Introduction to GNSS Base-Station

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Introduction

• GPS or GNSS observation has many types of errors. Due to these errors, the accuracy of a GPS receiver is limited. Currently about 10m accuracy is possible with Single Observation.

• However, some of these errors can be removed and reduced by using proper observation techniques to provide few millimeter accuracy. This can be done by using a Base-Station within a limited base-length from the Rover (user) receiver.

• In the next few slides, we will see types of errors and how they can be removed.
What is a Base-Station?

- A Base-Station is a station where a GNSS receiver is installed at a known location.
  - Also called Reference Station
  - CORS (Continuously Operating Reference Station)
- The location is pre-surveyed by either traditional methods or by GNSS observation for multiple days.
- The Base-station then provides error data for every observation compared to its known location.
Accuracy vs. Precision

• **Accuracy**
  • Capable of providing a correct measurement
  • Measurement is compared with true value
  • Affected by systematic error

• **Precision**
  • Capable of providing repeatable and reliable measurement
  • Statistical analysis of measurement provides the precision
  • Measure of random error
  • Systematic error has no effect

Neither Precise nor Accurate  Precise but Not Accurate  Accurate but Not Precise  Precise and Accurate
How accurate is GPS Position?

- **SPP (Single Point Position):** 50 cm grid
- **DGPS (Differential GPS):** 50 cm grid
- **RTK (Real Time Kinematic):** 5 cm grid
Errors in GPS Observation (L1C/A Signal)

<table>
<thead>
<tr>
<th>Error Sources</th>
<th>One-Sigma Error , m</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>DGPS</td>
</tr>
<tr>
<td>Satellite Orbit</td>
<td>2.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Satellite Clock</td>
<td>2.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Ionosphere Error</td>
<td>4.0</td>
<td>0.4</td>
</tr>
<tr>
<td>Troposphere Error</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Multipath</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Receiver Circuits</td>
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<td>0.5</td>
</tr>
</tbody>
</table>

If we can remove common errors, position accuracy can be increased. Common errors are: Satellite Orbit Errors, Clock Errors and Atmospheric Errors (within few km)

Table Source: http://www.edu-observatory.org/gps/gps_accuracy.html#Multipath
How to Remove the Errors?

• Averaging of Repeated Observation
• Modeling of Phenomena that Causes Errors
• Differential Corrections
  • DGPS, SBAS, GBAS
    • Single frequency observation is OK
    • Code Observation
  • RTK
    • Normally multi-frequency observations
    • Single frequency RTK is also performed for smaller base-length
    • Code and Carrier Observation
• PPP
  • Precise Point Positioning
Principle of Differential Correction

Base-Station
Antenna is installed at a known-position

For RTK, both rover and base receivers need to use the same satellites

Send Correction Data to Rover
For Real-Time Position

Rover
User in the Field
(Either fixed or moving)
Principle of QZSS MADOCA / CLAS Service

Correction Data:
- **Satellite Orbit Error** of GPS and Other Satellites
- **Satellite Clock Error** of GPS and Other Satellites
Which Method: DGPS, SBAS, RTK, PPP?

http://www.novatel.com/an-introduction-to-gnss/chapter-5-resolving-errors/