LAB 3: EECE 5554 – Robotics Sensing and Navigation

Part 1: Data Collection

In this part, the data was collected in the described manner. The two locations chosen were:

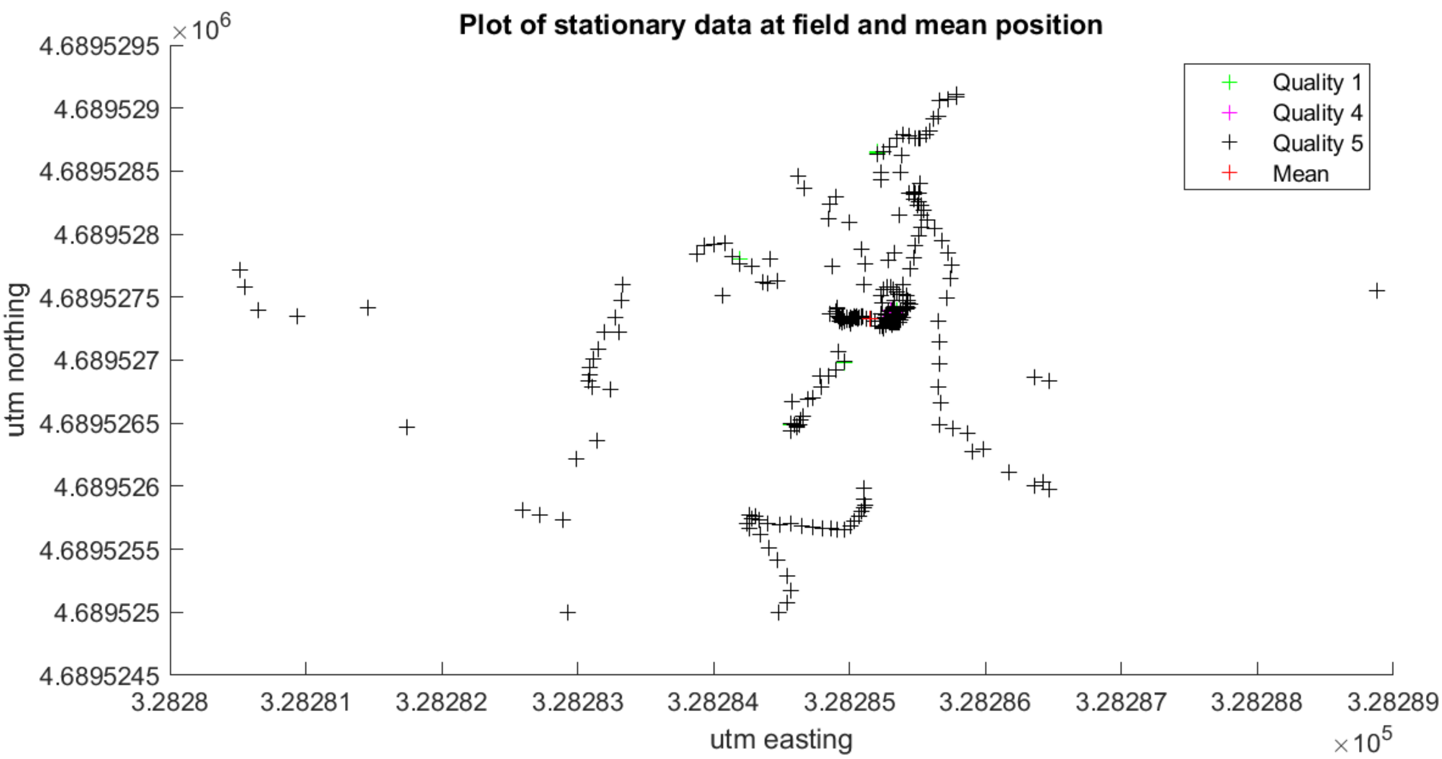
a) The football field on Columbus Avenue in line with the ISEC building
b) The sitting area outside the ISEC building

In both the cases, a set of stationary as well as walking (in a sort of rectangle) data was collected.

The driver for this lab has been uploaded to Gitlab in the prescribed folder structure. I have used the same package for all the labs till now, and hence, there are multiple scripts and message files in the package. The driver used for this lab is in the 'scripts' folder and has been named 'gps_rtk_driver'. The message file is located in the 'msg' folder and has been named as 'utm_rtk_msg'.

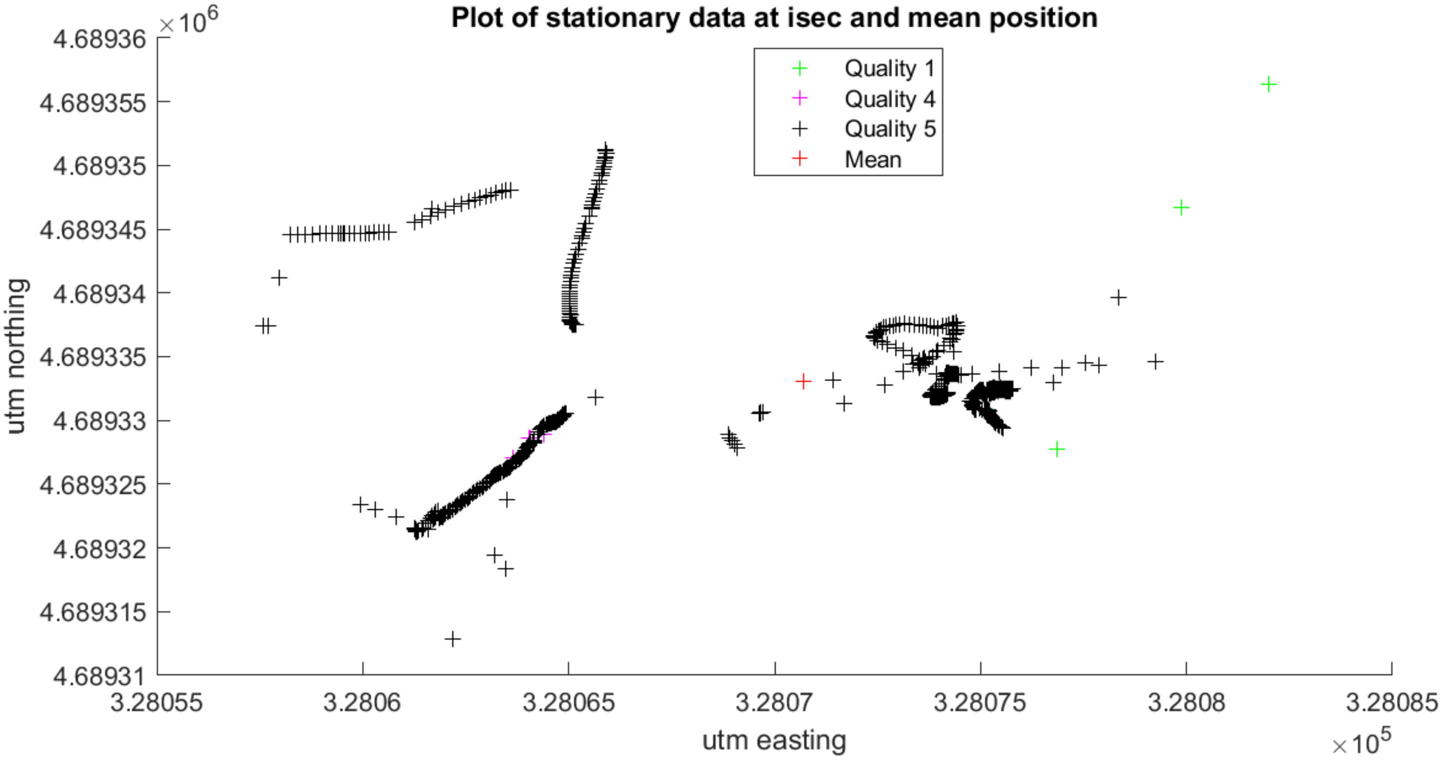
Part 2: Data Analysis

Data Plots and observations:

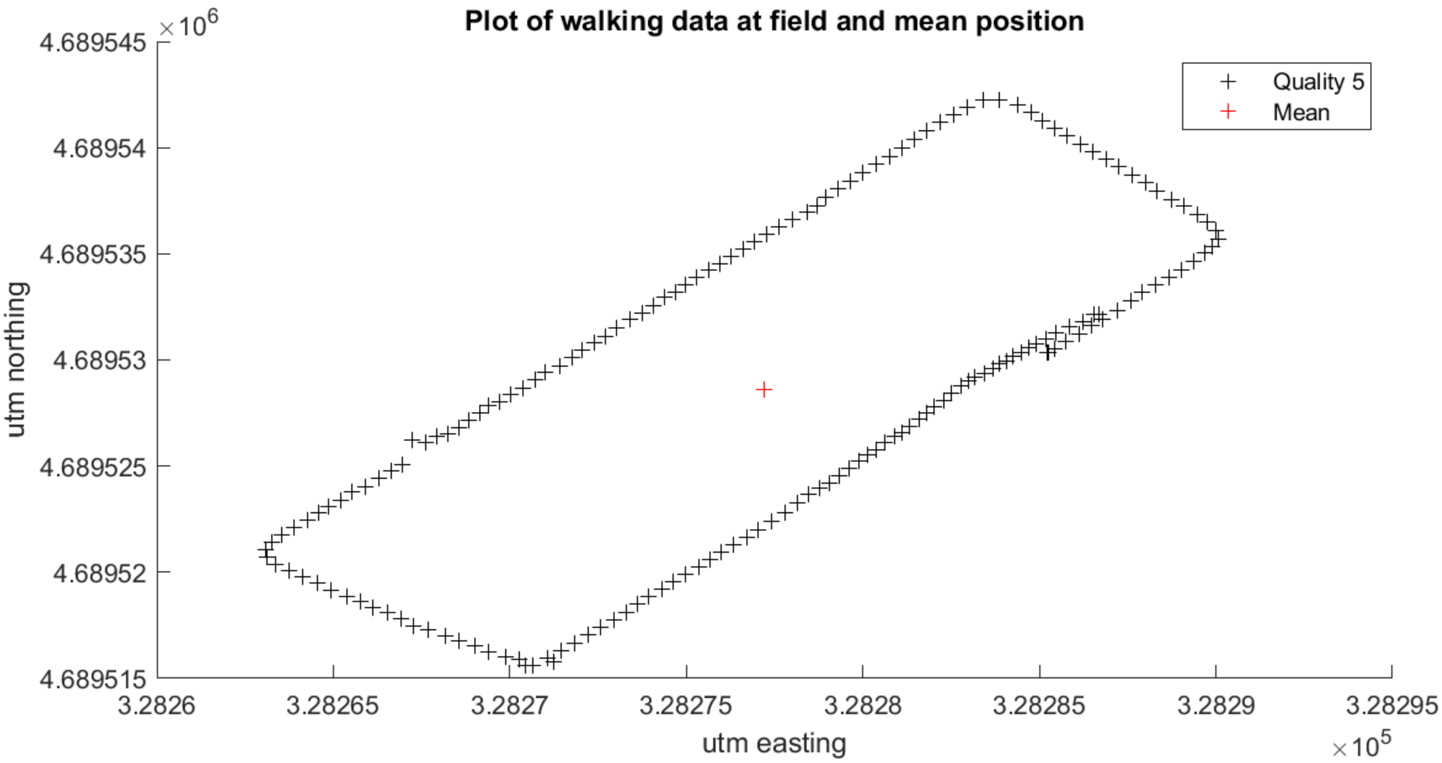


The data has been plotted using their utm easting and northing values. The plots are shown below:

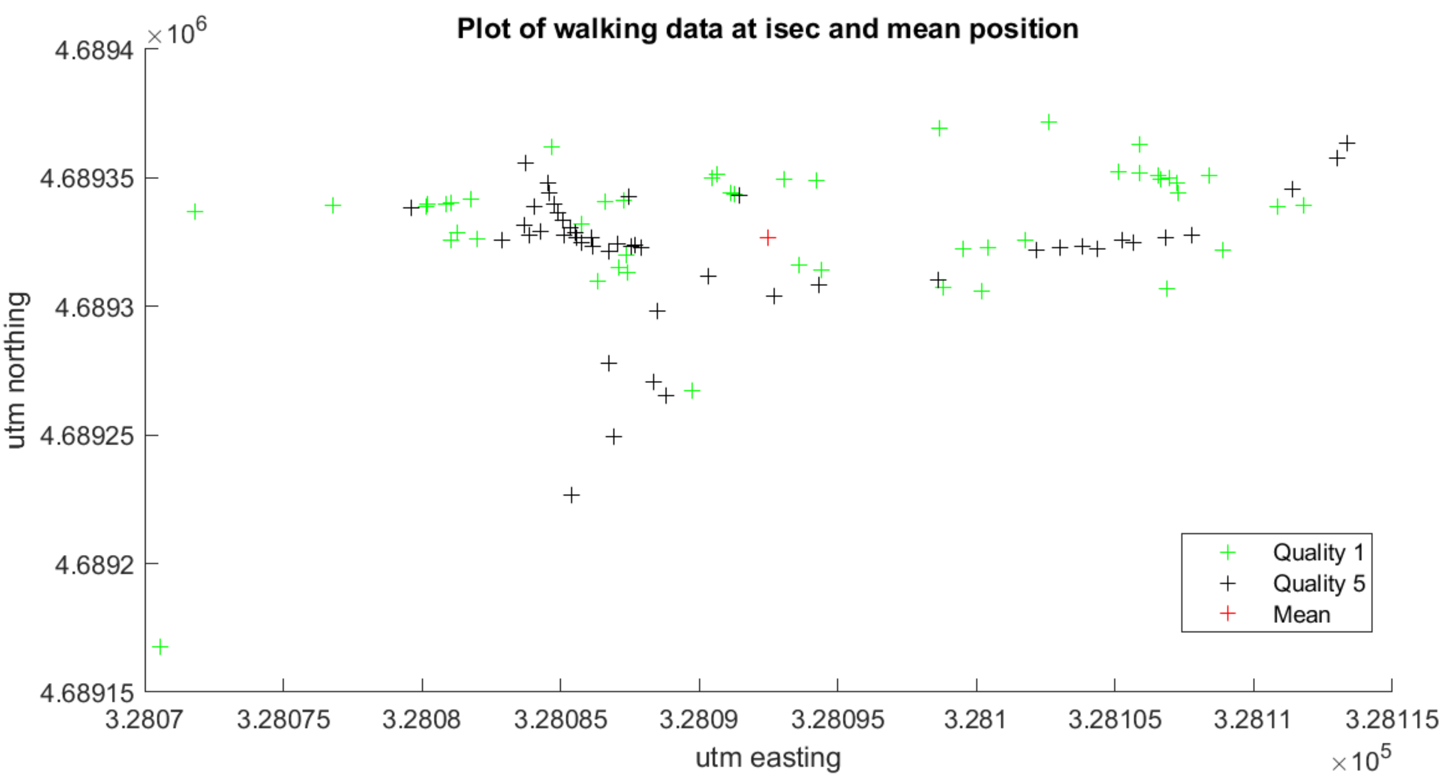
In the above graph, we can see that the data is more concentrated near the mean and more or less uniformly scattered around the mean as it goes farther away from the mean. There is no sudden concentration of data in random sections of the plot. This concentration of data points near the mean point could possibly be attributed to better signals in the open field since there were minimal disturbances in terms of structures that could block the signals of the satellites from the GPS.



In the above graph, the data seems to be scattered in a weird way. There isn't any visible pattern in how the data is scattered. It is concentrated at different placed that cannot be linked in any way to the positioning of the mean of the data. This could possibly be due to tall structures near the GPS sensors. At some points the data could have been blocked by the buildings, and at some points, it could give an overshooted estimate of the location due to reflection of the signals off the walls of the buildings surrounding this location. The factor of the signals bouncing off the buildings seems very convincing, especially with the observation of line-type distribution of points at certain places on the graph above. These lines could have been formed as a result of slowly increasing angles at which the signals from the satellites were being received as the satellites moved while exchanging data with the device. These increasing angles could result in the signals taking a little long to reach the device. And when the signal from a satellite was lost, the location estimation would abruptly change. Thus, the huge gaps between clusters of data points in the graph.



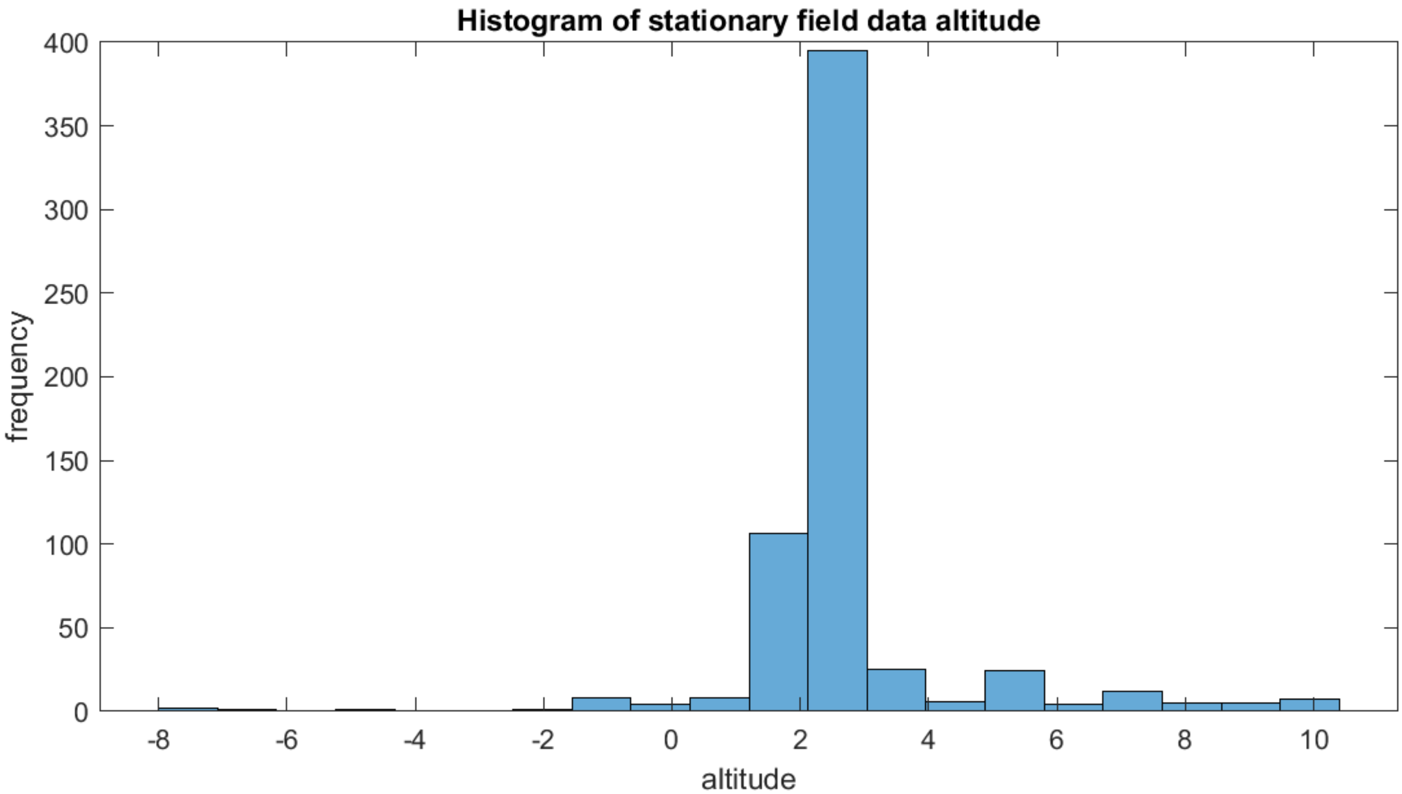
In the above plot of the walk in a rectangular shape on the football field, we can see that the data forms a really good rectangular shape. This shows that the data was quite accurate and has captured the position at these points quite accurately. This is again attributed to the absence of any blocking structures at the field. We can observe that the edges of the rectangle formed in the above plot are a little shifty and not straight lines. Some part of it could be attributed to the fact that the walking might not have been perfectly straight, but a major component of this is mainly attributed to error due to noise in the measurements.



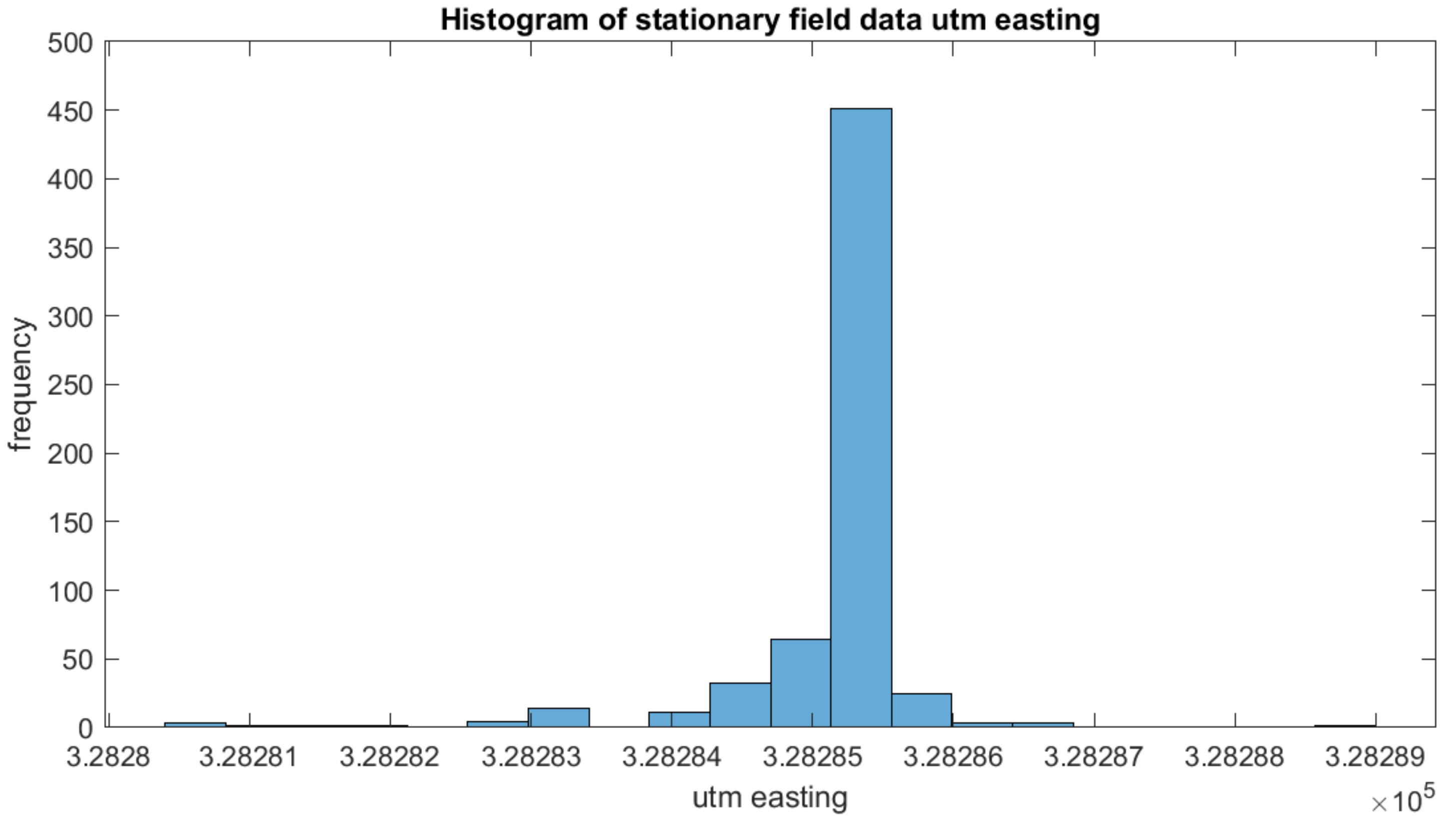
In this plot, we cannot see any sort of rectangle or a similar shape. If we assume the mean as the centroid of an imaginary rectangle, then we can somewhat visualize a pattern in the data that seems to be distributed around the mean in some way. This is though not a very strong pattern to base any strong conclusions on this data set since it seems very random and does not resemble the actual path traversed in any good sense.

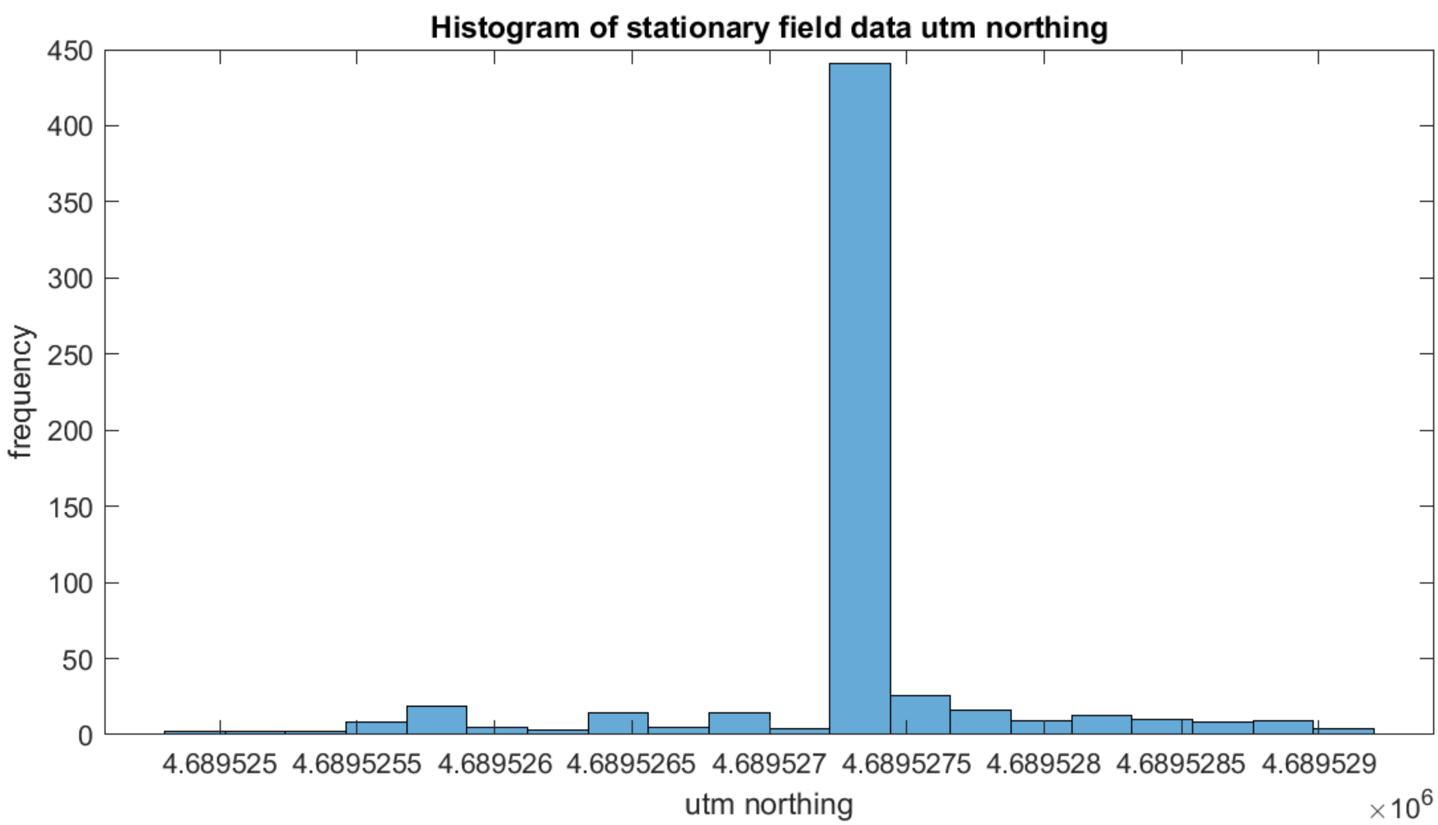
Data frequency distribution/histograms:

Football field stationary data:

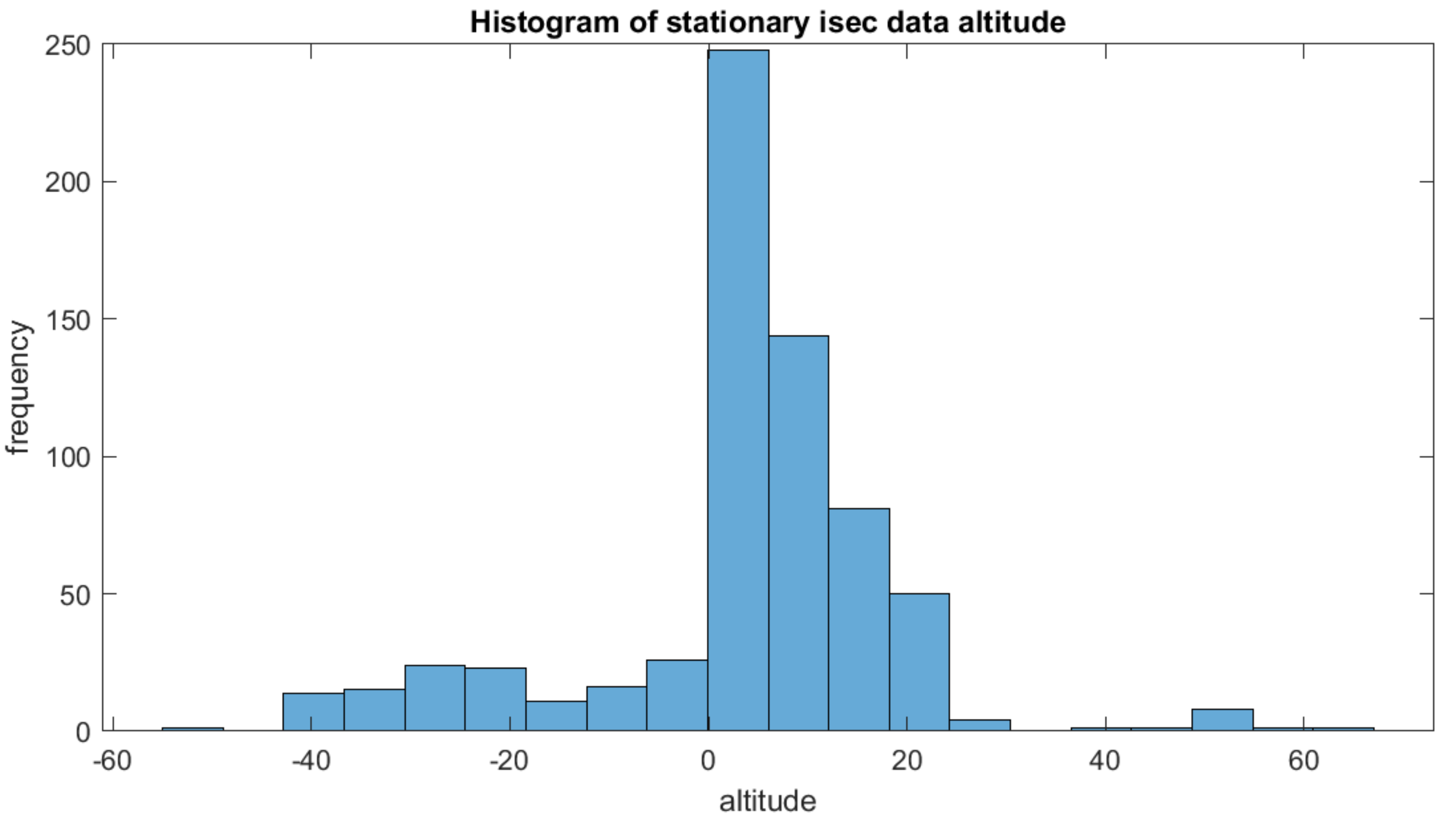


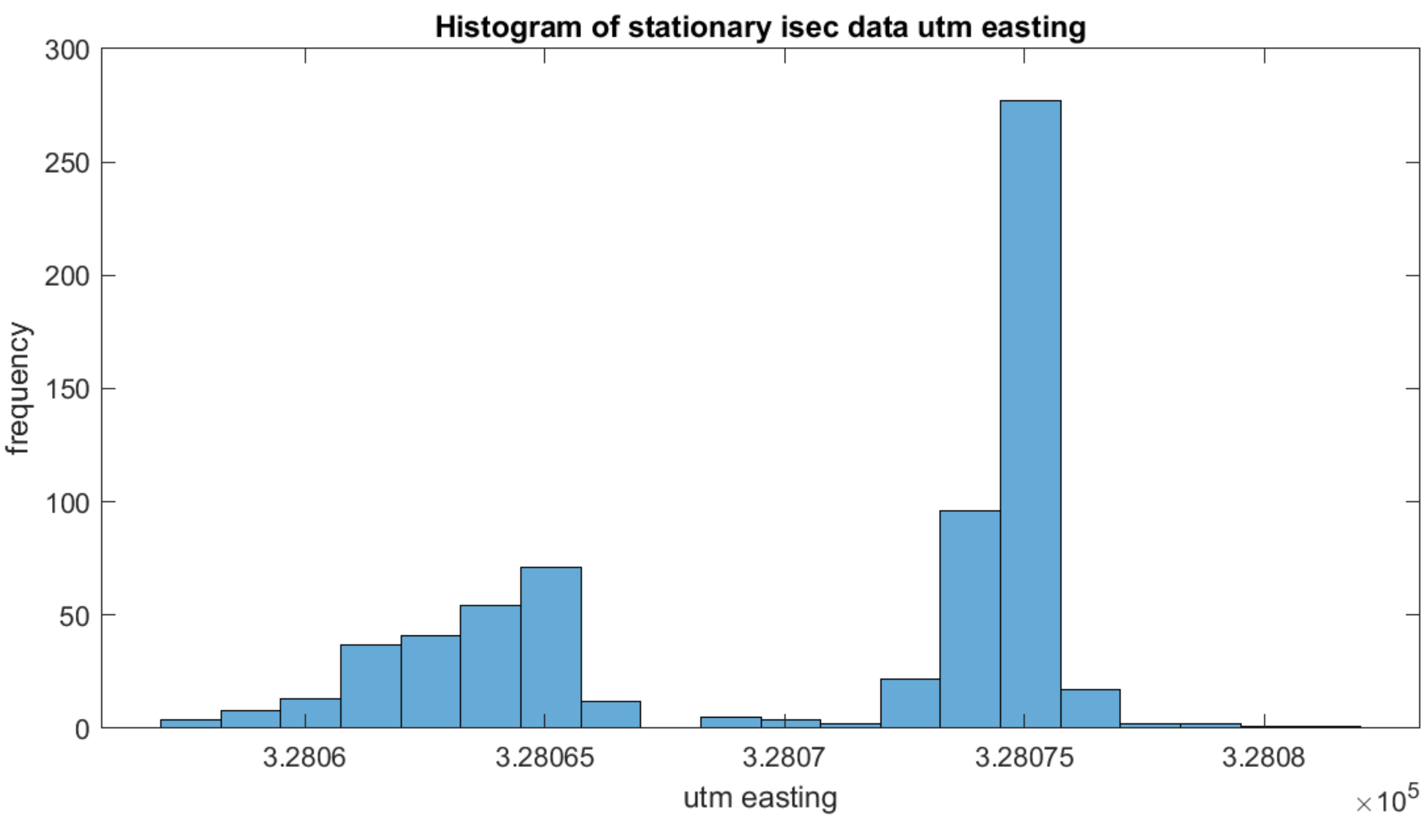
The three graphs for stationary data collected at the football field show the frequency distribution of the altitude, utm easting, and utm northing respectively. The data in all the three graphs seems to be distributed as a Gaussian. The Gaussian distribution has a very small variance in all the three cases. Even though the data strongly suggests a Gaussian type of distribution, there is a slight possibility that the data could have a Rayleigh's distribution and could be easily misinterpreted as Gaussian due to the very small variance in the data. This come forth as a possibility due to slightly higher frequencies on one side of the mean and lower values on the other. But despite this observation, the possibility of the data being of Gaussian distribution seems much more likely than it being of the Rayleigh distribution type.

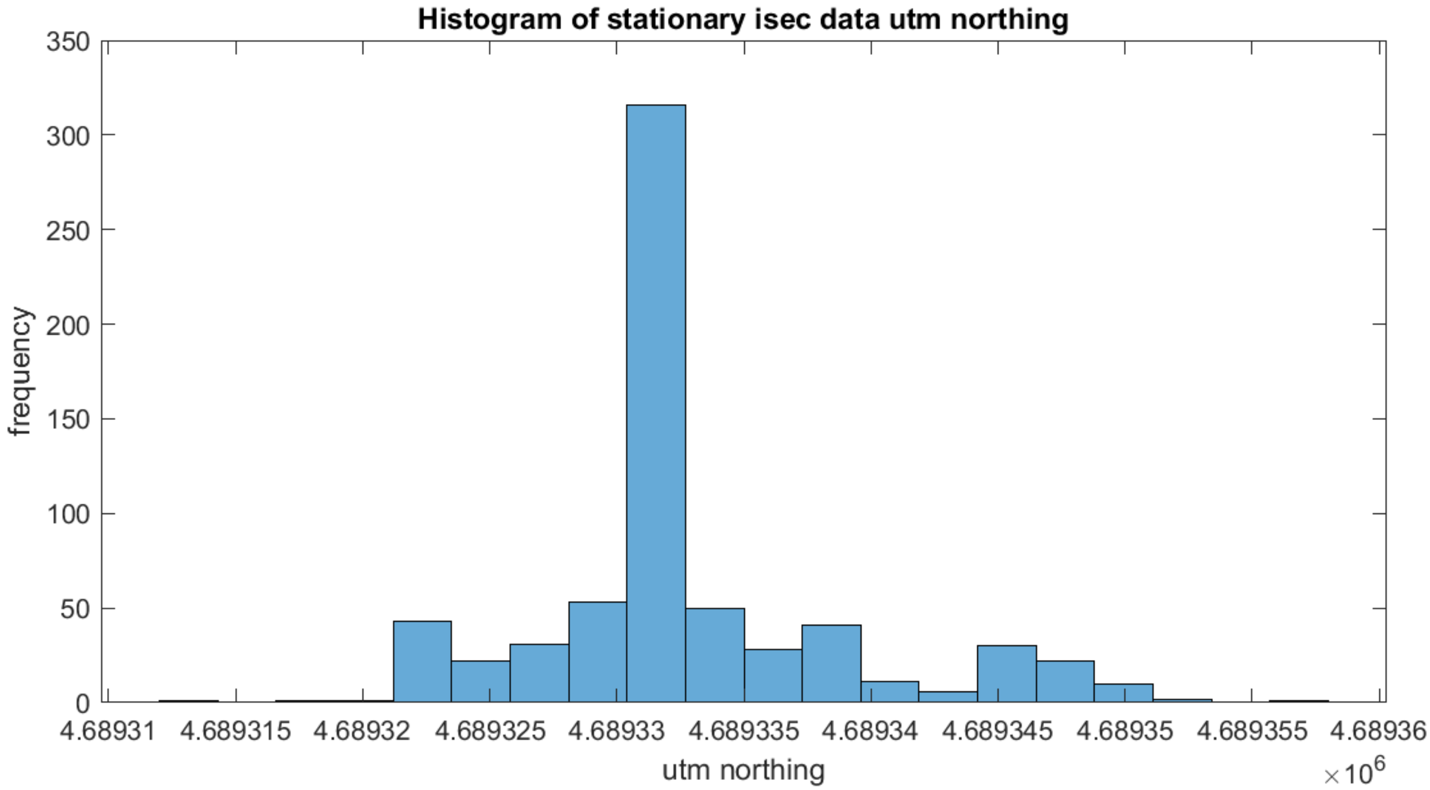

Histogram of stationary field data utm easting
frequency
utm easting
500
450
400
350
300
250
200
150
100
50
0
3.2828
3.28281
3.28282
3.28283
3.28284
3.28285
3.28286
3.28287
3.28288
3.28289
$\times 10^5$


Histogram of stationary field data utm northing
frequency
utm northing
450
400
350
300
250
200
150
100
50
0
4.689525
4.6895255
4.689526
4.6895265
4.689527
4.6895275
4.689528
4.6895285
4.689529
$\times 10^6$

ISEC stationary data:

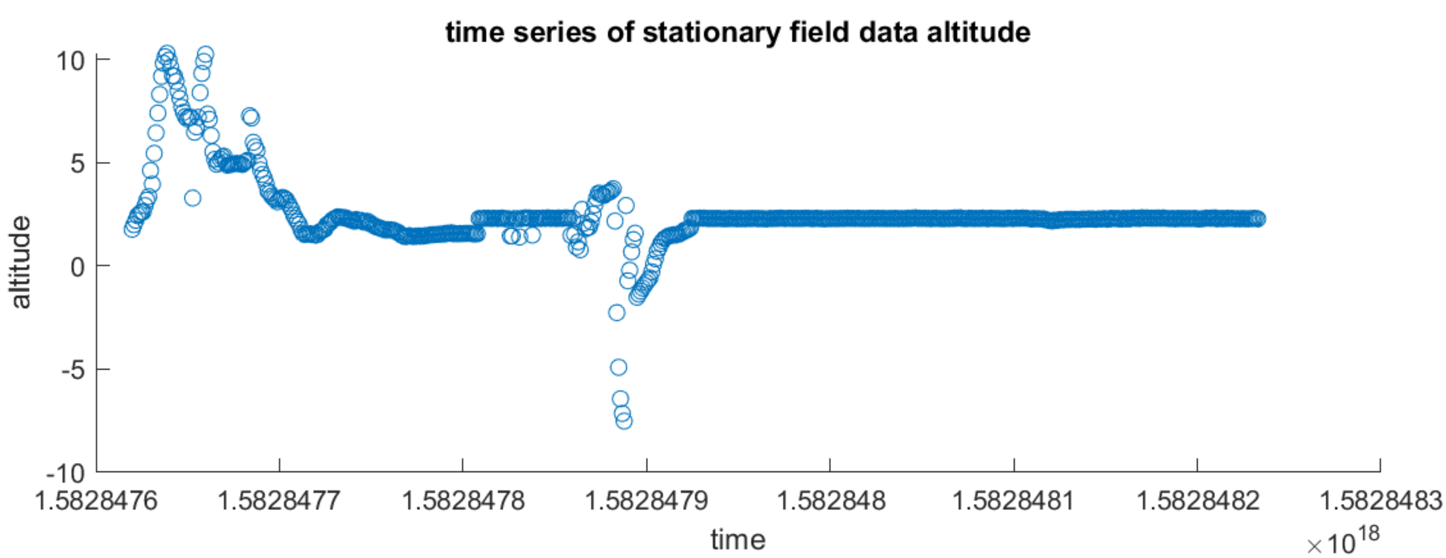


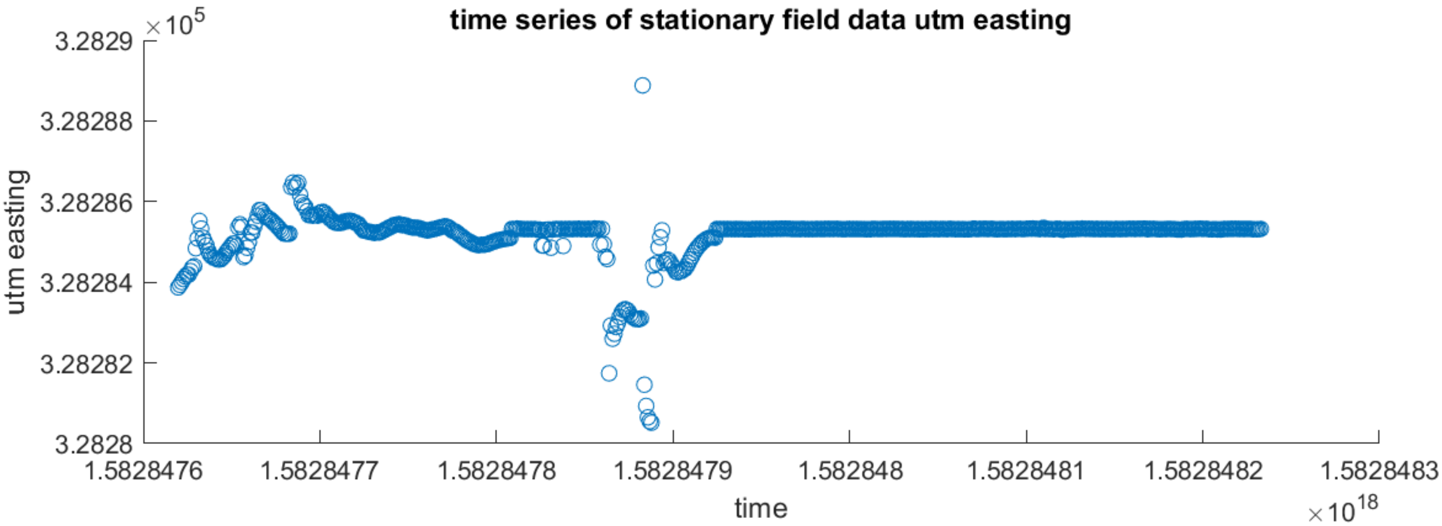


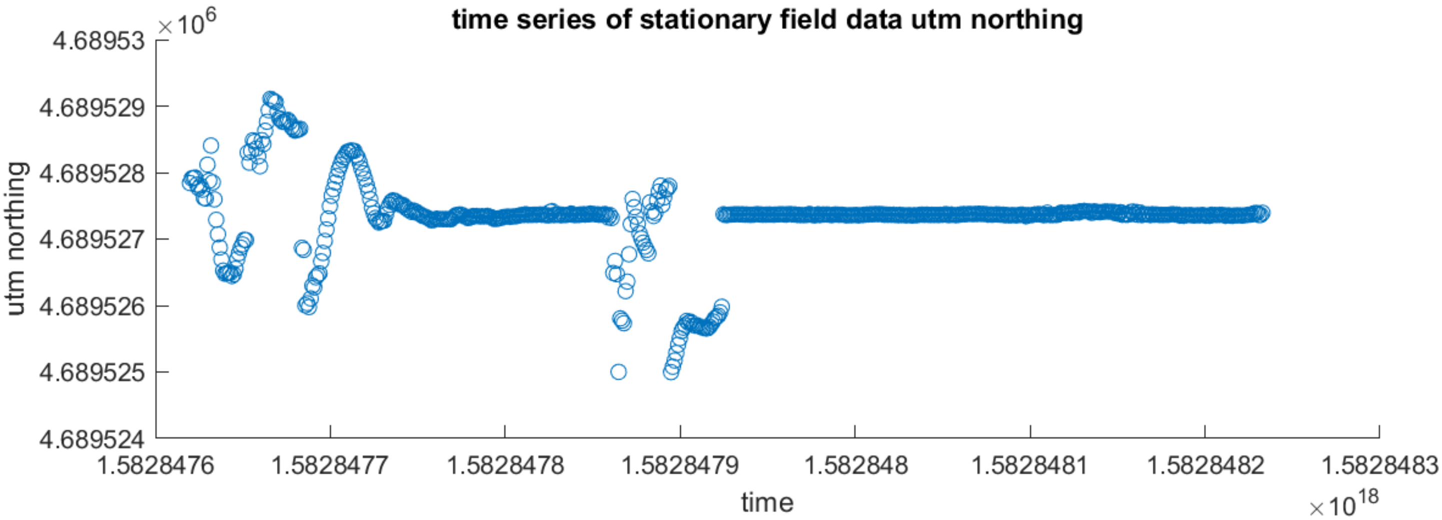


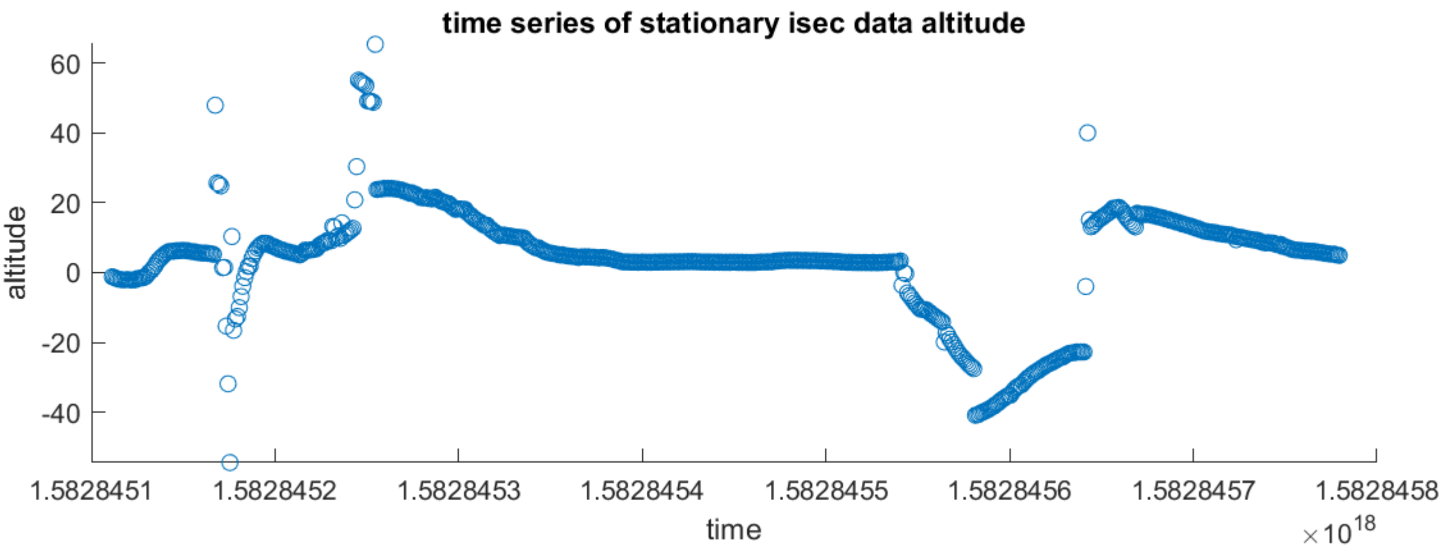
The three frequency distribution graphs for the data collected at the ISEC building does not clearly look like Gaussian in all the three cases. The altitude seems to be more like it is a Rayleigh's distribution than a Gaussian. The data abruptly increases on the left side of the mean and slowly decreases on the right side. In the histogram of the utm easting data, it does not look to represent a Gaussian or Rayleigh's distribution. Hence, it can be said with a certain confidence that it is neither Gaussian nor Rayleigh's. In the utm northing plot, it seems like a Gaussian distribution with a small variance. Considering all three together, it cannot be said with confidence that the data is distributed in a particular distribution. It seems very shifty and unstable to be classified as distributed in a particular distribution.

Time-series plots of stationary data:

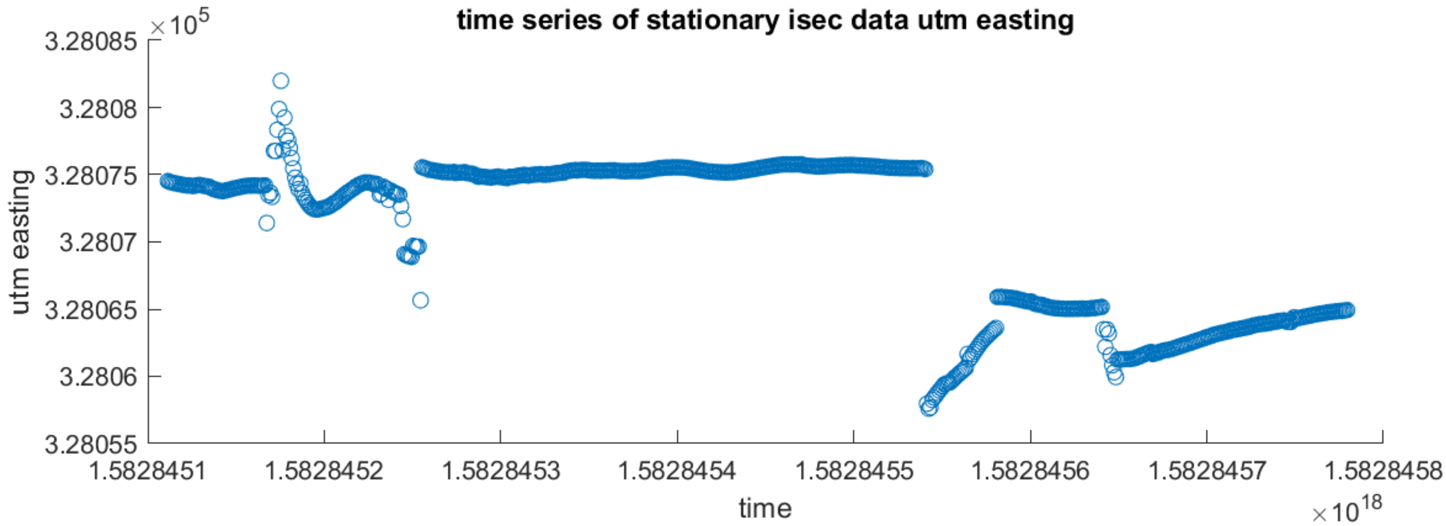


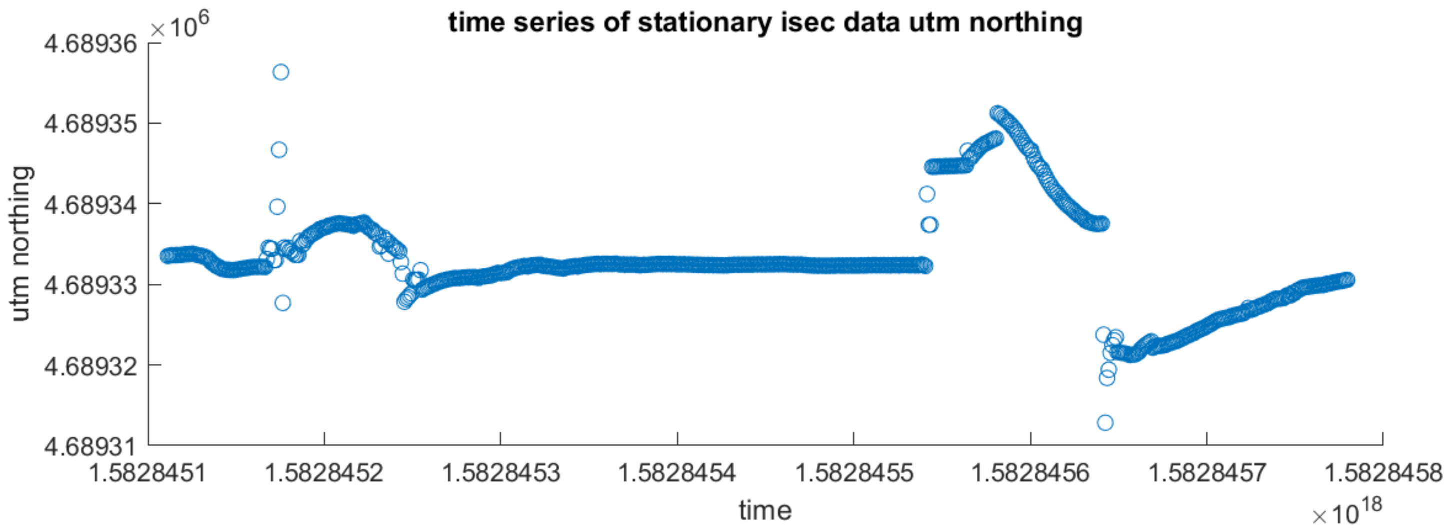






In the above plots, we can see that the data values taken at the field were unstable towards the beginning but get fairly stable in second half of the time period. But the data taken near ISEC is unstable almost throughout. The stable segment is shorter and lies somewhere towards the middle of the time series. Another point to note is the magnitude of the variations in each of the cases. The data taken at ISEC varies by a much larger magnitude than the data taken at the field.





Observations and analysis:

Standard deviation:
The data has the following standard deviation values:
Football field: Atlitude: 1.7705 m | Easting: 0.6483 m | Northing: 0.5760 m
ISEC: Altitude: 15.3816 m | Easting: 5.7550 m | Northing: 6.1178 m

Here, we can see that the deviation in the data at the ISEC location is very high compared to that at the field. This is due to the reasons stated earlier that give bad data near the ISEC building such as the blocking of signal and bouncing of signal on the building walls before reaching the device.

The root mean squared error too gave almost exactly the same results.

Range:
The range was also calculated to get a perspective of the magnitude of the spread of data in the plots shown above. The plots were made to fit the data well and were more spread out for the ISEC location than at the field. The range obtained for the data is shown below:
Football field: Atlitude: 17.8190 m | Easting: 8.3617 m | Northing: 4.1108 m
ISEC: Altitude: 119.7700 m | Easting: 24.3896 m | Northing: 43.4894 m

It can bee seen that the range of the data at ISEC is very large as compared to that of the field. This helps us get a perspective of the plots above in the first section of Part 2.
Some more observations and analysis that were attempted include trying to achieve a minimum error line fit on the walking data for both the locations. In the case of the data near ISEC, the data was way to scrambled to make such an attempt. In the case of the field data, an attempt was made, but the desired line fit could not be achieved successfully. The attempted code has been included as a commented section in the end of the MATLAB analysis file.

Conclusions:

The RTK GPS is a good system to ascertain one's location using the GNSS system. The location data is accurate to a great extent if there aren't too many structures around the device to block direct connection of the satellite signals with the device. While it is found to be unreliable when it is used around structures that could block a direct connection and hamper the accuracy obtained by the device. The reasons for this are felt to be mainly that certain signals are blocked, and some signals are bounced off the buildings and thus end up estimating a greater distance between the real position and the calculated one. The data was found to be accurate upto around a radius of 0.86 m for the stationary based on the standard deviation and RMS (Root Mean Squared) error calculation for the field data. The same kind of data was found to be accurate upto a radius of 8.4 m in the case of the ISEC location which was surrounded by buildings on most sides. In the case of the rover, we saw in the walking data collected on the football field that the accuracy was pretty good. Hence, provided the above conditions of good signal conditions, the rover GPS location of the rover was calculated quite accurately by the system.

Also, the GPS sensor was noted to have almost absolutely no signal indoors which limits its applications to only outdoor location parsing and not for applications where accurate locations might be desired with capabilities to work indoors too.