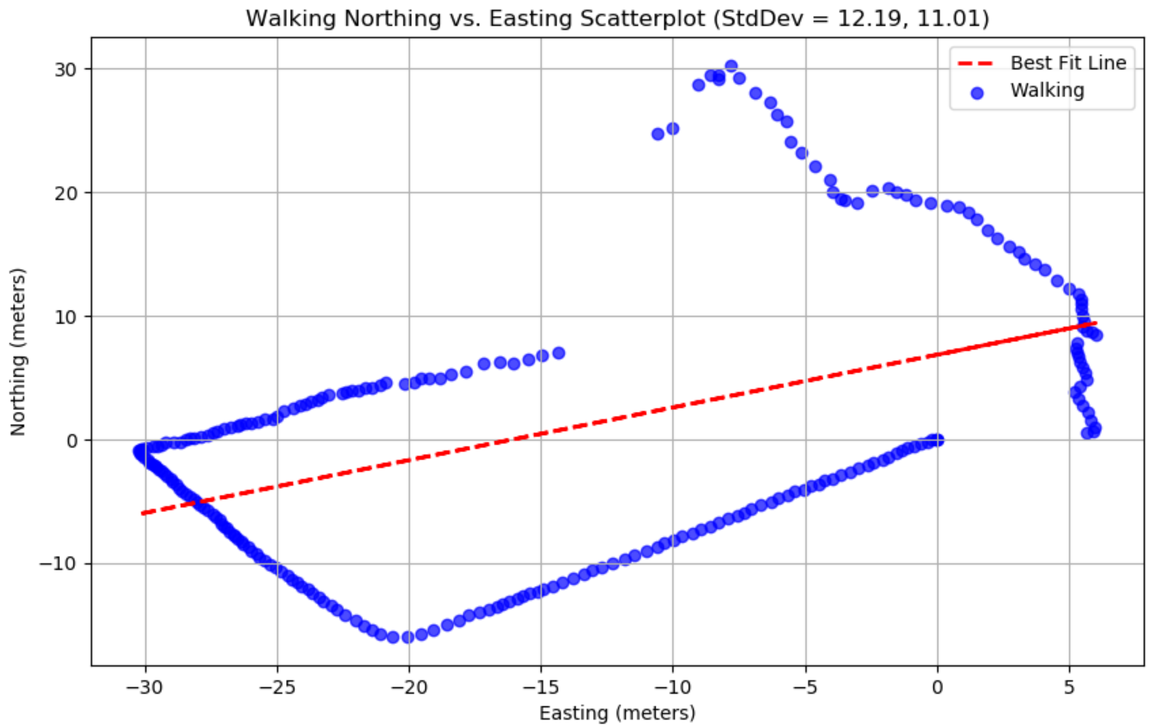
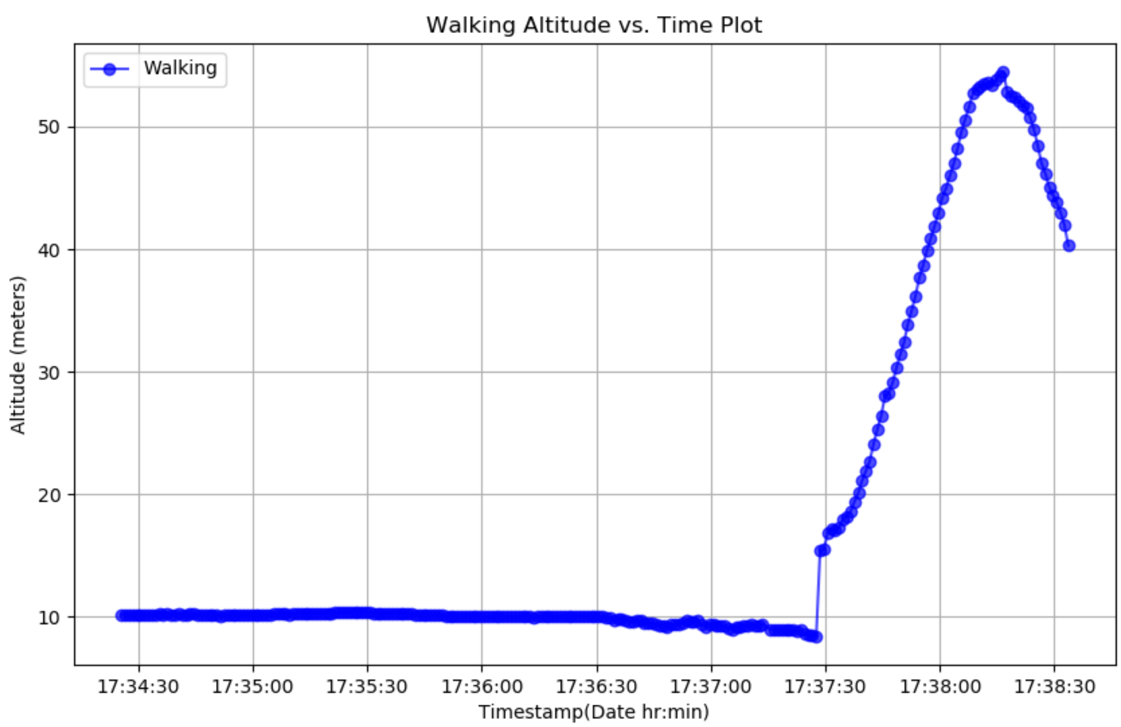
<u>Moving Analysis</u>

Moving Data with Buildings





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Error for Walking data: 15.54781443465594
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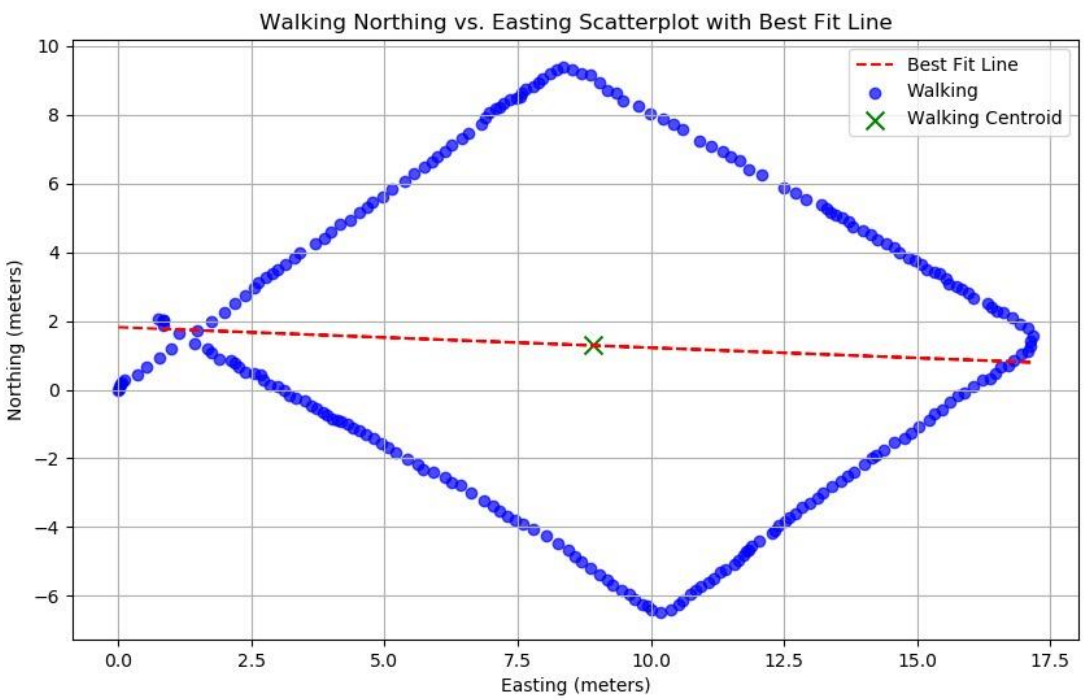
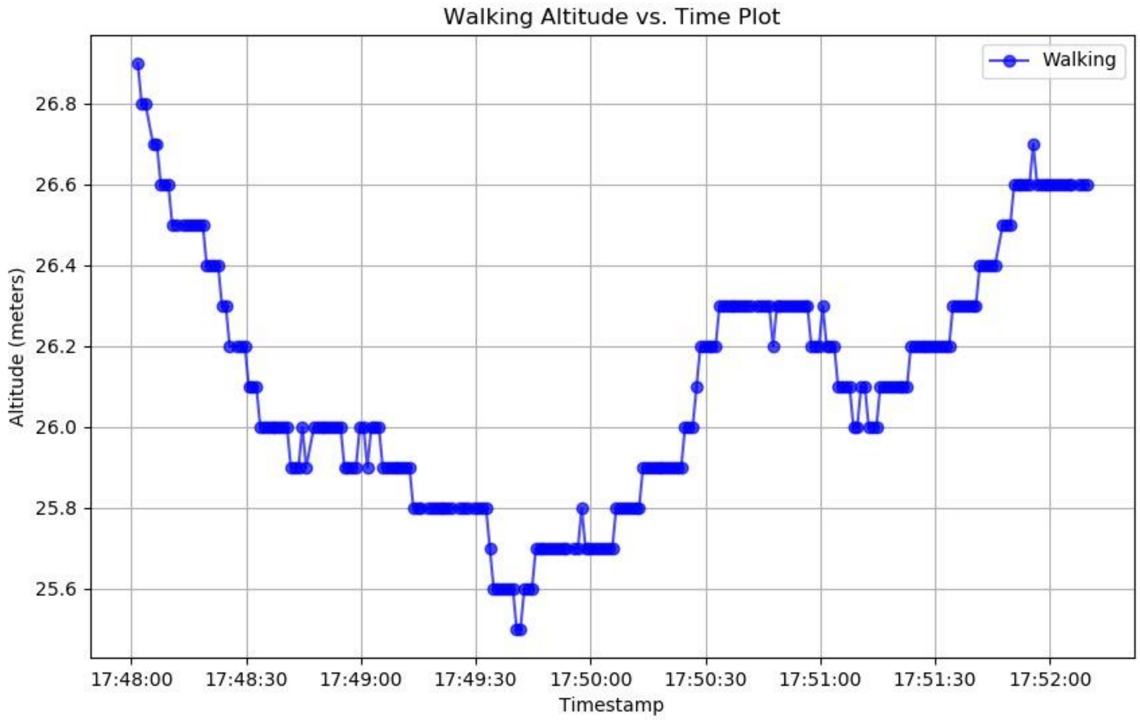
Moving Data without Buildings



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Error for Walking data: 6.652171208392726
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This plot demonstrates that the occluded data lacks consistency due to the fluctuating accuracy between float and fix states. Additionally, the altitude in the occluded data shows significant deviations, while the open data maintains a stable altitude. This indicates that the open data has better overall accuracy compared to the occluded data.

A) Compared to standard GNSS, RTK GNSS offers significantly enhanced accuracy. In open environments, standalone GNSS typically has an error of around 7.95 meters, while RTK GNSS achieves a much more precise error of approximately 0.06 meters. In obstructed environments, standard GNSS displays a deviation of about 0.587 meters, whereas RTK GNSS experiences a larger deviation of around 2.08 meters due to difficulties in maintaining a 'fix' solution. For walking analysis, the data plots show clear differences: in obstructed environments, data quality fluctuates between 'fix' and 'float' solutions, while in open environments, it remains stable.

B) The Easting vs. Northing data indicates that the mean of the data collected in open areas is much more closely aligned with the origin.

C) There is a noticeable difference between the data collected in Lab 1 and Lab 2. When near buildings, standard GPS data shows a deviation of about 5 meters, compared to 2.3 meters in open environments. However, data collected using RTK GPS shows a deviation of less than 5 meters near buildings, and just 0.1 meters in open environments. Achieving centimeters-level accuracy with RTK GPS is a notable improvement.

D) While collecting data during movement, it was observed that maintaining a consistent GPS fix was challenging. At times, no GPS signal was received, indicating that buildings obstruct the ability to maintain a fix. Data loss and noise levels were similar when stationary, both with and without buildings, but the error increased during movement due to intermittent signal from the base station.

E) Stationary data collected in an open field is more accurate. Even when the sensor remained static, the presence of nearby buildings caused significant data scattering due to occasional loss of signal from the base station. In contrast, the data collected in an open field consistently maintained a fix, achieving centimeter-level accuracy.

Conclusion:

RTK GNSS dramatically improves accuracy, reducing errors from meter-level to centimeter-level in open environments. However, its performance is still influenced by factors such as obstructed surroundings, limited satellite visibility, weather conditions, and signal quality. While stationary data can be corrected by addressing offsets, maintaining high accuracy in dynamic, moving conditions remains a challenge due to inconsistent satellite fixes and signal interference. Overcoming these challenges could lead to further improvements in RTK GNSS performance in dynamic environments.