ANALYSIS OF RTK GPS DATA

The following document aims to analysis the data collected from a RTK GPS puck using a custom driver written in Python and ran using ROS.

Stationary Data:

Figure 1

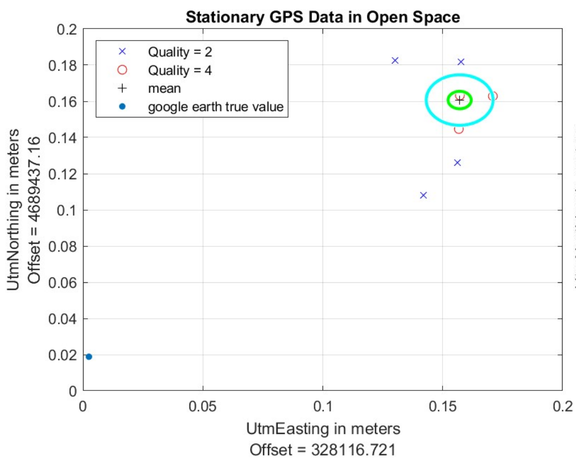
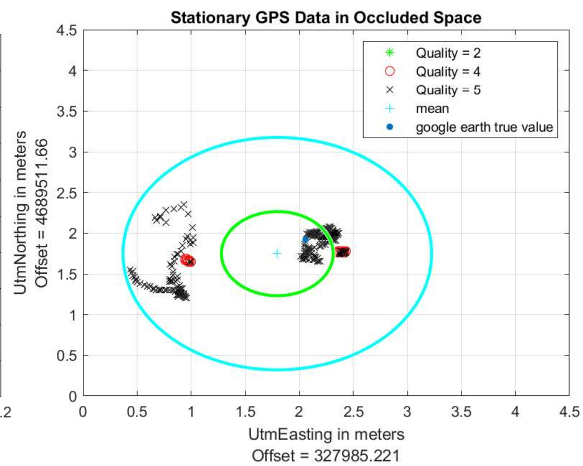


Figure 2



The Figure 1 shows the plot of the stationary data collected in open space at the top of Columbus Parking Garage for 10 minutes. The graph is drawn using UTM data, using the Easting and Northing values with their respective offsets. The mean has been calculated for the points. A mobile phone was used to get the GPS co-ordinates to get the "true-vale" for the location. The same is also shown in the graph. Different colors and symbols are used to show different quality values recorded in the data. The points are scattered under 5cm in UTM-Easting and 8cm in UTM-Northing.

Figure 2 shows the plot of the stationary data collected in occluded space in front of snell library for 10 minutes. The graph is drawn using UTM data, using the Easting and Northing values with their respective offsets. The mean has been calculated for the points. A mobile phone was used to get the GPS co-ordinates to get the "true-vale" for the location. The same is also shown in the graph. Different colors and symbols are used to show different quality values recorded in the data. The points are scattered under 2.2m in UTM-Easting and 1.5m in UTM-Northing.

Stationary GPS Data in Open Space	
Quality	**No. of Points**
2	4
4	636
5	0

Stationary GPS Data in Occluded Space	
Quality	**No. of Points**
2	1
4	182
5	458

In both the graphs I have shown two error bounds are shown using the standard deviation. The two error bounds are called Circular Error Probability (CEP) (the green circle) and Distance Root Mean Square (2DRMS) (the cyan circle). CEP is the measure of a system's precision. It is basically the radius of a circle, centered at the mean, which includes 50% of the points on the graph. 2DRMS here includes 98.1% of the points on the graph.

Analysis: In Open space, the google maps true value is 0.2 meters away from the mean of the collected data. In Occluded space, the google maps true value is 0.6 meters away from the mean of the collected data. Google maps itself is accurate to 1-3 meters. This error can be attributed to that.

The root mean square error was calculated using the formula

Error = TrueValue – GPSValue

The RMSE for Stationary Data in Open space = **0.2098 m**.

The RMSE for Stationary Data in Occluded space = **0.6338 m**.

It can be seen by this data that RTK GPS has lower error in open space as compared to occluded space.

Moving Data:

Figure 3

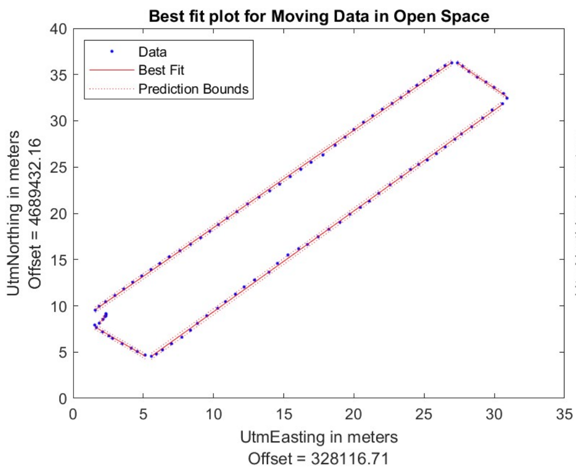


Figure 4

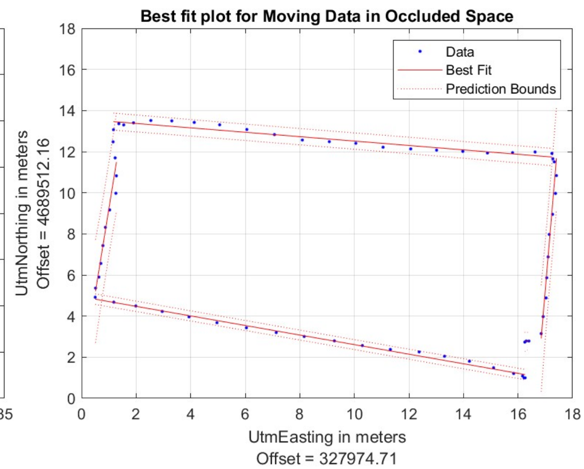


Figure 3 shows the best fit graph for moving data in open space. The data was collected at the top of Columbus Parking Garage. The graph is drawn using UTM data, using the Easting and Northing values with their respective offsets.

Figure 4 shows the best fit graph for moving data in occluded space. The data was collected in front of snell library. The graph is drawn using UTM data, using the Easting and Northing values with their respective offsets.

In both the graphs, the path traced can be seen clearly. The starting and ending point of the path do not intersect. This is a small error which can be attributed to human error. Best fit lines were drawn for each edge of the rectangle and the Root mean square error (RMSE) was calculated.

The RMSE for Moving data in Open space = **0.1173 m.**

The RMSE for Moving data in Occluded space = **0.4467 m.**

Figure 5

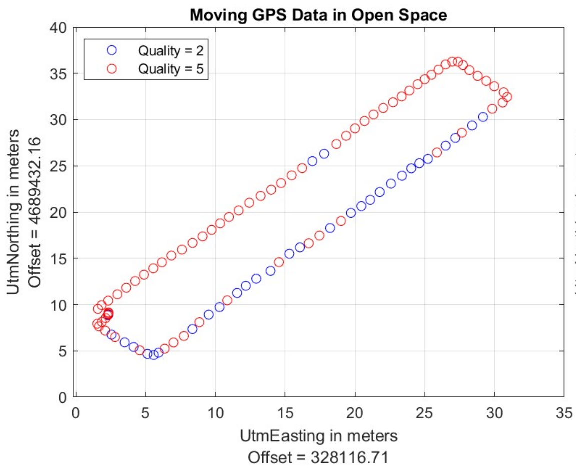


Figure 6

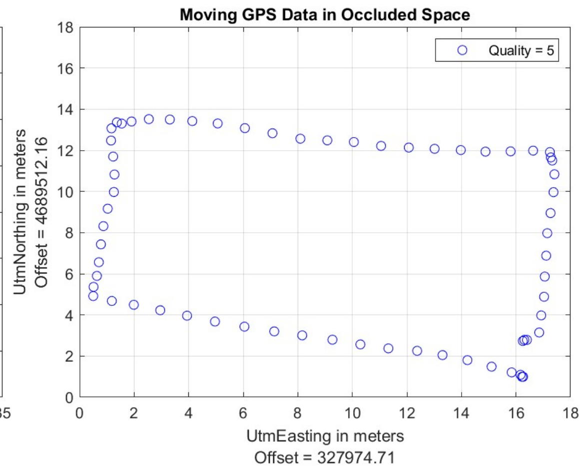


Figure 5 shows the same path traced as Figure 3 in Open space and Figure 6 shows the same path traced as in Figure 4.

Here the different colors indicate the different quality obtained while recording the data in each graph.

Stationary GPS Data in Open Space	
Quality	**No. of Points**
2	32
5	71

Stationary GPS Data in Occluded Space	
Quality	**No. of Points**
2	**0**
5	65

Altitude in Stationary Data:

Figure 7

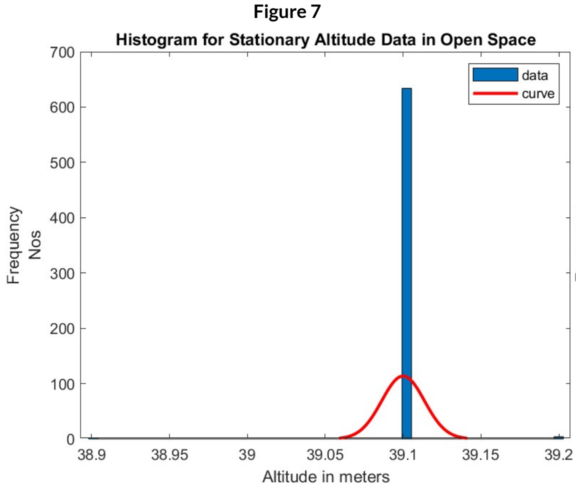


Figure 8

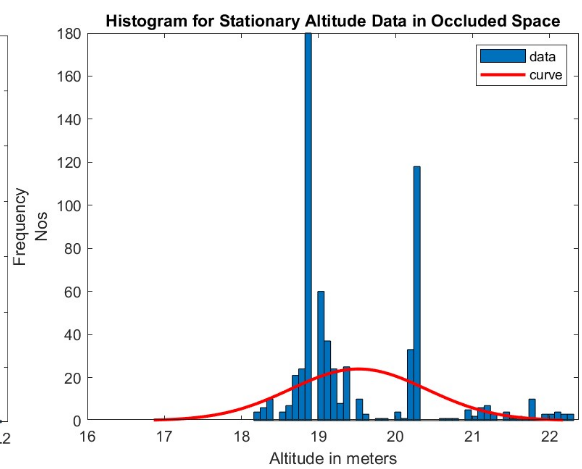


Figure 7 shows the histogram of the altitude recorded while colleting stationary data in Open space and Figure 8 shows the histogram of the altitude recorded while collecting stationary data in occluded space. It can clearly be seen in Figure 7 that the distribution is a normal distribution. In case of Figure 8, we can see the altitude show two different values. This could be due to the different quality values in occluded space.

Altitude in Moving Data:

Figure 9

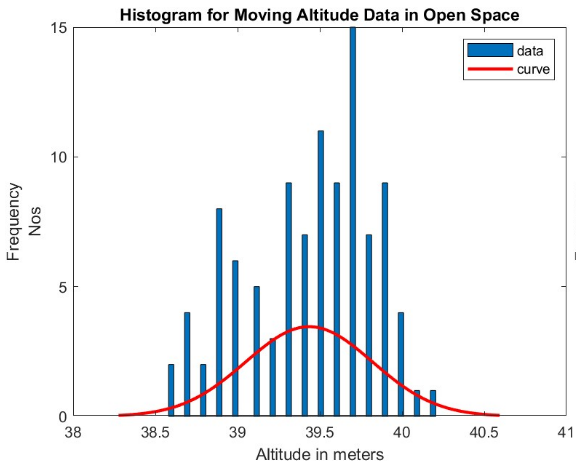


Figure 10

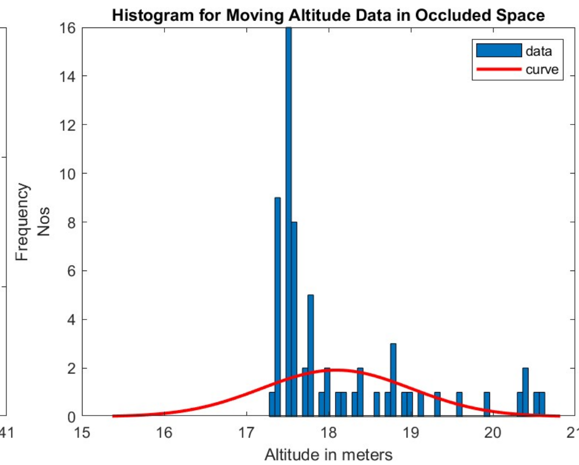


Figure 9 shows the histogram of the altitude recorded while colleting moving data in Open space and Figure 10 shows the histogram of the altitude recorded while collecting moving data in occluded space. It can seen in Figure 9 that the distribution could be a normal distribution. In this case the data is not exactly fitting the Gaussian curve. This error might have been due to human error while recording the data. In case of Figure 10, we can see the altitude has a peak at a value and tapers around it to with more on one side and thus could be rayleigh's distribution. This could be due to the different quality values in occluded space.

Histograms for UTM-Easting and UTM-Northing:

Figure 11

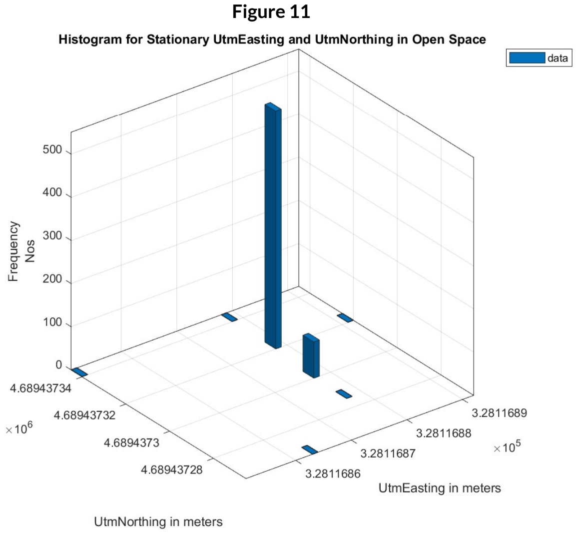


Figure 12

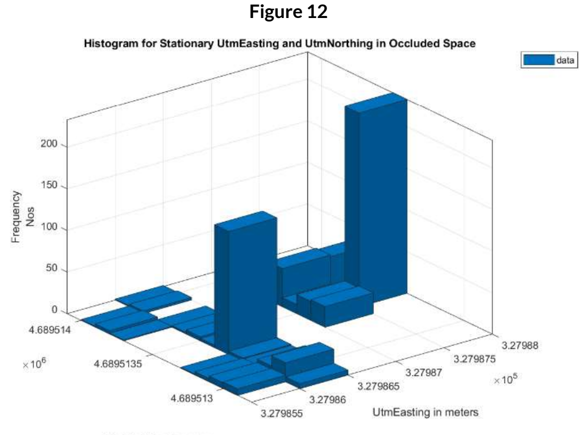


Figure 11 and Figure 12 show the 3D plot of the frequency at which a point is recorded which recording the Stationary data in open space and occluded space respectively.

Figure 13 and Figure 14 show the histogram for UTM-Easting values recorded while recording stationary data in open space and occluded space respectively.

Figure 15 and Figure 16 show the histogram for UTM-Northing values recorded while recording stationary data in open space and occluded space respectively.

Figure 13

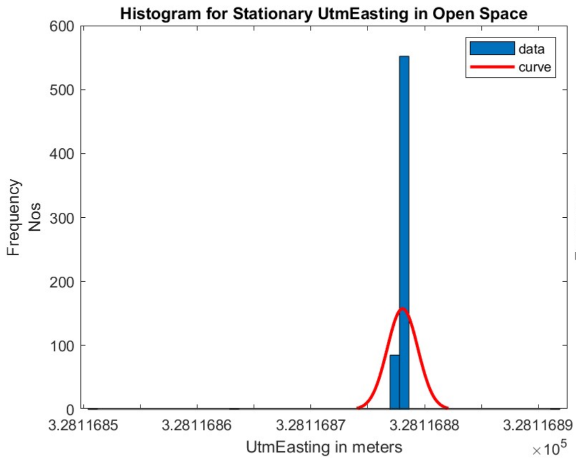


Figure 14

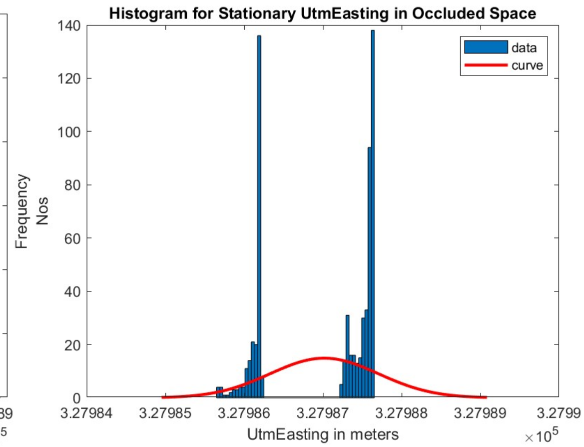


Figure 15

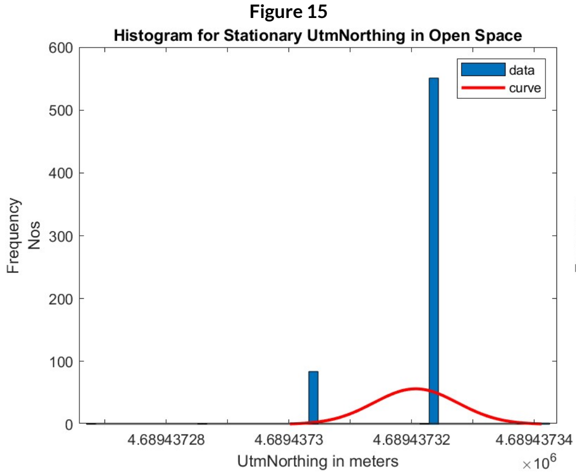
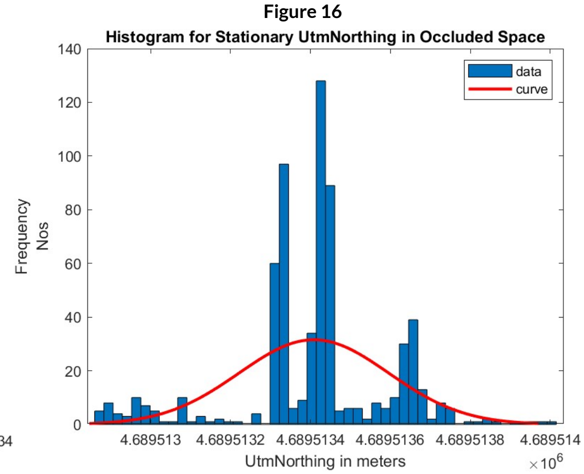


Figure 16



In case of open space, we can clearly see a Gaussian curve fitting the UTM-Easting values while a skewed Gaussian curve fitting the UTM-Northing values. Overall, it can be said that the data for open space is more likely to be a Gaussian Distribution.

In case of occluded space, there are two spikes in UTM-Easting both having a normal distribution around them. The two spikes could be due to multi path as we received quite a lot of data points in two locations. This can be concluded because as the satellite moves out of range, a new satellite comes and takes it place, which might have a different path either with reflections or without. But the change in data indicates presence of multi-path errors. In case of UTM-Northing, a similar effect can be seen but with lesser difference in the values. This break/change in data can be seen in the 3D plot of the occluded histogram (figure 12).

Figure 17

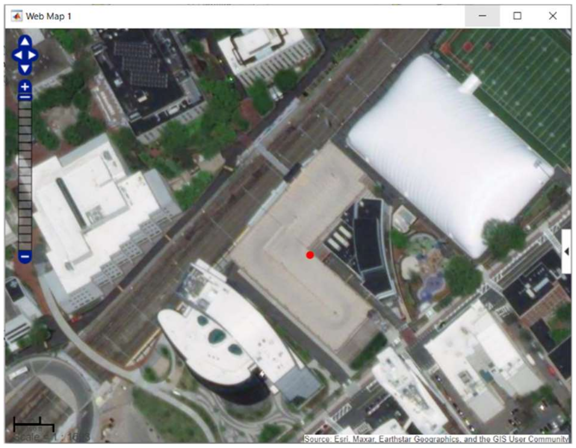


Figure 18

Figure 17 and Figure 18 show the points at which stationary data was collected in open space and occluded space respectively. Figure 19 and Figure 20 show the path traced while collected moving data in open space and occluded space respectively.

Figure 19

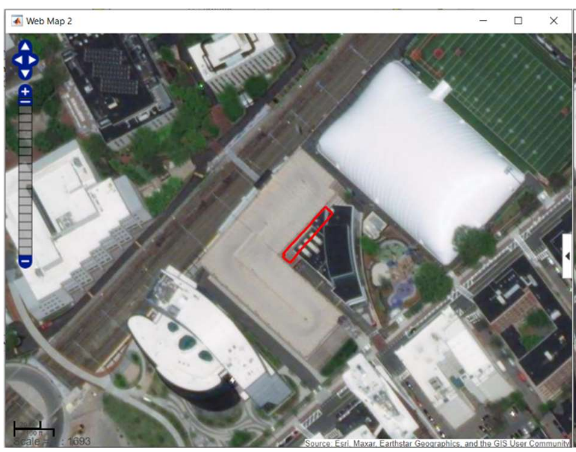


Figure 20

While plotting this data in MATLAB, I used the 'World Imagery' webmap. I found that this is not very accurate at this scale. The map has been shifted by 15 meters to the west and about 3 meters north. The path I walked while collecting data in open seems to be done next to Columbus parking garage, which in actual was taken on top the building. I also verified this by taking multiple points on this map and plotting them on google maps and then measuring the distance between them. That is how the error in the map was determined.

CONCLUSION:

Q. What does this say about RTK GNSS navigation? Look at the error estimates.

- Looking at histograms and all the graphs of the collected data, we can say that RTK GNSS is accurate upto 8 cm in open space. The accuracy drops down to 2.2 meters in occluded space. We can see that inspite of being in an occluded space, RTK GNSS is more accurate as compared to a basic GPS GPGGA which has an accuracy of 5 meters in open space (from LAB1).

Q. What can you say about the distribution of noise in the signal?

- After looking at the histograms, it can be concluded that the noise is distributed normally in open space and close to normal or Reighley distribution in occluded space.