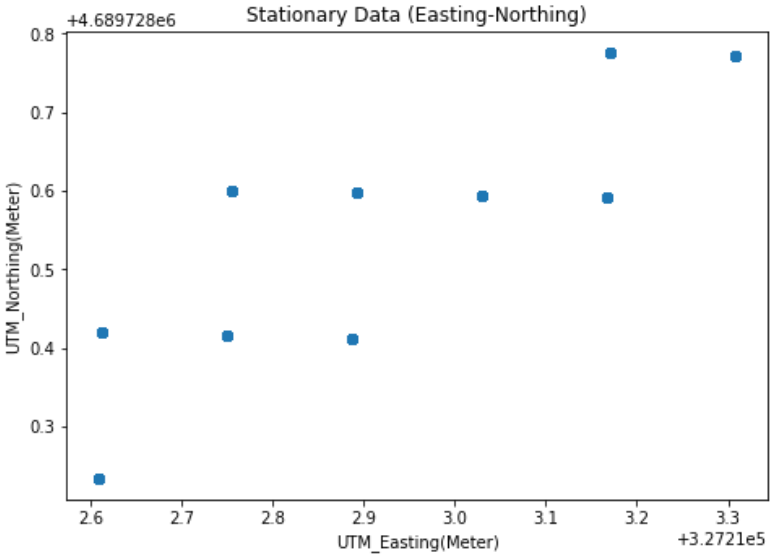
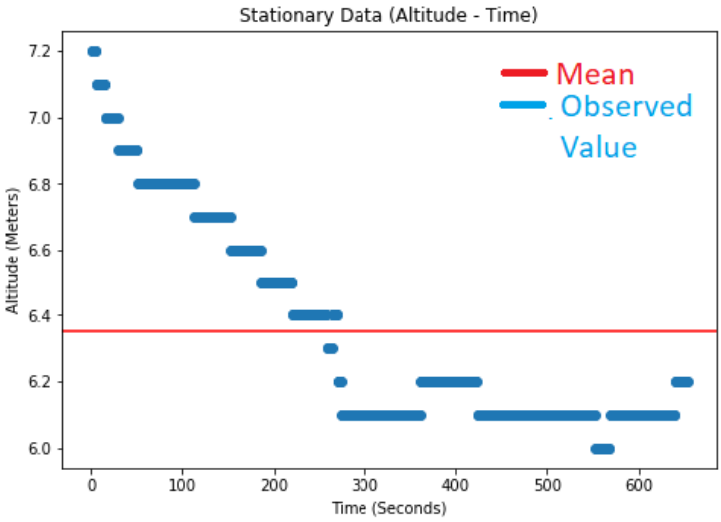
Robotics Sensing and Navigation
EECE 5554
LAB-1

Stationary data:





Both Stationary Data and Straight line walking data were collected in Clemente Field and for stationary data, the plots of Easting vs Northing and Time vs Altitude were plotted and analyzed using matplotlib library in python. Clemente field is a soccer ground and there were no buildings approximately in a radius of 0.4 miles giving a chance to collect data with more accuracy.

For Easting vs Northing the standard deviation was found to be as follows:

- Standard Deviation of UTM_Easting: 0.2176443902324567
- Standard Deviation of UTM_Northing 0.135421383124385

For Altitude vs Time the standard deviation was found to be as follows:

- Mean of altitude in meter: 6.349923430321593
- Standard deviation of altitude in meter 0.31250152434356104

1. What does this say about GPS navigation ?
   Taking readings from stationary data, we should have been able to get precise readings from GPS receiver but as we can see from the above plots, there are small errors in the readings. Which might be caused by several factors such as loss of signal strength, vertical positioning of satellites leading to dilution to precision.
2. What can you say about the distribution of the error in GPS ?

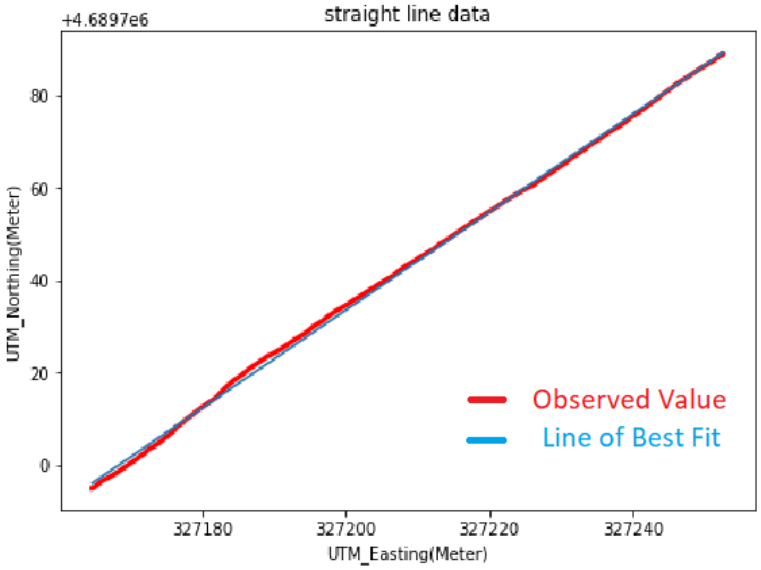
When it comes to UTM_Easting vs UTM_Northing there is deviation from true value and in case of altitude, it should have been constant but we can see dilution from the mean value. The distribution of error is not linear in case of stationary data.

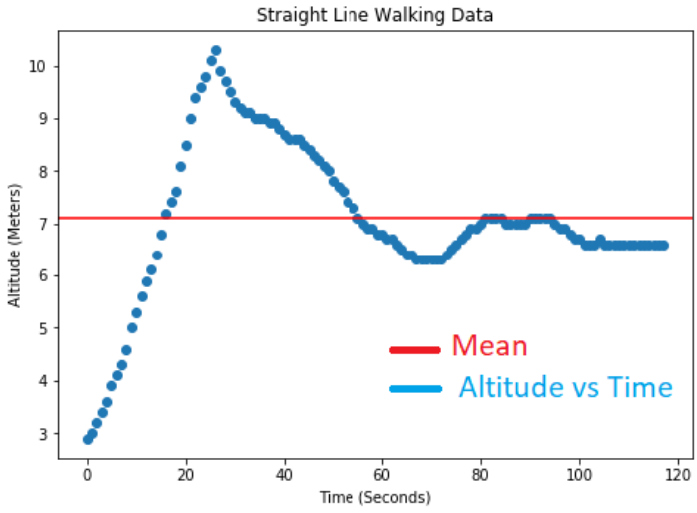
3. What is a good error estimate ?
   Because it is a stationary data, I have used the standard deviation as a measure to analyze the error. Based on mean value and standard deviation value we can say that 'Lower standard deviation means data is clustered around the mean and higher standard deviation means data is spread out from the mean'.

4. Can we put bounds on this error ?
   We can pout bound on this error by analyzing and calculating signal time arrival measurements, reduce multipath effects from surroundings and calculating ionosphere delays.

5. What is the source of these errors ?
   For stationary data the number of satellites transmitting are less, horizontal dilution of precision can also be a factor, loss of signal strength, atmospheric effects, multipath effects and positions of satellites matter(Geometric Dilution of Precision). If satellites are too close, the quality of GPS signals reduces.

Straight Line Walking data:





- In case of GPS data for straight line walking the following observations have been made and for UTM_Easting vs UTM_Northing a line of best fit was plotted and Mean Squared Error was found out.
  Mean Squared Error in square meter is 0.5839086421577871
  Root Mean Square Error in meter is 0.7641391510437003

- For Altitude standard deviation was found by plotting TIme vs Altitude
  Mean of altitude in meters 7.092372881355933
  Standard deviation in meters 1.4776486738602168

1. What does this say about GPS navigation when moving?
   When the data is collected by walking in a straight line we can see that we get more precise values as compared to stationary data. The reason for this is the number of satellites that are sending signals are more, Horizontal dilution of precision plays a factor and error correction can be made for moving data.

2. How does the error estimate change as you move as opposed to stay in a spot?
   When we are in stationary position we can not use methods such as line of best fit and mean square error but we use these methods for moving data to analyze the error between observed values and true values obtained by line of best fit.
   Error received are collectively less in moving data as compared to stationary data. I have got a ~ 0.764 meter error by calculating mean square error for the moving data which is a good accuracy.
   With respect to altitude stationary data has a standard deviation value of ~0.312 meters and moving data has a standard deviation value of ~1.47 meters. This means Altitude values are better for stationary data than moving data.
   In case of moving data we have to calculate the error caused by multipath effect, loss of signal strength, horizontal and vertical dilution of precision,etc. Wherein, the source of errors for stationary data is manageable. In case of mobile gps they use wifi network, nearby cell tower signals and other sources to minimize the error.

3. What can you say about the distribution of noise in this case ?
   The noise distribution of moving data is less compared to stationary data and it is not scattered like stationary data because of various reasons as mentioned above like more number of satellites, less deviation of mean square error from the line of best fit. A Real time kinematics GPS would be more precise than the present gps used.

- The soccer field with open space gave better accuracy than getting data in places where multipath effect could have created more errors. Overall, this lab provided me knowledge on how gps works, what causes the error and how to overcome the error.