EECE 5554 Lab 2: Real Time Kinematic GPS

**Learning Objectives**

After this lab, a successful student will be able to:

* State the high-level principles of RTK GPS
* Explain differences in setup between RTK GPS and GPS
* Compare results from RTK GPS collection with GPS collection

**Driver**

Your driver will be very similar to Lab 1. The NMEA string is ‘GNGGA’ instead of ‘GPGGA’. You should also modify your driver slightly to add the GNSS fix quality (rtk float or rtk fix) to the NavSatMsg. The fix quality will be useful for analysis. Everyone should make these changes to a create new driver, and push your driver to your git repo.

**Data Collection Policy**

* Plan data collection schedules amongst your teammates. You can talk to your teammates and ask questions on Piazza.
* Data acquisition should be done collectively in a team.
* Analysis on the collected dataset should be done individually.

**Hardware and Sensors**

* 1 x GNSS/ RTK Processing boards (type depends on group)
* 1 x GNSS Antennas 1

**Appendix List**

* RTK processing board setup

|  |  |
| --- | --- |
| Warning | Please make sure you follow the instructions ***exactly as listed*** in the appendix for setting up the RTK hardware. These instructions are vital to make sure the hardware is not accidentally bricked. |

After setting up, you should have a system where you have the "rover” RTK and a laptop working together, where the rover RTK is receiving GPS corrections.

**Data collection: Collect a total of four data sets**

1. Go outside and set up your rtk rover at a spot that is completely clear (eg. open park or roof of Columbus parking garage). Make sure your rover is in either RTK float or RTK fix mode (ideally RTK fix).

2. Collect a 10-minute stationary data set

3. Collect another dataset in this location where one teammate moves with the rover in a rectangular or square path (eg. forward 1 min, right 1 min, back 1 min, right 1 min etc.), coming back exactly to the same starting point with the same heading. You will want to make this path easy to plot against “true” position.

4. Collect two more datasets (stationary and moving rover) at a spot with partial occlusion and reflections nearby (eg. outside of ISEC) with the same structure.

**Analysis**

Examine the utm data for each of the datasets. Use some of the tools introduced in Lab 1 to plot and estimate deviation for each dataset.

**Report**

Write this lab up into a report in pdf format that gives a brief introduction to RTK, divulges differences between RTN GNSS and GNSS, and discusses source(s) of error in RTK GNSS. Your report should answer the following questions, drawing on your analysis to ground your conclusions:

a. What do the error (if you used a “true” position) or deviation (if you didn’t) tell you about the accuracy of RTK GNSS navigation, as compared to standalone GNSS without RTK?

b. What can you say about the ranges and shapes of your position in Easting and Northing from RTK GPS? (Make a 2D histogram, state the deviations of Easting and Northing, and draw additional conclusions about these data).

c. Is the shape or range of your histogram different than your dataset collected in Lab 1?

d. Give quantitative comparisons for how your moving data differ in the open and occluded cases, including error/deviation estimates? Does this have anything to do with GNSS fix quality?

e. How are your stationary data different in the open and occluded cases, including numerical error/deviation estimates? Does this have anything to do with GNSS fix quality?

Please post this report to **both GitLab (in your analysis folder) and Canvas**. This report may be 2-4 pages with figures and not more than that; and in a professional font (e.g., Times, Arial, 11-12 point single spaced, 1” margins).

**Grading Rubric (10 Points)**

* 1 point for ROS driver and data collection.
* 2 points for plots that demonstrate analysis on the dataset
* 3 points for analysis discussion and scripts (on own)
* 2 points for answers to questions (on own)
* 2 points for overall report presentation (on own)

**How to Submit Lab 2:**  
1. In your class repo ‘EECE5554’, create a directory called LAB2/src

2. Your driver should be in the LAB2/src directory.

3. Inside the package, create sub-directories ‘analysis’ and ‘data’. The collected GPS data should be in the ‘data’ folder.

4. Copy the MATLAB or Python code used for data analysis under ‘analysis’

5. Place your report in pdf format in the analysis directory

6. Push your local commits to (remote) GitLab server. You can verify this by visiting gitlab.com and making sure you can see the commit there.

7. **Upload your report in pdf format to Canvas Assignments under lab2**

Your repo structure should look similar to:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| EECE5554/ |  |  |  |  |
|  | LAB2/src |  |  |  |
|  |  | <your\_gnss\_ros\_driver\_package>/ |  |  |
|  |  |  | analysis/ | <analysis files>  report.pdf |
|  |  |  | data/ | <data sets> |

**Appendix:**

**RTK-GPS Setup Instructions - [ublox ZED-F9P module]**

**1. Setup on U-Center**

To work with a simple ublox ZED-F9P module, we can use their GNSS evaluation software, U-center. We used U-center version 22.07.

To configure the board to receive corrections via the internet, configure the boards using the following steps.

1. On windows, open the U-center software. Connect the serial port and select the baud rate (highlighted in the red box figure 1. We used a baud rate of 57600 for our work, so we will continue using that in the rest of the document.

A screenshot of a computer

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Figure 1: U-center main window.

2. We need to enable the following messages in U-center to work with the ros package - ublox driver.

(a) NMEA→GxGGA

(b) UBX→RXM→RAWX

(c) UBX→RXM→SFRBX

(d) UBX→NAV→PVT

• To do so for all these message types, let’s take the example of UBX→NAV→PVT.

• To enable this, first press F9. This would bring up the configuration settings.

• On the left, double-click on the UBX section to expand it.

• Then click on NAV to expand it.

• Right-click on the PVT and select enable message .

• If enabled, this message should get highlighted in bold color as shown in the figure 3

A screenshot of a computer

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Figure 2: Expand tree on left to enable and disable messages.

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Figure 3: Enabled messages will be highlighted in bold color

3. We need to correctly set the UART port of your F9P module to work with ublox driver. Go to the port settings at UBX→CFG→PRT and change the settings for UART1, UART2 and USB to the options shown in figure 4, figure 5 and figure 6.

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Figure 4: Settings for UART1.

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Figure 5: Settings for UART2.

A screenshot of a computer program

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Figure 6: Settings for USB.

4. Click Send to make sure the changes have been written to the board.

5. Measurement frequency may also be set. Go to UBX→CFG→RATE and set the measurement period to 100ms to set the measurement frequency to 10Hz as shown in figure 7.

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Figure 7: Values for measurement period

6. Click Send to make sure the changes have been written to the board.

7. These settings can be saved under UBX→CFG→CFG and clicking the send button to make sure the board will keep these settings after reboot.

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Figure 8: Save configuration.

8. The rover is now setup!

**2 NTRIP**

**2.1 U-Center [Windows]**

To achieve highly accurate RTK localization, we can input RTCM (correction) messages from a GNSS base station into the receiver. Nowadays many GNSS stations distribute their RTCM streams via the NTRIP protocol. We utilized corrections from the free NTRIP provider, rtk2go.com.

1. To configure rover to receive corrections via NTRIP protocol, select Receiver→NTRIP client from the menu bar.

2. Provide your email address as username and keep the password as none.

3. Select an NTRIP mount point suitable near your location. We used MACKLBG since it was close to our location[Boston]. The list of mount points can be found here.

4. Click Ok.

A screenshot of a computer

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Figure 9: NTRIP client settings.

5. Upon successful connection, the NTRIP connection status at the bottom of the window will be changed to the picture as shown in figure 10.

A close-up of a computer screen

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Figure 10: Successful connection

6. It is recommended to go to an open place and wait for a few minutes. We would be able to see a fix/float status in ‘Fix Mode’ on the u-centre window as shown in figure 11.

A screenshot of a computer

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Figure 11: U centre window with fix/float status.

**Instructions for setting up an Emlid Reach RTK receiver with the MA NTRIP broadcast network.**

1. One person in the group should register for an MaCORS account at

<https://www.mass.gov/how-to/the-massachusetts-continuously-operating-reference-station-network-macors> and subscribe for RTK corrections under “shop” once you have the account (it’s free)

2. Get the Emlid Flow app for a mobile device (Google Play for Android, Apple Store for iOS)

Once you have an MaCORS account that you can log into…

3. Connect the Emlid RTK receiver to the antenna, then connect to your laptop through the micro USB cable)

A picture containing text

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4. Find the SSID from the Emlid hotspot (will be Reach:xx:xx) in your laptop’s WiFi settings. Connect to this network. You may wish to do this NOT in the classroom so that you don’t accidentally connect to someone else’s receiver.

5. Set up a hotspot on your phone with an easy to remember SSID and password.

6. In a browser, connect your laptop to the Emlid by going to <http://192.168.42.1> in a browser. The password is emlidreach. You should get the Emlid’s settings, change the WiFi to your hotspot.

Do not connect the Emlid to NUWave or any other Northeastern Network. Please do not change the password.

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**Do not connect the Emlid to NUWave or any other Northeastern Network. Please do not change the password.**

7. In your MaCORS account page, change your NTRIP username and password to something easy to type/remember

Graphical user interface, text, application, email

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9. Open the Emlid Flow app on your phone and connect to the receiver. This will only work if you’re connected from Emlid receiver to phone via the *phone’s* hotspot.

10. Change your correction input to NTRIP, use macorsrtk.massdot.state.ma.us as the NTRIP Caster host name and 10000 as the port. Use your MaCORS NTRIP user/pass for user and password, select a mount point that begins with RTCM3 from the list.

11. After one to several minutes, your phone screen should look something like this. Ideally, you should get an RTK fix (I show float). If you have no solution or single, wait a little longer, move to a better area, or try to reconnect everything if you are in a clear area and it has been more than 5 minutes.

Graphical user interface, application

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12. You are done with Emlid Reach setup and can proceed with data collection as described in the lab! Your receiver should write GNGGA strings to the serial port just as the GPS puck did in Lab 1.