RTK GPS Data Analyzation

Luke Davidson - Professor Singh - EECE 5554 - Lab 2

Abstract

With all measurements come errors, especially when trying to identify the pinpoint location of a small GPS receiver on the surface of the Earth. Understanding the factors that directly relate to amplifying these errors is crucial when designing a system and understanding the limits of using GPS technology. In this experiment, we used two communicating Emlid RTK GPS devices to receive and correct GPS location data. We collected this data in both transient and stationary states in both an area with and without surrounding buildings.

Test Setup and Data Collection

Real Time Kinematics (RTK) is a technique of error reduction in GPS location data where a "rover" GPS receiver communicates with a "base" device, of which its precise location is known through initial computation. The base device is able to compute relative error between it's known location and the signals it is receiving from satellites and send this error information to the rover device in real-time. The rover device then applies this error correction information to the live signals it is receiving, eliminating a significant amount of error and achieving error levels of centimeter magnitude.

We collected both stationary and transient data in two locations: the soccer fields at Carter Playground and in front of ISEC. We collected data from the rover Emlid GPS device, parsed this data for the $GNGGA format, and published latitude, longitude, altitude, UTM Easting, UTM Northing and GNSS Fix data to a ROS topic in a custom message format.

ISEC Data

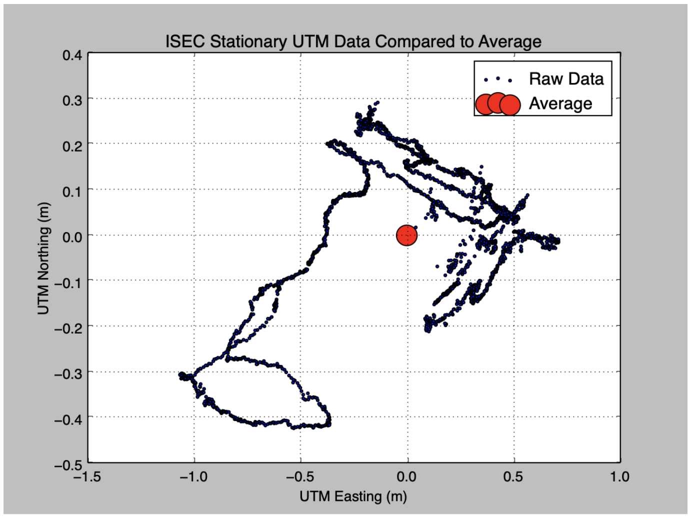

Figure 1: Average data point compared to raw stationary data

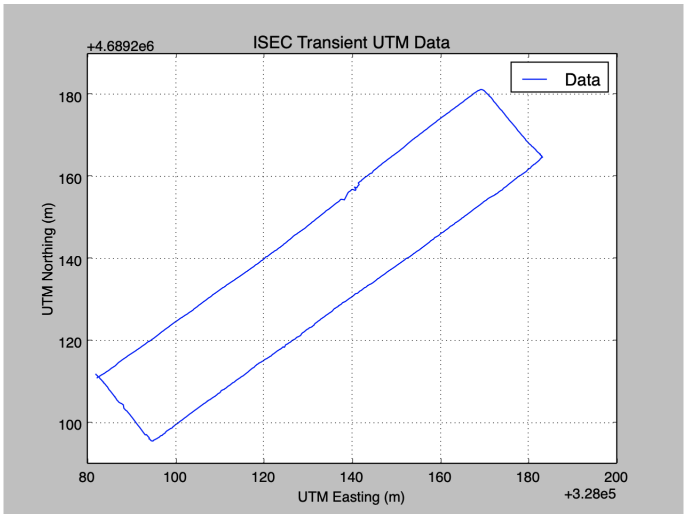

Figure 2: Raw Transient State Data

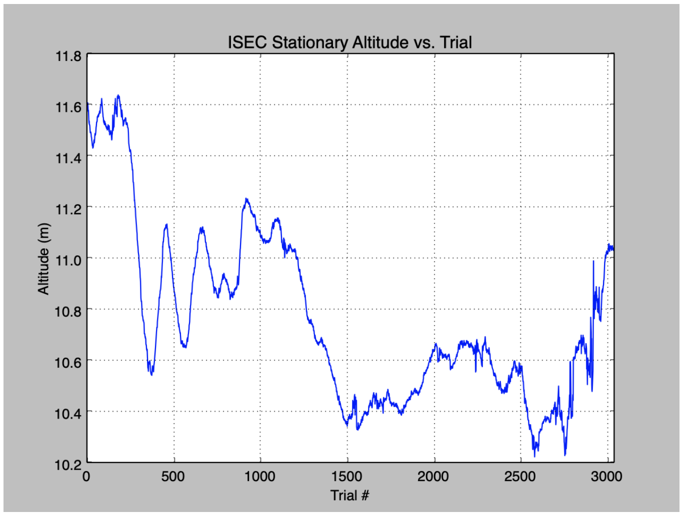

Figure 3: Altitude of Stationary Data

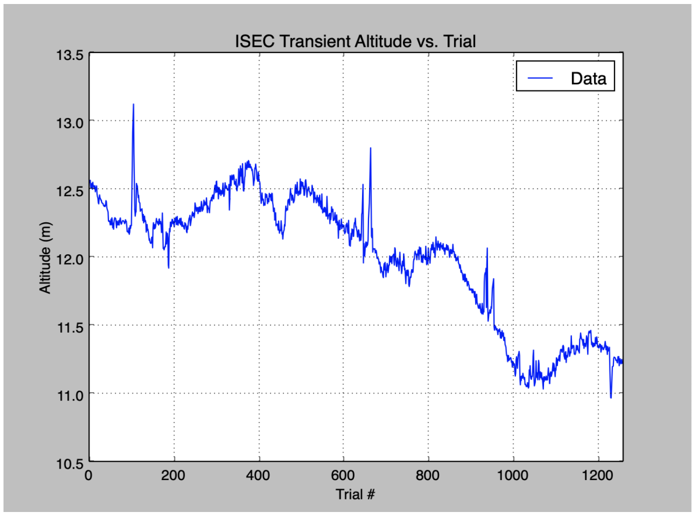

Figure 4: Altitude of Transient Data

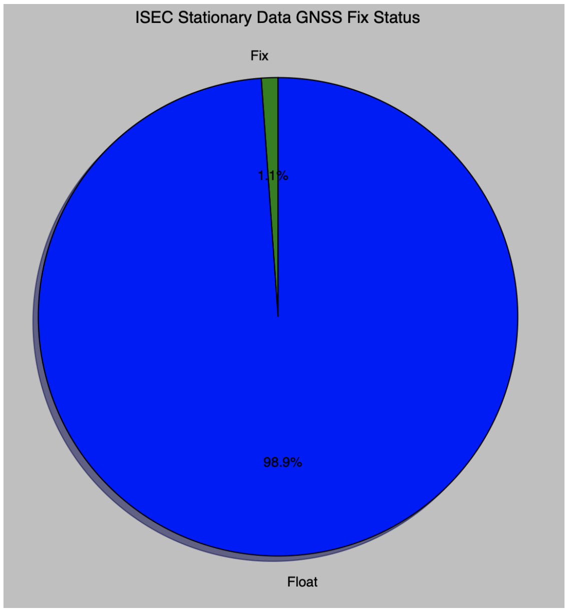

Figure 5: Stationary Data GNSS Fix Status

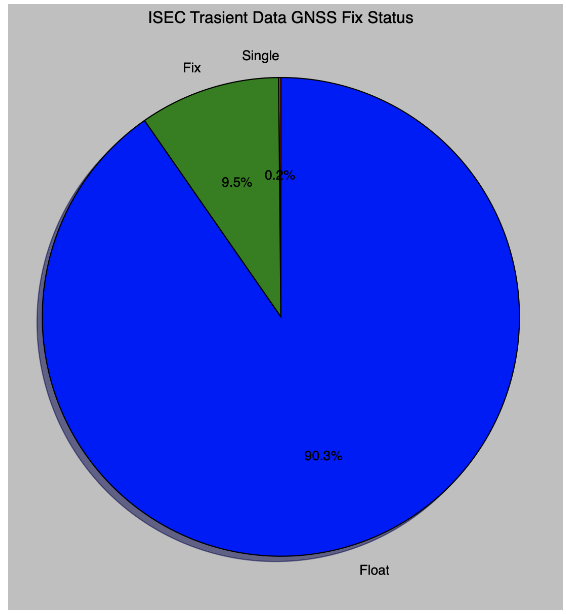

Figure 6: Transient Data GNSS Fix Status

Soccer Field Data

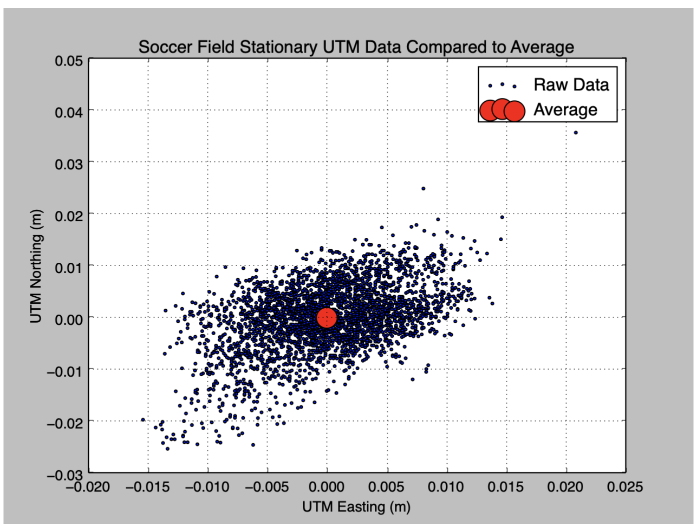

Figure 7: Average data point compared to raw stationary data

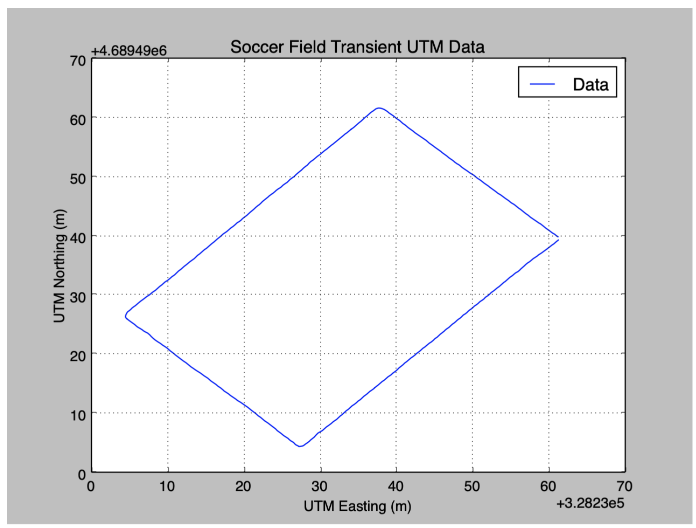

Figure 8: Raw Transient State Data

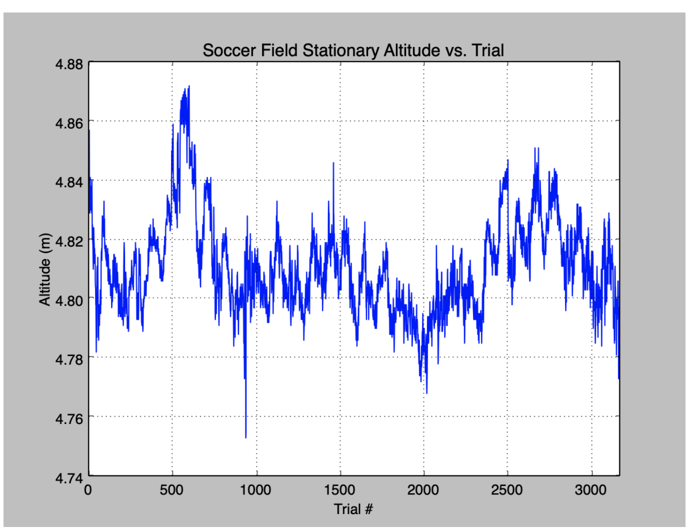

Figure 9: Altitude of Stationary Data

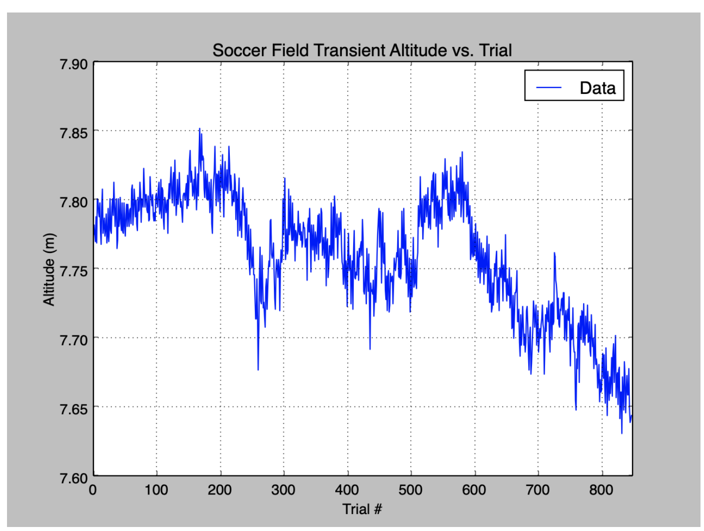

Figure 10: Altitude of Transient Data

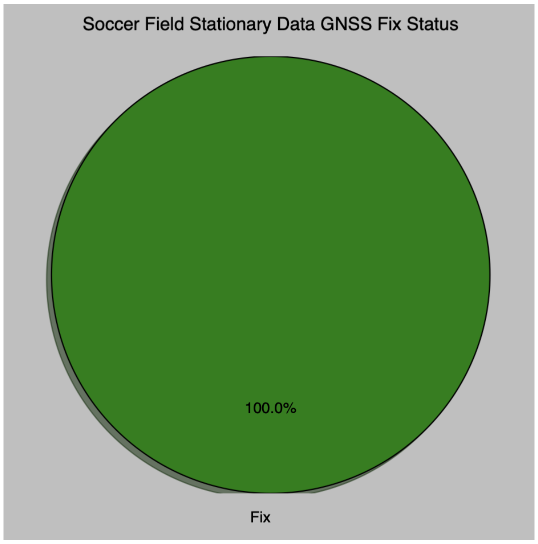

Figure 11: Stationary Data GNSS Fix Status

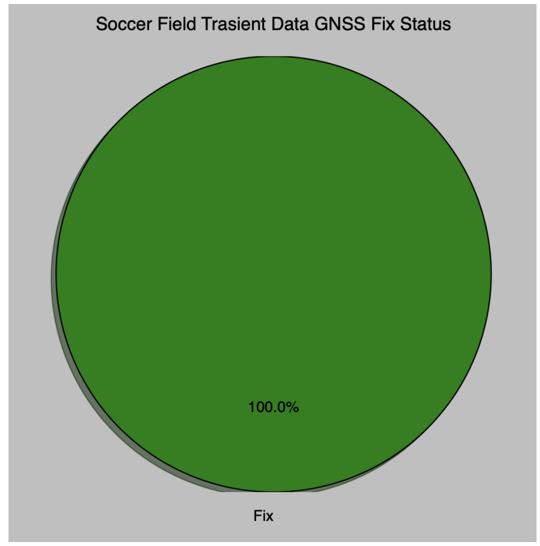

Figure 12: Transient Data GNSS Fix Status

Error Analysis

To analyze the error, I calculated the average distance of all of the data points to a theoretically correct location. The results are displayed below:

	Average Stationary Error (cm)	Average Transient Error (cm)	Average Altitude Error (cm)
ISEC Data	41.5454425572	16.6119764834	28.5141201355
Soccer Field Data	0.709495294342	3.61043319953	1.24587542088
Difference	-40.83594726	-13.00154328	-27.26824471

Table 1: Error Calculations

In the above table, “Average Stationary Error” is calculated by setting the theoretical correct location to the point: (Avg UTM E, Avg. UTM N), calculating the distance of each (UTM E, UTM N) point to that average, and averaging all of those values. Similarly, “Average Altitude Error” is calculated by setting the average altitude value from the stationary data as the theoretical correct location, calculating the difference between each altitude value to that average, and averaging those values. To calculate “Average Transient Error”, I fit four lines of best fit to our transient data sets since we walked in a rectangle. I then calculated the difference of each data point to its respective line of best fit, and averaged all of those values. The plots of the lines of best fit are shown below in *Figures 13* and *14*:

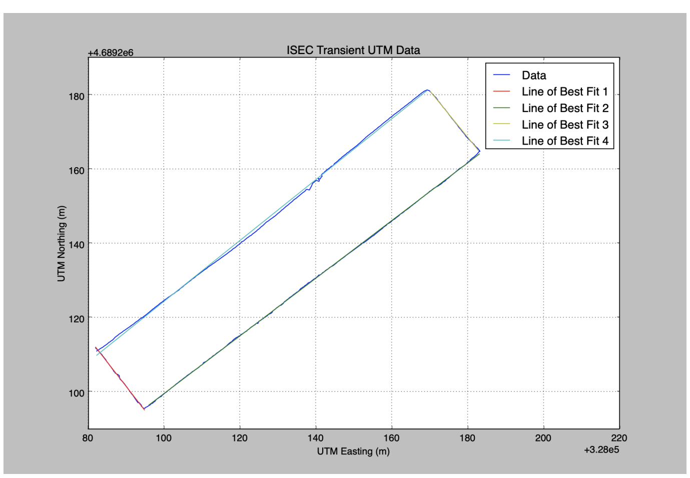

Figure 13: L.o.B.F. for ISEC Transient Data

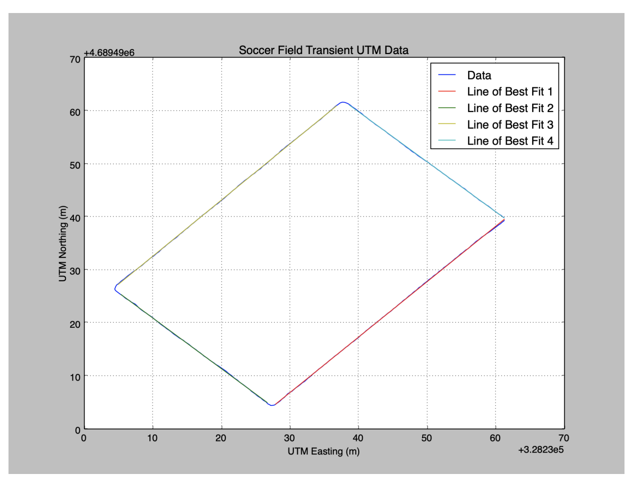

Figure 14: L.o.B.F. for Soccer Field Transient Data

As seen in *Table 1*, the average error calculations are much lower for the data set collected at the soccer field compared to the data set collected outside of ISEC, dropping about 40.84 cm, 13.00 cm, and 27.27 cm from the ISEC dataset to the soccer field dataset for stationary, transient, and altitude data respectively. This was the original expected behavior for multiple reasons.

We chose to collect data at these two locations for a specific reason: at the soccer field, there were no surrounding objects, while outside of ISEC, we were surrounded by multiple buildings in a tight area. The main source of error in this study is the obstruction of the direct line from a GPS device to surrounding satellites. Both GPS devices use the time it takes to communicate with a satellite in their calculation of position. When there are surrounding objects near the device, the signals between the device and surrounding satellites can bounce off the objects before directly reaching the device or can simply not reach the device at all. Error is amplified in both scenarios. When the signal bounces off an object before reaching the device, the time it takes to communicate with that satellite increases, causing the calculation of a false value. When a signal is fully blocked, there are simply less reference points to base a precise position off of. At the soccer field, there were no surrounding objects for our signals to bounce off or be blocked by compared to outside of ISEC. This is also seen in the GNSS Fix status in *Figures 5*, *6*, *11* and *12*. Outside of ISEC, only 1.1% and 9.5% of our data points for stationary and transient states, respectively, were collected in a "Fix" state. At the soccer field, the connection status remained at "Fix" for 100% of our data points, displaying a much stronger connection.

Another interesting calculation to note is that unlike Lab 1, our stationary data contains less error than the transient data in both locations. This is because when it comes down to magnitudes of a centimeter, human error of not walking in a perfect straight line is going to be greater than that of the sensor itself.

Conclusion

Real Time Kinematics proves to be a valuable method of eliminating error in GPS location data, bringing error magnitudes down from meters to centimeters. For certain applications this method is extremely helpful, however for others it is not practical. RTK only works when a rover is within a certain distance with the base it is communicating with. This makes RTK a practical solution in smaller environments such as construction sites and smaller localization applications. Other applications, such as navigating using Google Maps, will not be able to use RTK to eliminate location error. It is also much more practical to use RTK in open outdoor areas, compared to city streets with surrounding tall buildings. Through this study, we were able to successfully identify the sources that cause limitations to the use of RTK in eliminating GPS noise and error.