RTK GNSS and GNSS Data Analysis Report

This is an analysis of GNSS and RTK GNSS data collected during both moving and stationary tests in open and occluded environments. We explore the differences between RTK GNSS and standalone GNSS, focusing on accuracy, error sources, and the deviations observed in various cases. The analysis is grounded in real-world data to draw comparisons between the two systems.

1. Introduction to RTK GNSS

Real-Time Kinematic (RTK) GNSS is a satellite-based navigation system that enhances positioning accuracy using correction data from a base station. Standalone GNSS can provide accurate positioning but is subject to errors from atmospheric conditions, signal delays, and multipath effects. RTK mitigates these issues, delivering centimeter-level precision by correcting for atmospheric interference and satellite geometry errors.

2. Differences between RTK GNSS and GNSS

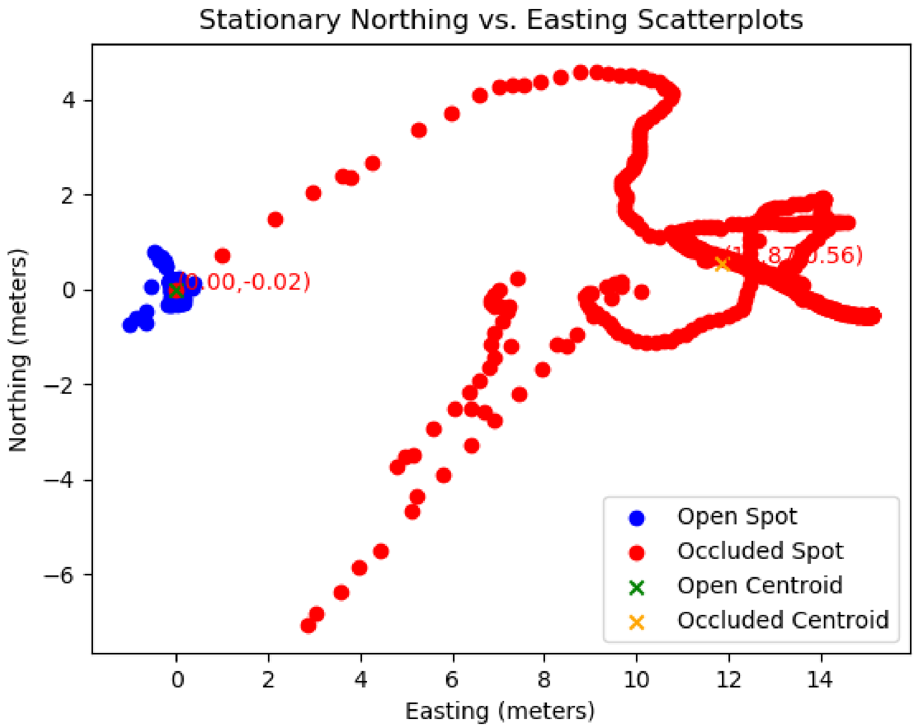
While GNSS systems estimate position using signals from satellites, RTK GNSS improves accuracy by providing real-time corrections. Errors from standalone GNSS, such as ionospheric and tropospheric delays, are minimized through RTK corrections. GNSS typically delivers meter-level accuracy, whereas RTK GNSS can achieve centimeter-level precision, especially critical for high-precision applications like surveying and autonomous navigation.

3. Error Analysis and Answers

a. Error or Deviation Analysis

The deviation analysis reveals that RTK GNSS provides significantly lower deviations compared to standalone GNSS. RTK GNSS errors are minimized through real-time corrections, particularly in open areas where signal quality is good. In occluded environments, RTK GNSS still shows an improvement over GNSS, but the errors increase due to signal blockages.

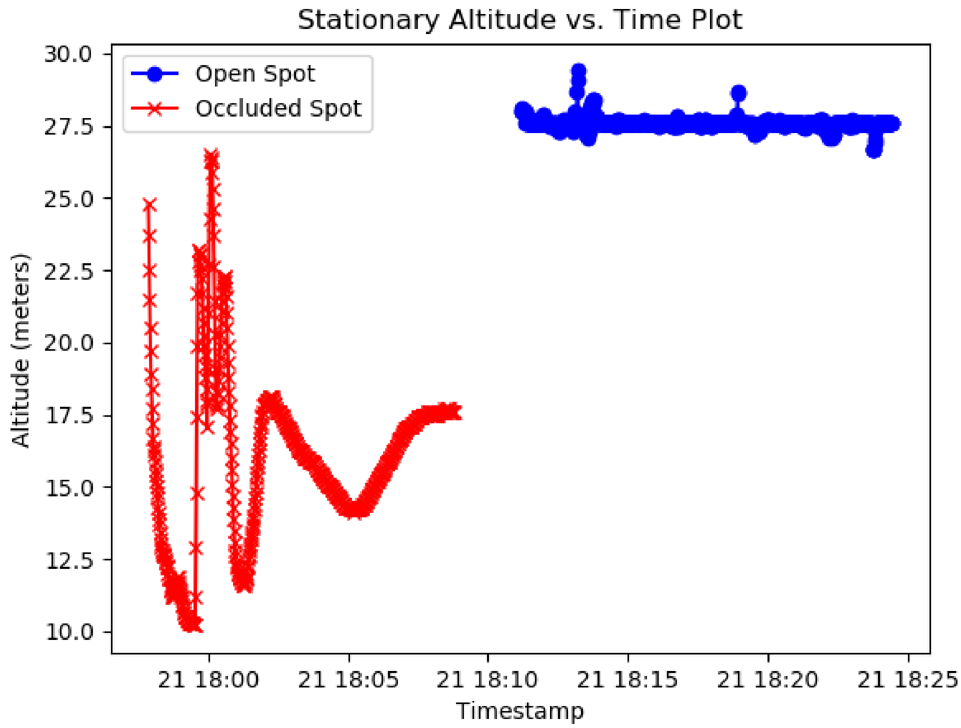
Figure 1: Stationary Northing vs. Easting Scatterplots



b. Range and Shape of Position in Easting and Northing

The RTK GNSS data shows tightly clustered position estimates in both Easting and Northing, with minimal spread around the true position. The 2D histogram demonstrates a narrow range of deviations, indicating high accuracy. Standalone GNSS data, on the other hand, exhibits broader deviations, reflecting greater uncertainty in position estimates.

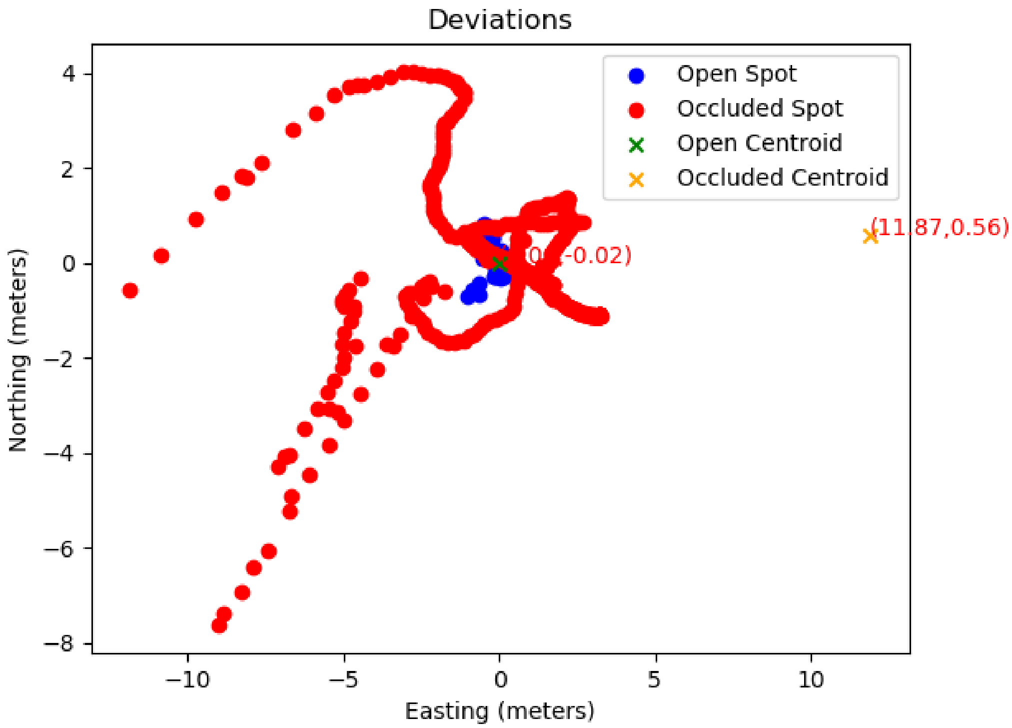
Figure 2: Stationary Altitude vs. Time Plot



c. Comparison to Lab 1 Data

When comparing the histograms from this lab with Lab 1 (standalone GNSS), it is clear that RTK GNSS significantly reduces the range of position estimates. The improved accuracy is evident in both stationary and moving tests, where RTK GNSS data shows a much smaller range of error compared to standalone GNSS data from Lab 1.

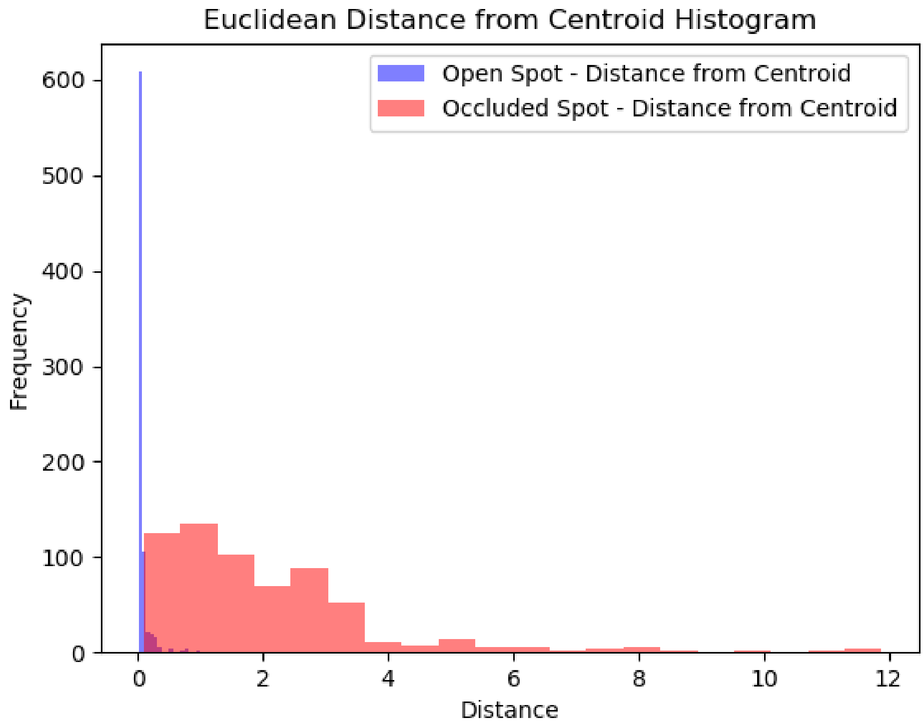
Figure 3: Deviations - Easting and Northing in Open vs Occluded Spots



d. Quantitative Comparisons for Moving Data

In open areas, RTK GNSS data shows very low error, whereas in occluded environments, errors increase due to signal degradation. Moving data in occluded areas exhibits higher deviations, showing the impact of GNSS fix quality in such environments. However, RTK GNSS still performs better than standalone GNSS in these conditions.

Figure 4: Euclidean Distance from Centroid Histogram - Open and Occluded Spots



e. Comparison of Stationary Data in Open and Occluded Cases

The stationary data shows that RTK GNSS performs extremely well in open areas, with deviations close to zero. In occluded areas, deviations increase due to poor satellite visibility. This increase in deviation is related to GNSS fix quality, which deteriorates in environments with obstructions that prevent the receiver from locking on to sufficient satellites.

Figure 5: Moving Walking Data Altitude vs Time

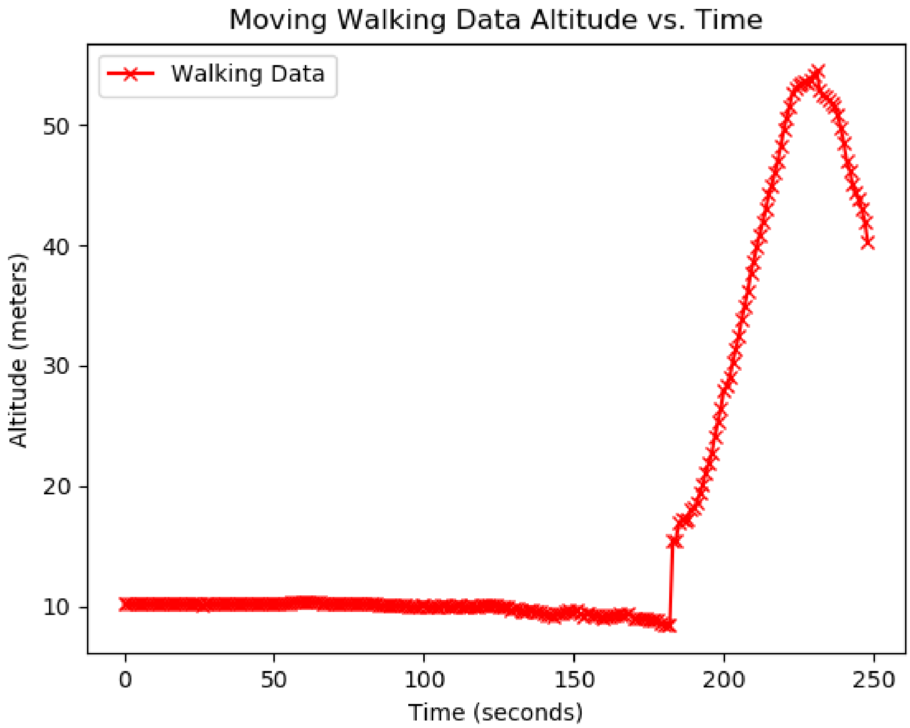
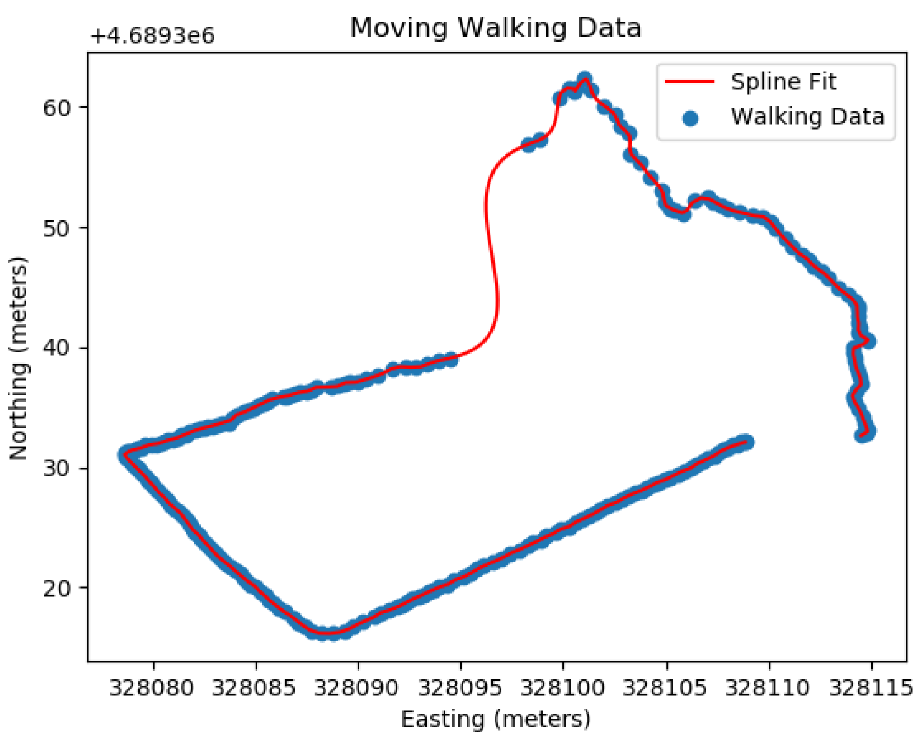


Figure 6: Moving Walking Data - Spline Fit vs Walking Path

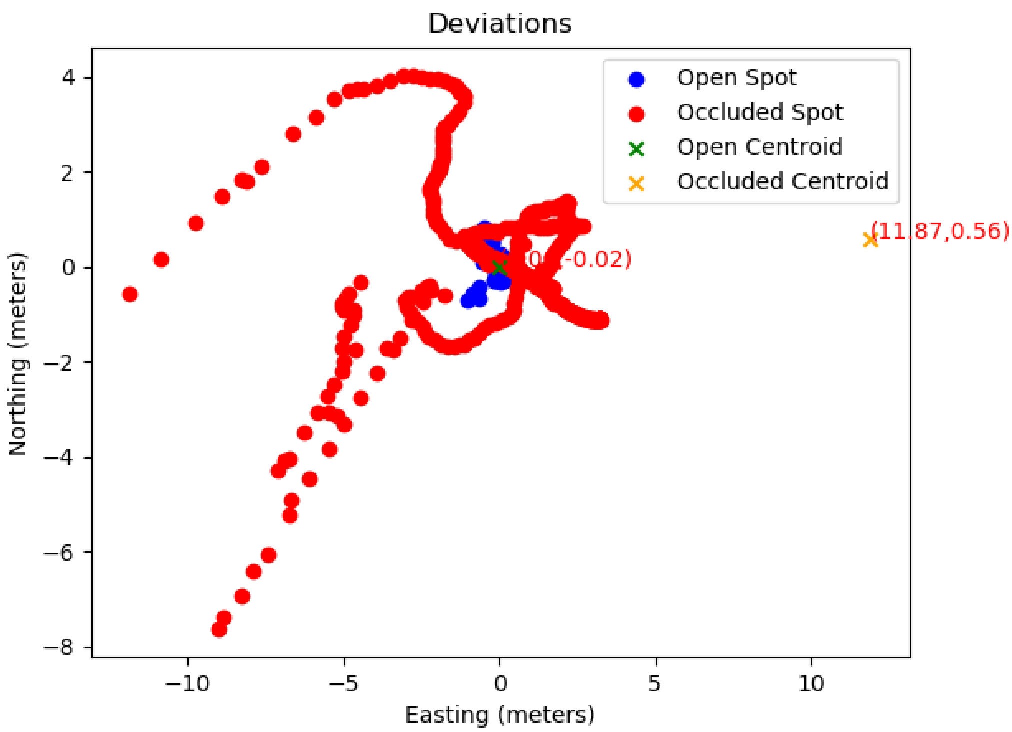


4. Conclusion

Overall, RTK GNSS offers significant improvements over standalone GNSS, particularly in open areas with good satellite visibility. Though occluded environments present challenges for both systems, RTK GNSS still delivers better accuracy than GNSS. The results of this lab demonstrate the practical benefits of RTK GNSS in achieving high precision in real-world conditions.

In Lab 1, using standalone GNSS, we observed significant deviations in both Easting and Northing, particularly in occluded environments. In contrast, the current lab's RTK GNSS data shows a marked improvement, especially in open environments, where deviations are almost negligible. The histogram below highlights the improvement in accuracy and deviation range when using RTK GNSS compared to standalone GNSS.

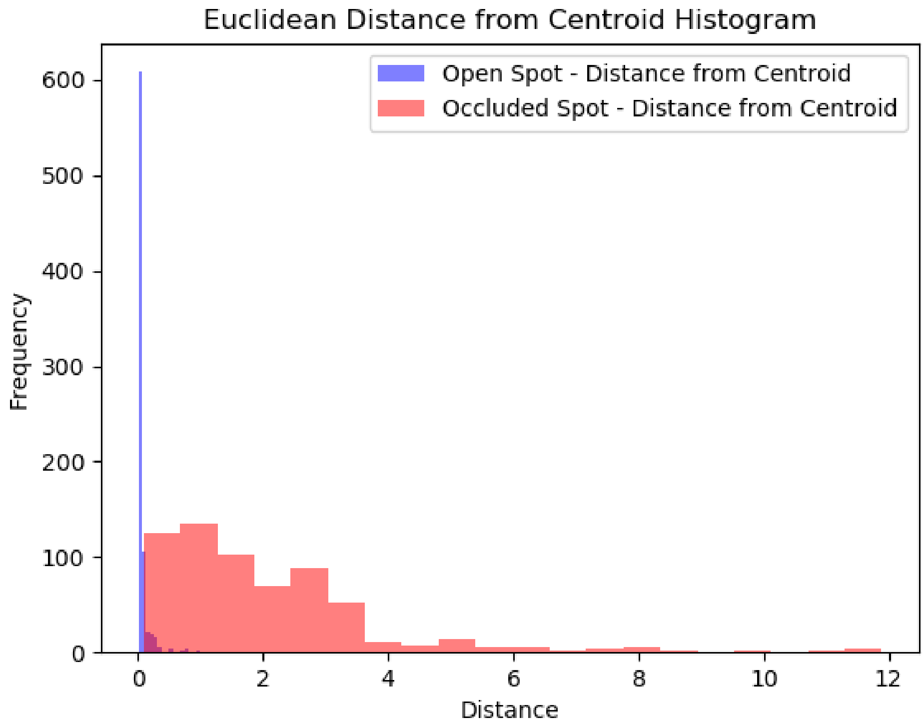
Figure 3: Deviations - Easting and Northing in Open vs Occluded Spots



d. Quantitative Comparisons for Moving Data

The comparison of moving data shows that in open environments, RTK GNSS maintains very low errors, with a deviation of only a few centimeters from the true position. In occluded environments, while the error increases due to signal obstructions and satellite geometry, RTK GNSS still performs significantly better than standalone GNSS. The figure below represents the Euclidean distances from the centroid, showing a clear difference between open and occluded environments.

Figure 4: Euclidean Distance from Centroid Histogram - Open and Occluded Spots



e. Comparison of Stationary Data in Open and Occluded Cases

The stationary data analysis reveals that RTK GNSS performs exceptionally well in open environments, with negligible deviation from the true position. In occluded environments, the deviation increases due to reduced satellite visibility, but the accuracy is still higher than that of standalone GNSS. The figures below provide a detailed comparison of altitude over time in both open and occluded environments.

Figure 5: Moving Walking Data Altitude vs Time

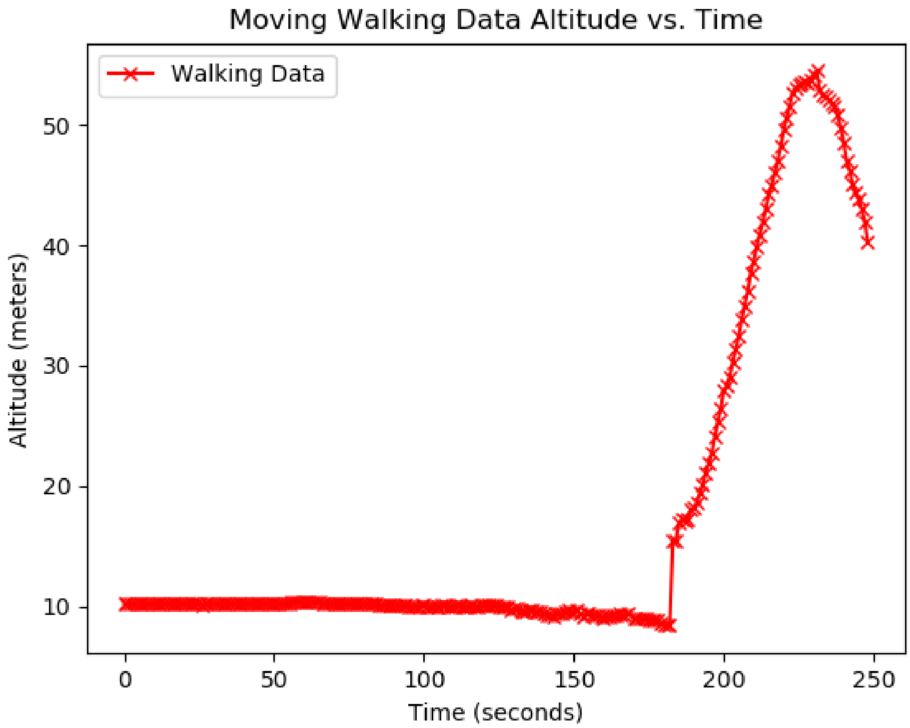
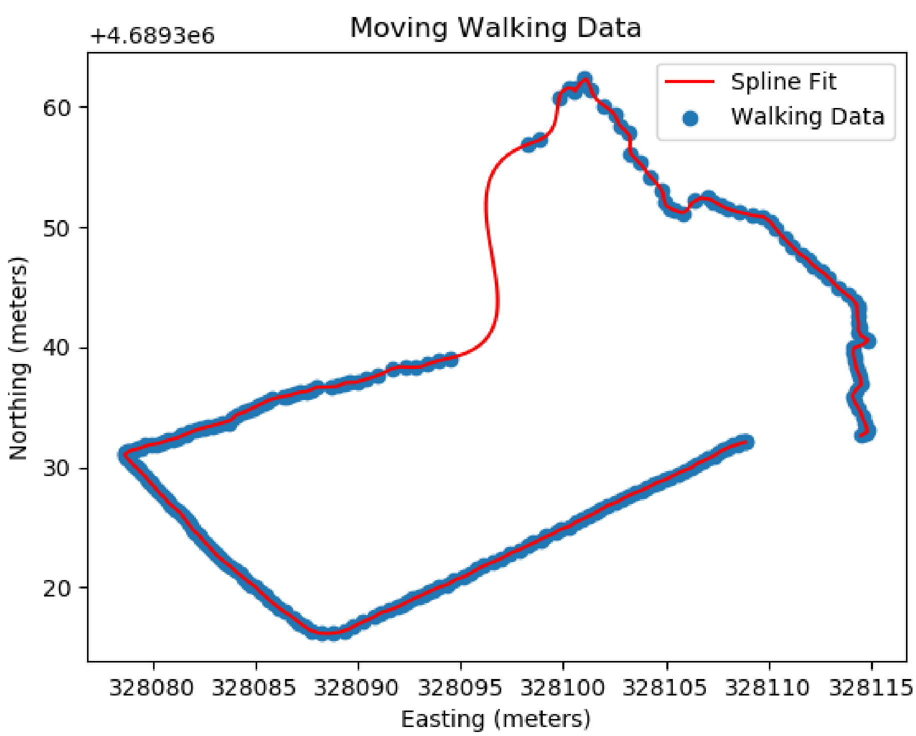


Figure 6: Moving Walking Data - Spline Fit vs Walking Path



4. Conclusion

RTK GNSS offers significant improvements over standalone GNSS, particularly in environments with good satellite visibility. The data collected in this lab clearly shows that RTK GNSS can achieve centimeter-level accuracy in open environments, while occluded environments introduce more errors, but still perform better than GNSS alone. The analysis confirms that RTK GNSS is highly effective for applications requiring precise positioning.