Real-time Precise Point Positioning with Ambiguity Resolution for Geosciences

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Precise Point Positioning

- Precise positioning at only a single station when precise satellite orbits and clocks are provided
  - Absolute positioning based on a sparse network
  - Homogeneous positioning accuracy on a global scale

- Current applications
  - Crustal deformation monitoring
  - Meteorology
  - Orbit determination of low Earth orbiters
  - Engineering surveying
  - Environmental applications
Precise Point Positioning

• Normal positioning accuracy
  • mm level using daily data in static PPP
  • dm level using hourly data in static PPP
  • dm level in real-time kinematic PPP

• Integer ambiguity resolution is ignored in PPP by most researchers in this field

• Integer ambiguity resolution has the potential to improve the positioning accuracy significantly
Ambiguity resolution in PPP

Differencing between satellites to remove common errors in receivers

However, no differencing to remove common errors in satellites

Determine the common errors in satellites using a network of stations
Ambiguity resolution in real-time PPP

Real-time observations & predicted satellite orbits

Network solution
- Compute wide-lane uncalibrated hardware delays
- Compute satellite clocks
- Compute narrow-lane uncalibrated hardware delays

Single station solution
- Wide-lane uncalibrated hardware delays
- Real-time satellite clocks
- Narrow-lane uncalibrated hardware delays

Positions, zenith tropospheric delays etc.

Wide-lane ambiguity resolution

No link between WL and NL???
A prototype of real-time PPP system
Continental real-time PPP

- 1-Hz data from EUREF-IP project on Day 188 in 2008
- 25 reference stations are selected with inter-station distances larger than 250 km
- 6 stations are chosen as ‘rover’ stations to conduct real-time PPP with ambiguity resolution
Orbit and clock accuracy in real time
final IGS products as truth
Kinematic positioning at station BSCN
Positioning accuracy improvement
L’Aquila Earthquake on April 6th

<table>
<thead>
<tr>
<th>Earthquake details (from USGS)</th>
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<tbody>
<tr>
<td>Magnitude</td>
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<td>Date-time</td>
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<tr>
<td>Location</td>
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<tr>
<td>Depth</td>
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<td>Region</td>
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</table>
| Distances                                         | 75 km (45 miles) W of Pescara, Italy  
85 km (55 miles) NE of Rome, Italy  
115 km (75 miles) SE of Perugia, Italy  
145 km (90 miles) S of Ancona, Italy |
Data & models

• 18 1-Hz stations from EUREF-IP project
• 3 1-Hz stations near the epicenter
• IGU predicted satellite orbits
• Zenith troposphere delays are estimated as a constant parameter within each hour
Location of 1 Hz stations
Station displacement at UNPG & UNTR
Station displacement at MOSE

Day 096

Day 095
Displacement during the Earthquake
Conclusions

• Integer ambiguity resolution contributes significantly to the improvement of the positioning accuracy in real-time PPP

• A prototype real-time PPP system for crustal deformation can be built

• Real-time PPP with ambiguity resolution has successfully determined the displacement caused by Earthquake in L’Aquila
Thank you for your attention!

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