LAB 2

RTK PRECISION GPS

Shakeel Ahamed | NUID 002199480 | Team 14 | Section 1

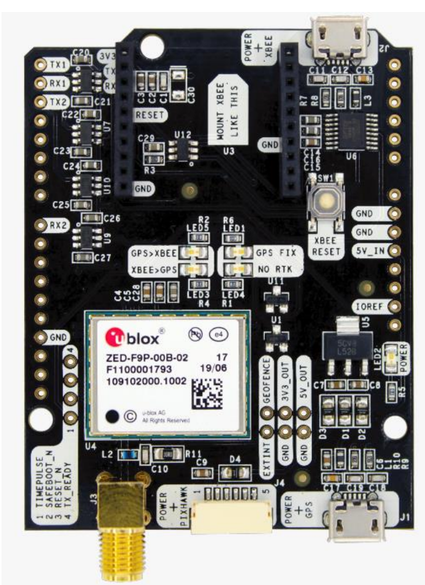
Objective:

The aim of this lab is to work with a type of precision GPS, RTK.

RTK or Real Time Kinematic is a type of GPS that uses a base & rover system to give precise positions in order of centimeters accuracy, traditional mobile GNSS receivers typically give you about 2-4 meters of accuracy which isn’t viable for drones, construction work etc where you’d need pinpoint accuracy and this is where you’d want to utilize RTK GPS systems, the idea is to have a configured base at a known location and have satellites, base and rover interconnected to get precise positions of the rover(objective) to perform tasks as flawlessly as possible.

Device:

The device we’ve been assigned is Ardusimple SimpleRTK2B-F9P, which comes with 2x GNSS processing Ardusimple boards, 2x 915 Mhz telemetry radio, 2x GNSS Antennas which claims to give <1 cm precision readings with base-rover setup and a convergence time of <10s since this is a multi-band RTK.



NMEA/GPGGA Structure:

The National Marine Electronics Association set standard is followed for this lab.

We care about the lines that start with GNGGA,

GN -> for multi GNSS solutions (since 2 GNSS receivers are involved, base & rover)

GGA -> Global Positioning System Fix Data

GNGGA Format:

TALKER ID	XX	All talker IDs usable
SENTECE ID	GGA	
UTC of position	hhmmss.ss	Fixed length 2 digits after dot
Latitude	llll.lllllll	Fixed length 4 digits before and 7 after dot
Hemisphere of latitude	N/S	N if value of latitude is positive
Longitude	lllll.lllllll	Fixed length 5 digits before and 7 after dot
Hemisphere of longitude	E/W	E if value of longitude is positive
GPS quality indicator	X	0: GNSS fix not available 1: GNSS fix valid 4: RTK fixed ambiguities 5: RTK float ambiguities
Number of satellites used for positioning	XX	Fixed length 01 for single digits
HDOP	XX.X	Variable/fixed length 1 digit after dot, variable before
Altitude geoid height	(-)X.XX	Variable/fixed length 2 digits after dot, variable before
Unit of altitude	M	
Geoidal separation	(-)X.XX	Variable/fixed length 2 digits after dot, variable before
Unit of geoidal separation	M	
Age of differential data		Empty field
Differential reference station ID		Empty field

A very important unit for this lab is the "GPS quality indicator", we Ideally want it to be 4 -> RTK Fixed (most accurate setting), the following is a table that explains all the different quality indicators.

Value	NMEA 2.1	NMEA 3.0
0	Invalid	Invalid
1	Standalone	Standalone
2	DGPS	DGPS
3	RTK	n/a
4	n/a	RTK fixed
5	n/a	RTK float

Mode of Operation	Expected Accuracy*
Standalone	10 to 30 metres
DGPS	2 to 10 metres
RTK	0.1 to 1.0 metres

Method:

The steps taken to get our readings:

- **Configured the Telemetry Radios:**
  Connected both the Radios to different laptops and configured them in Linux terminal via minicom and changed the settings as instructed in class.
  LED 1 was solid green; LED 2 was blinking red while sending data.
  We were able to successfully communicate between the laptops, being able to write on each other's terminals.
- **Setting up the Ardusimple Boards:**
  Connected all the 3 components together to the board and powered it using the microUSB port.
  Installed u-center (version 1).
  Configured and saved Rover settings first from u-center as instructed in the Lab-2 pdf.
  Configured base as instructed.
- **Modifying the Device Driver:**
  Modified GPS.py driver file and messages from lab1 to also include GPS.fix component to indicate the GPS quality indicator and to parse "GNGGA" instead of "GPGGA".
- **Data Collection:**
  We started collection on NEU parking lot roof by starting the survey-in period with 60s timer and a 5m accuracy and the rover laptop was ready with the device driver code to collect data into the ROSBag.
  The survey-in period is to calibrate the base and get a pinpoint on where the base is located before moving onto calculating the rover position.
  Unfortunately, we couldn't get RTX Fixed reading after multiple days and resorted to **borrowing data from Team 9** in section 1 after the notice from the professor.

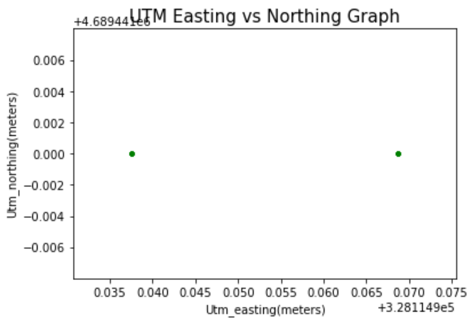
Data:

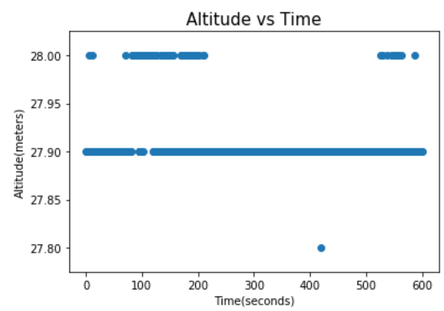
- **Data Locations:**
  The Open Sky data were collected from Columbus Garage
  The Obstructed data were collected from Centennial Common
- **Convert the ROSBag into CSV readable files:**
  The ROSBag data received was turned into a CSV file using a python script (saved as bagreader.py)
  The CSV files are open_stat.bag close_stat.bag, open_walk.bag, close_walk.bag
  The CSV files are open_stat.csv close_stat.csv, open_walk.csv, close_walk.csv

- **Parsing out the parameters needed:**
  Latitude, Longitude, utm_easting, utm_northing, altitude, RTK quality status and time(modified to represent start time as 0) were parsed out from the csv files and graphing and analysis were done on it as follows.

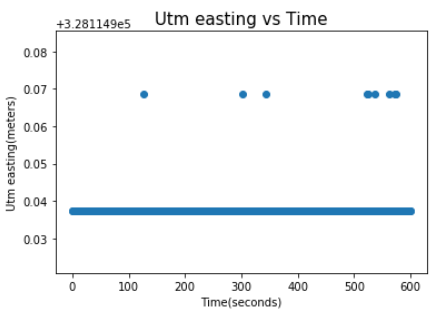
Analysis:

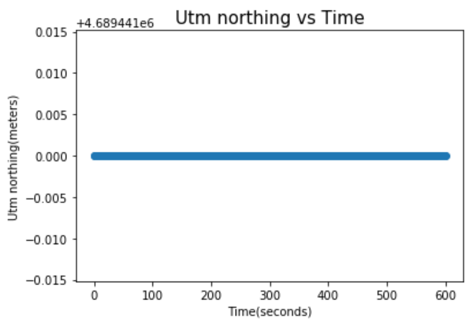
Open Roof Stationary Case

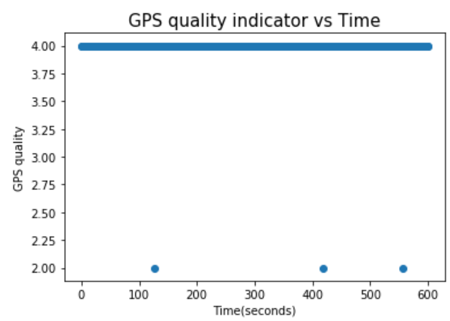





```
Variation(Max-Min) in UTM Northing: 0.0m, Standard Deviation is 0.0m & Mean is: 4689441.0m
Variation(Max-Min) in UTM Easting: 0.03125m, Standard Deviation is 0.00380m & Mean is: 328114.94m
Variation(Max-Min) in altitude: 0.200001m
```

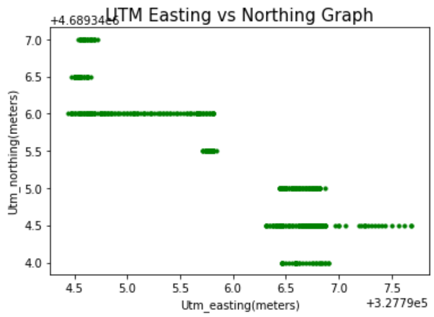


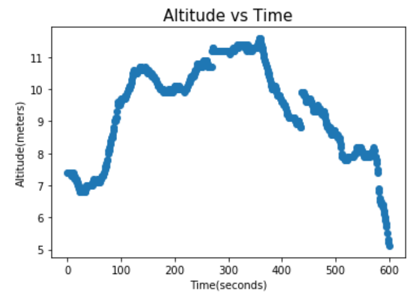




As expected from a precision GPS, the variation in data is 0.03125m or 3 cms which is very precise. The variation in the data can be explained by the GPS quality drops as seen in the GPS quality graph above, the GPS quality drop could be due to the sky not being perfectly clear, airflow to the processing board/electronics or even the temperature rising.
The altitude variation is 0.2m which again could be due to clouds interfering with the signals, changing the travel time which in turn causes variations in the altitude readings.

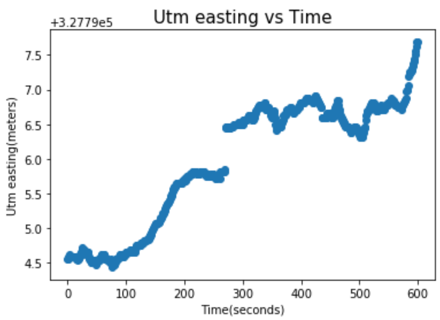
Obstructed Stationary Case

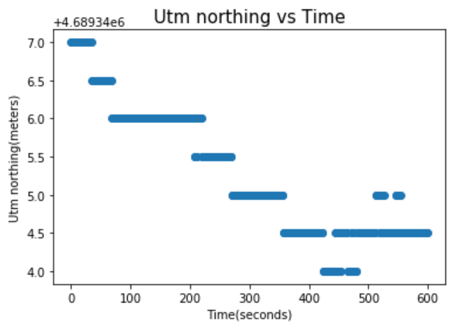


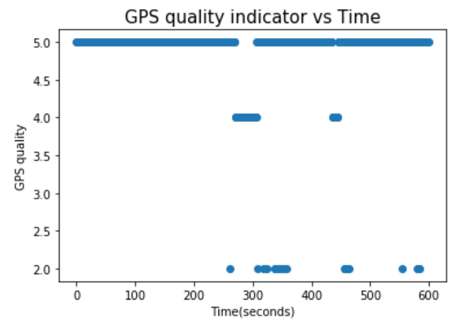



```
Variation(Max-Min) in UTM Northing: 3.0m, Standard Deviation is 0.83356m & Mean is: 4689345.2725m
Variation(Max-Min) in UTM Easting: 3.25m, Standard Deviation is 0.89243m & Mean is: 327795.9677604167m
```

```
Variation(Max-Min) in altitude: 6.500000m
```



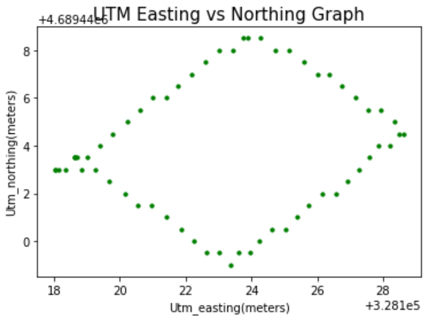


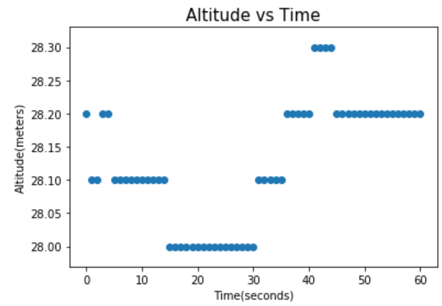


The Variation Range of the UTM values are 3.0, 3.25 m, standard deviation 0.833,0.892 which is lot higher than the open roof case indicating much lower accuracy.

The accuracy is a lot lower in the obstructed space data as expected majorly due to low signal strength in obstructed areas. The signal power from GPS is very low after all that travel, these low signals while getting obstructed by trees or tall buildings and entrance shades in Centennial Common will make the signal quality worse and hence affects our GPS quality, it was at 5, RTK_Float rather than 4, RTK_Fixed most of the time or 2 which shows our setup wasn't having a stable connection in the first place leading to lots of variations across the graphs above.

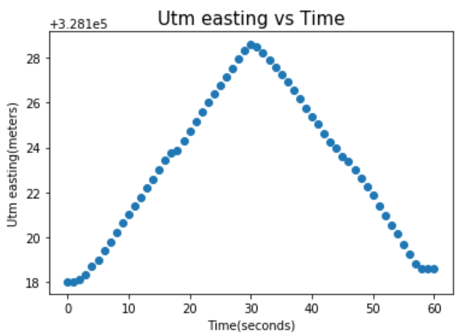
Open Roof Walking Case

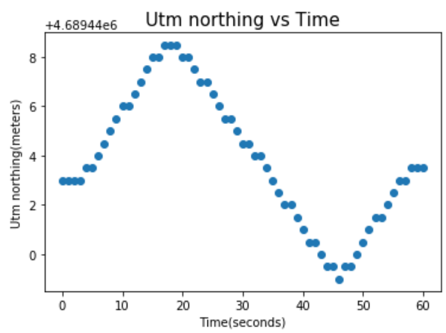


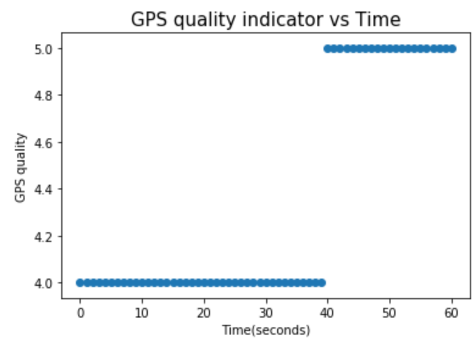



```
Variation(Max-Min) in UTM Northing: 9.5m, Standard Deviation is 2.72418m & Mean is: 4689443.84m
Variation(Max-Min) in UTM Easting: 10.59375m, Standard Deviation is 3.29512m & Mean is: 328123.17m
```

```
Variation(Max-Min) in altitude: 0.299999m
```







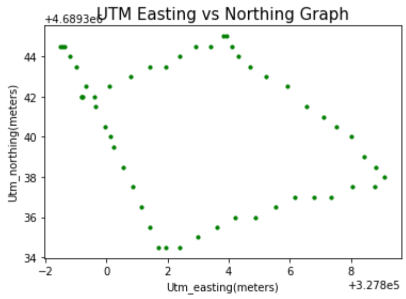
The appropriate way to analyze this would be by checking the endpoints or the vertices of the (somewhat) diamond shape in the northing vs easting graph. The right and left vertices should have similar UTM_northing values and the top and bottom vertices should have similar UTM-easting values.

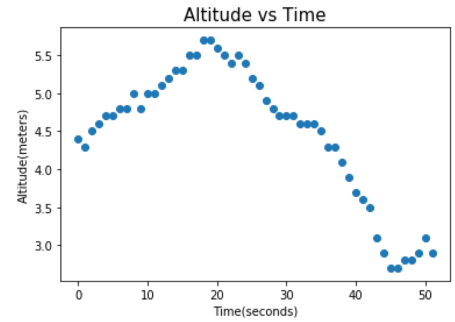
```
Top:  (328124.28125, 4689448.5)
Right:  (328128.625, 4689444.5)
Bot:  (328123.375, 4689439.0)
Left:  (328118.03125, 4689443.0)
```

Left and Right UTM Northing: 4689444.5-4689443.0 = 1.5m difference
Top and Bot UTM Easting: 328124.28-328123.375 = 0.9m difference

The above shown variations in endpoint expectations could be explained by the imperfections in the GPS quality and walk path, the GPS quality was not RTK fixed throughout and changed to RTK float which could be due to previous explained reasons and walking path might not have been perfect either, travelling X front -> Y right -> X back -> Y left can be a little impractical while holding a laptop during which the antenna probably had a lot of variations in different directions.

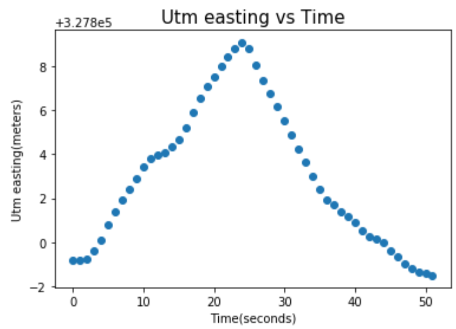
Obstructed Walking Case

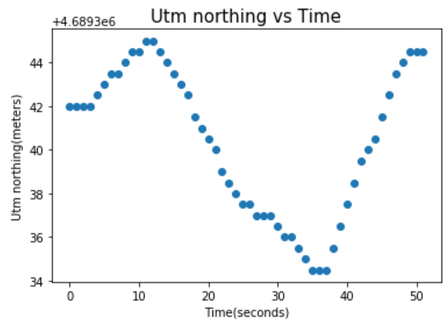


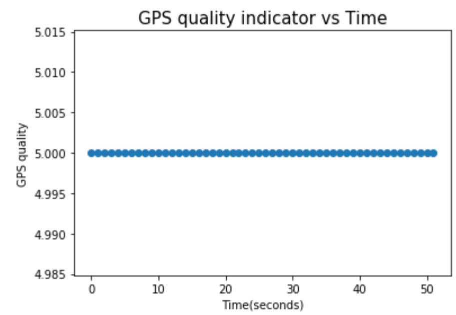



```
Variation(Max-Min) in UTM Northing: 10.5m, Standard Deviation is 3.39267m & Mean is: 4689340.40m
Variation(Max-Min) in UTM Easting: 10.59375m, Standard Deviation is 3.26559m & Mean is: 327803.05m
```

```
Variation(Max-Min) in altitude: 3.000000m
```







Checking the end points again from the scuffed diamond shape in the northing vs easting graph, the UTM easting, UTM northing values are as follows:

```
Top:  (327803.9375, 4689345.0)
Right:  (327809.09375, 4689338.0)
Bot:  (327801.6875, 4689334.5)
Left:  (327798.5, 4689344.5)
```

Left and Right UTM Northing: 4689344.5-4689338.0 = 6.5m difference
Top and Bot UTM Easting: 327803.94-327801.69 = 2.25m difference

The variation is a lot higher than the previous open sky case due to obstructions messing with the signal quality which leads to incorrect position tracking since the base itself is poorly calibrated during the survey-in period and this adds on to the inaccuracy of calculating the rover position, the signal quality never reached RTK Fixed either which means we never had perfectly stable trio at any point between rover, base and satellites.

Conclusion:

The RTK Precision GPS is a lot more accurate than traditional GNSS standalone receivers, the use of RTK system gives you <1cm precision in ideal scenarios as opposed to 2-4m accuracy obtained from your mobile phones and such, this could be very essential to Robots that need pinpoint positioning like drones for delivery, surveying or construction work.

They do have their disadvantages such as making it work indoors or setting it up, since it requires you to set up the base on a position you have accurate latitude and longitude of to get perfect readings.

For indoor purposes, RTK system is not practical out of box but can be made to work by using GPS antennas setup outdoor and sent through a GPS repeater indoors to get proper signal quality for better signals.