Farhan Sarfraz
EECE 5554 - Robotics Sensing and Navigation

Lab 2 - RTK GNSS Report

Background

The Real-Time Kinematics (RTK) is a method which allows for the improvement of accuracy compared to a GNSS receiver by itself. RTK allows for centimeter accuracy, and is why it is a more reliable system than a regular GPS system. The purpose of this lab is to observe and record the behaviors of the RTK system in four different scenarios: open-field stationary, open-field moving, occluded area stationary, and occluded area moving. The RTK system outputs a "quality" metric which is determined by a "0,1,4,or 5". For the purpose of this lab, qualities 4 and 5 are addressed. The "4" quality represents "RTK fixed ambiguities" , meaning the RTK is constrained to using integers which is due to poor satellite geometry, or poor radio links. The "5" quality represents "RTK float ambiguities" which allows the algorithm's ambiguities to be floating point values generating more precise values.

Analysis

1.1 Stationary Data (Open and Occluded)

For this part of the experiment, the RTK GPS data was collected without any movement for 10 minutes in both an open area and occluded area. Figures 1 and 2 represent the data collected in a form which can be observed for changes in behavior.

Within Figure 1, it can be observed that there are seemingly only two data points. These two data points are at (0,0) and (0,0.03125). This means that the RTK algorithm in this scenario produces slight noise/error up to 3.125 centimeters. For this scenario, 637 points of data were collected, and so in Figure 3, it can be observed that 520 data points were collected under the coordinates of (0,0), while 117 data points were collected under the coordinates of (0.03125,0). The two bins of data points can be described as the actual location vs. noisy location. It makes sense that a majority of the data points are under one data bin because of the fact the rover is not moving, so data points outside of one particular point would be considered noisy data.

Within Figure 2, it's been observed that there are seemingly 4 data points: (0,0),(0.01325,0),(0.0625,0), and (0.09375,0). These 4 data points demonstrate that the RTK algorithm produces considerably more noisy data, than the open-field data, that ranges between 0 and 9.375 centimeters. As shown in Figure 4, the four coordinate data points are repeated and can be seen to be distributed among the 4 bins. There were 649 data points collected, and 274 points (majority) were within the bin of the coordinate point (0.0625,0). In this scenario it is difficult to tell which location in particular is the actual location point, and although not as good as the open field data, this dataset is still relatively accurate to mere centimeters on the larger scale of this world.

1.2 Moving Data (Open and Occluded)

For this part of the experiment the RTK GPS data was collected while the rover was moving in a defined shape, in this case a rectangle. The data collected can be seen in Figures 5-8. By just observation we can see the differences in the shape of the path in Figures 5 and 7. The shape in the Open Field Moving data (Figure 5) is more detailed and pronounced, while the shape of the Occluded Moving data (Figure 7) is less defined and sparse in its shape. Another observation that can be seen is that the data points in Figure 5 are much closer together than that in Figure 7. For both graphs, the distances between each point and the next successive point, and taking the average of every distance were taken. For Open Field Moving data, the average distance between each point and successive point is 41 centimeters, whereas for Occluded Area Moving data the average distance is 67 centimeters.

Furthermore, taking one segment of the rectangle pattern produced by the collected data was used for linear regression and plotted in Figure 6 and 8. By just simple observation it can clearly be distinguished that the regression line produced by the Open field moving data is far more fitted than that of the Occluded Area moving data. In calculation, the standard error was determined for both linear regression lines. For Open field moving data, the standard error of the regression line to the data points is 0.0061, whereas for the Occluded Field moving data regression line has a standard error of 0.015. Based on these results, the Open field moving data regression line has a much smaller error than that of the Occluded field moving data regression line.

Discussion

From all the resulting analysis on the four different experiment scenarios, several conclusions can be made. In all regards, the RTK GPS is far more accurate than Post-Processing Kinematics that was used in the previous lab, where the RTK GPS is precise to the centimeter level. In this lab, although four different experiments were done, they can be split between Occluded data and Open-Field data. The data collected and analyzed contribute to the conclusion that the RTK GPS works more accurately in which there are no occlusions and the GPS is an open area.

In comparison of the stationary data of Open-Field vs. Occluded area, per the data, the occluded data showed more noise by showing four different coordinate bins of points and range of error between 0-9.375 centimeters, whereas, the open-field showed two bins of points with a much smaller range of error of 0-3.125 centimeters. This demonstrates in this case, that the Open-field data is more accurate and consistent.

In comparison of the moving data of Open Field vs. Occluded area, per the data, the occluded data still shows more noise and error compared to Open-Field. This can be seen through the fact the analyzed data shows the distance between each point were far greater in the occluded areas vs. the open-field. Furthermore, the linear regressions between both scenarios shows that the standard error is greater for the occluded data compared to the open-field data.

There are many reasons for these results. Foremost, the straightforward observation is that the environment plays a role in how the data is collected. For example, the state of pressure, weather, obstructions in the wavelengths between the satellite and base. Another thing to mention is the Quality metric in which the data was taken in. The occluded area showed a quality metric of ‘4’, which means that the RTK algorithm used fixed ambiguities, which may produce different results compared to a ‘5’ quality metric that uses float ambiguities. So noise ,in either scenario, can be due to which Quality metric the data point was collected under.

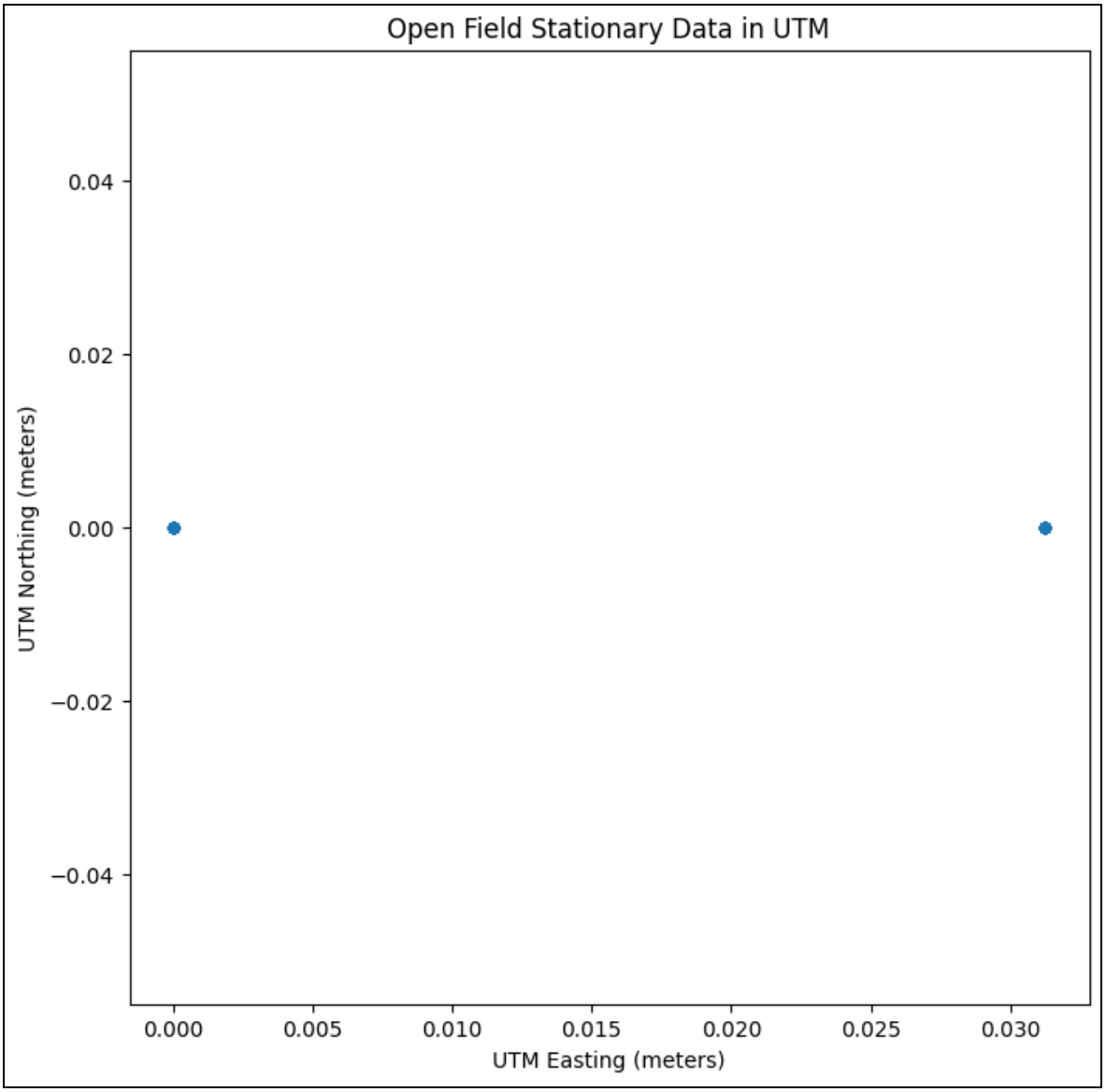

Figure 1: Open Field Stationary Data in UTM

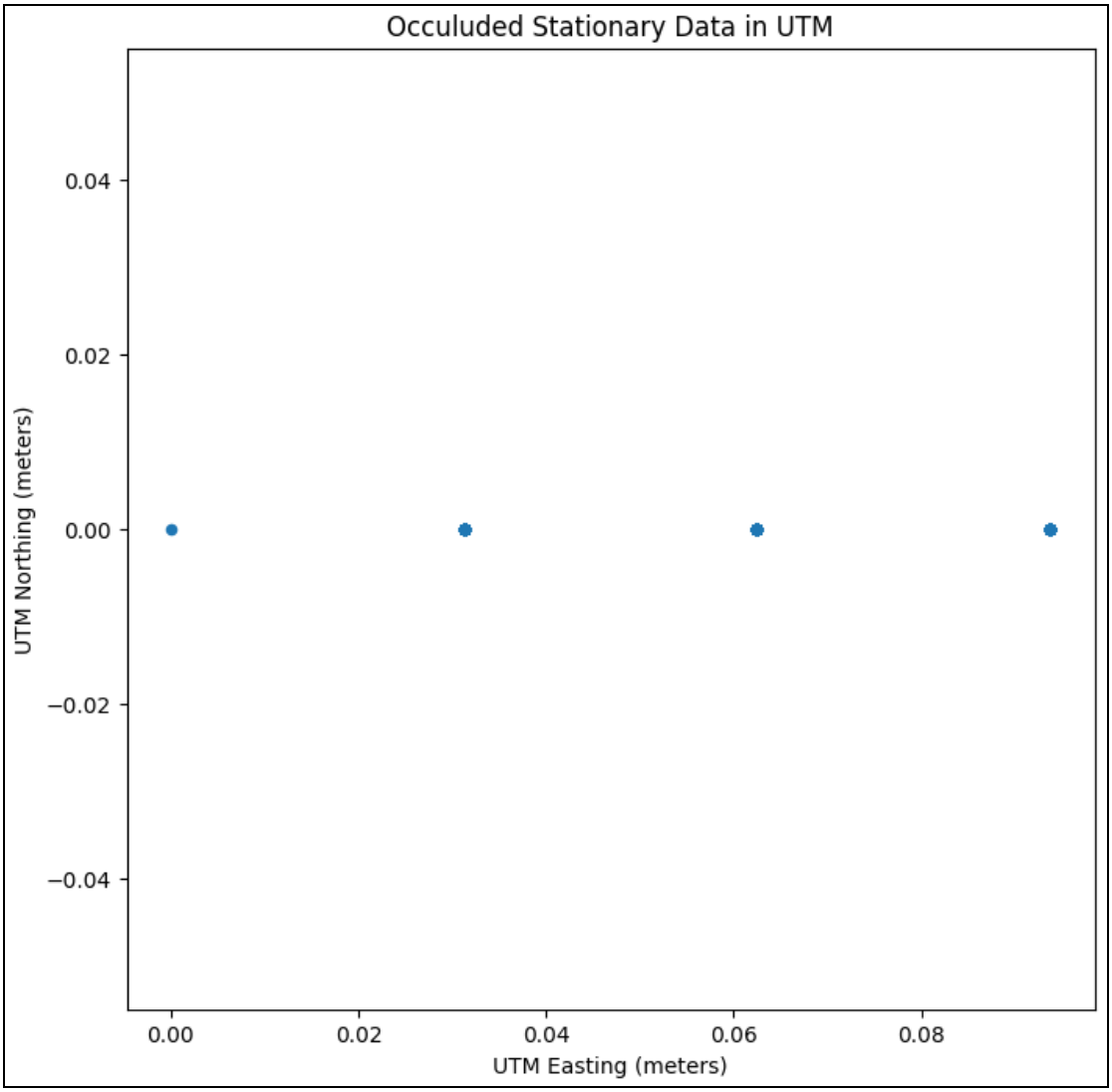

Figure 2: Occluded Area Stationary Data in UTM

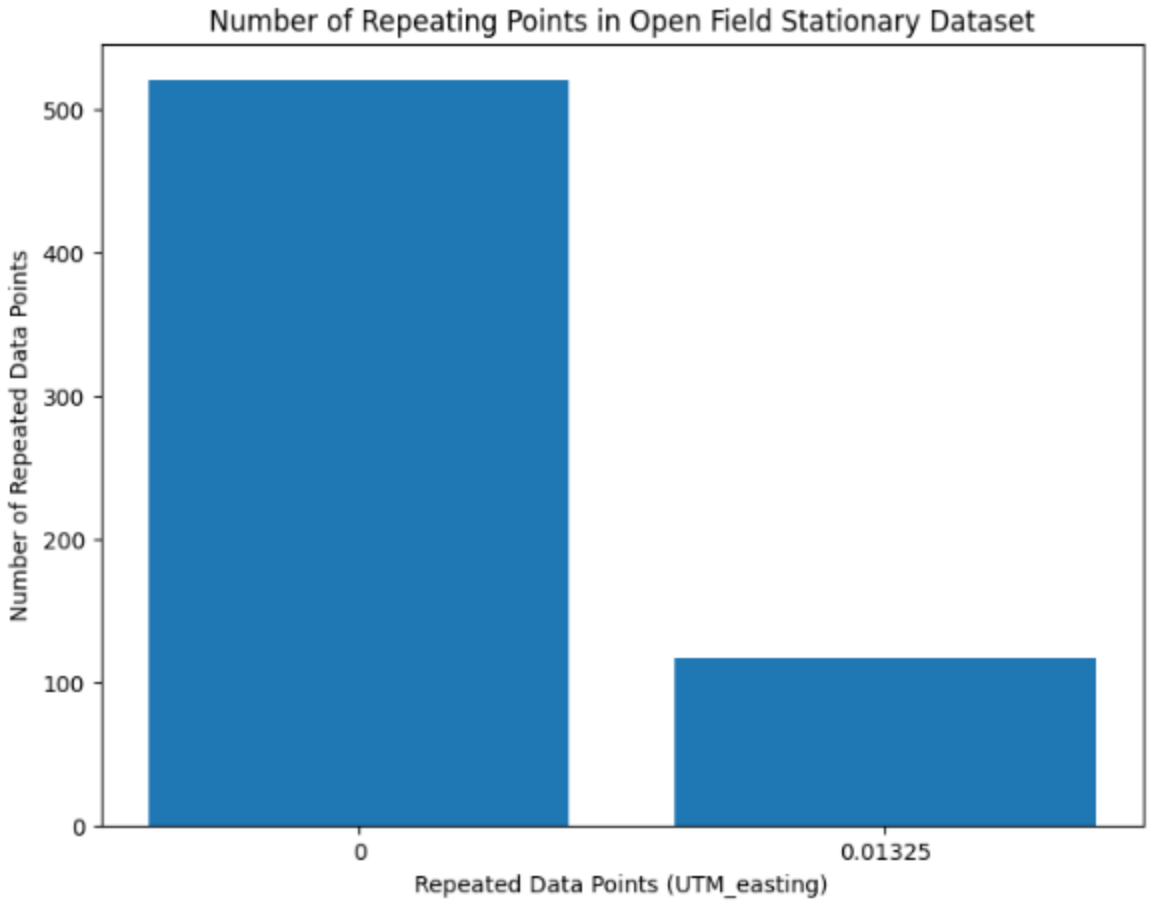

Figure 3: Bar plot of Number of Repeating Values in Stationary Open field Dataset

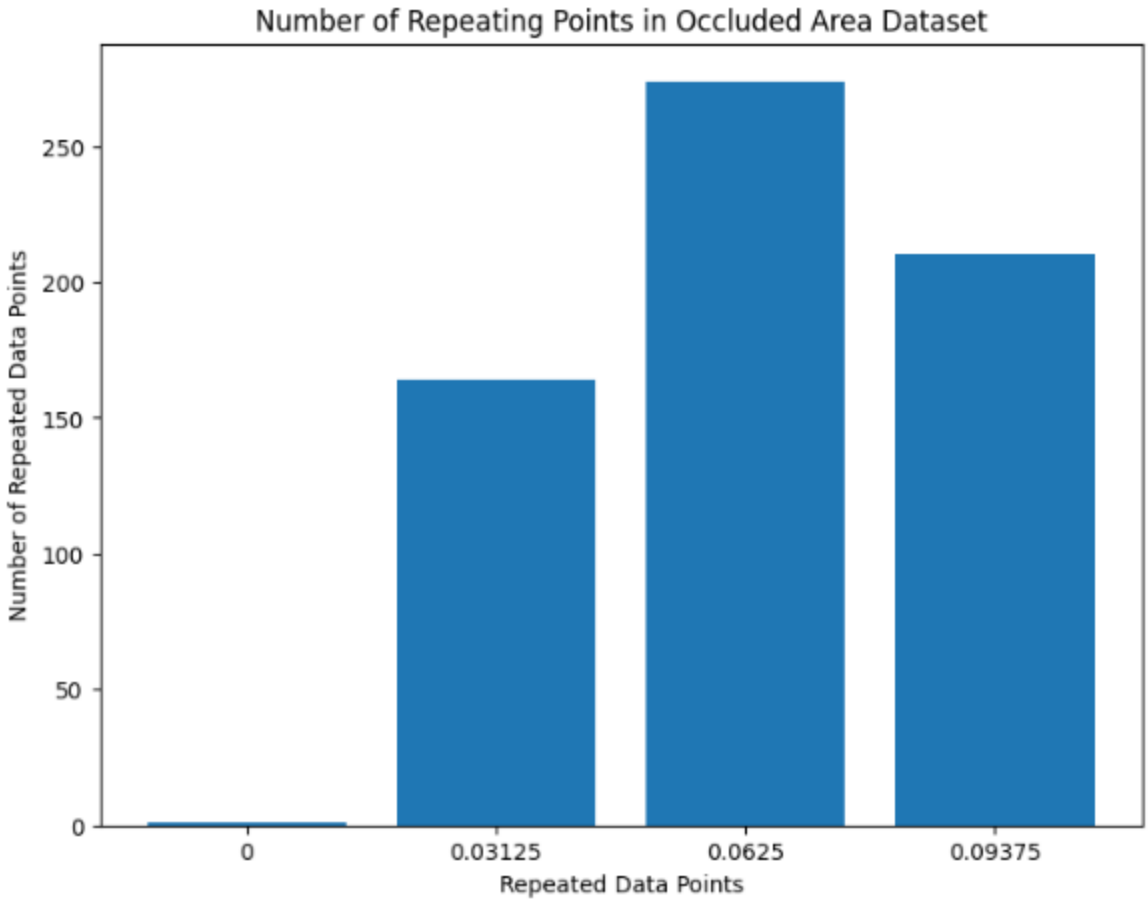

Figure 4: Number of Repeated Points in Occluded Area Stationary Dataset

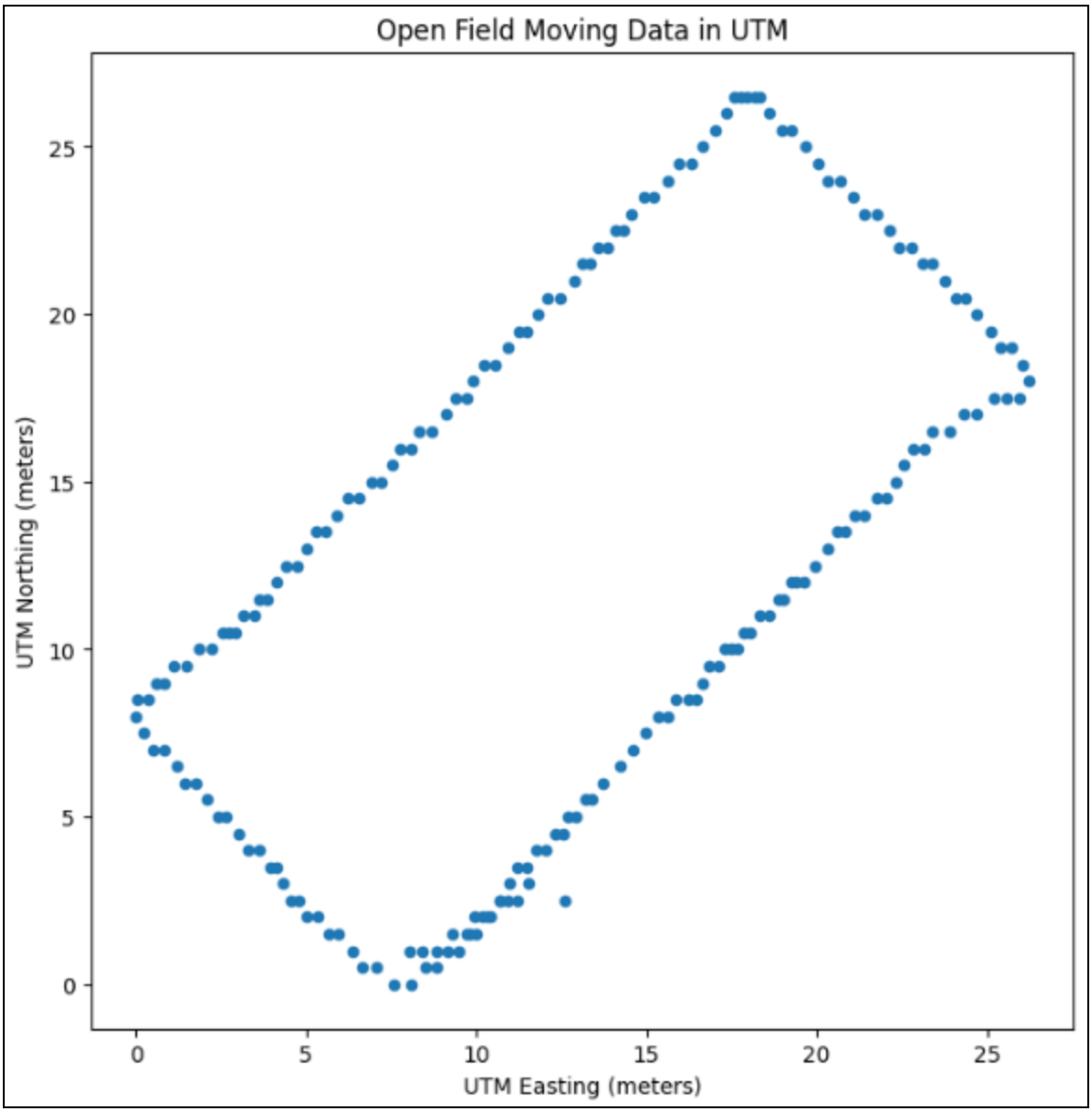

Figure 5: Open Field Moving Data in UTM

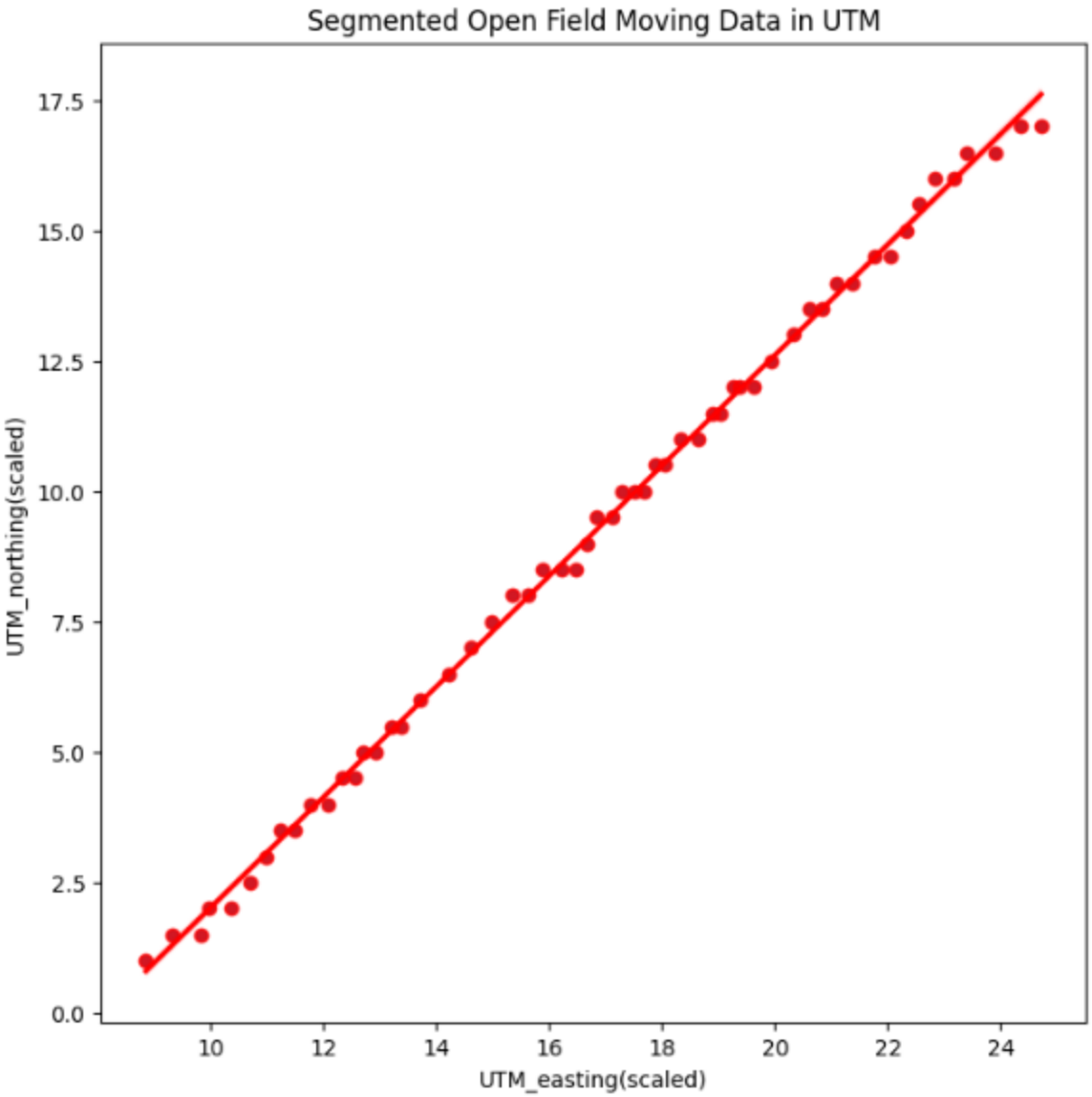

Figure 6: Linear Regression of Segmented Part of Open Field Moving Data

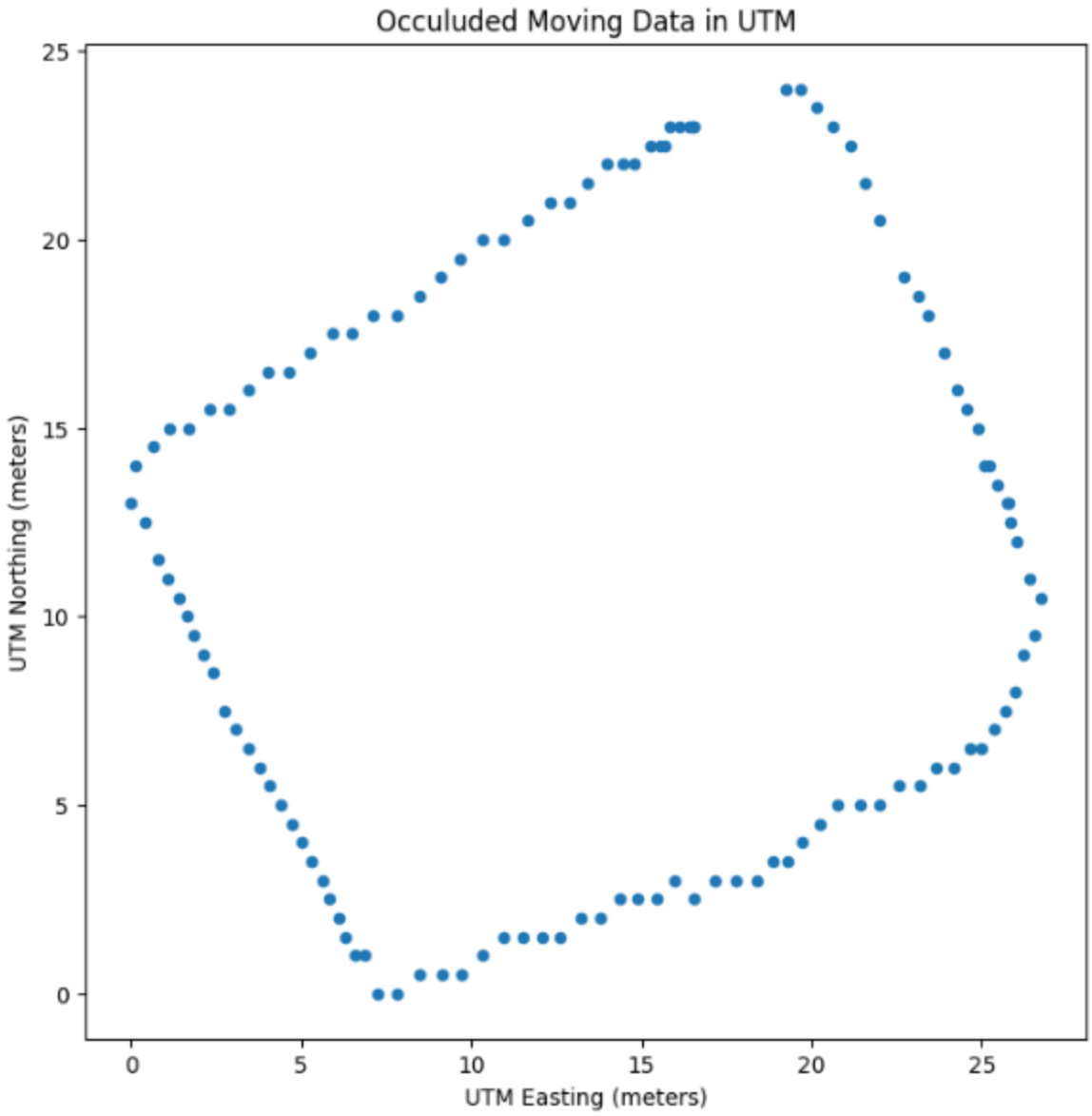

Figure 7: Occluded Area Moving Data in UTM

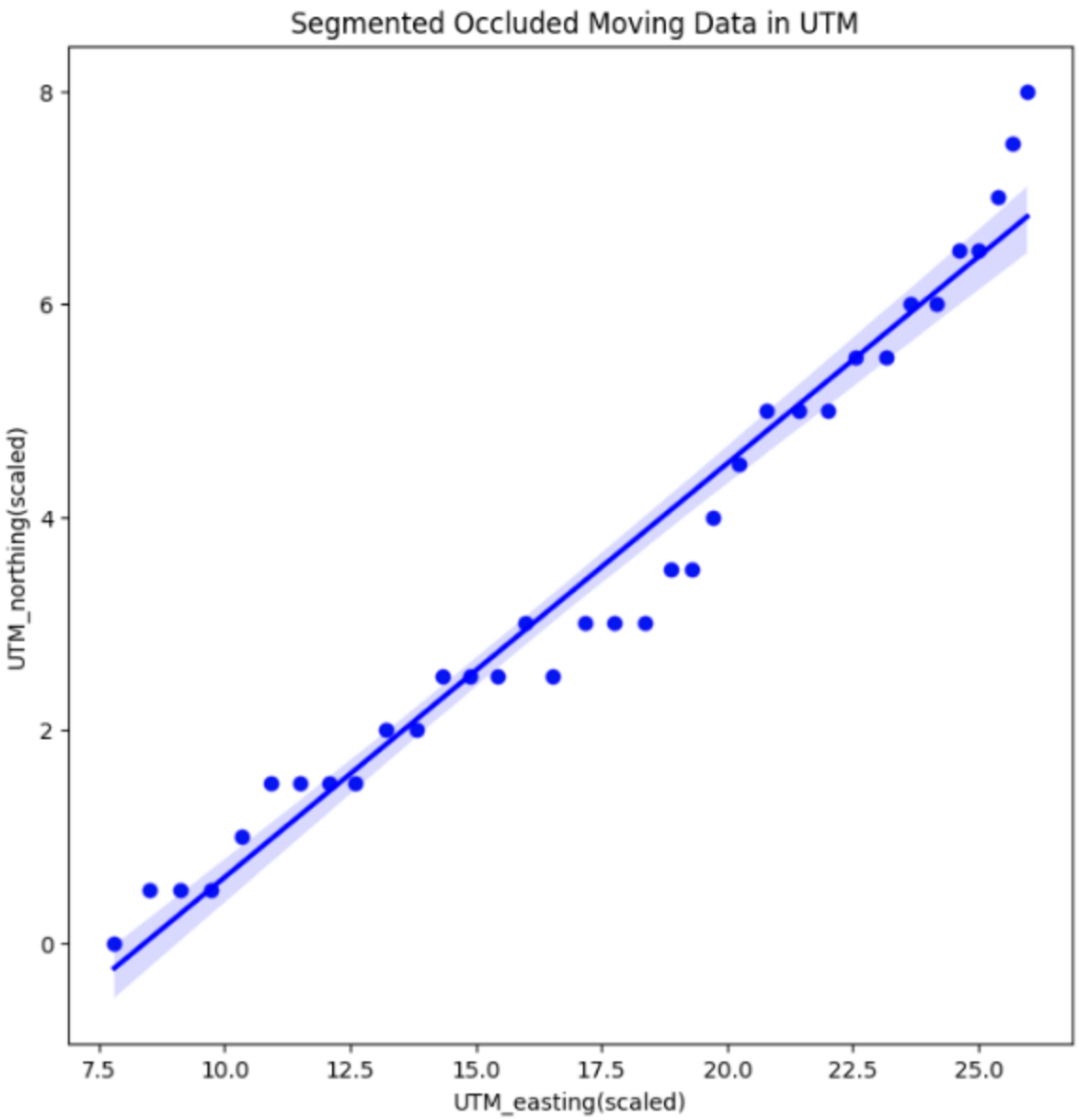

Figure 8: Linear Regression of One Segment of Occluded Area Moving Data