LAB1

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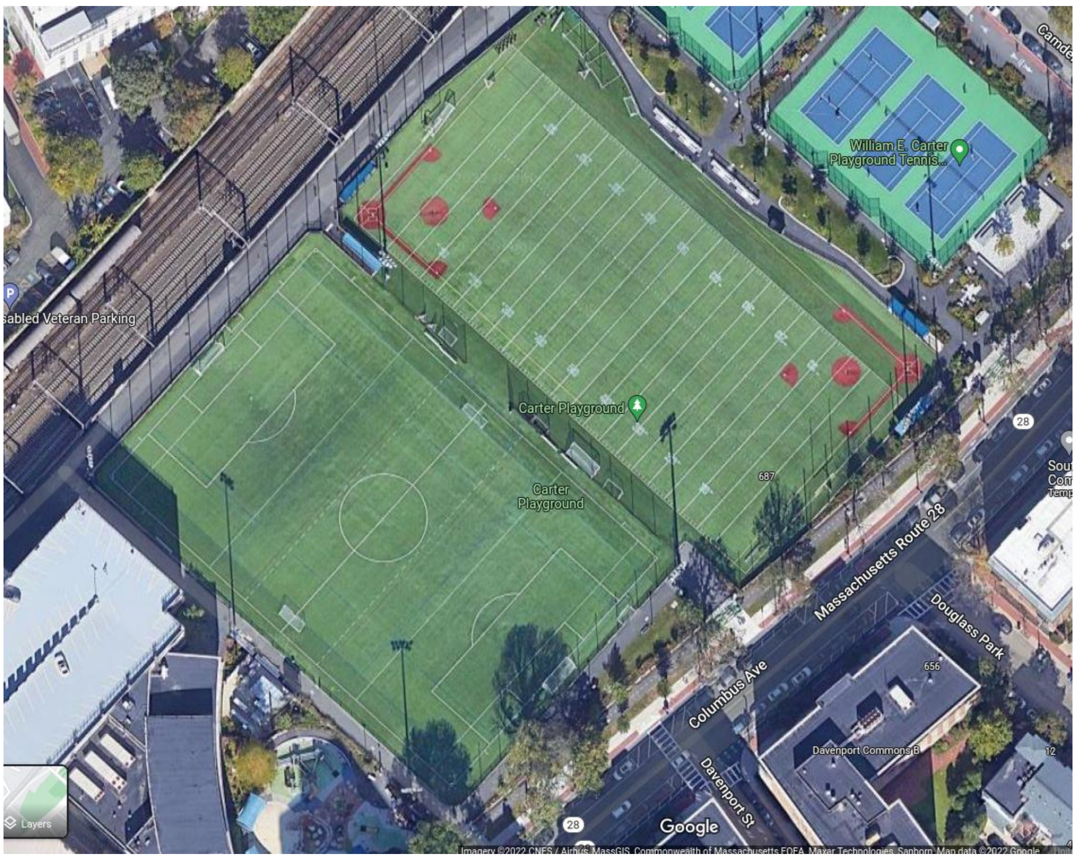
Preamble:

The following analysis has been performed on the GPS data collected under two conditions, *stationery & walking* cases. The site of the data collection was the *Carter Playground* (see fig) in order to reduce as much as possible, the multipath error (which will be further discussed). The files of the data collected are stored in the ~/`LAB1/src/gps_driver/data` folder as `.bag` files respectively.



Stationary Data:

The following analysis has been performed on the set of data UTM data points collected at a stationary spot. The data points are scaled to a smaller number by removing the continual numbers giving a much cleaner look. Figure 1 is a plot between the `UTM_easting` and `UTM_northing` data points. The collection of these data points was done from the *center* of the football field.

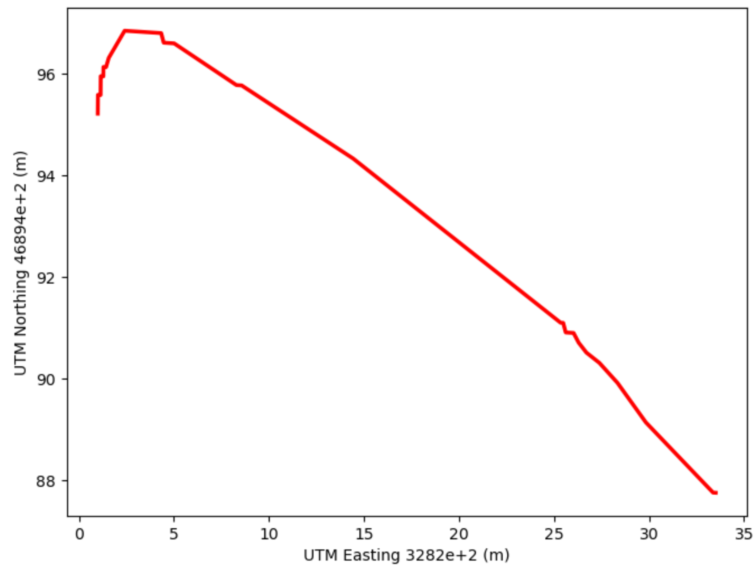


Figure 1

Figure 2 is a 3D plot of the change in `UTM_easting` and `UTM_northing` with respect to the `Time` at which the data points were calculated.

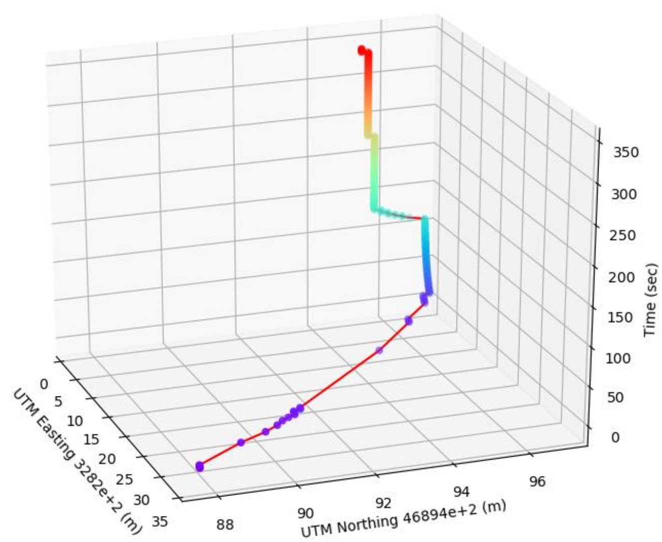


Figure 2

The final Figure 3 is the plot of these data points on a satellite view of google maps to determine the accuracy of the collected points.

Figure 3

Analysis:

1. What can we say about the collected GPS data?

On viewing the data on a closer level, from Figure 2 and 3 we can see that initially the data points approximated the GPS coordinates to the edges of the goal field D, and as time passes slowly starts to move towards the center (the actual location of the puck), of the football field. The GPS data seems to show taking massive amounts of corrections which took place for a longer period as the puck remained stationary.

2. What can you say about the distribution of error?

The error is a non-linear Gaussian distribution because of the number of too many discrete sources of the noise in the system.

3. What is a good error estimate?

In order to get a good error, “estimate” we can increase the sample space and linearize the system to get a Gaussian distribution. There are other methods in use that use multiple points of mean around the current state estimate using the covariance (Unsented Kalman Filter).

4. Can we put bounds to these errors?

We can find bounds based on the standard deviations, mean square deviations (finding the average of the squares of the error), using a bias (distance between the average of the collection of estimates).

5. What is/are the sources of error?

The sources of error can be ephemeris, multipath, or due to the disturbances in the Ionosphere (delay) and Troposphere. Ephemeris error is caused due to the deviations in the expected and actual positions of the satellites. Multipath can be a cause (which happens more often) due to the presence of a dense number of buildings in the path of the GPS. The GPS requires an open space and clear sky to reduce these errors as much as possible.

Walking Data:

The following analysis has been performed on the set of data UTM data points collected walking along the football pitch. The data points are scaled to a smaller number by removing the continual numbers giving a much cleaner look. Figure 1 is a plot between the `UTM_easting` and `UTM_northing` data points. The collection of these data points was done while walking along the *center* of the football field (not necessarily straight).

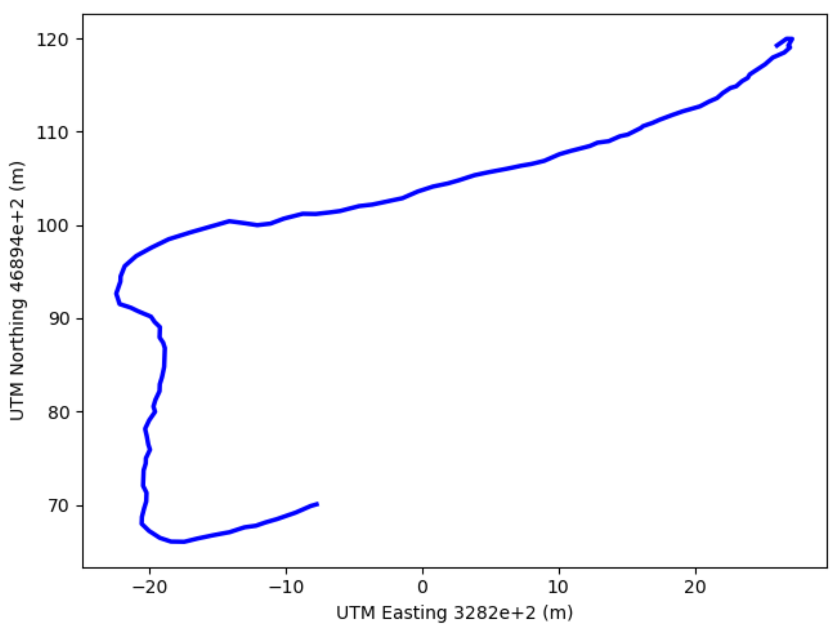


Figure 4

Figure 5 is a 3D plot of the change in `UTM_easting` and `UTM_northing` with respect to the `Time` at which the data points were calculated.

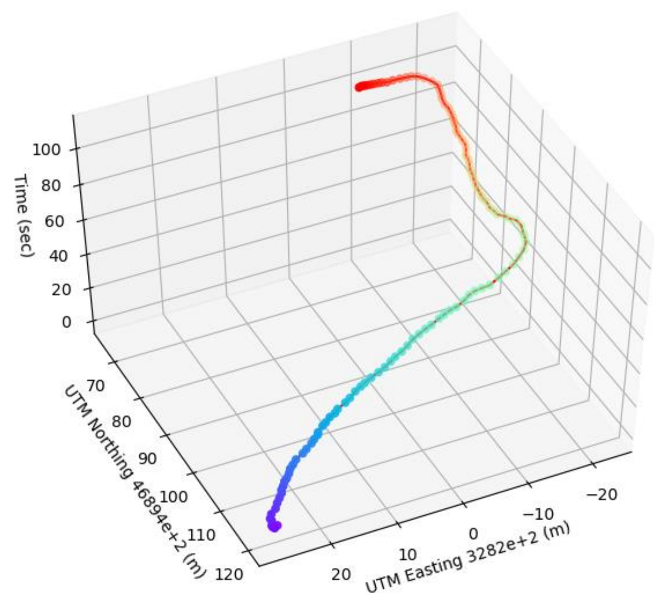


Figure 5

The final Figure 3 is the plot of these data points on a satellite view of google maps to determine the accuracy of the collected points.

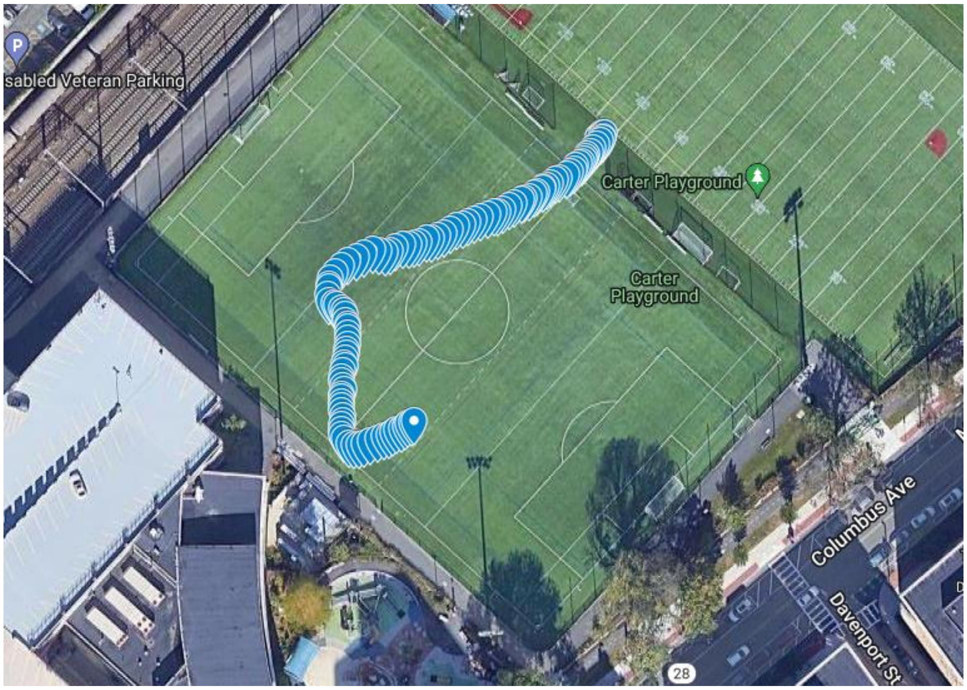


Figure 6

Realizing that I could have just walked in a straight line that could give me a better estimate of the accuracy (facepalm) I have collected a second set of walking data over the American Football field by walking on the lines at the edge of the field. The `UTM_easting` vs `UTM_northing` plots are as follows:

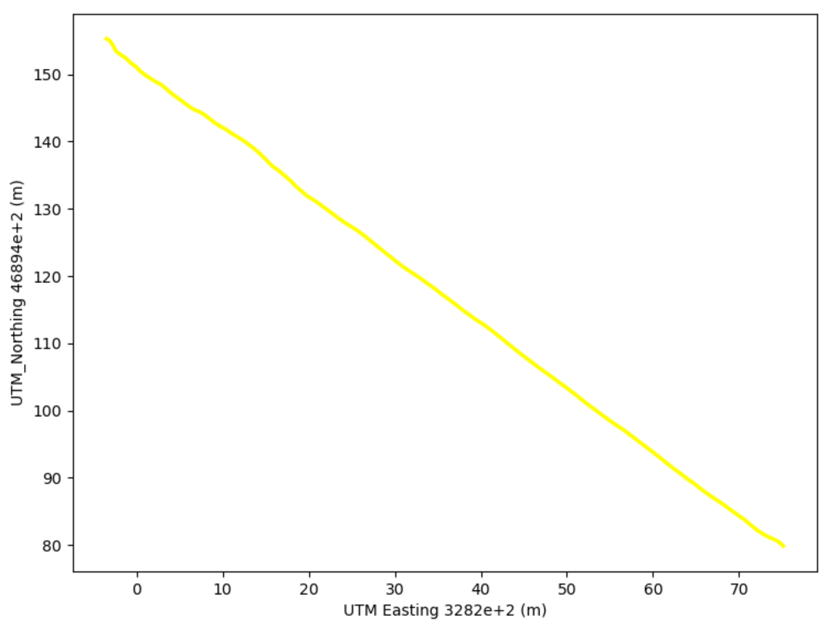


Figure 7

The corresponding plot on the google maps is as follows:

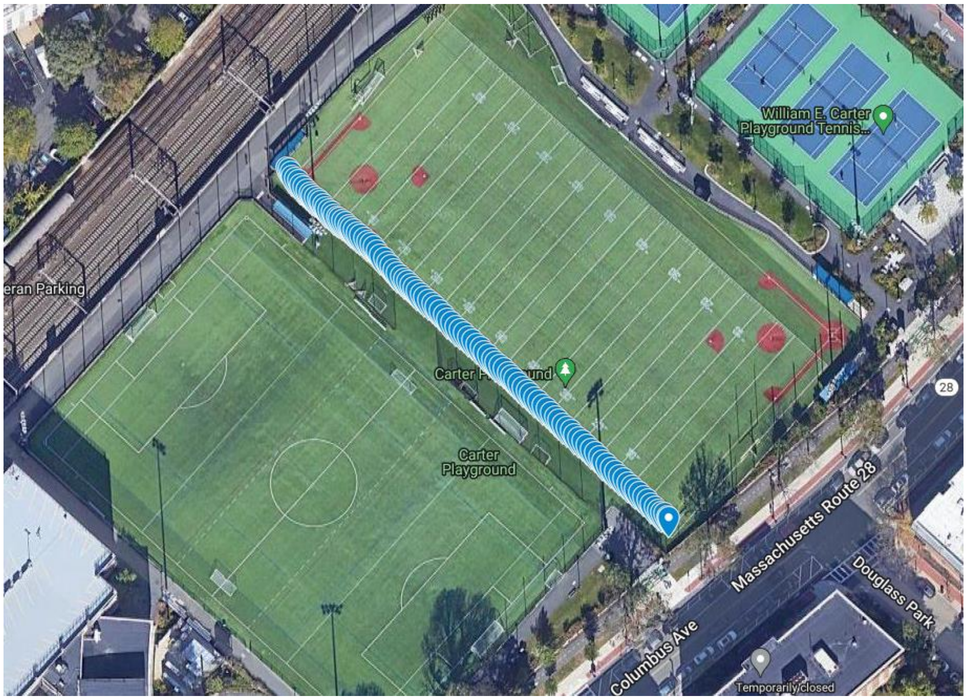


Figure 8

Analysis:

1. What does this say about GPS navigation?

The accuracy of the values is much better as compared to the stationary data. The GPS can correctly "estimate" my positions as I walk on the edge of the football field with little deviations from the true value.

2. How does the error estimate change as you move opposed to staying in a spot? What is the distribution of noise in this case?

The GPS uses a Kalman Filter (Extended Kalman filter to be precise) to filter the data obtained. The Kalman Filter uses a combination of initial estimates and error in a data set to figure out the Kalman Gain. The Kalman Filter can correct its estimate values very quickly provided it receives a collection of new measurements. In the case of stationary data, the filter does not receive any new values/ features that can correct the estimates. With the wrong initial estimate and no new features, the filter becomes slow to correct the position also as the variance in the process noise covariance matrix gets smaller the inconsistencies in the value increases. As we use an Extended Kalman Filter a non-linear model of the error is linearized by using Taylor Expansion, with the wrong initial estimate along with the static measurement data can cause the function to linearize on the wrong set of points which could also be a contributing factor (I think!).

Addendum:

The following is the Mean Square root error SD, Variance- Covariance matrix of the collected data -

Stationery:

Covariance Matrix - [30.65275015 -6.11183507] [-6.11183507 1.92945301]

Root means square error for UTM_easting - 328202.9334366525

Root means square error for UTM_northing - 4689495.663202298

Walking data:

Covariance Matrix - [300.00346166 247.45814657] [247.45814657 303.97059833]

Root means square error for UTM_easting - 328196.1571366295

Root means square error for UTM_northing - 4689494.098606538

Walking in a straight line data:

Covariance Matrix - [571.47501844 -547.23176704] [-547.23176704 524.08900545]

Root means square error for UTM_easting - 328233.2757756837

Root means square error for UTM_northing - 4689519.428131244