EECE 5554: ROBOTIC SENSING & NAVIGATION

LAB 2 – RTK GPS

BASIL REJI

Data Collection

As part of the Lab2, the data was collected with the RTK GPS. The two locations chosen were:
a) ISEC building of Northeastern University where the unobstructed data were taken.
b) In front of the Curry Student Center in Northeastern University where the obstructed data was taken
In both the cases, a set of stationary as well as walking (in a sort of rectangle) data was collected.

Hardware / Sensors:

2x GNSS/RTK Processing boards
2x GNSS Antennas
2x 915 MHz Telemetry Radios

Softwares/ Languages:

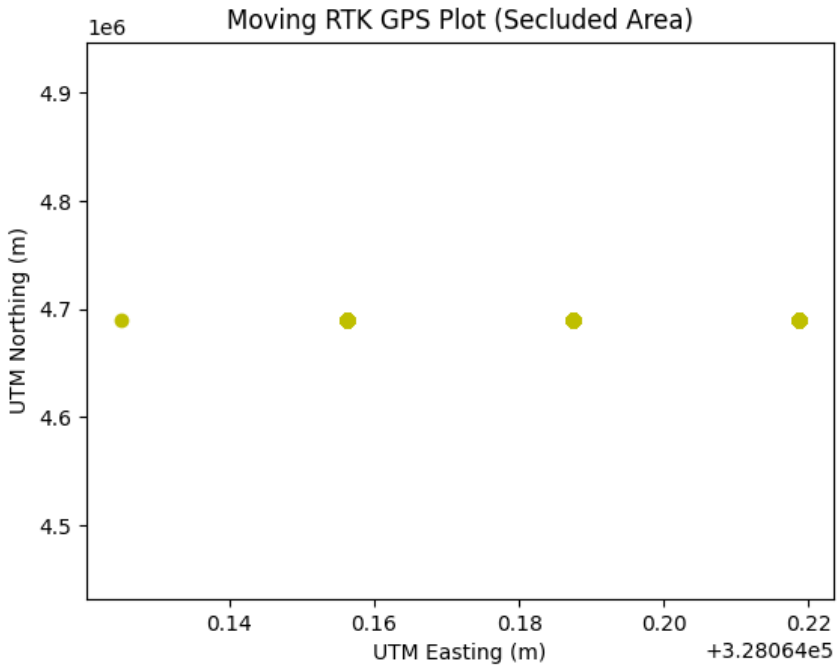
Ublox

ROS

Python

1. Stationary Data

Obstructed Data



The data was taken in front of Curry student center in Northeastern University where there were buildings and trees that could obstruct the data.

The statistics of Obscured data was found to be
Mean: -0.029131

Standard Deviation: 0.023755

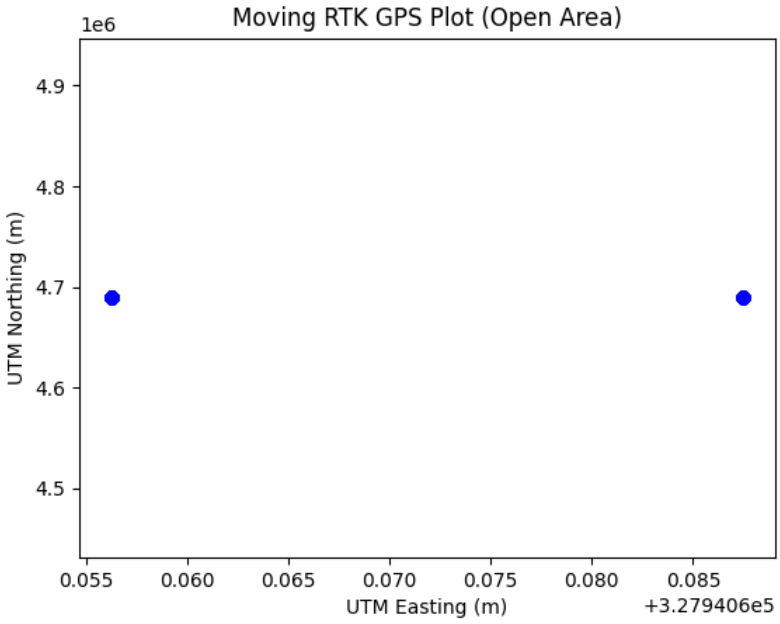
Root Mean Square Error: 0.037589

Mean Error: 0.000932

We can see that the data points are clustered in various separate areas. This is caused due to the Multipath effect. Multipath is the phenomenon of fluctuations in signal strength formed by incoherent combination of signals coming from different directions through reflection or scattering with the direct signal. These reflected or scattered signals have different amplitudes and phases compared to the one received directly. The signals of the GPS were reflected by the buildings around the area multiple times to cause this error.

Another cause of error can be due to Ephemeris. Ephemeris error is the difference between the expected and actual orbital position of a GPS satellite, reduces user accuracy. The factor by which the signal bounces off will be high. This occurs due to the slow increase in angles at which signals from satellites were being received while the satellite was moving and simultaneously exchanging data with the RTK GPS. When the satellite signal is lost, the location estimates abruptly change leading to gap between data points.The other possible reasons for the errors are low number of visible satellites during the time in the area for trilateration, bad signal strength and poor satellite constellation Geometry.

Open Data



The data was taken at the open ground near ISEC Research center in Northeastern University where there were less buildings and trees that could obstruct the data.

The statistics was found to be
Mean: -0.025510

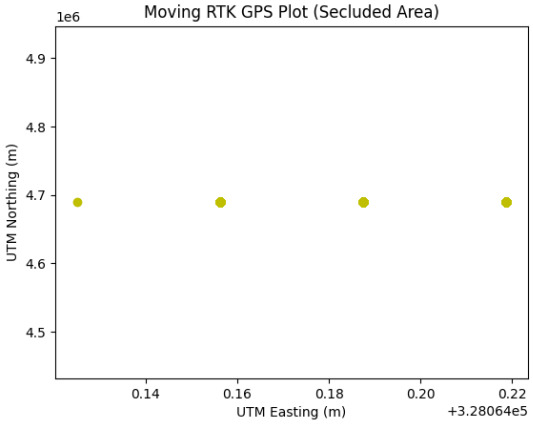
Standard Deviation: 0.012101

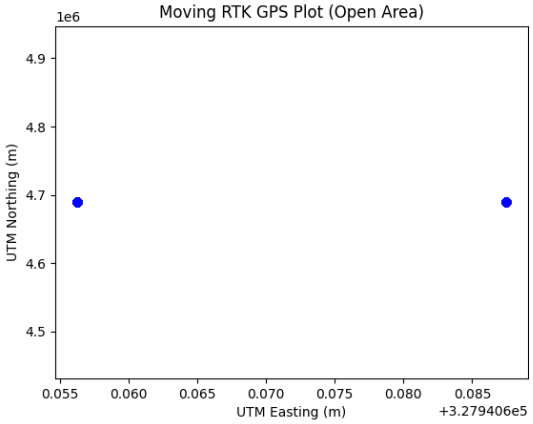
Root Mean Square Error: 0.028235

Mean Error: 0.000479

We can observe that the data is cleaner than what was found in an obstructed environment. This is because there are less buildings and trees that can reflect the signals. The open area also helps satellites to give more signal strength. This also helps in decreasing the concentration of data in random sections.

Comparison of Static Data





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Mean: -0.029131

Standard Deviation: 0.023755

Root Mean Square Error: 0.037589

Mean Error: 0.000932

The statistics of Open data was found to be
Mean: -0.025510

Standard Deviation: 0.012101

Root Mean Square Error: 0.028235

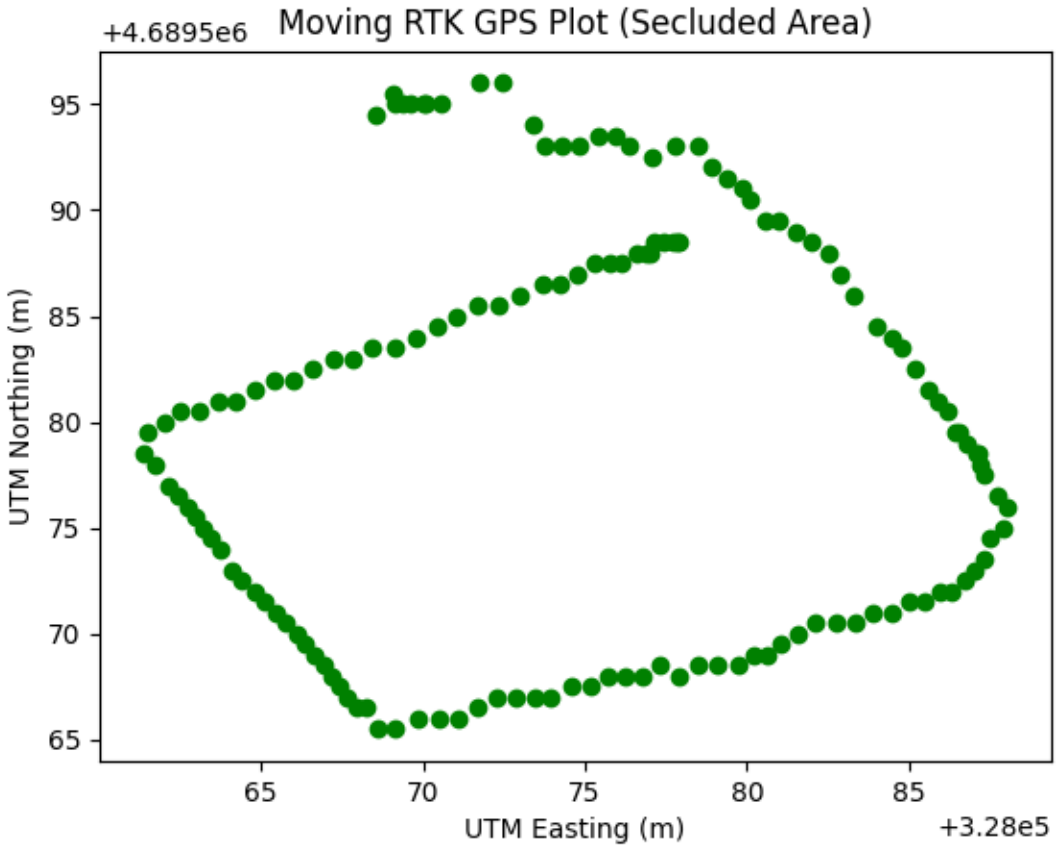
Mean Error: 0.000479

Statistical Analysis:

When comparing stationary data in the two different locations we can see the clear environment data is much more accurate than the obscure one. The clear data mean error is 64% lower. The root mean square error is 28% higher for the obscure data.

2. Moving Data

Obstructed Data



The data was taken in front of Curry student center in Northeastern University where there were buildings and trees that could obstruct the data. The data was taken by walking around in a rectangle.

The statistics was found to be
Mean:
Northing: -14.860140

Easting: 6.302448

Standard Deviation:

Northing: 9.424786

Easting: 7.857512

Root Mean Square Error: 10.072802

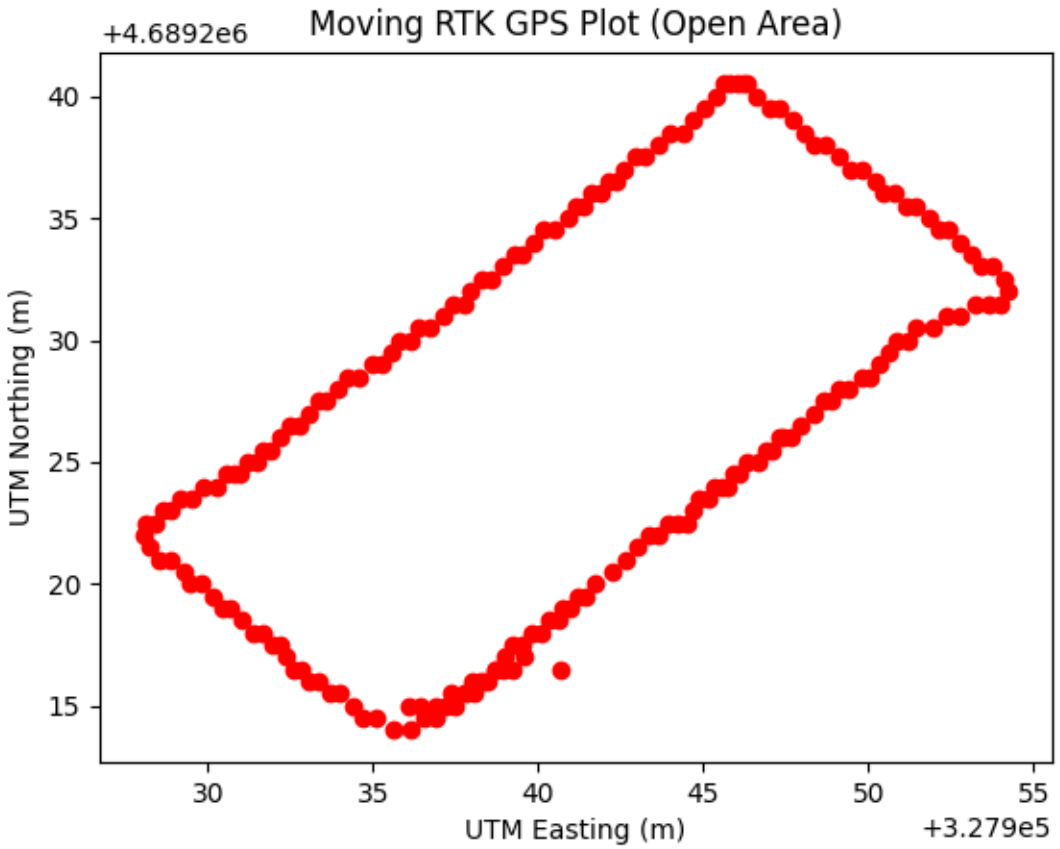
Mean Error: 0.657078

We can observe that the data we received is not a perfect rectangle and it contains noise and errors.
We can see that the data points have deviated from the rectangle in various separate areas. This is caused due to the Multipath effect. Multipath is the phenomenon of fluctuations in signal strength formed by incoherent combination of signals coming from different directions through reflection or scattering with the direct signal. These reflected or scattered signals have different amplitudes and phases compared to the one received directly. The signals of the GPS were reflected by the buildings around the area multiple times to cause this error.

The deviation can also occur due to human errors like not walking in straight line or in perfect rectangles. The environmental factors can also factor in causing increase in errors.

Another cause of error can be due to Ephemeris. Ephemeris error is the difference between the expected and actual orbital position of a GPS satellite, reduces user accuracy. This error will be more in moving data than in static data since both the satellite and the RTK GPS is in motion. The factor by which the signal bounces off will be high. This occurs due to the slow increase in angles at which signals from satellites were being received while the satellite was moving and simultaneously exchanging data with the RTK GPS.

Open Data



The data was taken at the open ground near ISEC Research center in Northeastern University where there were less buildings and trees that could obstruct the data. The data was taken by walking around in a rectangle.

The statistics was found to be

Mean:
Northing: 9.842105

Easting: 0.104934

Standard Deviation:

Northing: 7.887453

Easting: 7.299691

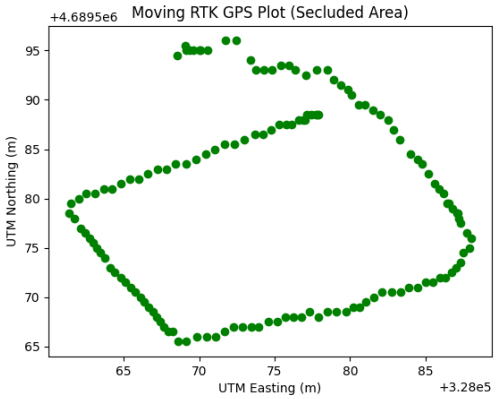
Root Mean Square Error: 7.300445

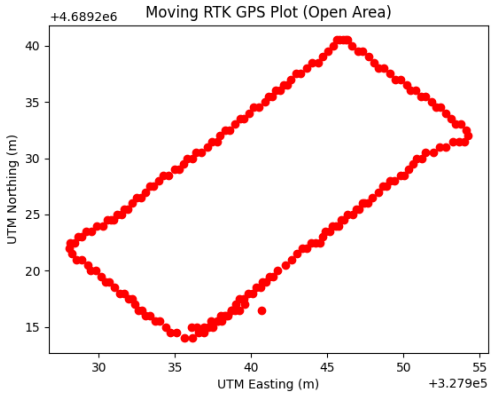
Mean Error: 0.529575

Here we can see that the data we got is a rectangle and hence the errors are minimal. There are no random concentrations of data in specific areas and less disturbances. This is because there are less buildings and trees that can reflect the signals. The open area also helps satellites to give more signal strength. This also helps in decreasing the concentration of data in random sections.

We can also see that the edge of the rectangle is not straight and sharp but are curved. This occurs due to human error as we do not walk in perfectly straight lines.

Comparison of Moving Data





The statistics was found to be

Mean:

Northing: -14.860140

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Standard Deviation:

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Root Mean Square Error: 10.072802

Mean Error: 0.657078

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Standard Deviation:

Northing: 7.887453

Easting: 7.299691

Root Mean Square Error: 7.300445

Mean Error: 0.529575

Statistical Analysis:

We can see that the clear environment has a 21% lower mean error rate. Also, the root mean square error
is 32% higher for the data taken in the obscure environment.

Conclusions

The RTK GPS is a good system to get location using the GNSS system. The location data is the most accurate if there aren't too many structures around the device to block direct connection of the satellite signals with the device.

Though it was found to have certain errors while in an obscured environment, it is still better than a conventional GPS Puck. The main errors that were found to be the reason for error was Multipath, Ephemeris and human errors.