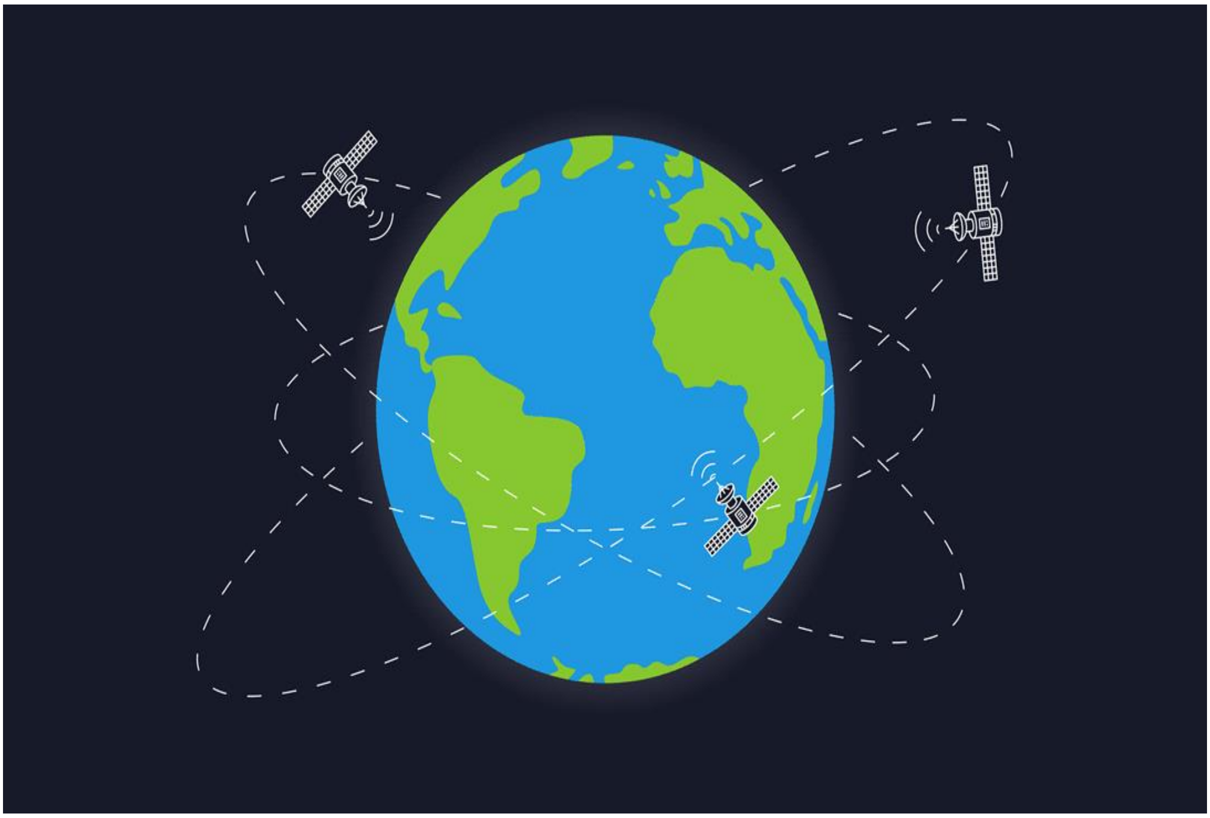
EECE 5554 Robotics Sensing and Navigation LAB 1

UTM Data Analysis by: Arvinder Singh



Description

Analysis of UTM Northing vs Easting data collected and parsed through a GPS puck for two cases- 1) GPS is stationary 2) GPS is moving in a straight line. The stationary data is collected for 10 minutes near Centennial Common and the moving data is collected for around 3 minutes while moving from West Village to Centennial Common. In this report I will also analyze Altitude vs Time for moving and stationary case.

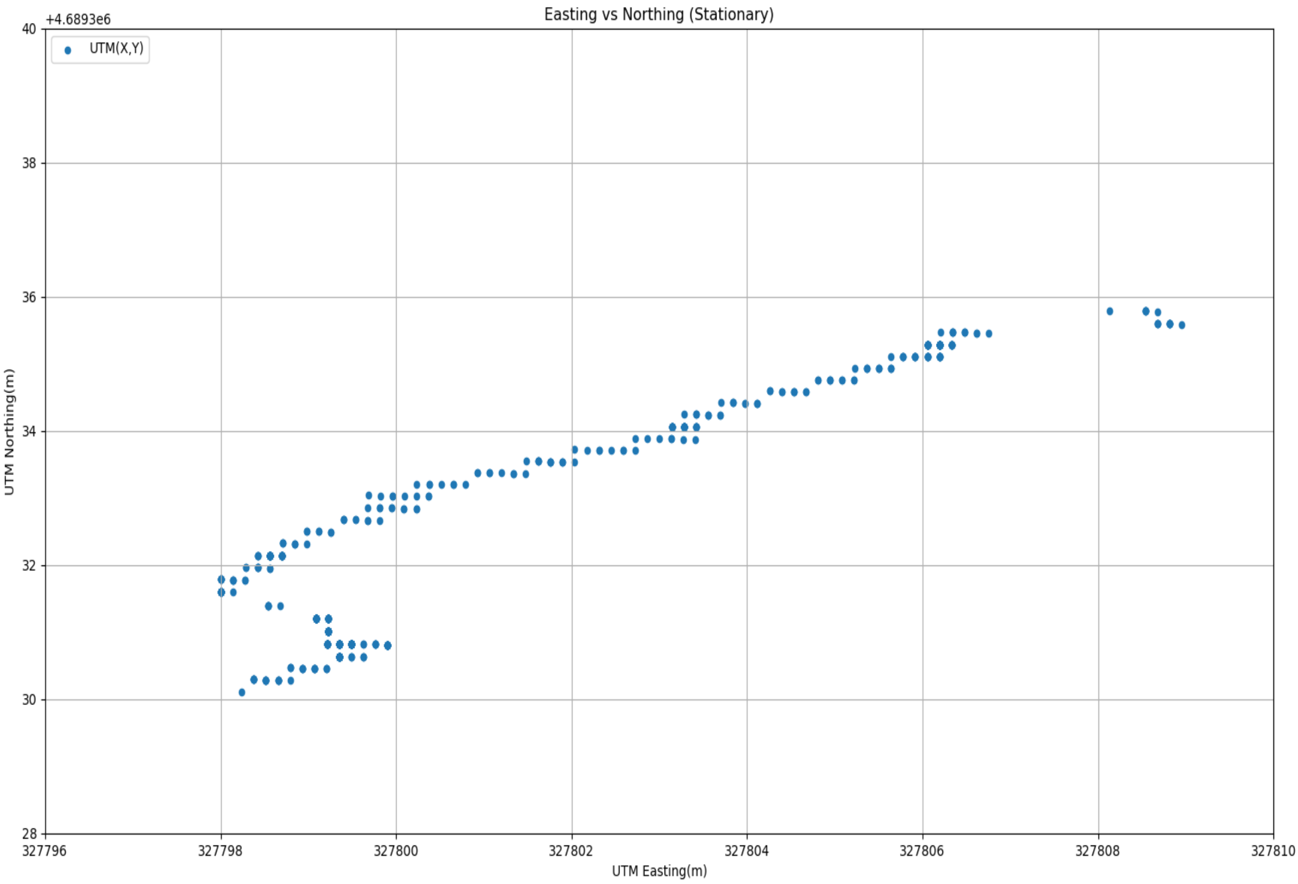
Stationary Data

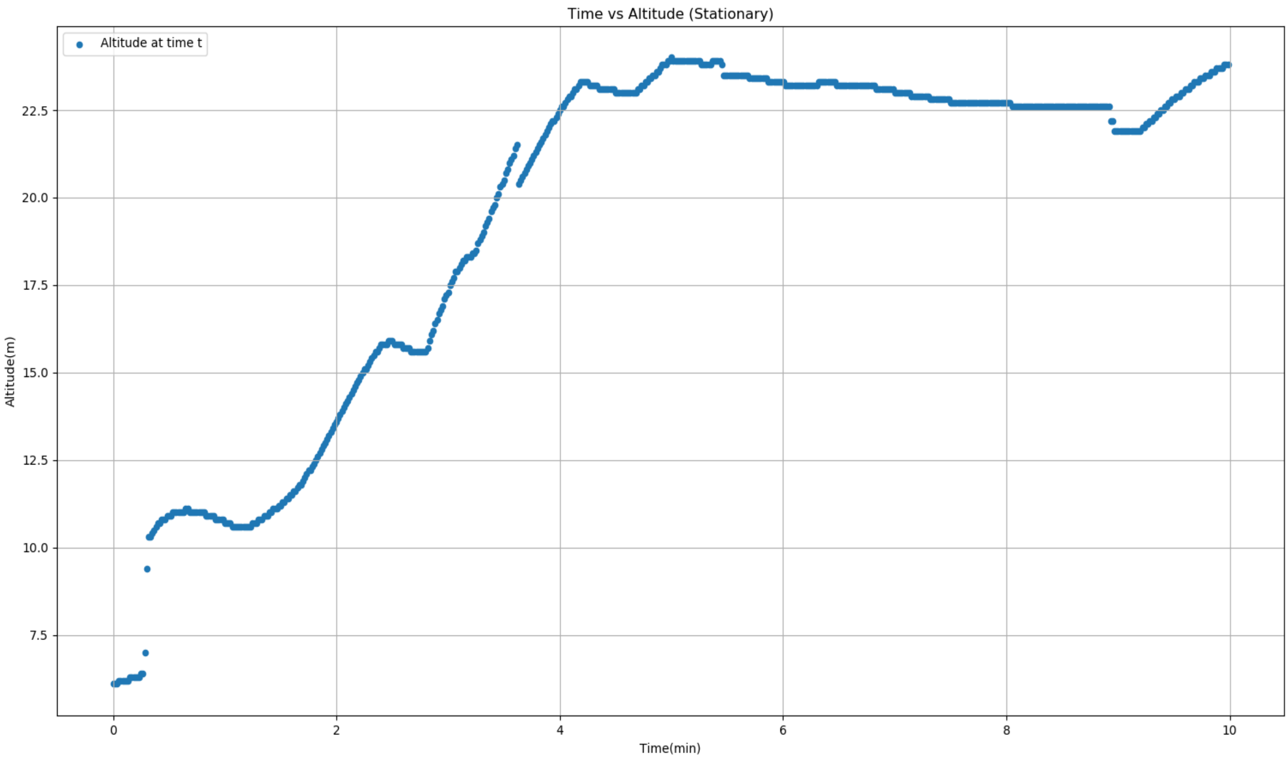
The stationary data obtained is plotted for UTM X(Easting) and UTM Y(Northing) & for Time vs Altitude using matplotlib, pandas is used to convert the rosbag data into a data frame. Even though the GPS puck was stationary there were sources of error due to which the eastings, northings and altitude measurements were not constant for the 10 minutes of time, while data was being recorded.

- UTM Easting varied from [327798, 327809]m
- UTM Northing varied from [4689330, 4689336]m
- Altitude varied from [6, 24]m

To calculate the horizontal error bounds we can find the maximum distance between 2 UTM coordinates. This is also how google maps works, it basically has a larger light blue circular area around dark blue circle (Measured latitude and longitude). The light blue circle depicts the horizontal accuracy of google maps. Similarly, I have calculated the maximum distance between 2 UTM coordinate of the data. This maximum distance comes out to be around 12.6m. Hence the horizontal accuracy of my stationary data is 12.6m. The error is a non-linear distribution curve. We cannot put bounds to the error as my data was for 10 minutes, it might be possible that as the time for data collection is increased, it is possible that we might get new UTM measurements which are more or less than the measurements collected earlier so the error may increase. For my data which was collected for 10 minutes, a good error estimate is of 12.6m horizontal error. There are multiple sources of error while collecting stationary data:

- Atmospheric Interference can cause errors in GPS data due to travelling through different layers of the atmosphere.
- Multipath: This is a major issue while collecting stationary data, as we can see in the graph below, the GPS puck shows multiple readings of northing for the same easting even though the GPS is stationary. This error is due to the GPS picking up reflected signals from buildings.
- The orbits of satellites are not fixed and may cause errors due to changes in their orbit due to gravitational forces.





Moving Data

The Moving data obtained is plotted for UTM X(Easting) and UTM Y(Northing) & for Time vs Altitude using matplotlib, pandas is used to convert the rosbag data into a data frame. The program also returns coefficient of determination and the maximum distance from the best fit line(error).

The Altitude data for moving GPS varied largely as compared to stationary GPS data. It varied from [31.5, 69]m, the error in Altitude readings can be due to movement of my arm while collecting data. The UTM X and Y did not follow a straight-line path and varied from their ideal path while moving. To calculate the horizontal error bounds I have tried to make a linear regression model of my system with UTM easting and UTM northing data using scikit. I have then tried to visualize how the UTM coordinates vary from the best fit line (Ideal straight path). I have also calculated the Coefficient of determination for our regression model to measure the scatter of data points around the fitted regression line which is a good way to calculate error in our GPS data.

The coefficient of determination r^2 comes out to be:

```
Coefficient of determination: 0.94
```

Which means 94% of our UTM coordinates fit the regression model of our system and 6% don't. 0.94 r^2 value means that our regression model fits the data well and the difference between observations and the predicted values are small. Hence, the error is small.

I have also calculated the maximum distance of a UTM coordinate from the best fit line which is the horizontal error of our moving GPS. The distance comes out to be: 7.0806m

```
Maximum Distance(error) from best fit line: 7.080677612684667
```

When compared to the stationary data the error is less in moving GPS data because - multipath error is very less in moving data; most of the signals received by the GPS are directly from the satellites and not reflected signals from buildings etc. because the GPS device is constantly moving. So, this means the error is lower in a moving GPS as compared to a stationary one but is similar in nature as both are nonlinear distribution curves.

Below are the graphs for UTM X and Y (Linear model) and Time vs Altitude for moving data.