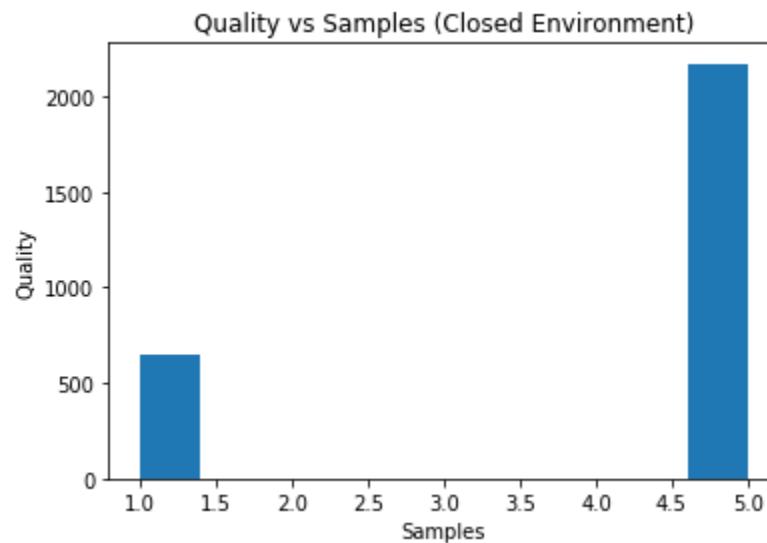


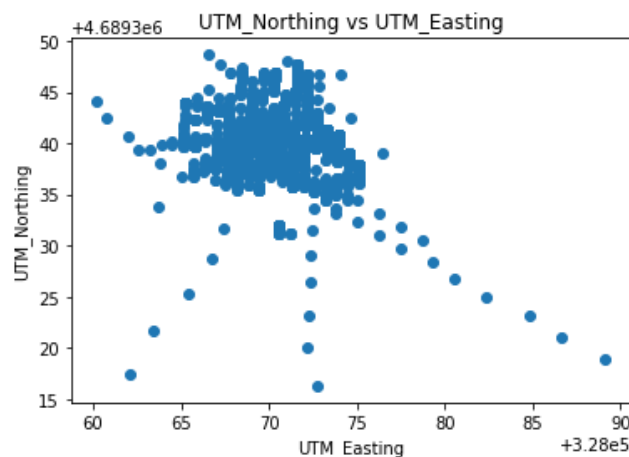
**EECE 5554 – Robotic Sensing and Navigation****LAB 3**

1. The Driver code has been uploaded to GitLab repository
2. Observation on Stationary data: (Data collected near ISEC building)

**NOTE:** The plot with the closed environment is where the data is collected in a place surrounded by buildings and the plot with open environment is where the data is collected in open football field

**a. Quality:**

Based on the graph above, out of nearly 2800 records collected near ISEC, around 700 have a quality of 1 (GPS fix) and over 2000 have a quality of 5 (RTK float mode) which is less accurate than quality value of 4 (RTK fix).



The above graph is the plot of UTM\_Northing vs UTM\_Easting. From the above graph, we can infer that most of the data points are concentrated  $n^*+35$  to  $n^*+47.5$  in northing and  $e^*+65$  to  $e^*+75$  whereas there are few points which are in scattered form.

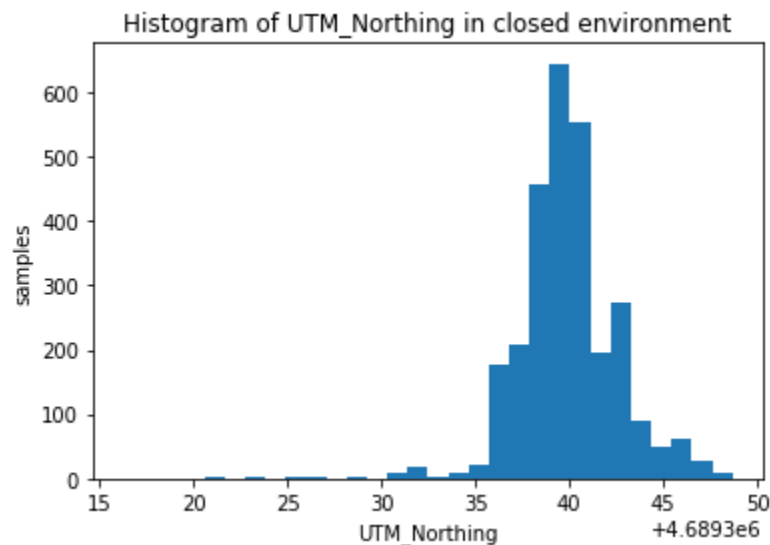
$n^* - +4.6893e6$

$e^* - +3.28e5$

b. UTM\_Northing:

**Mean:** 4689339.86 m

**Standard Deviation:** 2.76m

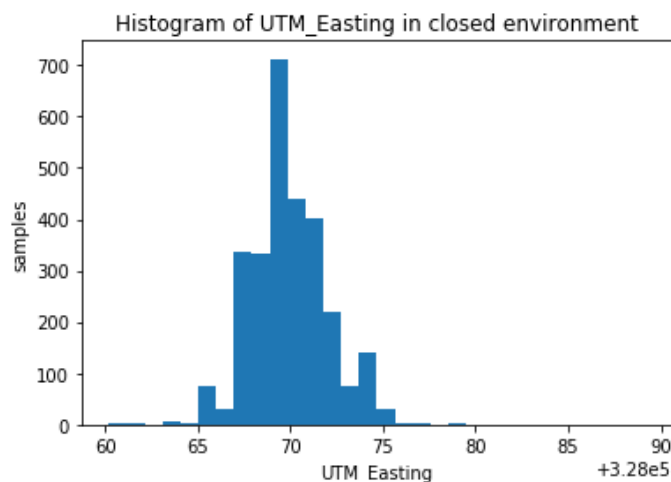


Based on the graph above, the mean 4689339.86 meters with a standard deviation of 2.76m (approx.). Based on the histogram, the distribution looks like **Gaussian distribution with peak at around 4689339 m**. The values have a range of 30m approx.

c. UTM\_Easting:

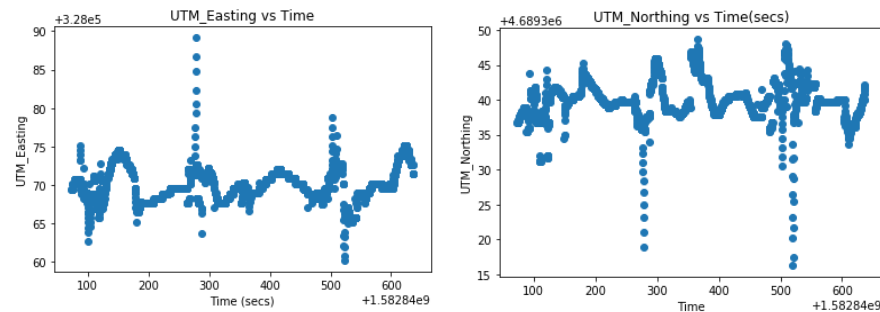
**Mean:** 328069.94 m

**Standard Deviation:** 2.17 m



Based on the graph above, the mean 328069.94 meters with a standard deviation of 2.17 m (approx.). Based on the histogram, it depicts **Gaussian Distribution with peak around 328069 m**. The values have a range of 20-30 meters

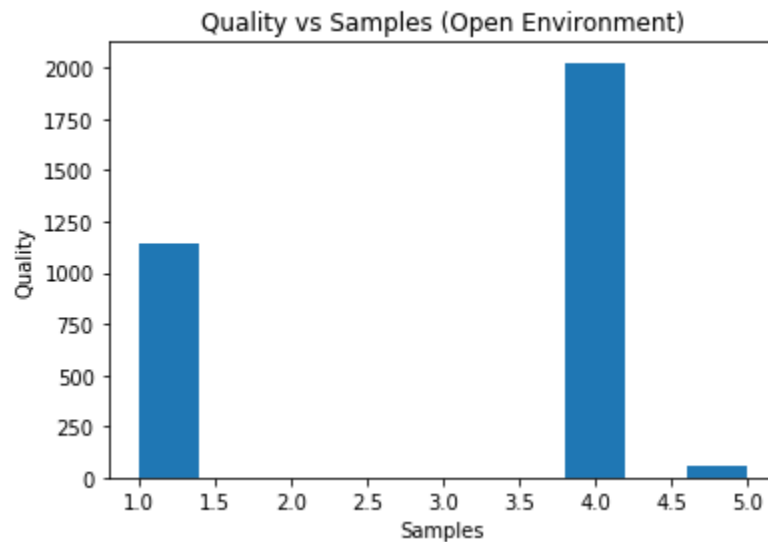
d. Easting, Northing with respect to time:



The above two graph shows Easting, Northing plotted with time. From the above graphs, we can infer that Easting and Northing values varies continuously with time.

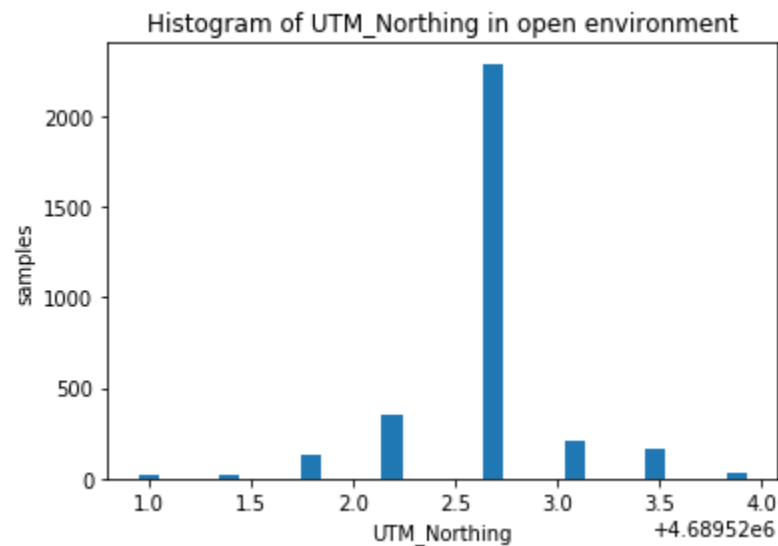
#### Scenario II: (Data Collected in park)

e. Quality:



Based on the graph above, out of nearly 3200 records collected near ISEC, around 1200 have a quality of 1 (GPS fix) and around 2000 have a quality of 5 (RTK fix mode) which is more accurate than quality value of 5 (RTK float). **We can infer from the above graph that Accuracy of RTK GPS sensor in open field is more accurate than accuracy of the same sensor in closed environment with surrounding buildings.**

f. UTM\_Northing:



**Mean:** 4689522.64 m

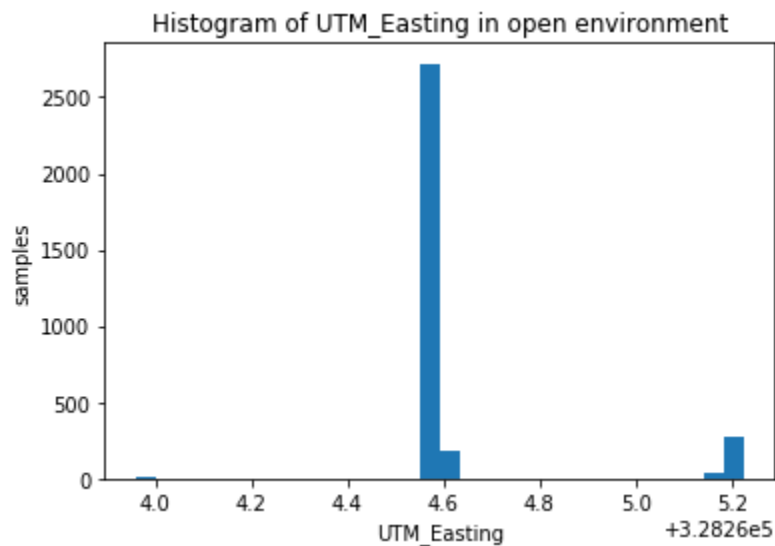
**Standard Deviation:** 0.374 m

Based on the graph above, the mean 4689522.64 meters with a standard deviation of 0.374 m (approx.). Based on the histogram, it depicts **Gaussian Distribution with peak around 4689526 m**. The standard deviation of UTM\_Northing at open field is less when compared to the one collected in closed environment which infers that the data collected in open field is more accurate. The distribution in open field is even more narrow when compared to the one with buildings. Unlike the scenario in closed environment, the values have a range of just 3 m when compared to 20-30m in previous condition

g. UTM\_Easting

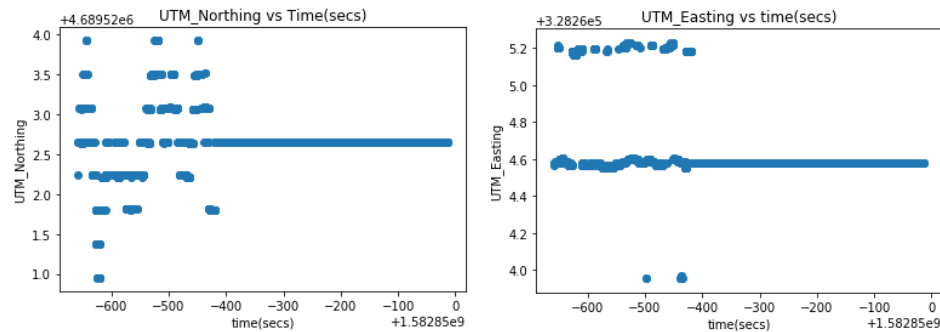
**Mean:** 328264.63 m

**Standard Deviation:** 0.188 m



Based on the graph above, the mean 328264.63 meters with a standard deviation of 0.188 m (approx.). Based on the histogram, it depicts **Gaussian Distribution with peak at around 328264.5 m**. The standard deviation of UTM\_Easting at open field is less when compared to the one collected in closed environment which infers that the data collected in open field is more accurate. The distribution in open field is even more narrow when compared to the one with buildings. The values have a range of less than a meter when compared to 20-30m in previous condition.

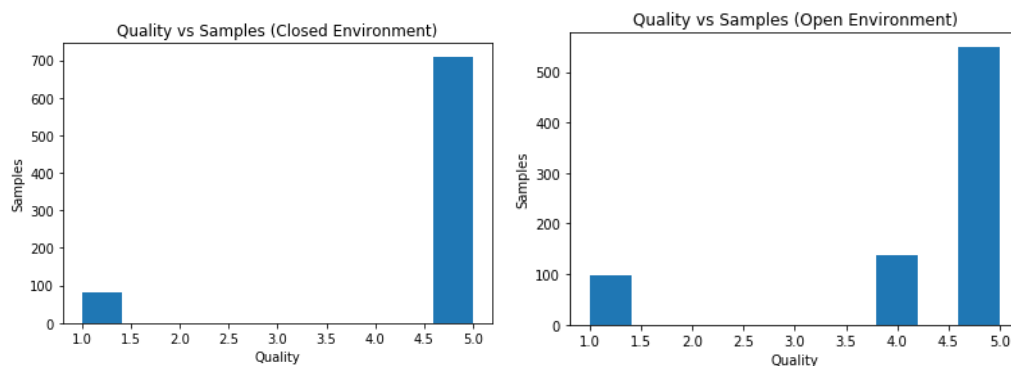
#### h. Easting, Northing with respect to time:



Unlike the previous condition, in the above graphs after some time the data settles to a fixed values till the end. In the first half, the distribution of error is discrete but in previous situation the distribution is continuous with some oscillating pattern.

### 3. Observation on moving data:

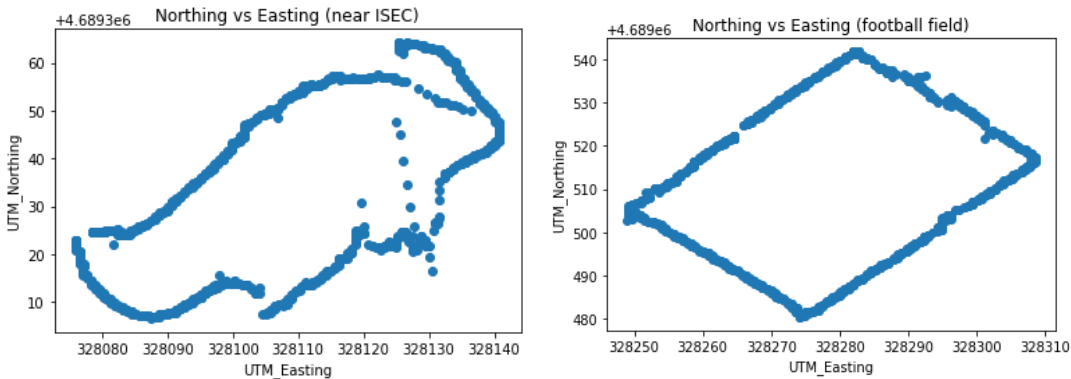
#### a. Quality factor



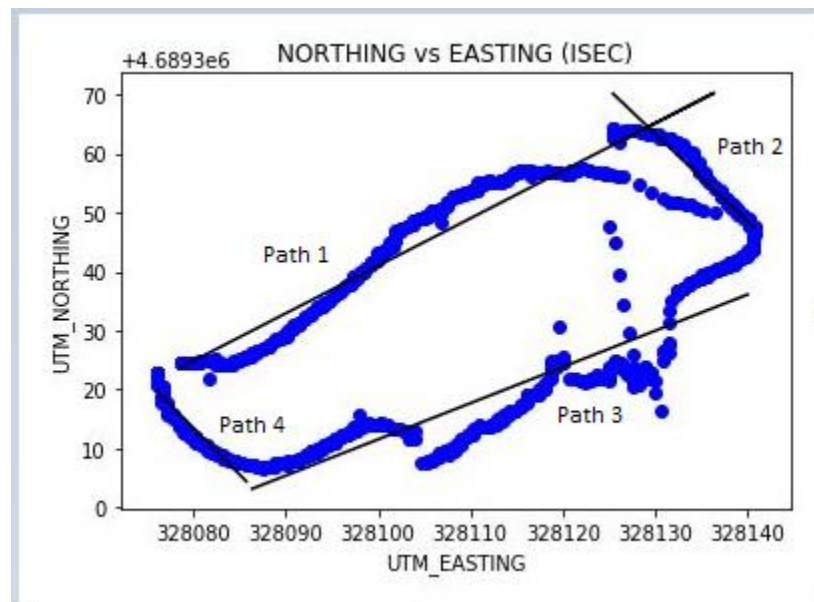
The above graph shows the plot between quality and samples taken in two different situations. The plot with the closed environment is where the data is collected in a place surrounded by buildings and the plot with open environment is where the data is collected in open football field. From the above graphs, we can infer that in closed environment most of the samples has quality of 5 and some has quality of 1. In Open environment, there are few samples with quality 4 which is more accurate than 5.

## b. Northing vs Easting

In this experiment, we walked in a rectangular path at two different locations. One near ISEC along the road and one inside the football field where there is no buildings nearby. Below are the observations:



From the above graph, we can infer that the data collected in football field looks like almost perfect rectangular path whereas the graph plotted from the data obtained near ISEC is erroneous.



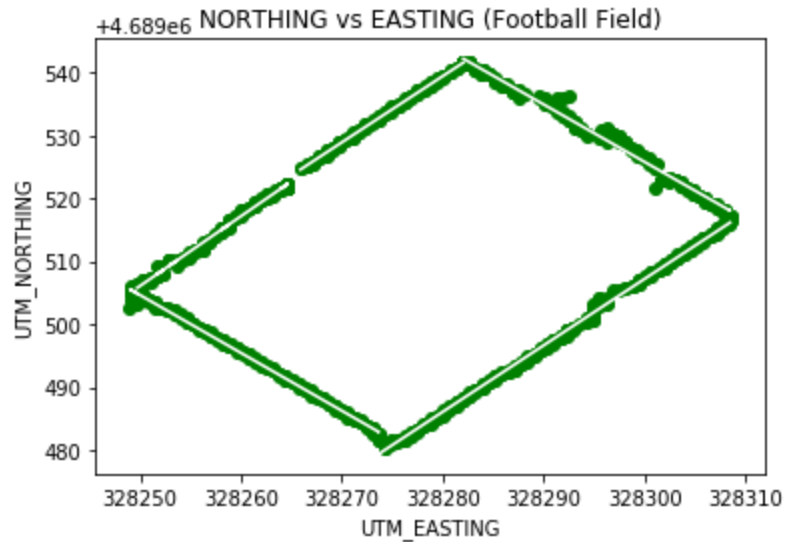
Mean Absolute Error (Path 1) = 3.31 m

Mean Absolute Error (Path 2) = 1.37 m

Mean Absolute Error (Path 3) = 4.17 m

Mean Absolute Error (Path 4) = 1.51 m

The above graph shows the data collected near ISEC and the deviation of the actual path from the best fit line. The mean absolute errors of all these paths are in few meters. Some of the reasons for the deviation of path and erroneous data is due to the presence of buildings, lot of interferences between RTK Rover and the RTK base. In Path 3 and Path 4, In addition to buildings there were lot of vehicles and people roaming around between the Rover and the base which resulted in the errors.



Mean Absolute Error (Path 1) = 0.195 m

Mean Absolute Error (Path 2) = 0.668 m

Mean Absolute Error (Path 3) = 0.376 m

Mean Absolute Error (Path 4) = 0.311 m

Mean Absolute Error (Path 5) = 0.392 m

Actual path: - Green line

Best Fit Line: - White line

The above graph shows the data collected in Football Field and the deviation of the actual path from the best fit line. The mean absolute errors of all these paths less than 0.5 meters. Here it is more accurate compared to the previous scenario because in this case there were no disturbances between the RTK Base and Rover. For the whole time, RTK Rover is at the line of sight from RTK Base

#### Reference:

1. The sample program given at the end of assignment and Lab 1
2. <https://www.gpsinformation.org/dale/nmea.htm#GGA>
3. <https://sciencing.com/difference-between-rtk-fix-rtk-float-12245568.html>