Positioning in Environments where Standard GPS Fails

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Outlines

• Introduction
• Assisted-GPS and high sensitivity GPS
• WiFi positioning
• Mobile phone positioning
• Integrating WiFi with other technologies
• Concluding remarks
Introduction

- The development of GPS/GNSS has revolutionised positioning, navigation and timing (PNT).
- The major shortcoming of GNSS is that it fails to operate where it is impossible or difficult to receive the satellite signals.
- In some difficult signal environments “high sensitivity” GPS/GNSS and/or A-GPS/A-GNSS can be used to improve PNT availability.
- In environments where GPS/GNSS completely fails alternative positioning technologies based on WiFi signals, and others, can be used.

High Sensitivity GPS

- One way to improve the “sensitivity” is to increase the integration time, within the receiver, of the GPS signal - e.g. by increasing the number of the correlators.
- For example, the SiRF-III receiver baseband chip has more than 200,000 correlators; ublox-5 chip has more than a million correlators.
High Sensitivity GPS Test

- Error is large
- TTFF is still too long
- Fail rate is too high
- But better than nothing?

<table>
<thead>
<tr>
<th>Test position</th>
<th>Horizontal Error (m) Mean</th>
<th>STD</th>
<th>Vertical Error (m) Mean</th>
<th>STD</th>
<th>TTFF (s) Mean</th>
<th>STD</th>
<th>No. of Sats Mean</th>
<th>STD</th>
<th>Failed tests (out of 100)</th>
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<td>75.7</td>
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<td>104.7</td>
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<tr>
<td>4</td>
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<td>22.0</td>
<td>50.5</td>
<td>49.7</td>
<td>53.0</td>
<td>17.1</td>
<td>4.7</td>
<td>0.9</td>
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</table>

A-GPS

- To reduce the time taken for signal acquisition, the A-GPS technique can be used.
- Most useful set of assistance data:
  - receiver position estimation
  - approximate clock time
  - almanac (or ephemeris)
- Essential to perform A-GPS
  - a wireless data link
  - a reference receiver
  - a processing server
SUPL Test

- Secure User Plane Location is an emerging standard developed by the Open Mobile Alliance.
- The SUPL standard allows a device to connect to a location server to request its location using the TCP/IP protocol.
- Two modes of A-GPS: mobile station assisted (MSA) and mobile station based (MSB).
- Compared to standalone high sensitivity GPS, shorter TTFF, no failed attempts (use MSB test as an example).

<table>
<thead>
<tr>
<th>Test position</th>
<th>Horizontal Error (m)</th>
<th>Vertical Error (m)</th>
<th>TTFF (s)</th>
<th>No. of Satellites (Mean)</th>
<th>Failed tests (out of 100)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Mean</td>
<td>STD</td>
<td>Mean</td>
<td>STD</td>
<td>Mean</td>
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Dynamic Test

- No large difference found between A-GPS and standalone high sensitivity GPS test results when positioning accuracy is considered.
Dynamic Test (cont.)

- Big differences were found when the TTFFs are compared: average difference in TTFF was 56.7s

Open Source GNSS Reference Server

- The OSGRS is an open source Java application that provides data for Assisted-GPS/GNSS clients
- It is cross-platform and provides client applications with current, relevant and specific assistance data
- The OSGRS utilises the GNSS Reference Interface Protocol (GRIP)
WiFi Positioning

- WiFi is an attractive alternative positioning technology:
  - widely deployed WiFi access points (AP)
  - growing number of WiFi-enabled mobile devices on the market
- Two approaches utilising WiFi signals for positioning:
  - Trilateration
  - Fingerprinting

Test of Commercial WiFi Positioning Systems

- Indoor test

Ekahau (left) and Skyhook (right) indoor UNSW test results
Outdoor Test

<table>
<thead>
<tr>
<th></th>
<th>Test point 1</th>
<th>Test point 2</th>
<th>Test point 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average distance error (m)</td>
<td>14.3</td>
<td>20.5</td>
<td>40.3</td>
</tr>
<tr>
<td>Standard deviation (m)</td>
<td>2.3</td>
<td>23.5</td>
<td>33.5</td>
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</tbody>
</table>

Ekahau outdoor test results for the Sydney CBD

Skyhook outdoor test results for the Sydney CBD

Mobile Phone Positioning

- Using the mobile network for positioning has been widely used for location based services.
- These techniques suffer from non-line-of-sight (NLOS) error.
- Wireless signal map matching approach was also proposed – the key aspect is that a large number of wireless signals are map-matched using statistical characteristics.

Cumulative error distribution before and after applying wireless signal map matching
Integrating WiFi with other technologies

- No technology appears to be a clear “winner” for ubiquitous positioning and navigation.
- In open sky conditions GPS is the best choice, but indoor using WiFi can deliver much better performance.
- In urban canyon areas, two satellites can be used to improve the performance of WiFi positioning.
- WiFi can also be integrated with an inertial navigation system (INS).
- Barometer, digital compass and RFID are other technologies that can also be integrated into a single system.

Concluding Remarks

- “Ubiquitous positioning” is the “holy grail”.
- In GPS/GNSS friendly environments, the GPS/GNSS receiver can meet the positioning requirements.
- In difficult GPS/GNSS environments, an augmentation, or even alternative, technology is required.
- There is no single “winner”, and integration of several different technologies is the way of the future.