EEC5554: Robot Sensing and Navigation
LAB 2-RTK GPS REPORT

Introduction:

RTK GPS (Real-Time Kinematic Global Positioning System) is an advanced positioning technique that significantly enhances the accuracy of GPS systems from meter-level to centimeter-level precision. RTK GPS uses 2 receivers: a base station and a mobile receiver. The base station calculates errors in GPS measurements by comparing its known position to the position calculated from satellite signals. It then transmits these error corrections in real-time to the mobile receiver. The mobile receiver uses these corrections to improve its own position calculations, achieving centimeter-level accuracy.

The key differences between RTK GNSS and standard GNSS lie in their accuracy, correction methods, signal processing, and convergence time. RTK GNSS achieves centimeter-level accuracy (often within 1-2 centimeters) by utilizing real-time corrections transmitted from a base station to the mobile receiver and employing carrier phase measurements of the satellite signal for higher precision. In contrast, standard GNSS typically provides accuracy within 2-4 meters, relies solely on satellite signals, and primarily uses code-based measurements for signal processing. While standard GNSS provides position information almost instantly, RTK GNSS requires a short convergence time to achieve its full accuracy. These distinctions make RTK GNSS superior for applications requiring high precision, despite the additional complexity and infrastructure requirements

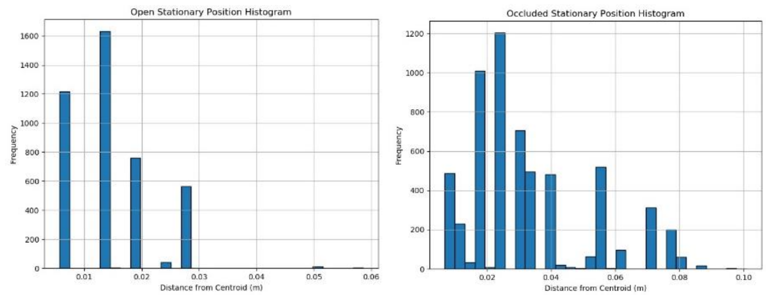
Several major sources of error affect GPS accuracy, including multipath error, which occurs when satellite signals reflect off surfaces before reaching the receiver, causing delays and inaccuracies. Baseline distance error is another factor, where errors accumulate at approximately 1mm per kilometer as the distance between the mobile receiver and base station increases. Poor satellite signal quality due to obstructions like dense forests or buildings can also lead to errors. Additionally, local effects such as engine or motor vibrations and signals from other transmitting devices in the immediate environment can cause interference and contribute to inaccuracies in GPS readings.

Data Analysis:

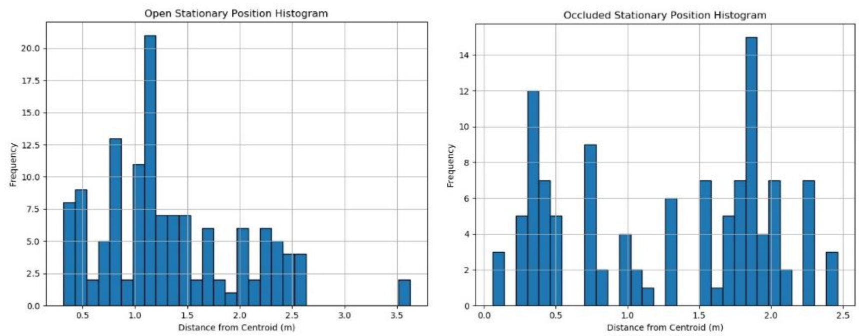
Analysis of deviation from centroid:

The centroid represents the average position calculated from multiple GPS readings taken at the same location. Deviation from this centroid measures how much individual GPS points differ from this average position. The analysis of both RTK GNSS and standard GNSS data regarding their deviation from the centroid is represented in histograms for open and occluded cases.

As we can observe in the plots below, the range shows that RTK GNSS exhibits much less deviation from its centroid compared to standard GNSS. The frequency of the deviation is higher near zero for RTK GNSS, while standard GNSS displays an irregular distribution of frequency throughout the scale. Hence, the shape of the histogram is a declining graph increasing from zero for RTK GNSS but an irregular distribution for standard GNSS.



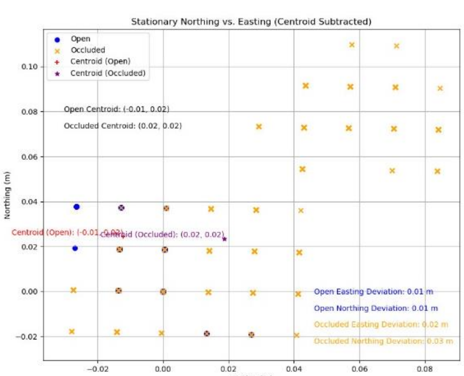
RTK GPS Histogram Data for Open and Stationary Cases



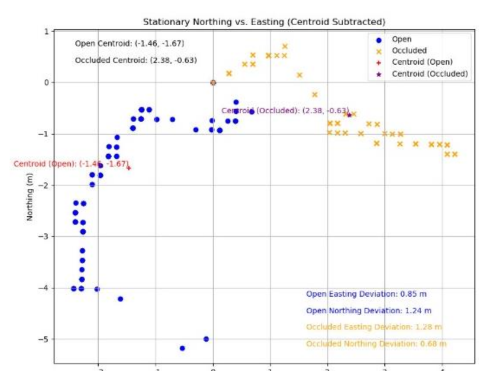
Standard GNSS Histogram Data for Open and Stationary Cases

Stationary data analysis:

The behavior of RTK GNSS in stationary conditions has been analyzed using the scatter plot below. From the scatter plots we can observe that the data acquired in an open environment is more accurate compared to the data taken in occluded environment which is scattered for a larger area from the actual centroid position. Also, by quantitative comparison of the Easting and Northing deviation for open environment is about 0.01 meter each whereas, the Easting and Northing deviation for occluded environment is about 0.02 and 0.03 meter respectively. Showing that the open environment has less deviation.



Stationary Scatter plot for RTK GNSS

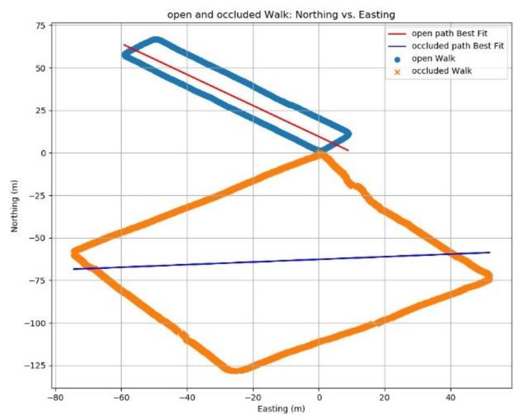


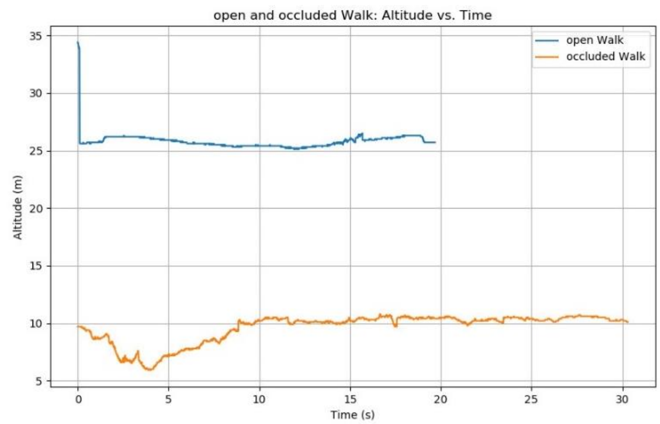
Stationary Scatter Plot for Standard GNSS

Comparing the deviation numbers of RTK GNSS and standard GNSS, we can observe that the deviation of RTK GNSS is much less than standard GNSS. This shows that RTK is much more accurate compared to GNSS without RTK.

Moving data analysis:

The behavior of RTK GNSS while in continuous motion has been analyzed using the scatter and altitude plots below.



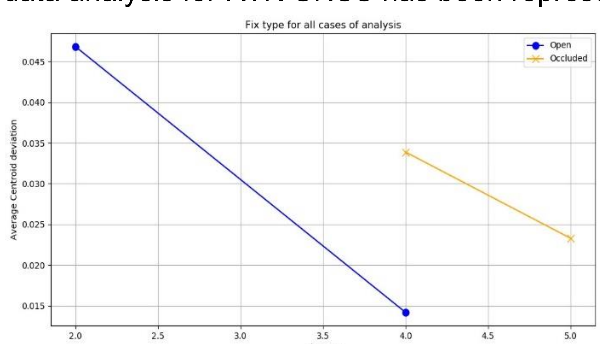


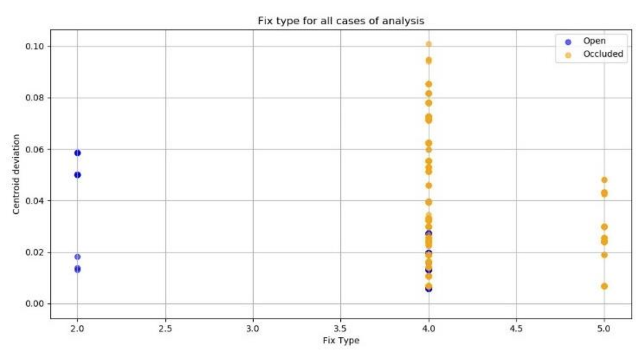
Scatter Plot for RTK GNSS **Altitude vs Time plot for RTK GNSS**

The scatter plot shows the path walked while taking the coordinate data, where the orange represents the occluded environment (walked around a building), and the blue represents the open environment (walked on the roof of a building). The altitude plot shows the open scenario to have higher altitude value as it was recorded on rooftop of a building. Also, the occluded scenario shows fluctuations at the beginning due to its environmental influences. The fix type was comparatively better for the open environment moving scenario than the occluded environment moving scenario.

Fix Type Analysis:

The quality of data acquisition can be measured by using the fix type data and the fix type data analysis for RTK GNSS has been represented below.





Avg. centroid deviation vs Fix type **Centroid deviation vs Fix type**

From the above plots we can understand that for the open and occluded scenario, the fix type is higher when the deviation gets lower. This can be inferred that the GPS points near the centroid position have higher fix value which then implies more accurate estimation of position. Therefore, by logic the open case has a higher fix value compared to the occluded case. However, from the above plots we can observe that the occluded case has higher fix value than the open case in an average. This could be due to environmental interferences or human error while recording the data.