Matthew Luongo
EECE 5554 — Lab #2 Report
17 February 2023
Professor Dorsey

The use of GNSS, or Global Navigation Satellite System, is critical to daily navigation across a multitude of sectors, including robots. GNSS relies on messages from a network of satellites to pinpoint a robot's location; the satellite streams its timestamp, location and other useful information. Distance can be is calculated from the time lag between a signal generated by the robot and the one obtained from the satellite.

A specialized form of GNSS is Real-Time Kinematic (RTK) GNSS. RTK adds a stationary "base" to the equation. This base also receives information from the satellites, and it sends corrections to the "rover" (the robot) to make up for some of the satellite error. Regular GNSS allows for global location with a precision of around 30–50 cm, while RTK GNSS provides a precision of up to <2 cm (https://www.fjdynamics.com/blog/91-GNSS--RTK). While RTK improves upon GNSS's resolution from satellite positioning errors (DOP), it is still subject to the urban canyon/multipathing errors (and atmospheric interference) that regular GNSS suffers from.

In this lab, position data was collected in four scenarios: stationary on centennial common, stationary near Behrakis center (underneath the front awning), walking around centennial common, and walking around Behrakis center while hugging the wall. The data for each case can be found in Figs 1a–1d below:

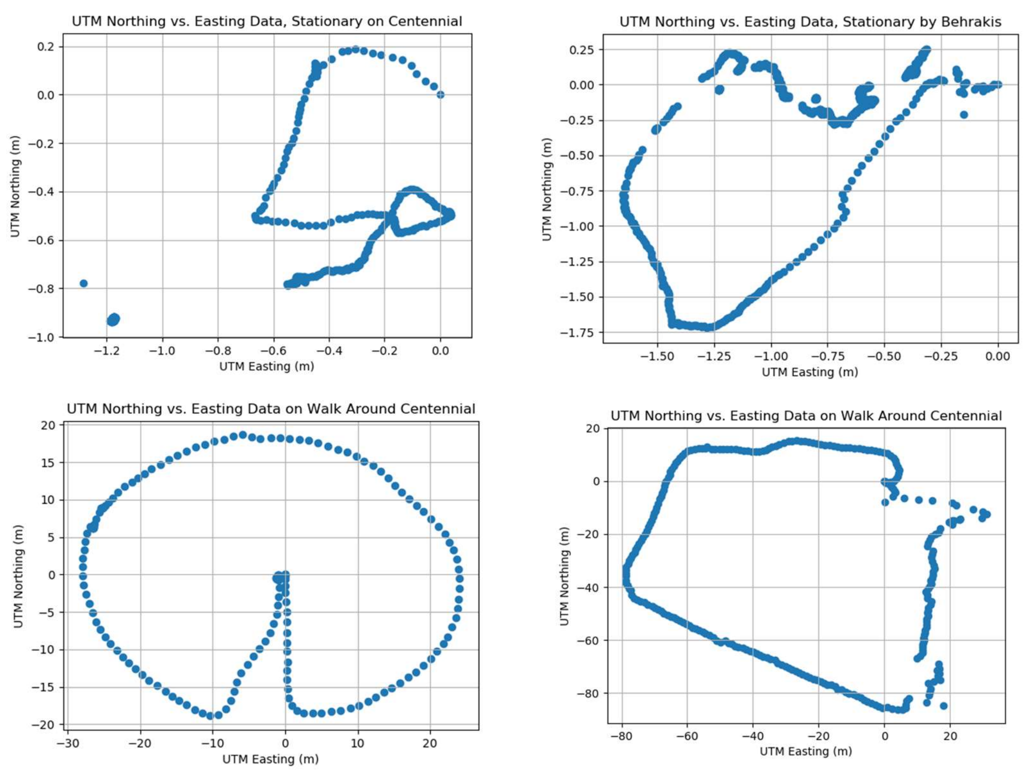

Figure 1a–1d: UTM Northing vs. Easting data for each scenario

Notably, the data for the mobile scenarios were clipped for easier analysis. These plots can be found below in Fig 2a–2b. Histograms of error can be found in Fig 3a–3d below:

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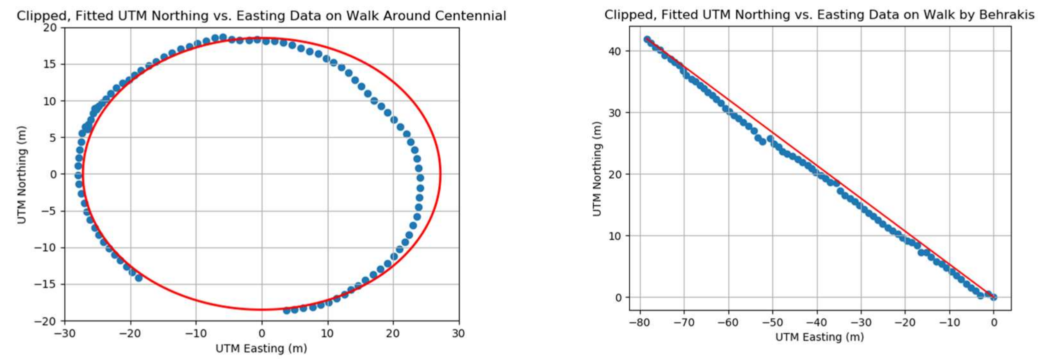

Figure 2: Clipped datasets for the mobile scenarios. An elliptical fit was used in a. with a COD (coefficient of determination) of .765. A linear regression was used in b. with a COD of .727.

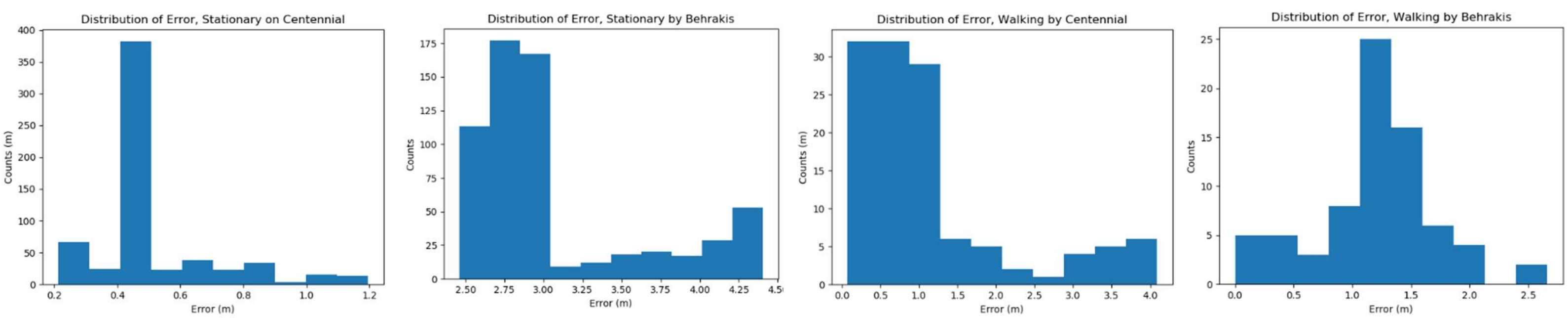

Figure 3: Error distributions for each scenario

a. The average error in the stationary datasets were 0.505 and 3.073 m in the open (centennial) and occluded (Behrakis) datasets. The corresponding errors from Lab 1 were 2.55 and 16.9 m. I believe these errors are partially due to my ‘known’ positions being taken from Google maps, where I had difficulty choosing the exact location of our data collection. I do not remember which part of the hill we stood on, so this would have a greater effect on error than the RTK data itself. The RTK errors still outperform the regular GNSS errors from Lab 1. The average errors for the mobile datasets were 1.170 and 1.201 m, compared to 0.182 m in Lab 1. This is most likely due to the ill-fitting (~.7) regressions that I used. All errors were calculated using DRMS, or in the elliptical fit case, the absolute value of the difference in radius between the data point and the ellipse.
b. The distributions scatter plots are tighter than the GPS data from Lab 1 (within 1–2 m each), which spanned 6 and 20 m in the open and occluded cases. This means the RTK data is much more precise.
c. RTK GNSS boasts a much higher precision than regular GNSS; the employment of a stationary base (with a known position) that transmits corrections means that the corresponding data will be much more precise. The fix quality of these corrections can be seen in Fig. 4 (next page). Note that a value of 4 is more precise than a value of 5.
d. The moving data in the open case is skewed to the left (meaning a higher quantity of small errors) while the occluded data is more normally distributed; however, the moving data spans a larger range of values. The larger range of values might be attributed my poor-quality elliptical fit, but the frequent low errors are owed to the persistent ‘float,’ meaning the data was calculated with a high degree of accuracy. The data from moving around Behrakis has a larger error due to the more-frequent dips to 1, which constitutes an unfixed datum. Both datasets look roughly correct when thinking about the paths we took while moving the rover, having to step around obstacles/people.

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e. The error distribution in the open, stationary set was skewed right; I already explained this, but I believe my placement of the "known" coordinates on Google maps was somewhat incorrect; however, the errors are still relatively low. The open error is much smaller than the occluded error: looking at the fix quality, about half of the centennial data benefitted from 'fixed' corrections, meaning they have the highest degree of accuracy. The occluded data spends more time in the 'float' region, so those data would naturally have higher errors. Overall, the error makes perfect sense with the fix quality.

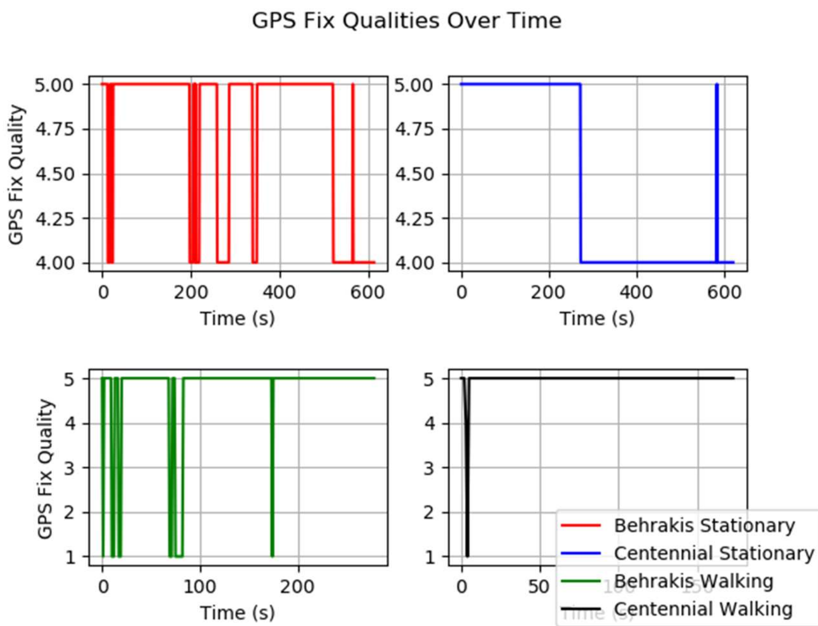

Figure 4: GPS fix quality over time for each scenario.

All-in-all, this lab successfully showed the benefits of RTK GNSS compared to regular GNSS/GPS. The fix quality of the data is clearly tied to the error within the dataset. RTK is naturally more beneficial to small robots that require a high degree of precision when navigating tough environments.