Northeastern University

Robot Sensing and Navigation - EECE5554
LAB 2 Analysis Report

Varun Samala

Introduction to RTK

Real-Time Kinematic (RTK) is a highly accurate Global Navigation Satellite System (GNSS) technology that relies on a rover and a stationary base station to calculate the phase difference in satellite signals. This method provides exceptional precision in determining the exact position and is used in various applications, including autonomous vehicles, land surveying, and precision agriculture, where utmost accuracy is essential.

Difference between RTN GNSS and GNSS

Timing and positional information are established through the utilization of a satellite constellation within the Global Navigation Satellite System (GNSS). The accuracy of a GNSS receiver may fluctuate within a range of a few meters. In contrast, Real-Time Network (RTN) GNSS relies on a network of reference ground stations to continuously monitor satellite signals and provide real-time corrections to achieve positional accuracy at the centimeter level. Consequently, GNSS and RTN GNSS are better suited for applications that require high precision and those that involve straightforward navigation, respectively.

Sources of error in RTK GNSS

Despite its high level of accuracy, RTK GNSS can still be susceptible to various error sources, including atmospheric disturbances, inaccuracies in ephemeris data, and multipath reflections.

I. Open Area Analysis

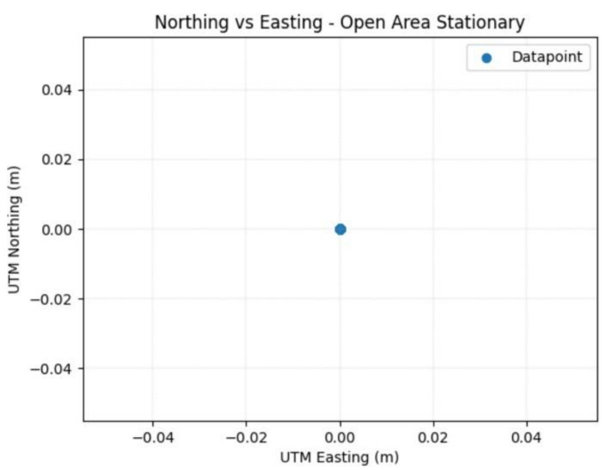


Fig.1 UTM Northing vs Easting for Open Stationary data
Data was collected in an open field for more than 10mins.

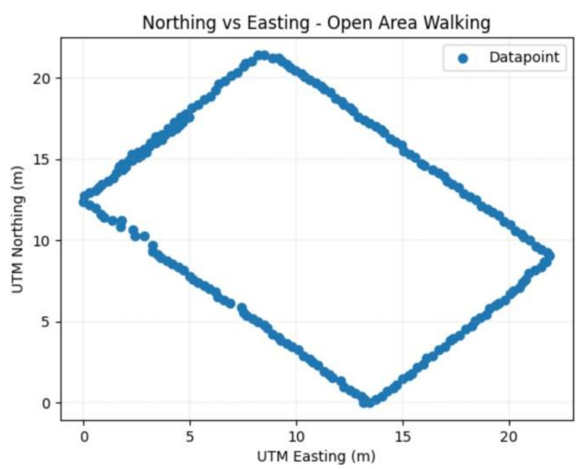


Fig.2 UTM Northing vs Easting for Open Walking data
Data was collected by walking in a rectangular path in an open field.

II. Occluded Area Analysis

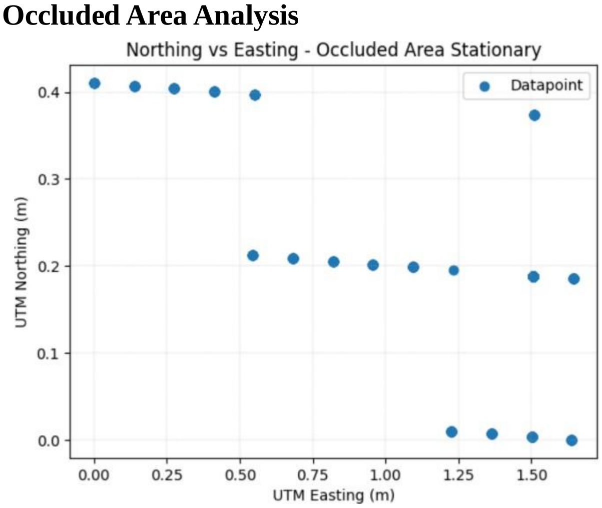


Fig.3 UTM Northing vs Easting for Occluded Stationary data
Data was collected in an occluded area (near ISEC) for more than 10mins.

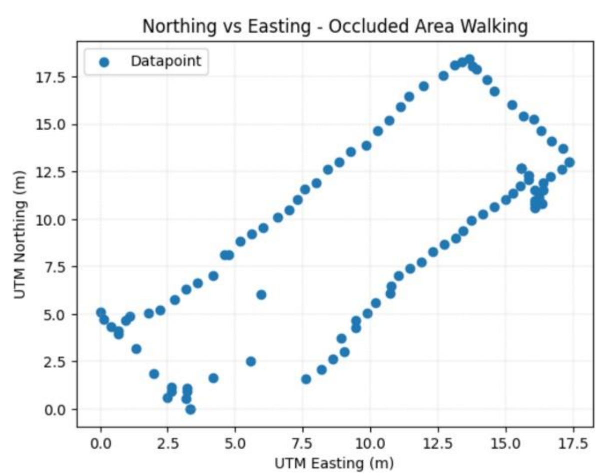
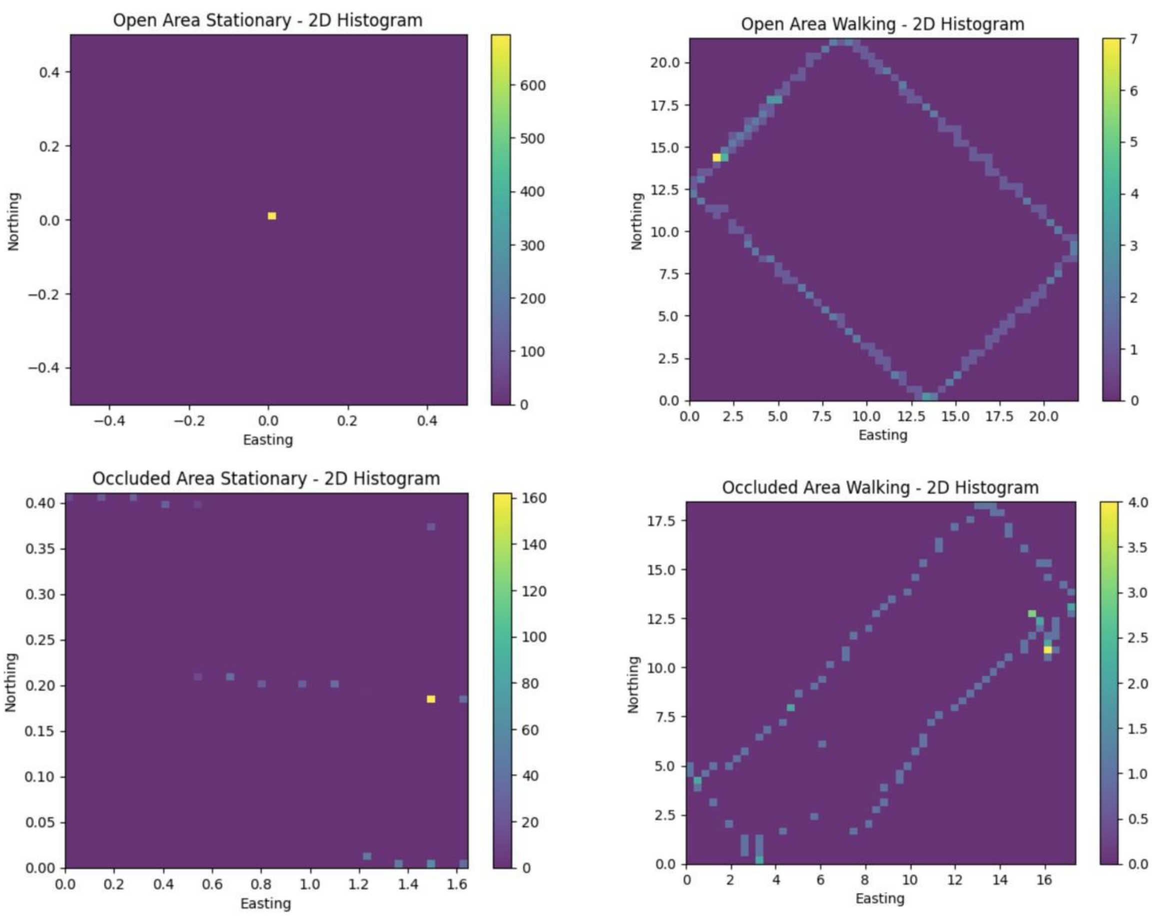


Fig.4 UTM Northing vs Easting for Occluded Walking data
Data was collected by walking in a rectangular path in an occluded area (near ISEC).

Questions and Answers

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?**
   RRTK GNSS navigation offers significantly higher accuracy compared to standalone GNSS systems that lack RTK correction. This enhanced accuracy is attributed to the continuous reception of real-time phase measurement corrections from nearby base stations. Without these corrections, standalone GNSS can be susceptible to notable inaccuracies or deviations, often on the order of meters. In contrast, RTK GNSS tends to exhibit deviations in the millimeter range, making it a highly precise positioning technology. However, it's important to note that even RTK GNSS is not immune to potential errors, including those related to atmospheric disturbances, ephemeris inaccuracies, and multipath reflections, as mentioned earlier.

2. **What can you say about the ranges and shapes of your position in Easting and Northing from RTK GPS?**
   The position data obtained from the RTK GPS system exhibited noteworthy differences in both range and shape between open and obscured areas. In open environments, where the rover remained stationary, the standard deviations in Easting and Northing coordinates were consistently zero. This indicates that the RTK GPS provided extremely precise and consistent position data, resulting in a very tight range.



   Conversely, when the rover was situated in obscured areas, the standard deviations in Easting and Northing coordinates increased to approximately 0.47 meters. This increase in standard deviations implies that the accuracy and consistency of the RTK GPS measurements decreased in occluded regions, resulting in a wider range of positional data.

   Despite these variations in accuracy, the RTK GPS system accurately recorded the shape of the rectangular path when the rover was in open areas. The positional data aligned with the expected path shape, demonstrating the system's capability for precise positioning.

   However, in the obstructed areas, the GPS data occasionally deviated from the anticipated path shape. This variability in shape is evident in the histogram graphs provided. These histograms illustrate that the GPS measurements were influenced by external factors present in the obscured area, leading to occasional deviations in the recorded path shape.

The primary factors contributing to these deviations in occluded data are the interference caused by reflective surfaces and the presence of trees located outside the ISEC facility. These elements have the potential to disrupt or block satellite signals essential for GPS positioning. Consequently, these environmental factors are responsible for the variations observed in the GPS data recorded within obscured areas.

3. **Is the shape or range of your histogram different than your dataset collected in Lab 1?**
   Yes, there are notable differences in the histograms between Lab 1 and Lab 2 data. The histograms from labs 1 and 2 differ in terms of both shape and range. Lab 1 data had larger variances, with discrepancies spanning several meters, whereas Lab 2 data showed much smaller deviations in the range of a few centimeters. This demonstrates the significantly improved accuracy achieved in Lab 2 with the use of RTK GNSS compared to Lab 1's uncorrected solo GPS data.

4. **Give quantitative comparisons for how your moving data differs in the open and occluded cases, including error/deviation estimates? Does this have anything to do with GNSS fix quality?**
   The comparison between data collected in open and occluded areas while moving in a rectangular path reveals substantial differences in terms of accuracy and deviation. In open fields, where there are minimal obstructions, the path is consistently and precisely traced, as demonstrated in Figure 2. Conversely, in occluded areas, such as those with buildings and trees, the accuracy in tracing the path tends to fluctuate, as indicated by Figure 4. These variations in data accuracy are primarily attributed to obstructions like buildings and trees in occluded areas. These obstructions often result in the blocking or reflection of satellite signals, which directly affects the quality of GNSS fixes.

   The quality of GNSS fixes is closely linked to the number of visible satellites. Open areas typically have a higher number of visible satellites, resulting in more reliable and precise GNSS fixes. In contrast, occluded areas, with their obstructed satellite signal paths, receive signals from fewer satellites, leading to less accurate GNSS fixes. Therefore, the observed differences in data accuracy and deviation between open and occluded areas are indeed associated with GNSS fix quality. GNSS fix quality plays a pivotal role in determining the accuracy and reliability of collected data, with occluded areas experiencing diminished fix quality due to satellite signal obstructions. This highlights the crucial influence of the surrounding environment on the performance of GNSS technology in data collection.

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?**

   Differences in stationary data collected in open and occluded areas, accompanied by numerical error estimates, reveal distinct variations. In open areas, as depicted in Figure 1, northing and easting values exhibit minimal variation, with negligible deviations. Conversely, in occluded areas, northing values display fluctuations of up to 0.4 meters, while easting values demonstrate larger variances, reaching 1.6 meters. These discrepancies are attributable to environmental factors and the quality of GNSS fixes. The quality of GNSS fixes significantly contributes to these variations. In open areas, stationary data consistently maintains an "RTK Fixed" status, signifying high accuracy and reliability. In contrast, occluded area data shifts between "RTK Float" and "RTK Fix," reflecting changes in GNSS fix quality. "RTK Fix" indicates a more precise and reliable fix compared to "RTK Float." Therefore, deviations in stationary data, particularly in occluded areas, are closely linked to varying GNSS fix quality, with open areas consistently offering superior accuracy and stability.