Lab 01 Report
Analysis of GPS Navigation

Objective:

This lab experiment is to analyze the behavior and accuracy of GPS navigation in two facts. First is in motion and second is in a stationary position.

Methods:

1. Data Collection:

a) Stationary Data: GPS device is hold at a fixed position for a 10-minute period.

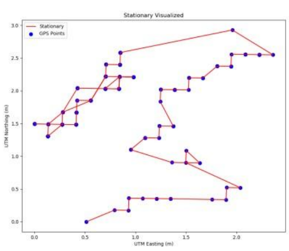
b) Walking Data: GPS device collected data while walking on Huntington Drive for 300 meters.

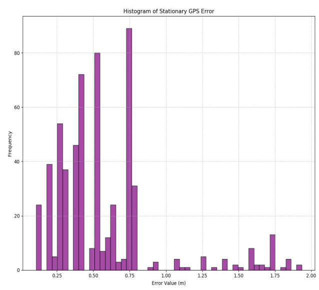
2. Data Analysis:

Converted the data format to UTM. Using python as coding language, related libraries such as matplotlib to visualize and statistically analyze the data.

Stationary:

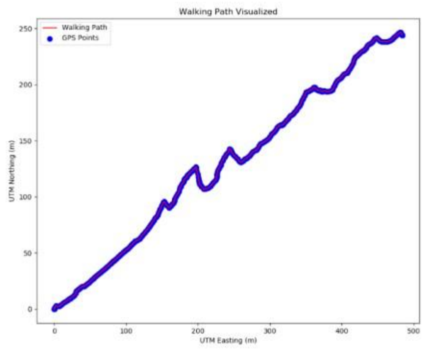
In the following graphs. I used UTM Easting and UTM Northing as x and y axis for the plotting points one.The data displays minor deviations around the center point, which in the first graph begins at the coordinate (0,0). Idealy it should only display one point and no error in the second graph, but since there are mutiple factor could effect this, it shows as the graphs below in the real situation. I used frequency and euclidean distance error as x and y axis for the error histogram.





Walking:

The data clearly depicts a line of movement with some noticeable scatter, indicative of noise.



Discussion:

1. Errors for walking:

a) Several buildings along Huntington Drive might have caused reflections on the GPS signal. If the signal reflects off a structure, it inevitably travels a longer distance, consequently taking more time to reach its destination. While stationary, this effect remains consistent; however, when in motion, it might vary rapidly.

b) Differences in walking speed might also contribute to the errors observed. Rapid movements could cause the GPS to lag behind the actual position. Several traffic lights along Huntington Drive could have necessitated changes in walking speed or even complete stops.

c) Although Huntington Drive isn't perfectly straight and has minor turns, this factor likely had a minimal impact on the results given the short walking distance of only a few hundred meters. Additionally, the rainy and cloudy weather on the day of the experiment might have introduced errors due to atmospheric interference.

2. Errors for stationary:

a) In the outdoor parking lot, there are too many cars as metallic surfaces can reflect the GPS signals. These reflections can create multipath errors. The movement of cars in and out of the parking lot can also dynamically change the reflective environment lead to fluctuating errors.

b) Weather was raining. Rain and clouds can introduce delays in the GPS signal as it passes through the atmosphere. Water in the atmosphere can refract the GPS signals, causing delays that lead to positional errors.

c) The position of the satellites can impact accuracy. Satellite geometry can be sub optimal during the data collection period.

3. Distribution of Noise:

For a stationary GPS in an outdoor scenario, the noise is expected to follow a normal distribution centered around the true position. In the data section, I adjusted all the values by subtracting the smallest value from them. This effectively assumes the smallest value to be the accurate position. The visual representation clearly depicts a nearly symmetric distribution along a diagonal line that originates from the point (0,0) and is inclined at a 45-degree angle. Ideally, in the error histogram, one would expect zero frequency at any given meter. However, the observed results demonstrate an Exponential Distribution. This distribution reveals a pattern where there are numerous small errors and a few significantly larger ones, leading to a right-skewed graph. Identifying that stationary GPS errors align with an exponential distribution implies that although the majority of the data is reliable and accurate, a minor portion may be influenced by the previously discussed factors.

For a moving GPS in an outdoor setting, the noise distribution might deviate from a normal pattern due to the more complex interactions with the surroundings, as detailed in the previous Errors section. There are distinct differences between the errors for longitude and latitude. This could result in an elliptical noise distribution pattern rather than a circular one. Walking data that mostly forms a line but has twisted sections provides valuable feedback about the performance and limitations of the GPS system in dynamic conditions

Conclusion:

GPS readings exhibit greater variability during motion compared to when stationary. Error estimations become multifaceted during motion due to a variety of influencing factors. Stationary GPS data typically presents a more consistent noise distribution, whereas dynamic positioning introduces more intricate noise patterns.