MS ROBOTICS

LAB-2 REPORT

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Analysis Report

1.1 Stationary data with no obstruction

The data was collected in an open football ground “carter ground” near the Isec building at Northeastern University. The data was collected keeping the base and rover static. Considering the ideal data, it has to be at one point, but by looking at Fig 1 it shows a few scattered points around.

GPS position – 10min

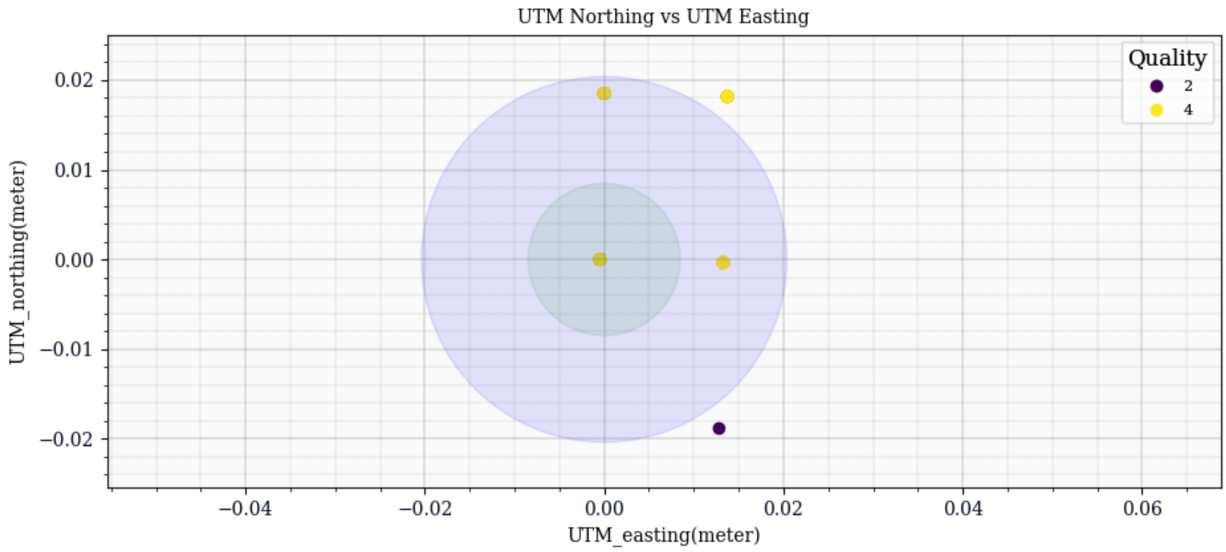

Fig 1 UTM northing vs UTM easting at the static, the green area represents CEP, and the blue region represents the 2DRMS, GPS Position 10 min represents the time taken to record the data in a static state.

1. The base and the rover were kept at one single location for more than 10 min and the data set was collected, there are a few data points scattered here and there it is because of the errors caused due to atmospheric, multipath error, etc, the error distribution for the data we collected is not gaussian.
2. The CEP(50%) radius was calculated by the standard deviation by using CEP = 0.59(\sigma+\sigma-y), and 2DRMS (95%) radius is calculated by 2DRMS=2\sqrt{\sigma_x^2+\sigma_y^2}[3].

1.2 Moving data with no obstruction

The moving data was collected in an open football ground “carter ground” near the Isec building at Northeastern University. The data was collected walking around the perimeter of the ground, the same is plotted in Fig 2 which visualizes the data points along the path taken.

The path taken was straight along the four segments, however, after analyzing the entire situation, we understand that the sides of the quadrilateral must be straight. To achieve this, we could draw the best-fit line on every side, then by doing so, we could calculate the total root mean square error for the path. Initially, this could be done by summing the residual squares, mean square error, and root mean square error by [2]-

-Residual sum of squares python = $\sum\left(y_i - \hat{Y}_i\right)^2$

-Mean square Error = $\Sigma \frac{(y_i - \hat{y}_i)^2}{n}$

-Root mean quare Error = $\sqrt{\quad} mean\ square\ error$

- The total error estimate is ~ 30 cm, which is very much nearly accurate.

GPS Moving 7 min

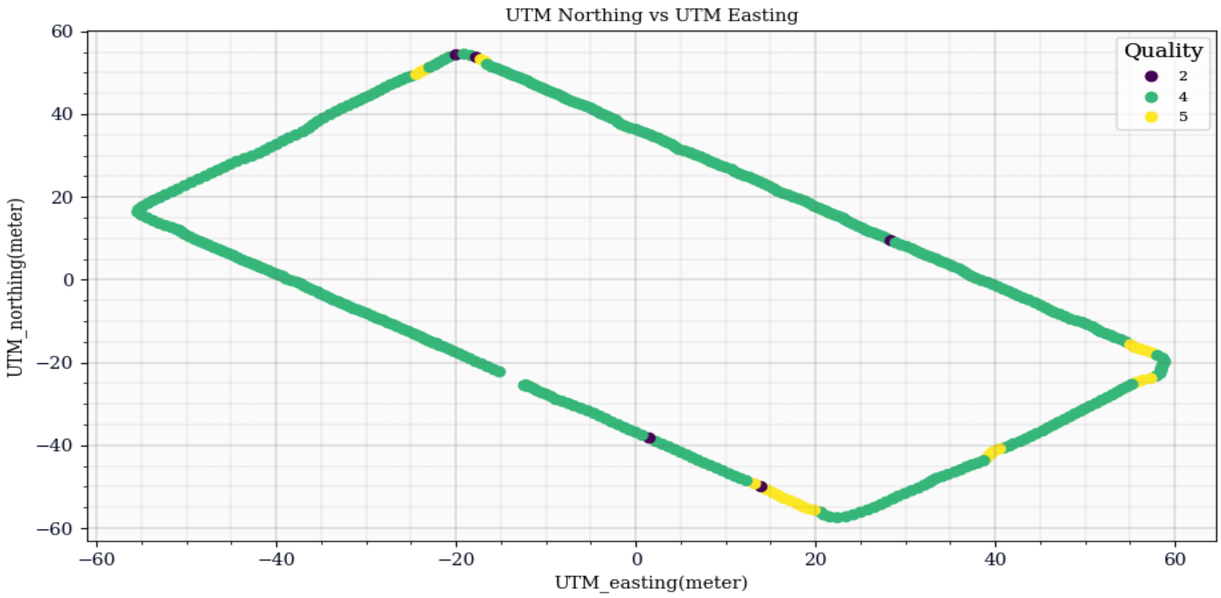

Fig 2 Scattered plot of standardized northing and easting when walking along the specified path, GPS Moving 7 min represents the time taken to record the data moving along the path.

When inaccuracy is taken into account, it appears to be significantly less in motion than in a fixed position with no obstacle. As a result, the base station's error correction and extended Kalman filter's continuous prediction update are reducing the motion noise. We may still model GPS noise as being somewhat gaussian because there are many various forms of noise effects that affect it, allowing the Kalman filter to come close to being adequate.

1.3 Stationary data with obstruction

The data was collected in front of the Isec building at Northeastern University, it was collected for about a duration of 15 min, The data was collected keeping the base and rover static. Considering the ideal data, it has to be at one point, but by looking at Fig 3 it shows a few scattered points around

GPS position 10 min

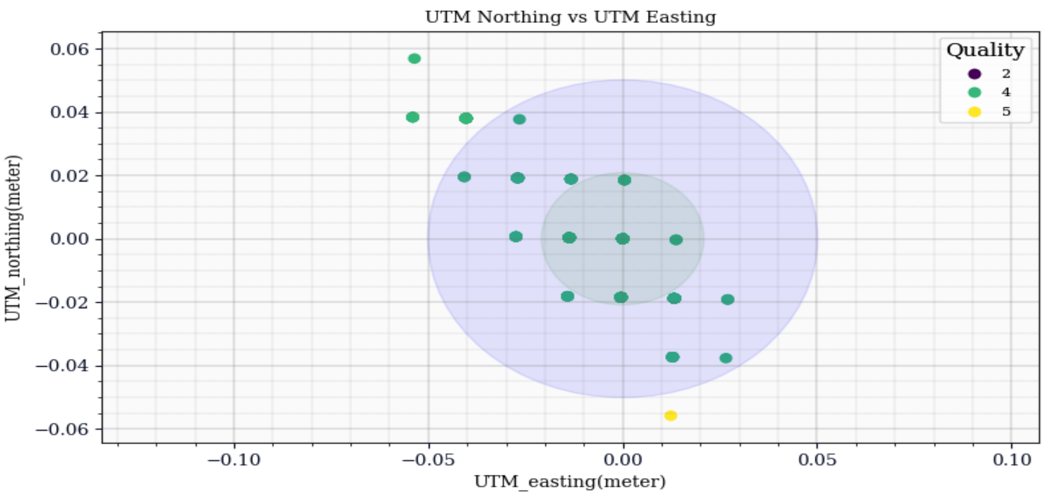

Fig 3: scattered plot of standardized northing and easting in static state, the green area represents CEP and the blue region represents the 2DRMS, GPS Position 10 min represents the time taken to record the data in a static state.

1. The scatter plot in Fig 3 we can see that even when the GPS device is kept at one point for more than 10 min, the data dint converges at one single location, instead it has dispersed around several locations.
2. Since each observation is randomly generated without affecting the values of the other variables and because there are numerous samples obtained from the observations, it is possible to compute the arithmetic mean of all the observed values. If this process is repeated numerous times, the probability distribution of the average will closely resemble a normal distribution and eventually tend to be gaussian.
3. Representing the circles and define the equation to find the radius.

3.1 The Green circle represents the CEP range and the blue color represents the 2DRMS range, this could be obtained by [1][2]-

- Circular error probable = 50 % = 0.5 m error circle radius = $\pm$0.5m
- 1-sigma = 68% =0.6m error circle radius = $\pm$0.6m
- CEP = $0.62\sigma_y + 0.56\sigma_x$

3.2 The blue color represents 2DRMS range –

2DRMS = $2\sqrt{\sigma_x^2 + \sigma_y^2}$

1.4 Moving data with obstruction

The data was collected in front of the Isec at Northeastern University, the moving data with obstruction was collected moving along Columbus ave that is Massachusetts route 28 for a duration of 8 min. The data was collected walking around the road, the same is plotted in Fig 4 which visualizes the data points along the path taken.

GPS Moving 8 min

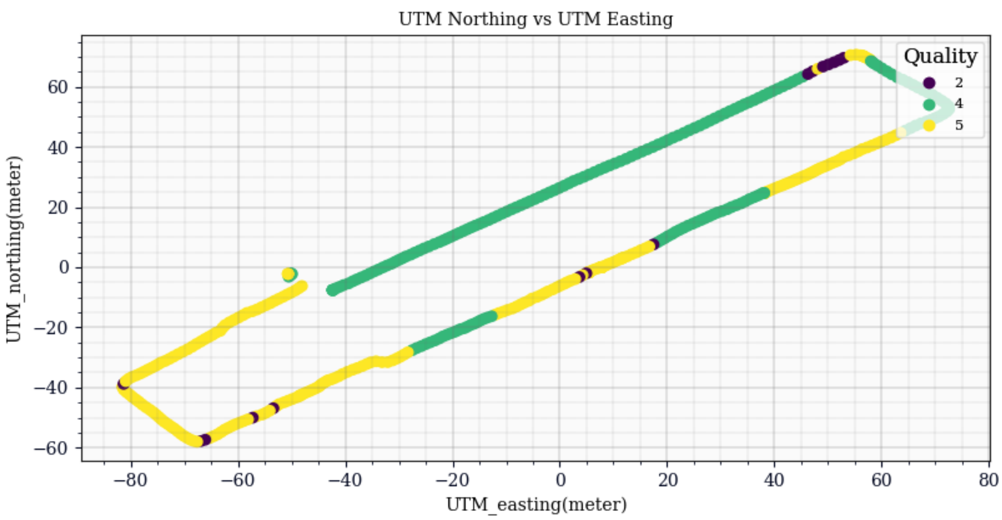

Fig 4 plot of standardized northing and easting in moving along the specified path with obstruction around and GPS Moving 8 min represents the time taken to record the data moving along the path.

1. The moving data collected with obstruction is much worse than the moving data collected without obstruction, but this error is much better than the stationary data collected in the same condition the error correction is due to the base station and the extended Kalman filter that is continuously updating its prediction. Since multi-noise impacts can cause mistakes in the GPS, we can still model it so that it is close to gaussian so that Kalman filters can operate at their best. The change in direction at the end is caused by the divergence from the isec path that we altered.

2. The path taken was straight along the four segments, however, after analyzing the entire situation, we understand that the sides of the quadrilateral must be straight. To achieve this, we could draw the best-fit line on every side, then by doing so, we could calculate the total root mean square error for the path. Initially, this could be done by summing the residual squares, mean square error, and root mean square error [2].

   -Residual sum of squares python = $\sum\left(y_i - \hat{Y}_i\right)^2$

   -Mean square Error = $\Sigma \frac{(y_i - \hat{y}_i)^2}{n}$

   -Root mean quare Error = $\sqrt{\quad} mean\ square\ error$

   - The total error estimate is ~ 80 cm, when compared to moving in the field the error is a bit more because of the obstruction around the data collection area.

2.0 References

[1] statis global positioning system surveying - https://www.e-education.psu.edu/geog862/print/l7.html

[2] relationship between RMSE and RSS- https://stats.stackexchange.com/questions/206274/relationship-between-rmse-and-rss

[3] calculating your own GPS accuracy - https://blog.oplopanax.ca/2012/11/calculating-gps-accuracy/