An Introduction to RTKLIB open source GNSS processing software

Ryan Ruddick and John Dawson
Overview

• Introduction and Installation of RTKLIB.

Post-Processing Tutorial

• Observation Data Quality.
• Single Point Post-Processing.
• Precise Post-Positioning.
What is RTKLIB?

- An open source package for GNSS Positioning.
- Developed by Mr Tomoji Takasu of the Tokyo University of Marine Science and Technology.

- Support for multi-GNSS.
- Positioning modes for both real-time and post-processing.
- Supports standard formats and protocols.
- GUI and CUI Apps on Windows and CUI Apps on Linux.

- Freely distributed from [www.rtklib.com](http://www.rtklib.com) under a BSD license.
Potential Uses of RTKLIB
Installation of RTKLIB

• The current release is v2.4.3 (*rtklib_2.4.3.zip*)

• Copy file from provided thumb-drive or from github and unzip to a directory (eg. *Program Files*).

• Double click the *rtklib_2.4.3* directory and you will find:
  
  *bin*\    *(contains the executables)*
  
  *doc*\    *(contains the user manual)*

• To begin, double click the executable *rtklaunch.exe*. 
RTKLIB Apps

- STRSRV
- RTKCONV
- RTKNAVII
- RTKPOST
- RTKLAUNCH
- NTRIP Browser
- RTKPLLOT
Post-Processing Tutorial
Example Data

- Niue Tide Gauge
- 24 hours static observation
- GPS L1+L2

- niut0880.16o
- niut0880.16n
Observation Data Quality (RTKPLOT) (1)

RTKPLOT can be used to assess the quality of RINEX observation data and to assist in planning the ideal time to undertake a GNSS occupation.

Visual Analysis Includes:

• Satellite Availability
• Dilution of Precision (DOP)
• Signal to Noise Ratio (SNR)
• Multipath

A QC summary file is also available through a TEQC analysis.
Observation Data Quality (RTKPLOT) (2)
Observation Data Quality (RTKPLOT) (3)

Satellite Availability

SNR and Multipath (L1)
RTKPOST

RTKPOST is a post-processing application that computes positioning solutions by various modes including single-point, DGNSS, kinematic, static and PPP.

Single-Point Positioning Example

• Standard positioning mode using L1 Pseudorange only.

Objectives

• Introduce GNSS post-processing using RTKPOST.
• Plot the results using RTKPLOT.
Single Point Positioning – Options (RTKPOST)

- Import data and execute processing.
Single Point Positioning – Plotting Results (RTKPLOT)

- RTKPLOT can be used to display the solution per epoch.
## Standard Positioning v Precise Positioning

<table>
<thead>
<tr>
<th></th>
<th>Standard Positioning (code based)</th>
<th>Precise Positioning (carrier based)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observables</td>
<td>Pseudorange</td>
<td>Carrier + Pseudorange</td>
</tr>
<tr>
<td>Receiver Noise</td>
<td>30 cm</td>
<td>3 mm</td>
</tr>
<tr>
<td>Multipath</td>
<td>30 cm to 30 m</td>
<td>1 to 3 cm</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Discontinuity</td>
<td>No Slip</td>
<td>Cycle-Slip</td>
</tr>
<tr>
<td>Ambiguity</td>
<td>-</td>
<td>Estimated /Resolved</td>
</tr>
<tr>
<td>Receiver</td>
<td>Low Cost (Single Freq.)</td>
<td>Expensive (Dual Freq.)</td>
</tr>
<tr>
<td>Accuracy (RMS)</td>
<td>3 m (Horizontal)</td>
<td>5 mm (Horizontal)</td>
</tr>
<tr>
<td></td>
<td>5 m (Vertical)</td>
<td>10 mm (Vertical)</td>
</tr>
<tr>
<td>Application</td>
<td>Navigation, Timing ...</td>
<td>Surveying, Mapping ...</td>
</tr>
</tbody>
</table>

Table adapted from GNSS Precise Positioning with RTKLIB: Part 2, IPNT-J Seminar, Tokyo, April 26, 2011
Static Post-Processing (RTKPOST)

The static positioning mode processes a baseline between a known reference point (base) and a static antenna (rover).

Requires:

- Reference station data with reliable coordinates.
- Precise satellite orbits.
- Antenna information.

Objectives

- Configure RTKPOST for precise positioning.
- Find reference station data and coordinates from a global data centre.
- Download precise satellite orbits (RTKGET).
Reference Station Data

http://www.igs.org
Precise Satellite Orbits

<table>
<thead>
<tr>
<th>Type</th>
<th>Accuracy</th>
<th>Latency</th>
<th>Updates</th>
<th>Sample Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast</td>
<td>~100 cm</td>
<td>Real-time</td>
<td>-</td>
<td>daily</td>
</tr>
<tr>
<td>Ultra-Rapid (predicted half)</td>
<td>~5 cm</td>
<td>Real-time</td>
<td>at 03,09,15,21 UTC</td>
<td>15 min</td>
</tr>
<tr>
<td>Ultra-Rapid (observed half)</td>
<td>~3 cm</td>
<td>3 – 9 hours</td>
<td>at 03,09,15,21 UTC</td>
<td>15 min</td>
</tr>
<tr>
<td>Rapid</td>
<td>~2.5 cm</td>
<td>17 – 41 hours</td>
<td>at 17 UTC daily</td>
<td>15 min</td>
</tr>
<tr>
<td>Final</td>
<td>~2.5 cm</td>
<td>12 – 18 days</td>
<td>every Thursday</td>
<td>15 min</td>
</tr>
</tbody>
</table>

RTKGET

- Used to download IGS products, such as satellite and clock information as well as observation data.
Antenna Phase Centre Variation Models

- The antenna PC is the part of the antenna that receives the signal.
- Due to manufacturing differences and satellite geometry PC’s vary between antennas.
- Robotic antenna calibrations are available that provide models to correct for the PC variation.
- [ftp.igs.org/pub/station/general/igs08.atx](ftp.igs.org/pub/station/general/igs08.atx)
Static Post-Processing – Options (RTKPOST)

Setting 1

1. Base Data
2. Precise Orbit
3. Solution File
Static Post-Processing - Options (RTKPOST)

**Setting 2**

**Options**
- Integer Ambiguity Res (GPS/GLO/BDs): ON
- Min Ratio to Fix Ambiguity: 3
- Min Confidence / Max PCD to Fix Amb: 0.9999
- Min Lock / Elevation (°) to Fix Amb: 0
- Min Fix / Elevation (°) to Hold Amb: 0
- Outage to Reset Amb / Slip Thres (s): 5
- Max Age of Diff (s) / Sync Solution: 20.0
- Reject Threshold of i(DOP)novation (m): 30.0
- Max # of AR Iter / # of Filter Iter: 3
- Residual Length Consistency (m): 0.000

**Output**
- Solution Format: Lot/Lon/height
- Output Header/Processing Options: ON
- Time Format / # of Decimals: mm:ss:SSS, CPST: 3
- Latitude / Longitude Format: ddd mm ss s
- Field Separator: 
- Delim/Height: WGS84, Ellipsoid
- Good Model: Elevation
- Solution for Static Mode: Single
- MMA Interval (s): RPC: GGA, EIA/DPY
- Output Solution Status / Debug Trace: OFF

**Positions**
- Rover: Lot/Lon/Height (deg/m): 0.000000000, 0.000000000, -1395367.6285
- Base Station: Lot/Lon/Height (deg/m): 0.000000000, 0.000000000, 0.000000000

**Files**
- Satellite/Receiver Antenna PCV File: ANTEXINGS PCV
- E (user) Data File
- DBS Data File
- EOP Data File
- OTL BLOCK File
- Ionosphere Data File

*Sponsors: Land Information New Zealand, Leica Geosystems, Trimble*
Comparison of Solutions (RTKPLOT)

<table>
<thead>
<tr>
<th>Point</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIUT (RTKLIB)</td>
<td>-19°03’10.79414” ± 1 mm</td>
<td>-169°55’14.34912” ± 3 mm</td>
<td>37.6594 m ± 3 mm</td>
</tr>
<tr>
<td>NIUT (AUSPOS)</td>
<td>-19°03’10.79419” ± 6 mm</td>
<td>-169°55’14.34923” ± 5 mm</td>
<td>37.6515 m ± 11 mm</td>
</tr>
<tr>
<td>ΔN 3 mm</td>
<td>ΔE 2 mm</td>
<td>ΔU 8 mm</td>
<td></td>
</tr>
</tbody>
</table>
Questions