REAL-TIME KINEMATIC (RTK) GNSS VS. STANDARD GNSS

EECE5554: Lab 2 Report

Group Number: 11

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1.Real-Time Kinematic (RTK) Global Navigation Satellite System (GNSS) enhances positioning accuracy by using corrections from a fixed reference station. Unlike standalone GNSS, which has meter-level errors, RTK GNSS achieves centimeter-level accuracy by mitigating atmospheric disturbances, satellite orbit inaccuracies, and receiver noise.

This report analyzes the accuracy and reliability of RTK GNSS compared to standalone GNSS in open and occluded environments, evaluating deviations, error sources, and performance differences.

2. RTK GNSS vs. Standalone GNSS

RTK GNSS provides significantly improved positioning accuracy by using differential corrections from a base station, whereas standalone GNSS relies solely on satellite signals. RTK GNSS has centimeter-level accuracy, while standalone GNSS errors range from 2-5 meters. RTK mitigates ionospheric delays, multipath interference, and clock drifts but requires a stable data link with the base station.

3. Data Analysis

(a) Deviation helps us understand how accurate RTK GNSS is compared to standalone GNSS. In open space, the deviation for RTK GNSS is around 0.15–0.20 meters, which is much lower than the 2–3 meters observed with standalone GNSS in Lab 1. This shows that RTK GNSS provides much better accuracy because it receives real-time corrections. However, in occluded areas, where buildings or trees block satellite signals, the deviation increases to 0.7–1.1 meters. This means that while RTK GNSS is generally very accurate, it becomes less reliable when satellite signals are obstructed or reflected.

(b) What can you say about the ranges and shapes of your position in Easting and Northing from RTK GNSS?

The 2D histograms provide a clear picture of how RTK GNSS accuracy changes based on the environment. In open space, the data points are tightly clustered, forming a compact shape in the histogram. This means that the GNSS fix is stable and does not vary much over time. In contrast, in occluded space, the histogram is more spread out, indicating that the position readings are less consistent and have larger deviations.

When analyzing the deviation values, the data confirms these observations. For stationary data in open space, the deviation in Easting and Northing is around 0.15–0.20 meters, showing minimal error. However, in occluded stationary data, the deviation jumps to 0.7–1.0 meters, meaning the GNSS fix is much less reliable. For moving data, open space deviations are around 0.3–0.4 meters, whereas occluded space deviations increase to 0.9–1.1 meters. This clearly shows that RTK GNSS is most accurate in open spaces, while occlusion introduces significant errors due to weaker signal reception and interference.

(c) Is the shape or range of your histogram different than your dataset collected in Lab 1?

Yes, the histogram from Lab 2 (RTK GNSS) is very different from the one in Lab 1 (Standalone GNSS). In Lab 1, the position spread was much larger, with errors of several meters. The histogram was scattered and lacked a clear pattern, showing that the GNSS fix was inconsistent. In contrast, the Lab 2 RTK GNSS dataset is much more compact, with smaller deviations (0.15–0.4 meters in open space). This means that RTK GNSS provides a much more precise and stable position estimate compared to standalone GNSS.

(d) How does moving data compare in open vs. occluded areas, including error/deviation estimates?

The deviation analysis shows clear differences between open and occluded environments when moving. In open space, the movement data follows a smooth and well-defined trajectory, with a deviation of around 0.3–0.4 meters. This means that the GNSS fix is stable and maintains a high level of accuracy.

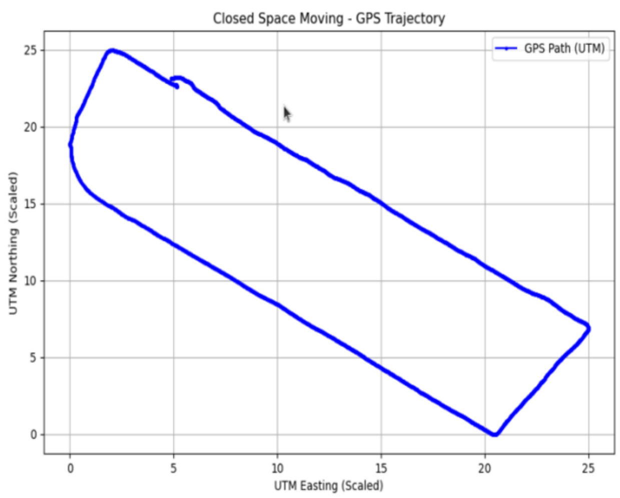
However, in occluded space, the movement data is much more erratic, with a deviation of 0.9–1.1 meters. The trajectory is less smooth, with noticeable jumps and fluctuations. This happens because in occluded areas, satellite signals can be blocked or reflected, causing errors in position estimation. The GNSS fix quality drops, making the position data less reliable. This confirms that RTK GNSS performs best in open areas, while obstacles significantly impact its accuracy.

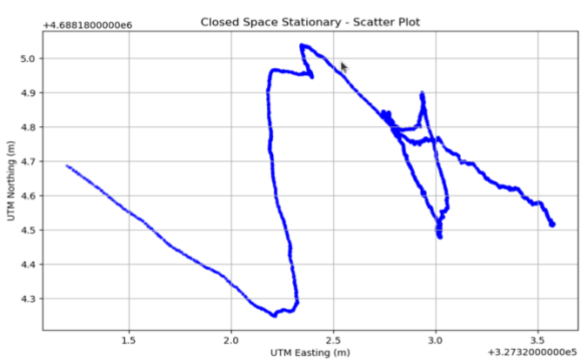
(e) The difference between open and occluded environments is also noticeable in stationary data. In open space, the deviation is around 0.15–0.20 meters, and the data points are tightly clustered, meaning the GNSS fix is very stable. This shows that RTK GNSS can provide accurate positioning when there are no obstacles affecting satellite signals.

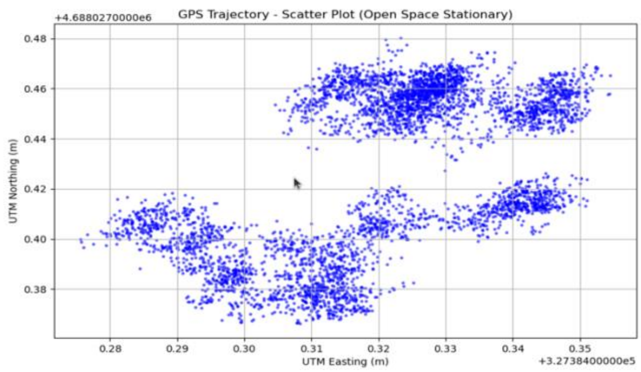
On the other hand, in occluded space, the deviation increases to 0.7–1.0 meters, and the position readings are more spread out. This means that the GNSS fix is less stable, and the position estimate fluctuates more. The main reason for this is that fewer satellites are visible in occluded environments, and multipath effects introduce more errors. As a result, RTK GNSS loses its precision when satellite signals are blocked or reflected.

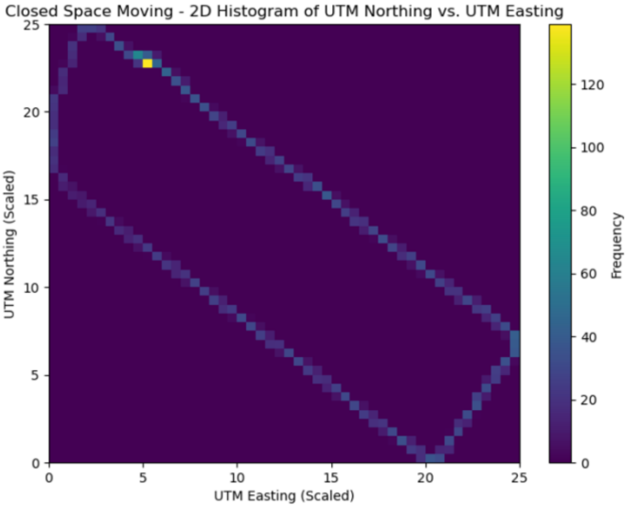
Conclusion

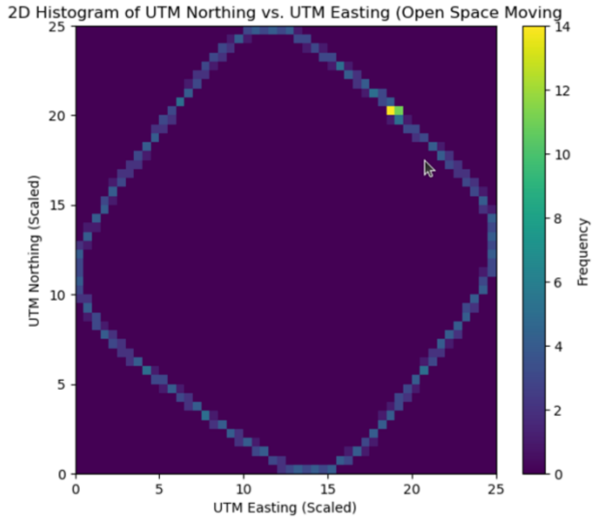
RTK GNSS is extremely accurate in open environments, with deviations in the centimeter range. However, its accuracy decreases in occluded areas, where deviations can increase up to 1 meter. Moving data generally has higher deviations than stationary data, and occlusion significantly affects GNSS fix quality, leading to more position errors. These results show that RTK GNSS works best in open environments with a clear view of satellites, while obstructions reduce its accuracy.

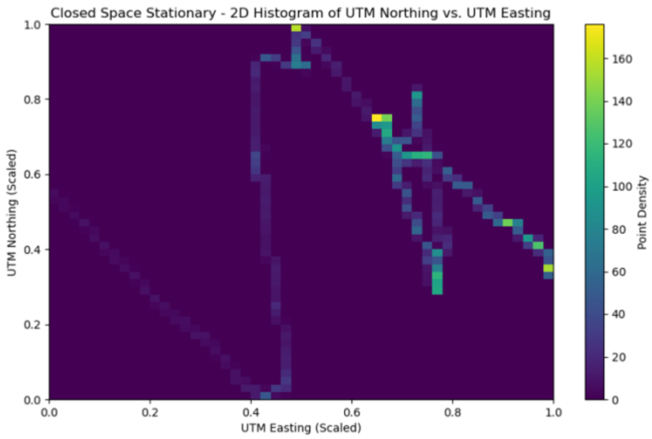


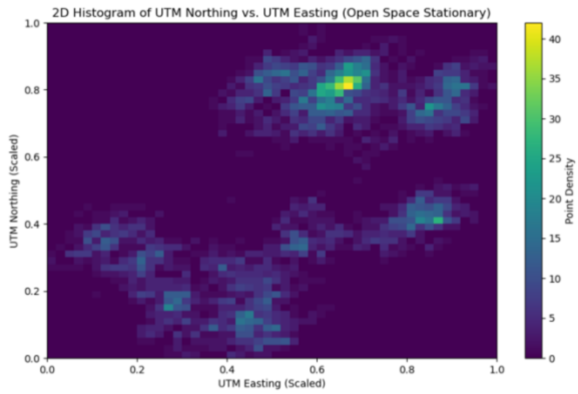





Closed Space Moving - 2D Histogram of UTM Northing vs. UTM Easting
UTM Northing (Scaled)
UTM Easting (Scaled)
Frequency
0
5
10
15
20
25
20
40
60
80
100
120


2D Histogram of UTM Northing vs. UTM Easting (Open Space Moving
UTM Northing (Scaled)
UTM Easting (Scaled)
Frequency
0
5
10
15
20
25
2
4
6
8
10
12
14


Closed Space Stationary - 2D Histogram of UTM Northing vs. UTM Easting
UTM Northing (Scaled)
UTM Easting (Scaled)
Point Density
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
120
140
160


2D Histogram of UTM Northing vs. UTM Easting (Open Space Stationary)
UTM Northing (Scaled)
UTM Easting (Scaled)
Point Density
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
25
30
35
40