

Ubiquitous Positioning: A Pipe Dream or Reality?

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What is Ubiquitous Positioning?

Multi-sensor, low-cost and robust positioning

- Based on single or multiple users
- Different types of platforms and sensors
- Autonomous or cooperative navigation

Seamless transition

- Different sensors
- Different platforms
- Different algorithms
- When transitioning between different environments

Plug-and-play concept

Continuous positioning across all environments

- Open areas, partially obstructed, indoor

New technology

More GNSS satellites

More GNSS signals

Communications

WiFi / RFID

UWB, Sparse Band

Digital broadcasting

Pseudolites, Localites

Smaller, cheaper inertial sensors

Digital mapping (outdoor & indoor)

More processing power

Drives new applications



New applications

Seamless indoor-outdoor
personal navigation

Intelligent Transport Systems

Rail signalling & control

Precision aircraft landing

Ships in harbours

Location-dependent billing

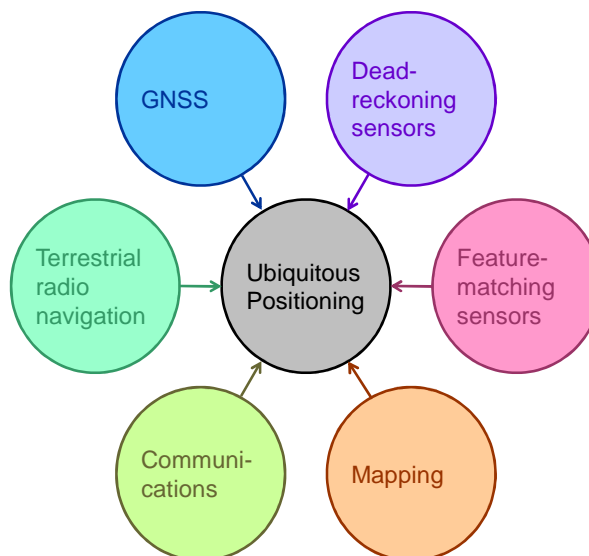
Virtual security fences

Tracking people/animals/assets

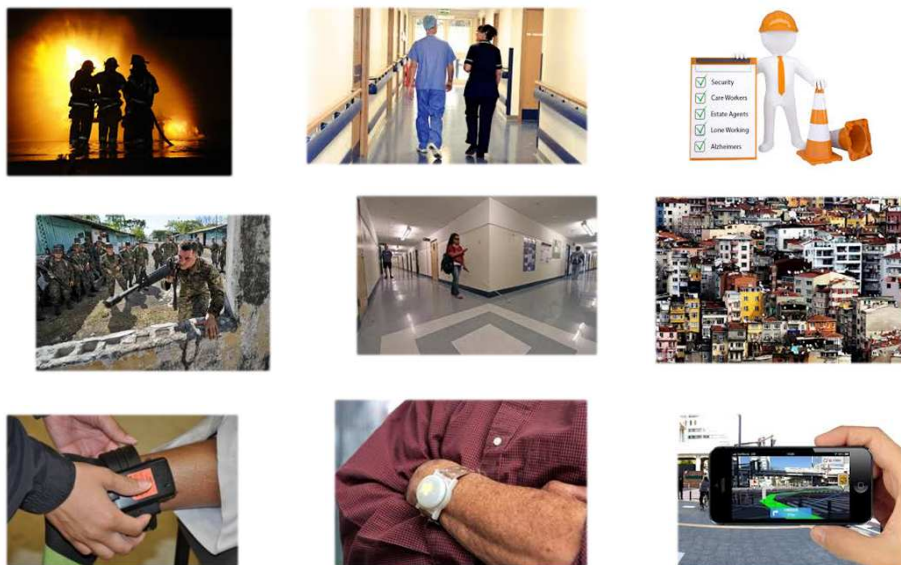
Social inclusion

Creates new challenges

With thanks to Dr Paul Groves, UCL

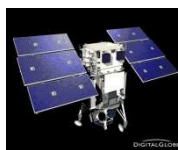


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Space



Air

Fixed wing
Helicopter
UAV/UAS



Land

Indoor/outdoor
Vehicle
Autonomous
Pedestrians



Water

Ship
Autonomous
Man-portable



With thanks to Prof Dorota Grejner-Bzrezinska, OSU

Space

Air

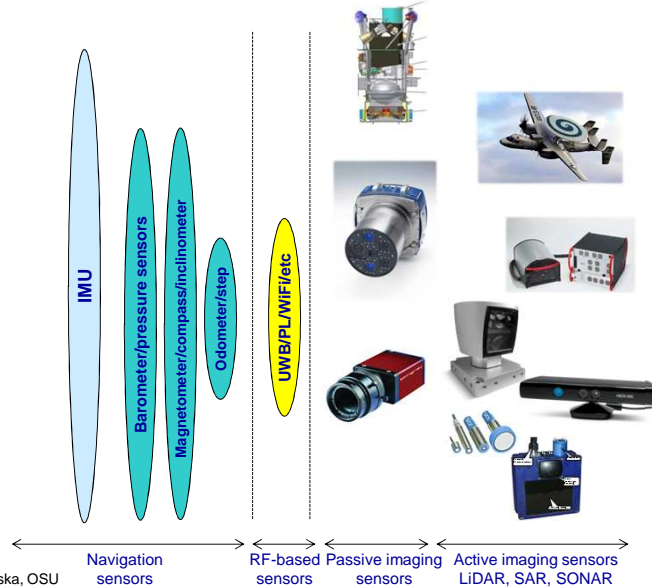
Fixed wing
Helicopter
UAV/UAS

Land

Indoor/outdoor
Vehicle
Autonomous
Pedestrians

Water

Ship
Autonomous
Man-portable



Dedicated Infrastructure

RFID or proximity devices
Ultra Wide Band
Static (building) or mobile (eg fire-tenders)
Airports, rail stations, shopping malls, universities



Ad hoc Infrastructure

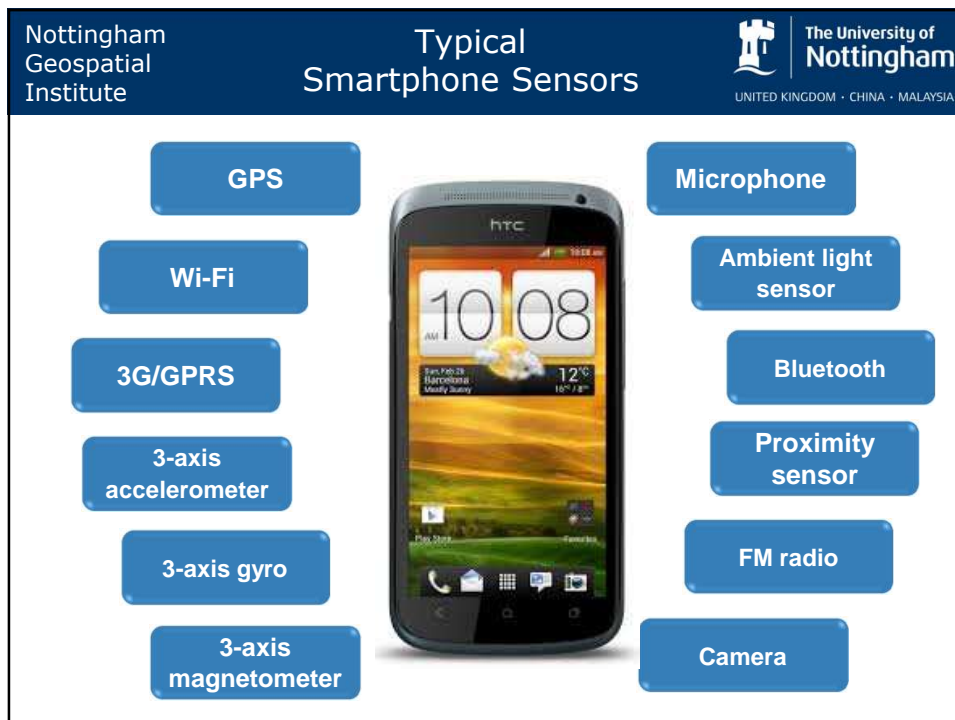
WiFi access points
Signals of opportunity
Images, building information or plans



No Infrastructure


No existing infrastructure or destroyed
Only using sensors carried by the user
Autonomous or collaborative



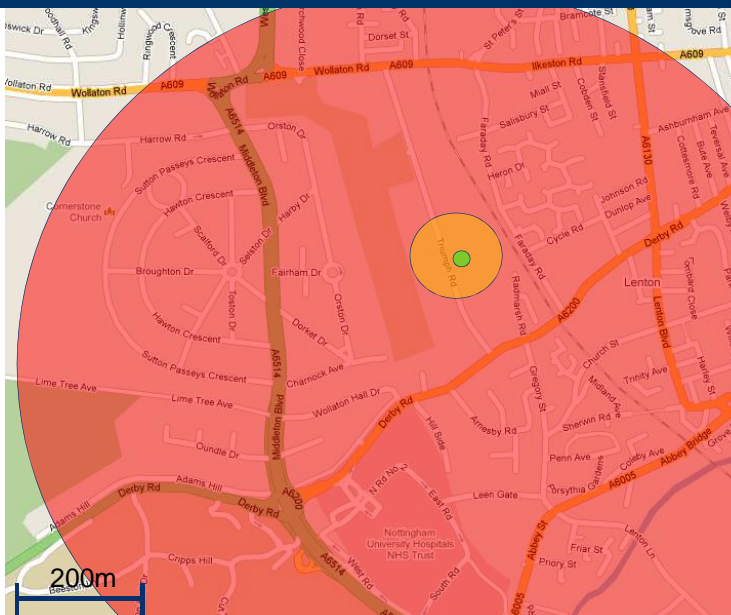


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Current Positioning Methods


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- Cell-ID
- Wi-Fi
- GPS



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Wi-Fi Fingerprinting


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GPS

Wi-Fi

3G/GPRS

3-axis accelerometer

3-axis gyro

3-axis magnetometer



Microphone

Ambient light sensor

Bluetooth

Proximity sensor

FM radio

Camera

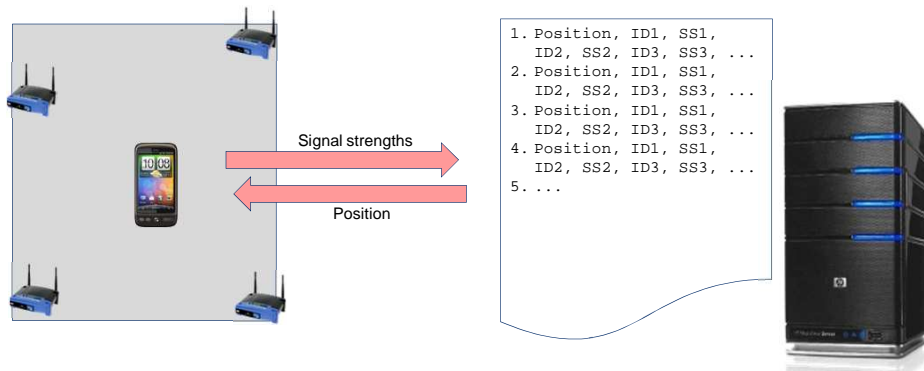
Measure signal strengths to all Access Points in view

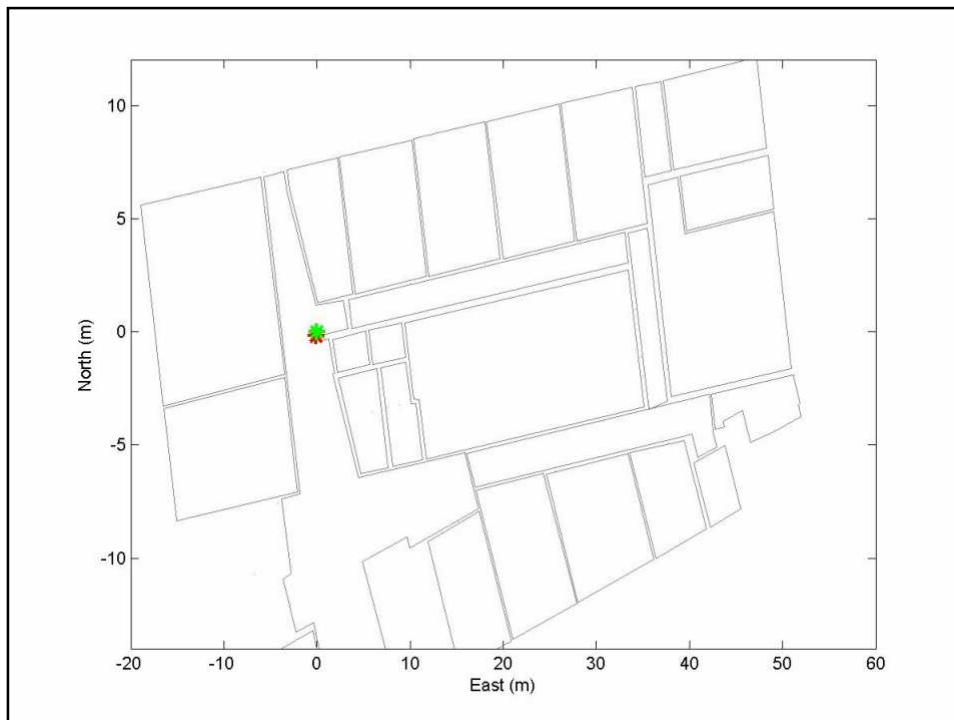
Match measured signal strengths to database

Requires database of:

Location

signal strengths to all Access Points (APs) in view





Works better indoors where walls/ceilings/furniture will attenuate signals the most

Accuracy comes from signal strength varying spatially

Advanced algorithms

Particle filtering

How do we build databases?

Skyhook use fleet of vehicles with GPS (tribe sourcing)

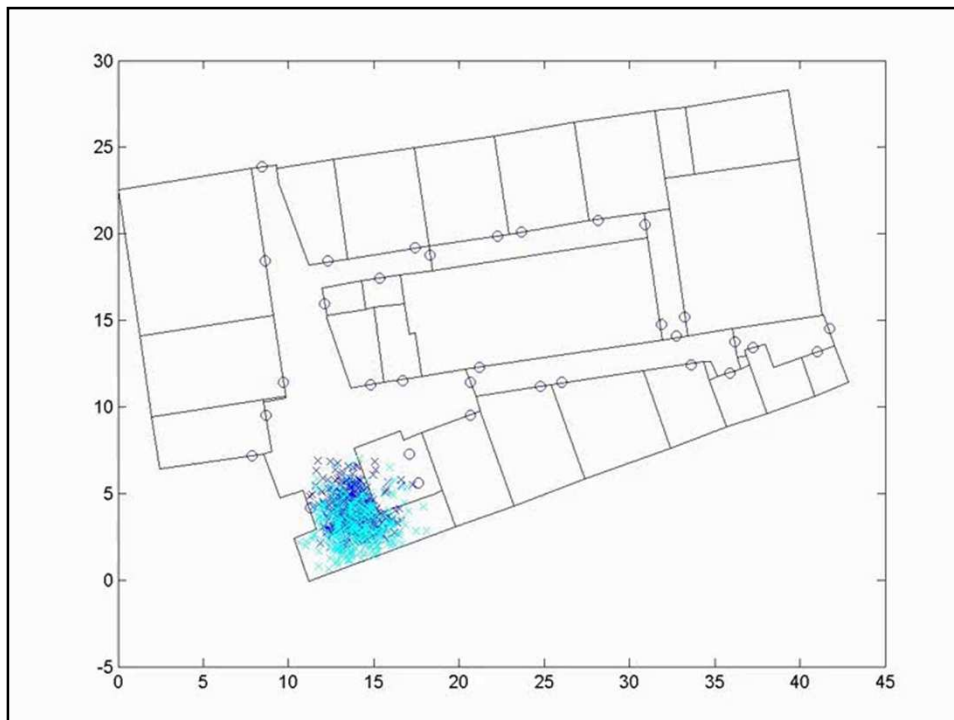
Google use crowd sourcing

But what about inside where GPS isn't working?

Slow database generation using building plans

Scalability?

How do we keep the database up-to-date?



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Inertial Navigation

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GPS

Wi-Fi

3G/GPRS

3-axis
accelerometer

3-axis gyro

3-axis
magnetometer

Microphone

Ambient light
sensor

Bluetooth

Proximity
sensor

FM radio

Camera

3 gyros and 3 accelerometers

Orientation from integrating gyro output

Displacement from:

- Rotate measurements to Earth frame (using gyros),
- Removing gravity and ...

- Double integrating accelerations

MEMS are getting better

- Cheaper (higher volumes - Wii, smartphones)

- Better manufacturing

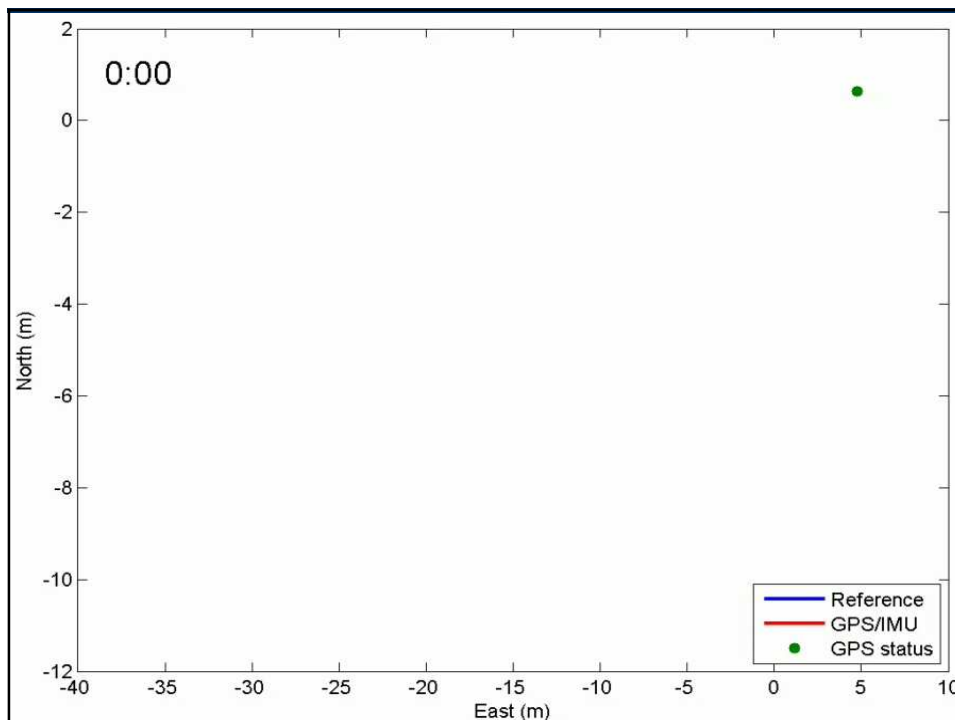
- Calibration

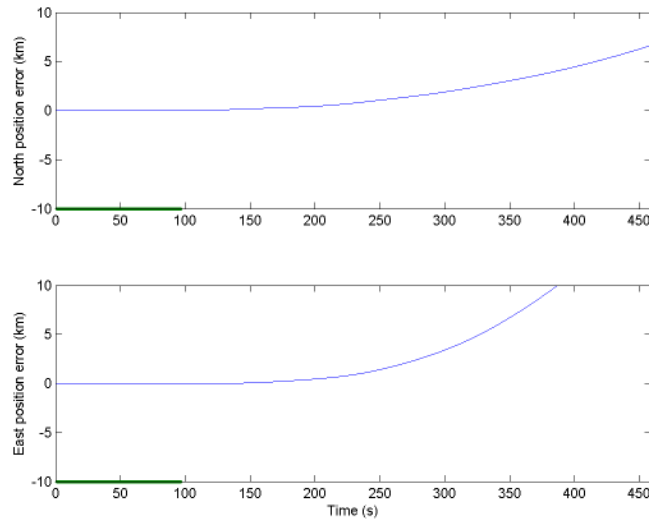
Successful results usually from

- Good sensors

- Integration with GPS, magnetometers,
zero velocity updates

- Step detection algorithms



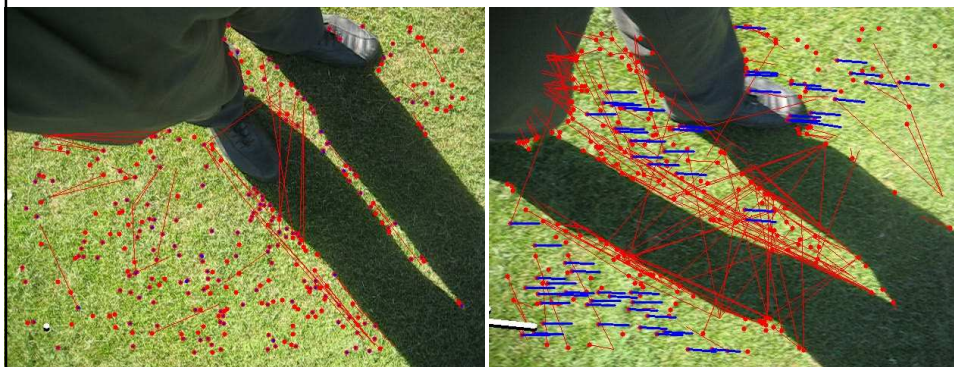


Time (s)	Horiz error (m)
60	231
120	891
180	2781
240	6297
300	11819
360	19287



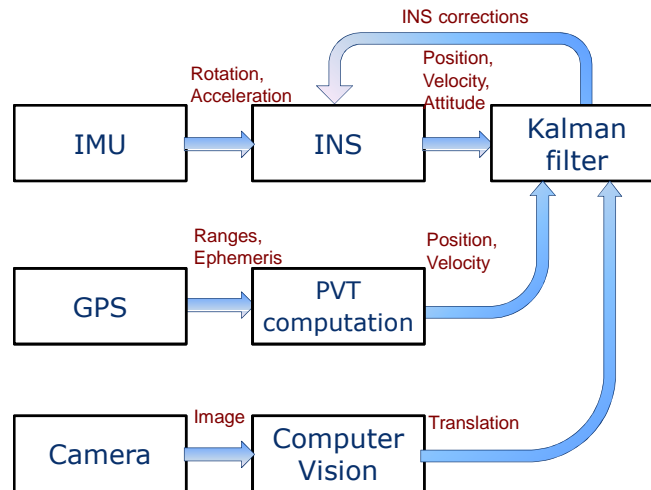


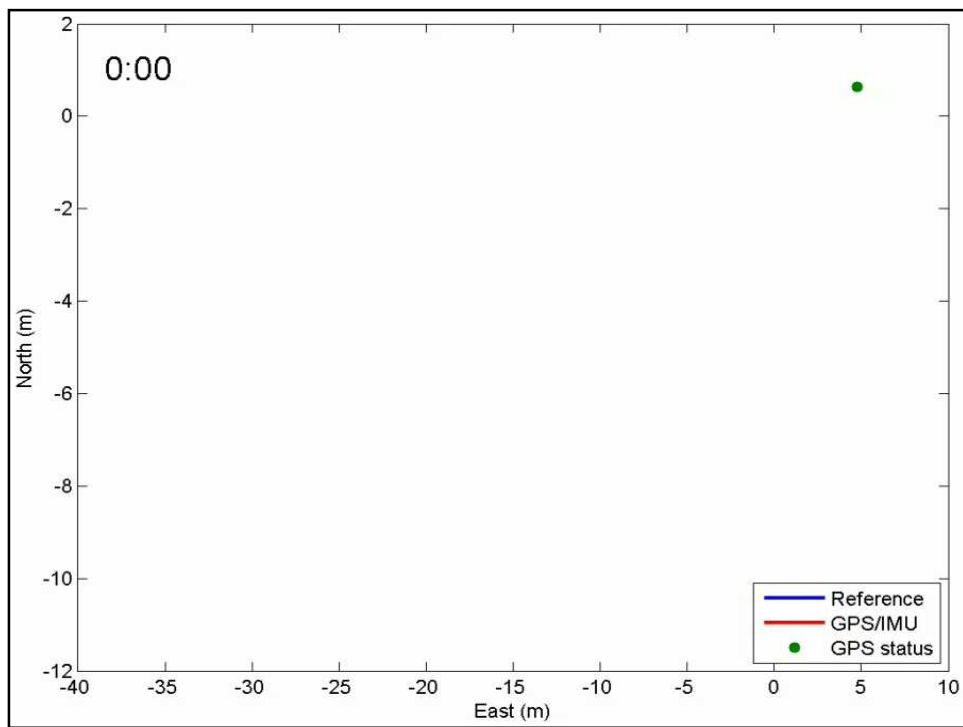
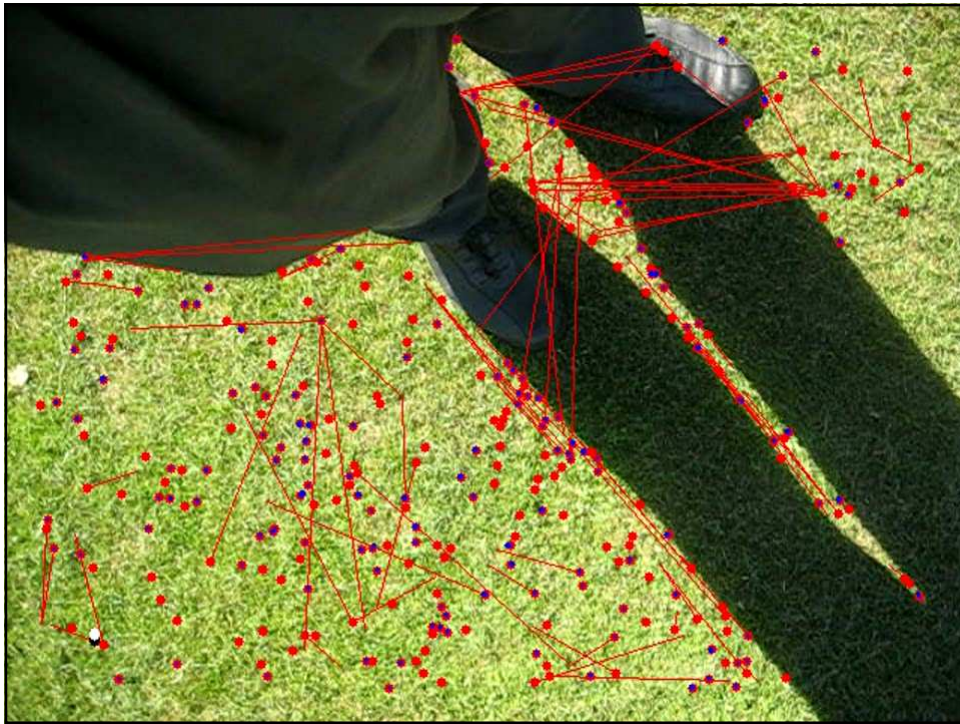
Examples...

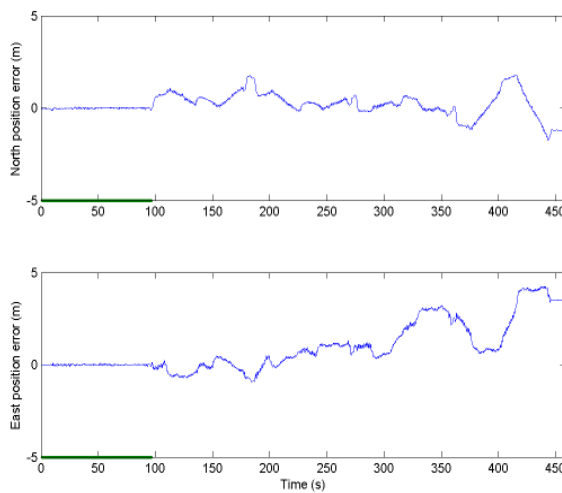


Blue (inlier correspondences)

Red (outlier correspondences)







Time (s)	Horiz error (m)
60	0.4
120	0.4
180	0.9
240	3.0
300	0.9
360	3.7

Advantages

- Good position accuracy
- Makes use of sensors already on smartphones
- Handheld
- Works with or without GPS

Disadvantages

- Needs to be initialised e.g. with GPS
- Problems in low light conditions
- Computationally expensive

High accuracy indoor positioning system

Foot mounted Inertial Measurement Unit (IMU)

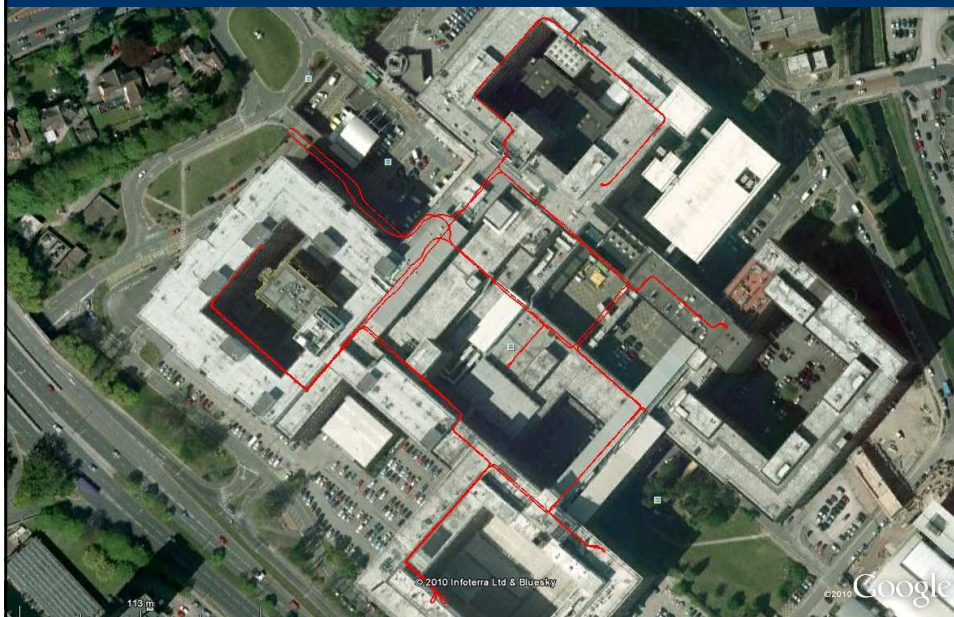
Zero velocity update, every step

IMU <\$2000

Requires initialisation on known point

Novel heading algorithm used to correct heading errors

Shown to consistently maintain <5m accuracy over 40 minutes



Joint between FIG WG 5.5 & IAG WG 4.1.1

Performance characterization of positioning
sensors and technologies for ubiquitous
positioning systems

Theoretical and practical evaluation of current
algorithms for measurement integration

Development of new measurement integration
algorithms

Joint Field Experiments

The Ohio State University, September 2010

The University of Nottingham, May 2012

www.ubpos.net



Positioning Sensor Fusion

Clear synergy between GNSS and INS
Focus has been on 'fixing' GNSS to provide continuity
Tailored blend of sensors for particular scenarios

A Changed Navigation Philosophy

Consider INS as the primary navigational sensor
Focus has to be on bounding the growth of INS error
Flexible and adaptive blend with other sensors
'Plug and Play'

Research Challenges

Flexible software architecture
Adaptive filtering / fusion of the data
Stochastic transition between different hybridisations

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