About the Lab

In this lab, we had to use hardware (Arduisimple- simpleRTK2B board and Telemtery radio V3) along with software (Ublox) to configure and set up a base and rover station to collect data for analysis from two locations - an occluded space and an open space.

Data collection in an Open location

Method

This collection was carried out on the roof of Columbus parking garage. Position of the base station and rover for the stationary dataset has been marked by the green marker and red marker respectively. The path of the rover for the moving dataset has been marked by the arrows.

Fig 1.0 Columbus Parking Rooftop

Stationary Data

With the base and rover kept immobile, data was collected for a period of 10 min at a rate of 1 message published per second; a total of 601 data points were collected. The following plots were plotted from the received data.

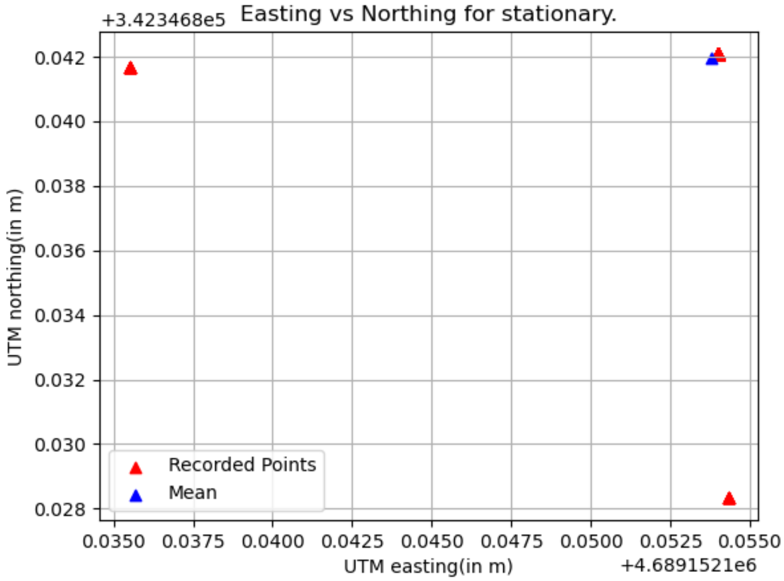

Fig 1.1 Easting vs Northing

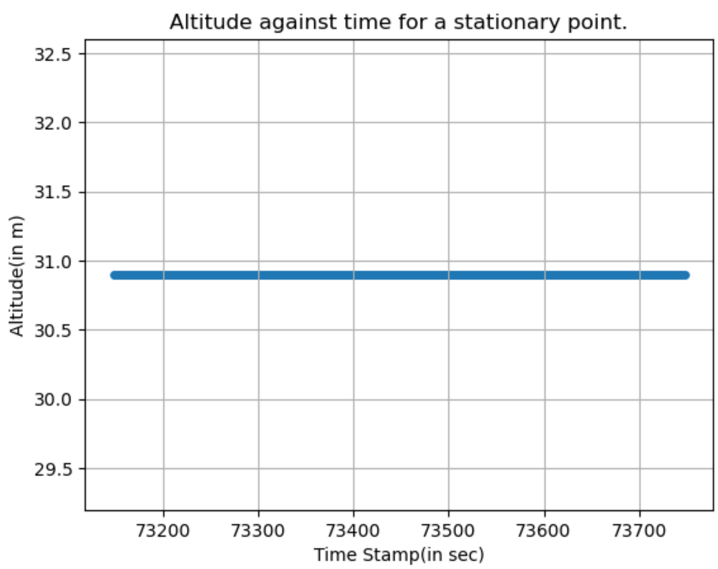

Fig 1.2 Altitude against time while stationary

- Mean position of the points collected is (342346.8419585514, 4689152.153796171) m as marked by the blue marker in Fig 1.1. Keeping the mean as the true position, the calculated mean square error for northing and easting are 0.001 mm and 0.004 mm respectively. The root mean square error value for northing and easting are 1.247 mm and 1.986 mm respectively.The survey in conditions were 5 m and 60 sec.
- Unlike the first lab result where the GPS data for stationary was found to vary wildly, the presence of RTK correction has reduced the variance for this lab experiment and increased accuracy from the meter scale to cm scale as can be seen from Fig 1.1.

Northing varies between 3.5 cm to 5.5 cm whereas easting varies between 2.8 cm to 4.2 cm.

- The rover and the base were kept at an altitude of 30.85 m above mean sea level and this is reflected with zero deviations in Fig 1.2.
- The open space had great line of sight with minimal obstructions. Hence, the great data.

Moving Data

With the base immobile, data was collected while moving around in a rectangular path on a slightly slanted slope.

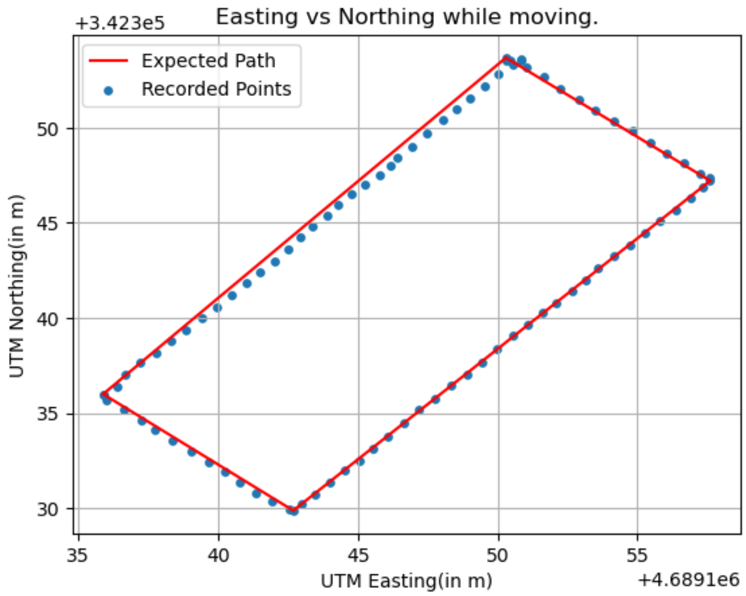

Fig. 1.3 Easting vs Northing while moving

Fig. 1.4 Error Plot

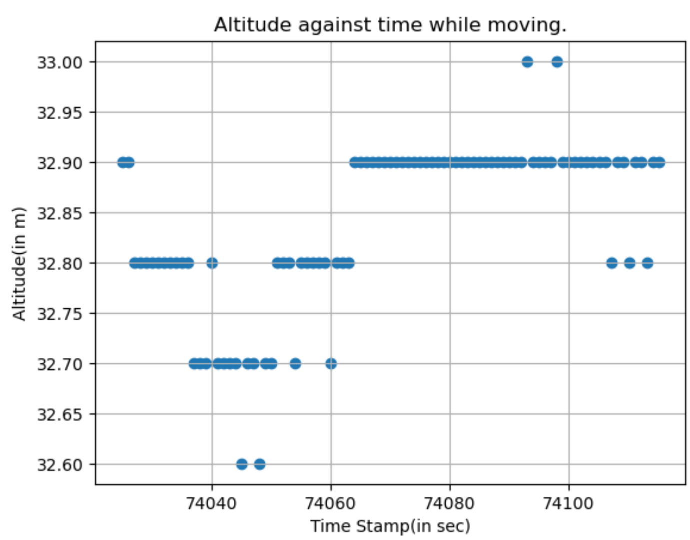

Fig. 1.5 Altitude against time when moving

- Fig 1.3 shows the recorded points to be almost concurrent with the expected path (all straight lines). A histogram of the deviations of the recorded data from the expected has been shown in Fig 1.4. A half-normal distribution can be seen in this plot with error values of 0 m to 0.05 m can be seen having greater density.
- The mean square error of the data is 0.0061 m, and root mean squared error is 0.0780 m. This is once again in the scale of cm as opposed to that of the result that was to be obtained in lab 1.
- This path was traversed on a slope, hence the varying altitude plot. It can be seen from Fig 1.5 that we first descended the slope, then walked up it and then finally descended back to the starting altitude. This was also done while holding the gps puck in hand, hence the slight variation of (+/- 0.1 m) caused by the instability of the hand holding it.The open space had great line of sight with minimal obstructions. Hence, the great data.

Data collection in an Occluded location

Method

This collection was carried out at Snell Quad (outside Snell library). Position of the base station and rover for the stationary dataset has been marked by the red marker and yellow marker respectively. The path of the rover for the moving dataset has been marked by the green arrows. This data was also recorded under cloudy skies with slight winds.

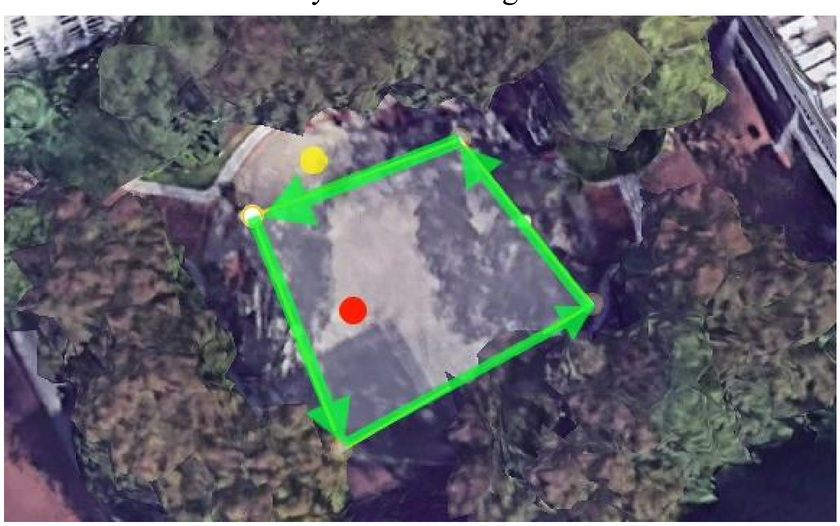

Fig. 2.0 Snell Quad

Stationary Data

With the base and rover kept immobile, data was collected for a period of 10 min at a rate of 1 message published per second; a total of 609 data points were collected (delay in shutting it down). The following plots were plotted from the received data.

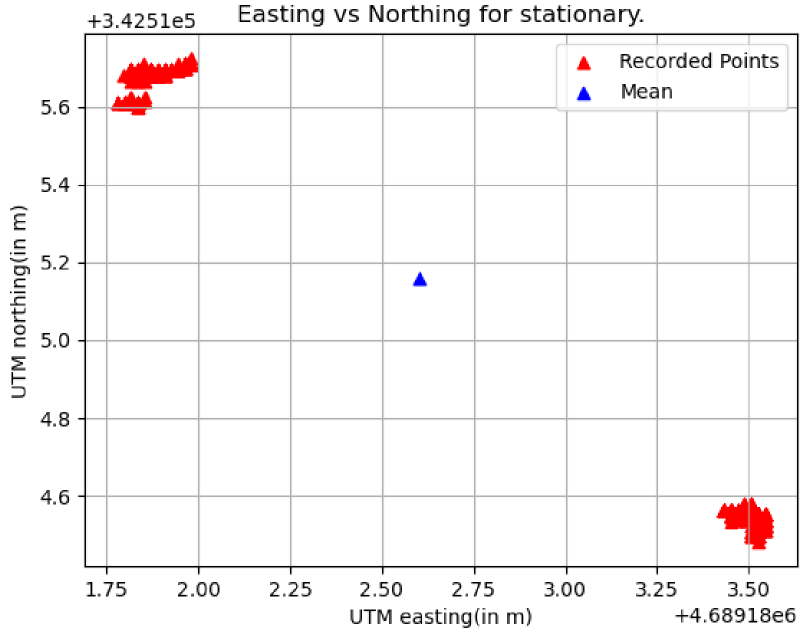

Fig. 2.1 Easting vs Northing while stationary

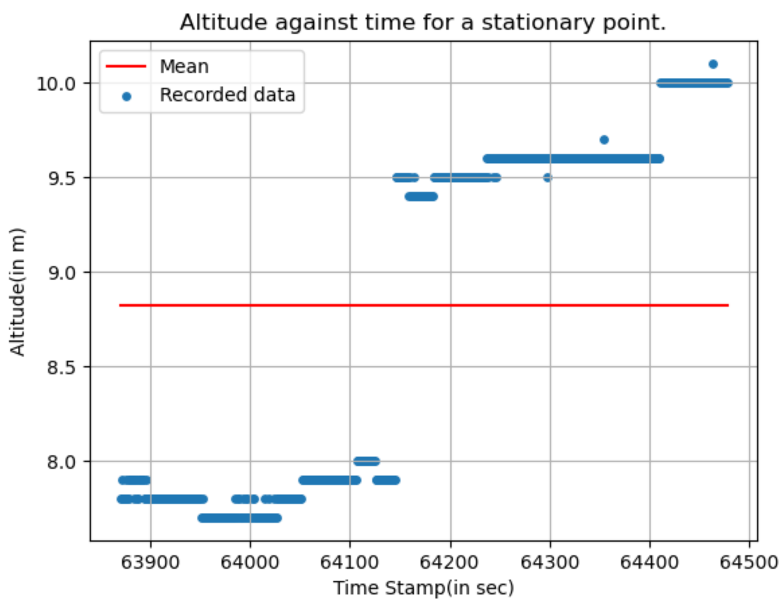

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Fig. 2.2 Altitude against time taken when stationary

- Mean position of the points collected is (342346.8419585514, 4689152.153796171) m as marked by the blue marker in Fig 2.1. Keeping the mean as the true position, the calculated mean square error for northing and easting are 31.953 cm and 67.182 cm respectively. The root mean square error value for northing and easting are 56.527 cm and 81.964 cm respectively.

- The data experiences more deviation here because of the presence of people and other objects such as trees and buildings. The data was found to shift between 4 and 5 quality factor during collection. It shows a variation of 1.75 m in easting and 1.2 m in northing. The survey in conditions were 50 m and 10 sec.
- The data shows a varying altitude with a mean of 8.8203 m above mean sea level.

Moving Data

With the base immobile, data was collected while moving around in a rectangular path on a slightly slanted slope.

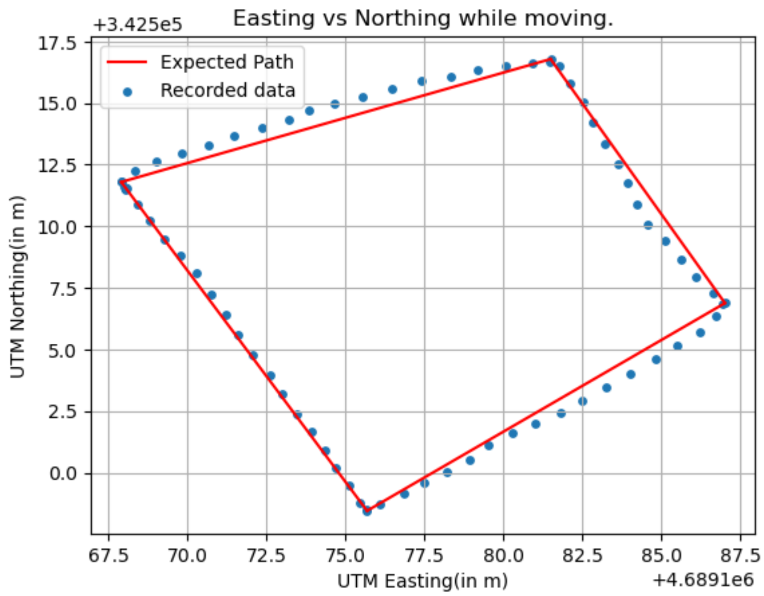
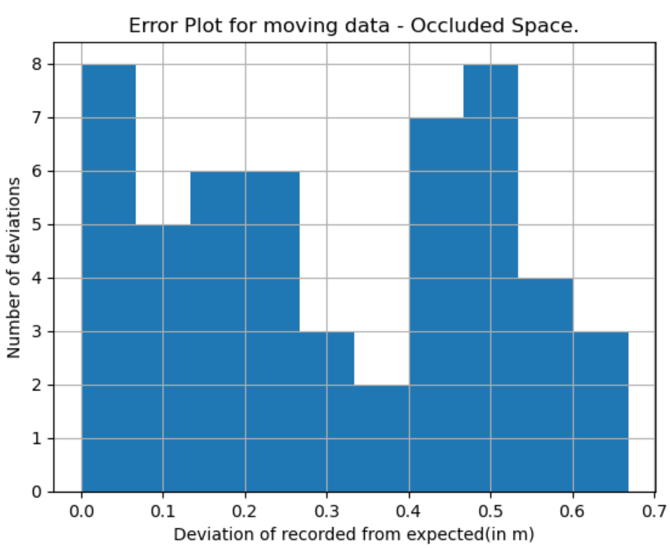


Fig. 2.3 Easting vs Northing while moving



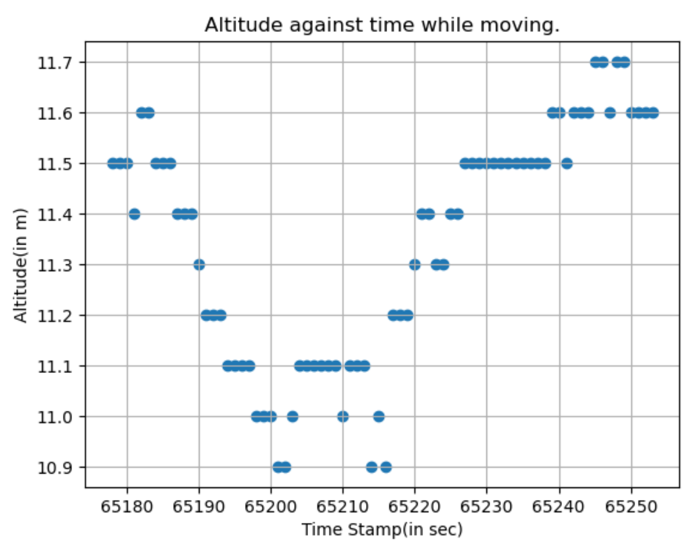


Fig. 2.4 Error Plot

Fig. 2.5 Altitude against time when moving

- Fig 2.3 shows the recorded points to be along the expected lines, however, at a glance the deviations are more visible than in the case of the open space. A histogram of the deviations of the recorded data from the expected has been shown in Fig 2.4. This histogram does not resemble any familiar distribution. The error plots here show that the presence of obstructions (discussed in next section), can clearly affect the quality of data obtained.
- The mean square error of the data is 0.136 m, and root mean squared error is 0.368 m. This is once again in the scale of cm as opposed to that of the result that was to be obtained in lab 1.
- This path was traversed on a slope, hence the varying altitude plot. It can be seen from Fig 2.5 that we first went up and then descended in height after which we ascended and then descended to the starting position again. Once again, the rover puck was moved by hand, hence, altitude deviation would also occur from the instability of the hand.

Results

The data obtained from the open space and occluded space show a great deal of difference in accuracy. The following observations were made from the stationary data:

- In the open space, the stationary data seem to give consistent data with a few deviations. This is a huge improvement compared to the result obtained from Lab 1, where the Kalmann Filter resulted in more deviations due to its incapability to pinpoint its orientation. Here, the RTK corrections using a base station has helped overcome that issue and has given a clean set of data.
- In the occluded data set, we once again see a some deviations; however these are due to presence of obstructions like trees and moving people. Forest canopy has some negative effects on the GPS signal including obstruction, attenuation, and reflection.[1] Therefore, multipathing occurs and leads to deviations in positional data. The survey in conditions were also relaxed, so as to obtain better quality factor with fix.
- Despite that, we see an improvement in accuracy of centimeters scale as opposed to an accuracy of meters in the absence of the corrective action.
- As mentioned, the altitude reading while suffering a few deviations were mostly correct, especially in the case of open sight, where they were very precise. Hence, the problem of drift in stationary gps has been dealt with here.[1]

From the moving data, we observed:

- With the RTK corrections, our recorded data has mostly coincided with the expectation lines (drawn under the assumption of straight line traversal).

- In the case of occlusion, we can consider multipathing to be the main reason for the increased errors as compared to the Columbus data.
- Despite that we see once again that the errors for the occluded set are all below 0.7 m and had a mse of only 0.136 m.
- A few of the deviations caused in the altitude readings might have been caused by some shaking of the person carrying the rover gps puck around. This is not the case for the stationary data, as the pucks were placed on the ground.

Discussion

- The data proves that site selection is a significant factor for improving the quality of the GPS data we receive. It is important to reduce environmental effects such as multipathing and interference. [2]
- This effect of surroundings on gps data can also be seen in this review by A. Pirti[1], that evaluates the repeatability and accuracy of RTK GPS in a setting with many surrounding trees.
- This setup has eliminated nearly all drift that occurs when a gps is kept stationary.

Conclusion

The RTK GPS setup shows much better positional data as compared to lab 1, where the presence of the filter led to extra deviations. The corrective action using the signals recieved from the base station via the radios helped in deducting external atmospheric errors that may have been caused to both the base and rover stations.
With an accuracy in the scale of cms, it far outclasses the performance of the individual pucks used with an accuracy in the scale of meters.

References

[1] Pırtı, Atınç. (2011). Evaluating the repeatability of RTK GPS. Survey Review. 43. 177-186. 10.1179/003962611X12894696204984. (Link)

[2] Jeffrey, C. (2010). *An introduction to Gnss: Gps, Glonass, Galileo and other Global Navigation Satellite Systems*. NovAtel.

[3] *Centimeter precision GNSS explained - RTK in detail*. ArduSimple. (2022, July 12). Retrieved October 12, 2022, from https://www.ardusimple.com/rtk-explained/

Image credits

Fig 1.0 and Fig 2.0 were taken from Google Earth