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.

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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.

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High Sensitivity GPS Test

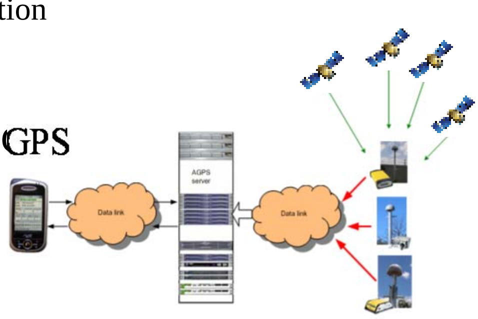
- •Error is large
- •TTFF is still too long
- •Fail rate is too high
- •But better than nothing?

Test position	Horizontal Error (m)		Vertical Error (m)		TTFF (s)		No. of Sats		Failed tests (out of 100)
	Mean	STD	Mean	STD	Mean	STD	Mean	STD	
1	36.7	0	75.7	0	115	0	3	0	99
2	20.6	13.6	72.9	40.0	59.6	6.6	4	0	95
3	99.0	75.7	68.1	4.3	104.7	21.7	3.7	0.6	97
4	20.8	22.0	50.5	49.7	53.0	17.1	4.7	0.9	26

SSIS

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



SSIS

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)

Test position	Horizontal Error (m)		Vertical Error (m)		TTFF (s)		No. of Satellites (Mean)	Failed tests (out of 100)
	Mean	STD	Mean	STD	Mean	STD		
1	23.4	20.5	37.5	34.3	23.7	8.2	6.2	0
2	38.8	34.1	68.4	50.3	22.1	10.0	6.3	0
3	69.9	44.1	69.4	53.5	20.2	7.5	5.5	0
4	21.3	17.6	39.6	39.9	10.3	1.8	7.4	0

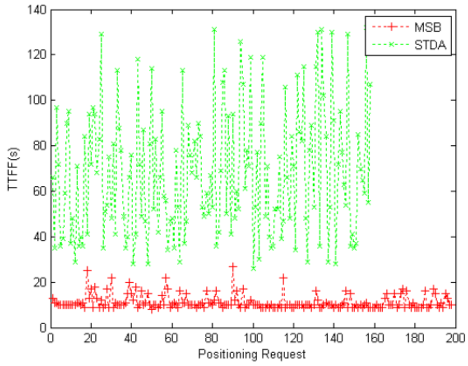
Dynamic Test

- No large difference found between A-GPS and standalone high sensitivity GPS test results when positioning accuracy is considered

A-GPS (green cross) and standalone high sensitivity GPS (red circle) positioning results

Dynamic Test (cont.)

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



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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)

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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

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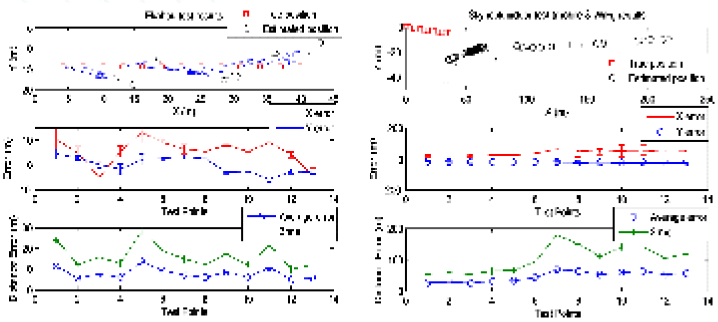
Test of Commercial WiFi Positioning Systems

- Indoor test



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

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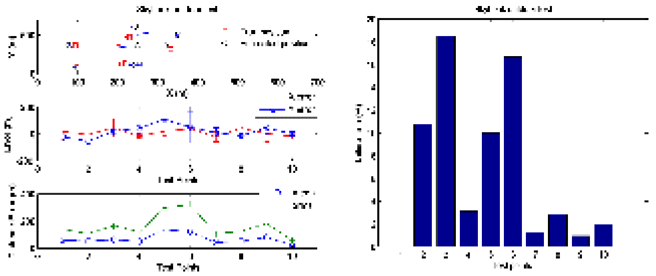
Outdoor Test

	Test point 1	Test point 2	Test point 3
Average distance error (m)	14.3	20.5	40.3
Standard deviation (m)	2.3	23.5	33.5

Ekahau outdoor test results for the Sydney CBD



Skyhook outdoor test results for the Sydney CBD

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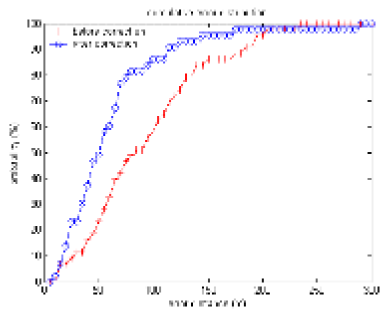
Mobile Phone Positioning

- 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

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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.

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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.

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