Overview of Current Indoor Navigation Techniques and Implementation Studies

FIG ww 2011 - Marrakech

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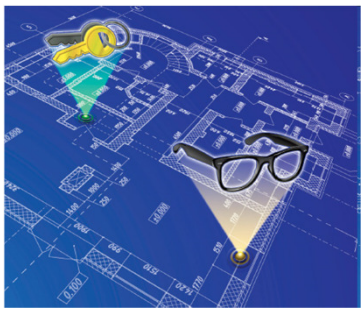
Agenda

- Motivation
- Systems and Sensors
- Algorithms
- Implementation
- Conclusion and Outlook

Motivation

- Increasing mobility
- Increasing mobile information technology

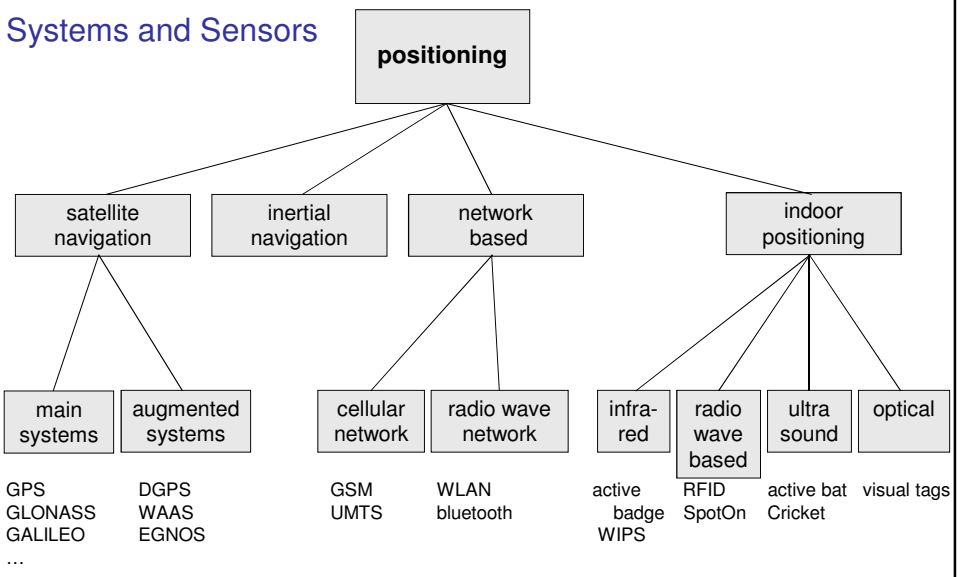
→ Navigation not only for cars



Large Plant

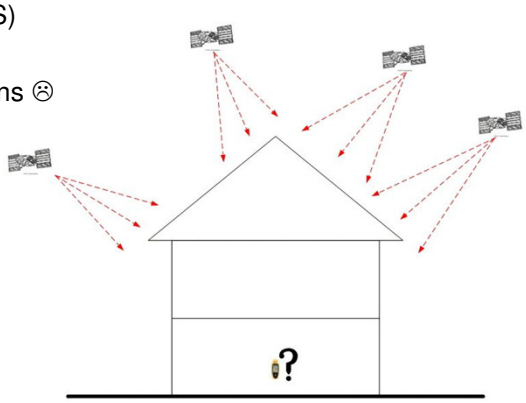
- How do I find Mr. Smith's office E 3.401 in building 42 ?

Systems and Sensors



Satellite-based technologies and cellular networks

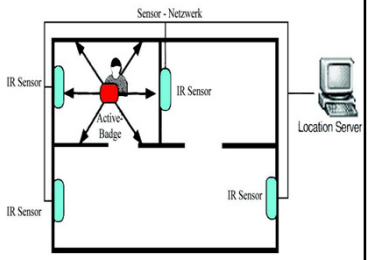
- Most outdoor positioning methods based on GPS or GSM solutions or in combination of these (aGPS)
- GPS indoor usage with restrictions ☹
- GSM isn't accurate enough ☹



Infrared systems

- Coverage: few meters / no penetration of walls
- active infrared badge emiting coded infrared light pulses
- every room has IR-beacon (receiver)

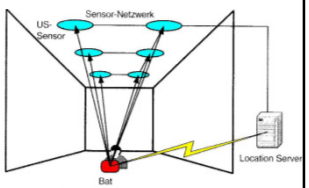
Proximity Detection

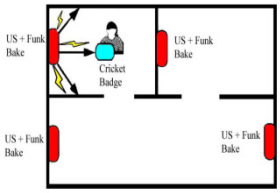


Ultra sound:

- Coverage a few meters / reflection at walls
- method 1 (Active Bat):
  - moving badge has ultra sound sender
  - Typical antenna displacement: 1,2 m
  - accuracy of position **10cm with trilateration**
- method 2 (Cricket):
  - moving badge has ultra sound receiver

  Proximity Detection





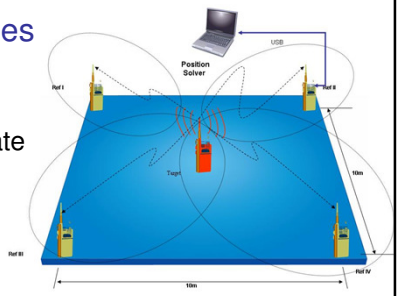
Quelle: http://knol.google.com/k/himmelsrichtungsinformationen-in-der-it-aufbereiten#

Electromagnetic wave based techniques

Ultra Wide Band (UWB)

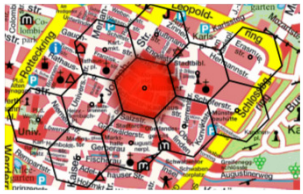
Main use: transfer huge data with high data rate

- Coverage 10 m to 50 m
- Accuracy 20 cm



WLAN

1. Cell of Origin (COO)
   (Proximity Detection)
2. Received Signal Strength (RSS)
   - Triangulation methods
   - fingerprinting (pattern)



Bluetooth

- minor coverage → Proximity Detection

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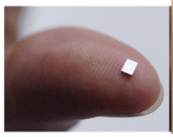
Radio Frequency Identification (RFID)

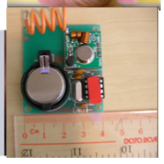
Contact free identification, localisation and data collection

active transponder (with battery)
• enhanced coverage up to 100m

passive transponder (gets energy from high frequency field)
• coverage between a few millimeter and 6 meter

Proximity Detection





Optical methods - Using inbuild camera

- **QR Code** (**Q**uick **R**esponse) Markers for orientation
Proximity Detection and additional information

- line detection supports orientation

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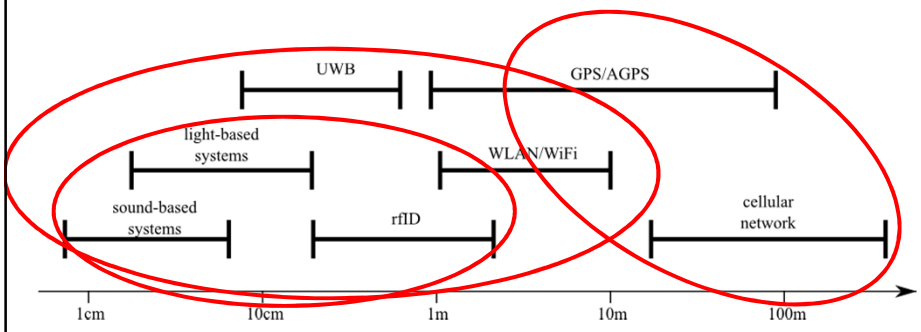


Disadvantage of most systems / sensors:

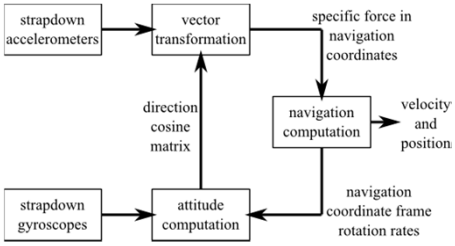
degraded accuracy indoor

high costs for infrastructure and proximity positioning

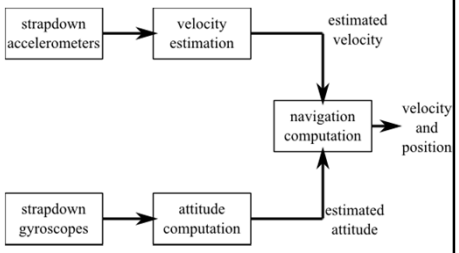
➔ Autonomous system for navigation: inertial navigation system

Inertial Navigation Algorithms

Strapdown algorithm



Pedestrian dead reckoning



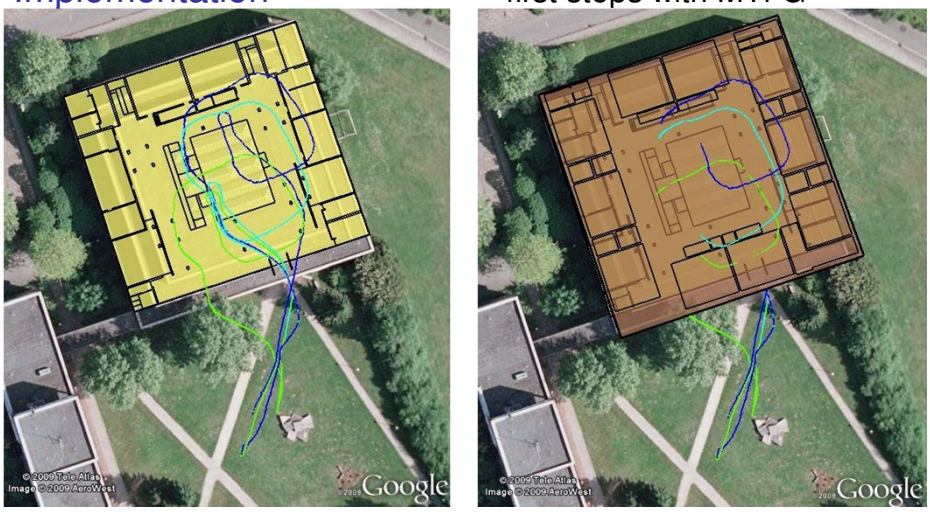
- Kalman filter

  mathematical model (linear or nonlinear → EKF), measurement model, stochastical model (observed data and process noise, Gaussian distributed)
- Particle filter

  multi-modal density function based, each particle represents a possible realization of state vector, random distribution

Implementation

first steps with MTi-G



indoor navigation results, including the stairs transition. Left: ground floor, right: first floor. (blue – forward filtering, green – backward filtering, cyan – optimal filtering)

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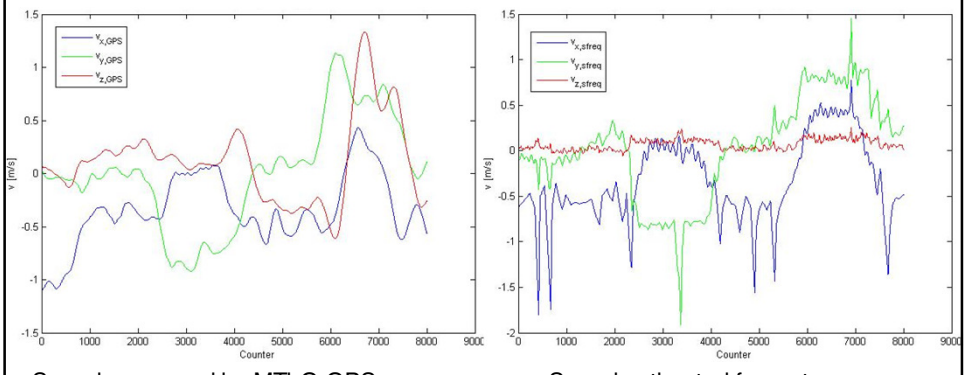
Implementation

first steps with MTi-G

Speed of GPS and

speed of step frequency



Speed measured by MTi-G GPS sensor

Speed estimated from step frequency and average step length

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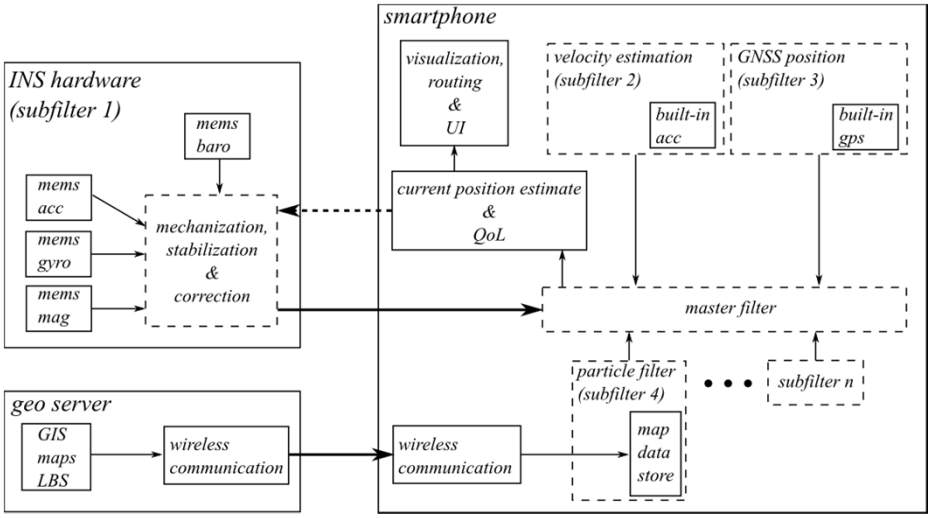
Smartphone-based indoor navigation



Smartphone-based indoor navigation

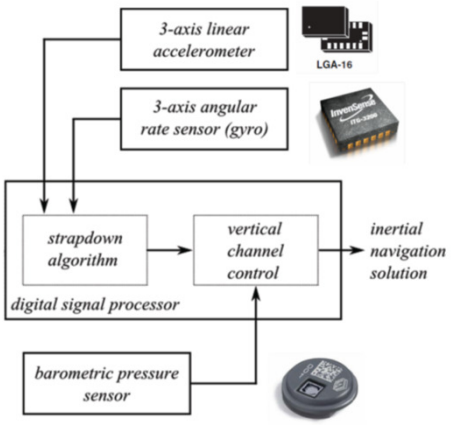
Smartphone

Ultra portable
Fitted with many sensors and communication
Highly integrated hardware
Powerful CPU
No 'additional' device

Nokia N900

Linux
Low-level access to sensors and data
High-level programming languages

Smartphone-based indoor navigation



Smartphone (yet) lacks gyros → custom hardware

- Inertial navigation system
- Highly integrated circuits (MEMS)
- High-performance digital signal processor
- Interfacing with smartphone (platform independent)

Conclusion

- Ultra portable pedestrian (indoor) navigation system
- Independent of (dedicated) infrastructure
- Independent of additional external hardware (step counter, antennae, etc.)
- Independent of utilized platform (key component (INS) designed removable)

Outlook

Potential uses

- Indoor location-based services
- Guide inside (public) building
- . . .

Idea: Synchronization of device with 'smart' point of information at points of entrance

- Shopping Malls / Trade / science fairs
- Museums / (Public) buildings (town halls, large plants)
- . . .

The End

www.geomatik-hamburg.de/digitalcity

Thank you for your kind attention!

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