


– SENSORSYSTEME 2010 –

MEMS sensor applications for consumer electronics

Dr. Wolfgang Schmitt

Bosch Sensortec

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Agenda

Bosch Sensortec

Next generation ‘user interface’ in mobile phones

Sensor supported pedestrian navigation

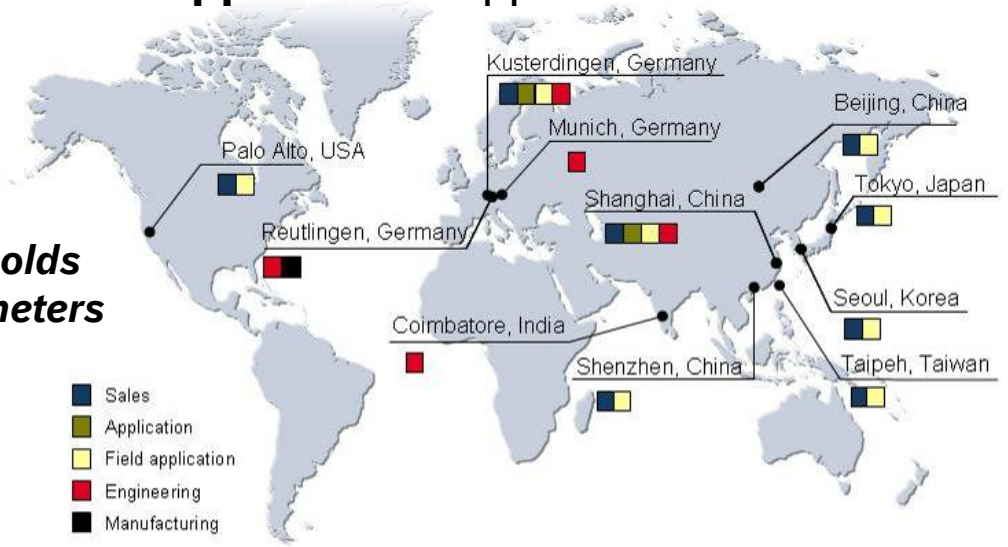
Bosch Sensortec

- Provides **MEMS solutions** for the **consumer electronics market**
- Is **Technology leader** in the addressed markets
- Focuses on **customer sales and application** support

Headquarters in Reutlingen, Germany

"Bosch Sensortec is the fastest growing manufacturer of accelerometers for consumer electronics and cell phones. It holds 27% of the market for accelerometers in cell phones."

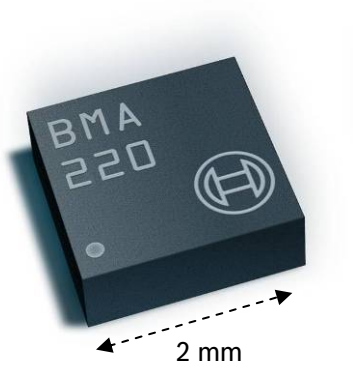
Jérémie Bouchaud, iSuppli, December 2009



What is a MEMS?

„MEMS“ = „**M**icro-**E**lectro-**M**echanical **S**ystem“

- MEMS are miniature systems which usually combine tiny mechanical structures with electronic circuits. Typical individual structures have a size of a few µm
- The MEMS sensor element is usually packaged together with an ASIC into one unit, e.g. into an LGA package



MEMS Technology leader Bosch

Proven track record

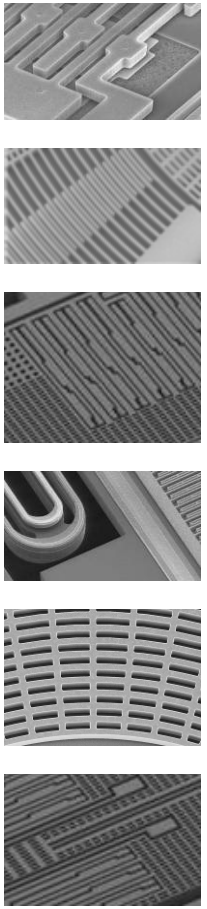
- Bosch produced more than 1.2 billion sensors

Pioneering innovations

- Sizes development, trendsetting size of 3x3x0.9 (2007) and 2x2x0.98 mm³ (2010)
- Extensive MEMS IP portfolio
- German innovation and advanced technology prize received for key MEMS technologies, enabling mass production and prize reduction

Best products according to customers needs

- Bosch Sensortec is strongest growing company in Consumer MEMS sensors



Bosch receives German innovation and advanced technology prize

- Highest award given by Federal President Horst Köhler once a year
- Bosch-team develops five new key technologies for series-production, thus enabling penetration of Consumer Electronics market

Bosch “DRIE”

MEMS process

DEUTSCHER ZUKUNFTSPREIS
Preis des Bundespräsidenten
für Technik und Innovation

2008

The winner team with the federal president: Dr. Frank Melzer, Prof. Dr. Horst Köhler, Dr. Jiri Marek, Dr. Michael Offenberg (l. to r.)

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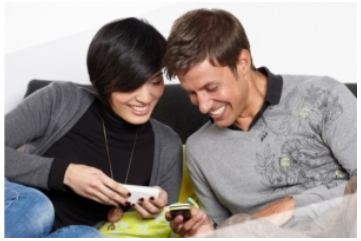
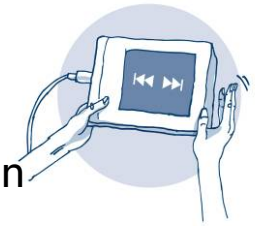
Mobile phones and portable media players



User interface
- Tap control
- Gaming input
- Menu navigation



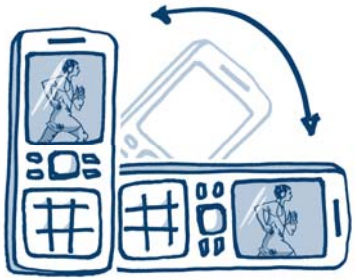
Motion detection
- Step counting
- Activity monitoring
- Power management

Position detection
- Upside down
- Portrait / landscape
- Free speech profile

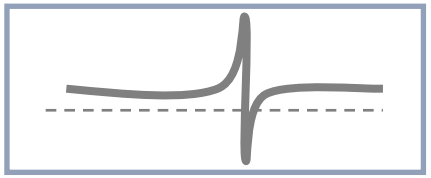
Pedestrian navigation
- Speed & distance estimation
- Altitude detection
- Location based services

Portrait / landscape recognition

- Use g-change of defined axes to detect the position and / or the change of the position of device: portrait/landscape & face-up/face-down detection

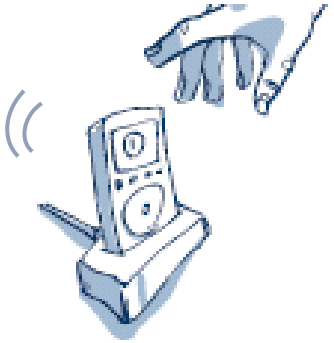


- Example use cases:
  - Automatic switching of graphic user display between portrait mode and landscape mode
  - Switch off buzzer when display is put on the table with face-down



Tap sensing

- Using an any-motion interrupt function or slope change detection to identify the tapping of the device shell

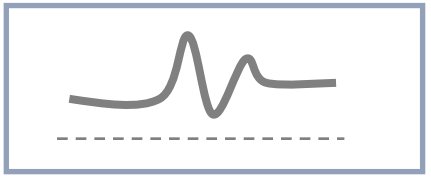


- µController counts the number of interrupts within a defined time frame to trigger events or
  the triaxial sensor allows to detect direction & location of tap event

- Example use cases:
  - Tap / tap-tap to switch to silent mode
  - Switch back and forth between songs for MP3 player

Auto wake-up & power saving

- Using the acceleration sensor auto wake-up feature in combination with an any motion interrupt function: the sensor wakes the system up via an interrupt signal to the µController
  - Sensor remains in <10µA auto wake-up mode or,
  - Sensor switches into active mode by latching the interrupt. The interrupt can be reset via a programmable hysteresis or a master reset

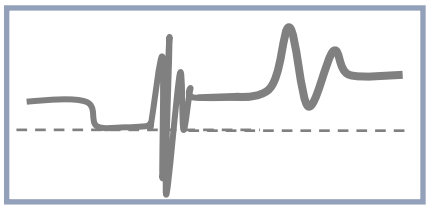


- Example use cases:
  - Motion power management
  - System wake up if device is moving or picked-up

Drop detection for warranty logging

- Detection of a dropping event
  - A free-fall event uses a low-g interrupt feature to detect a falling device, i.e. all axes are falling below a defined threshold
  - The sensor allows 255ms of validation time to detect if a situation is real free-fall event.

- Height-of-fall detection
  - The combination of a low-g interrupt (start of fall) and an any motion interrupt (hitting ground)
  - The sensor allows (AND/OR) combination of interrupt events



- Example use cases:
  - Warranty logging to detect if the user device has been dropped
  - Hard-disk protection

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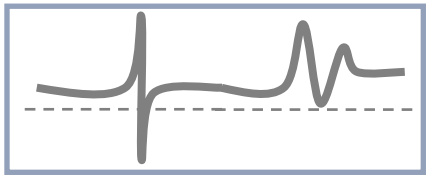
Menu navigation and HMI*

- The tilting of the device changes the g-value of the measurement axes. This allows to detect the position of a mobile device and its motion by reading out the g-values via a µController.

- Example use cases:
  - HMI*, menu navigation
  - Browser control, picture scrolling
  - Gaming

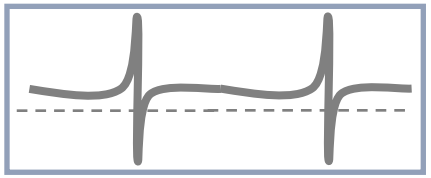


* = Human Machine Interface

Step-counting

- Step-counter
  - Provide walking distance
  - Provide step frequency
  - Provide calories consumption

- Example use cases:
  - Step-counting, pedometer, calorimeter
  - Distance counter
  - Dead-reckoning



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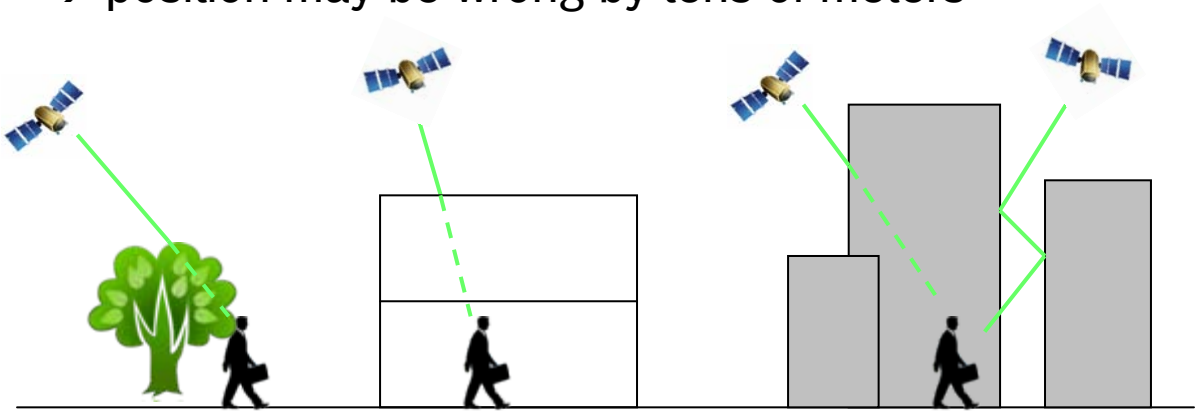
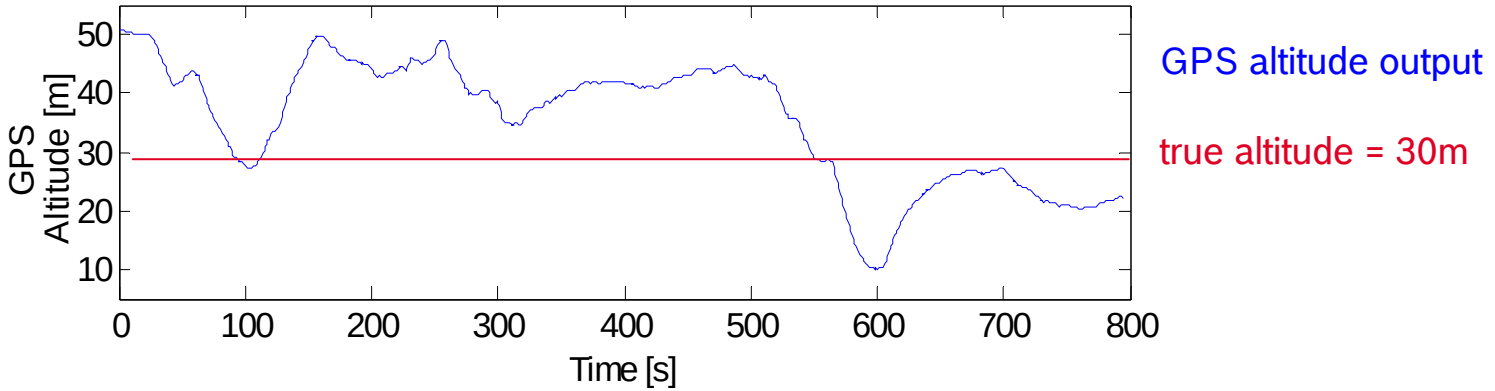
GPS shortcomings in urban environment

- GPS position may be distorted by…
  - Signal attenuation and blockage (trees, inside buildings,…)
    - RF engine has problems to track weak satellite signals
      → increased position distortion
  - Multipath effects
    - delays in signal runtime due to reflection at building walls (especially in ‘urban canyons’)
      → position may be wrong by tens of meters



GPS shortcoming: altitude

- GPS altitude has higher errors than x and y position.
  Inside buildings, GPS altitude error is typ. ±20m



Measurement taken at fixed location in 2nd floor of 2 storey office building

- Altitude signal is already highly filtered by GPS chipset (here SiRFstarIII).
- **GPS standalone can't detect floors for indoor navigation.**

High performance digital pressure sensor: BMP085

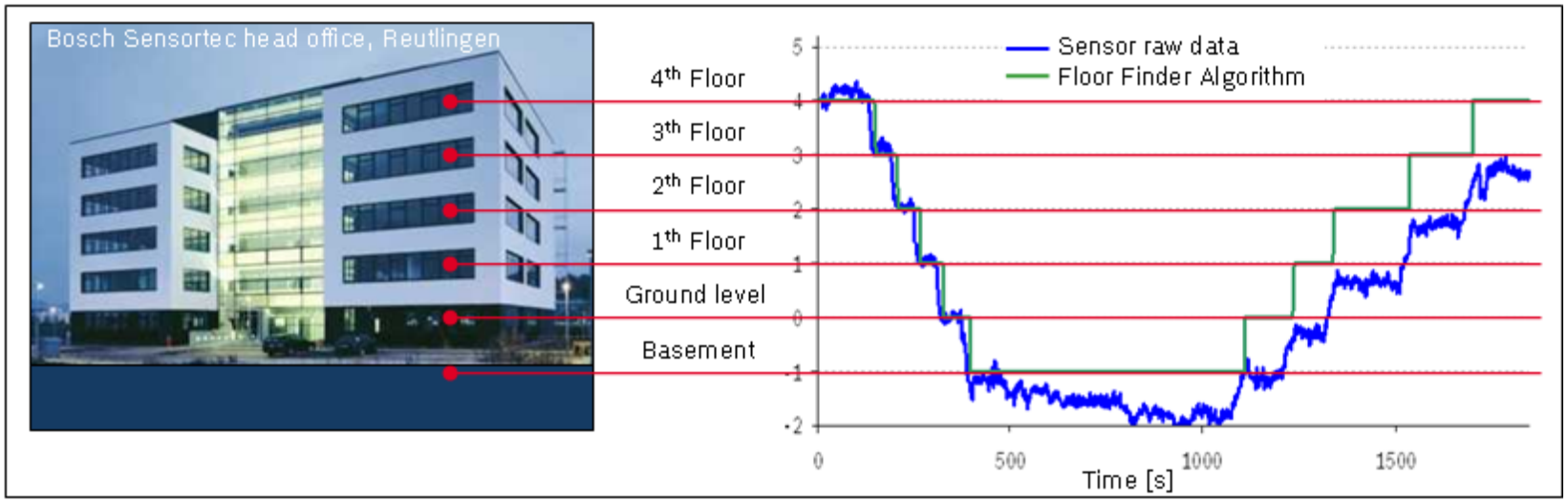
Unique features:

- High absolute accuracy
- Extremely high resolution 25cm (rms)
- Very small, robust LCC8 ceramic package
- Ultra-low current consumption: 5µA
- Digital I^2C interface

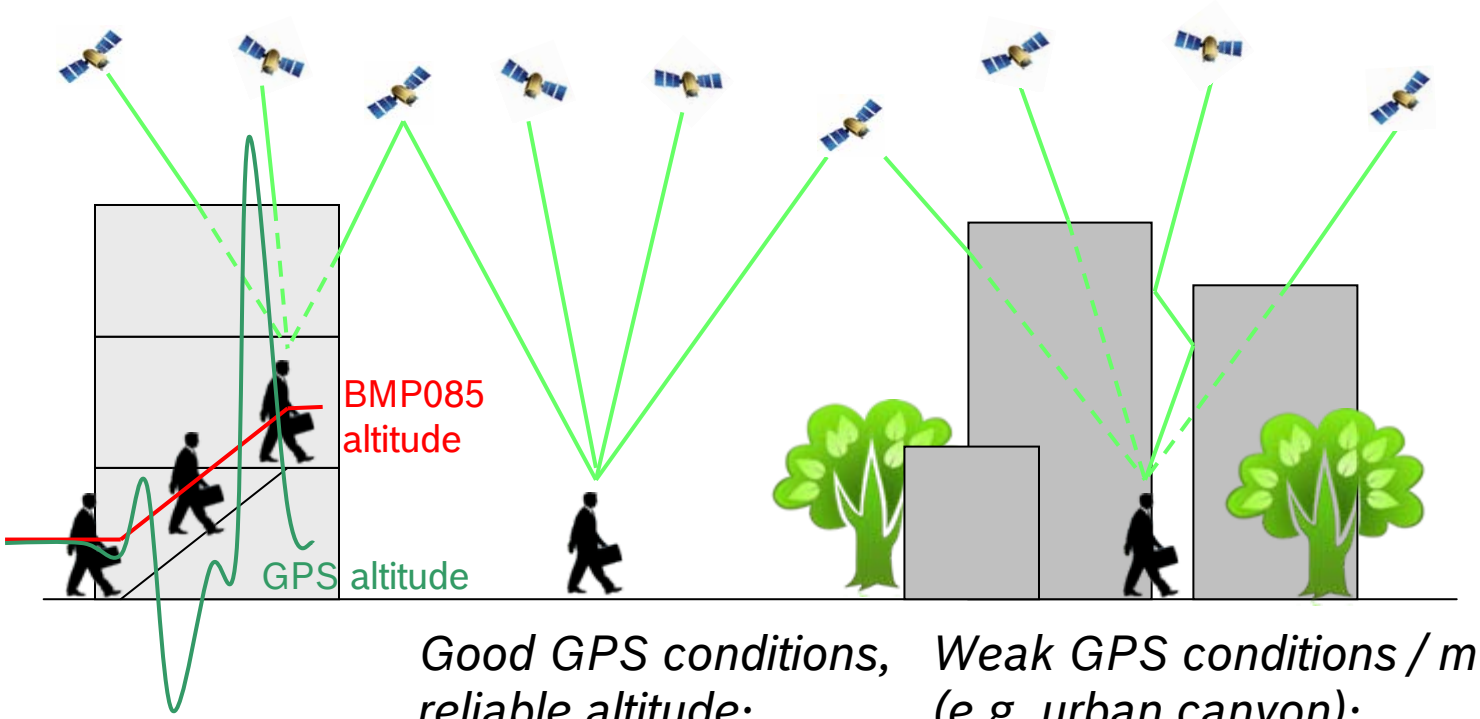
size: 5 mm x 5 mm x 1.2 mm

Accurate floor level sensing with altimeter

- Correct floor level is tracked by altimeter, even if environmental pressure shows distortions.
- Smart algorithm filters out drift from
  - weather changes
  - noise
  - wind pressure fluctuations



Advanced fusion of BMP085 and GPS



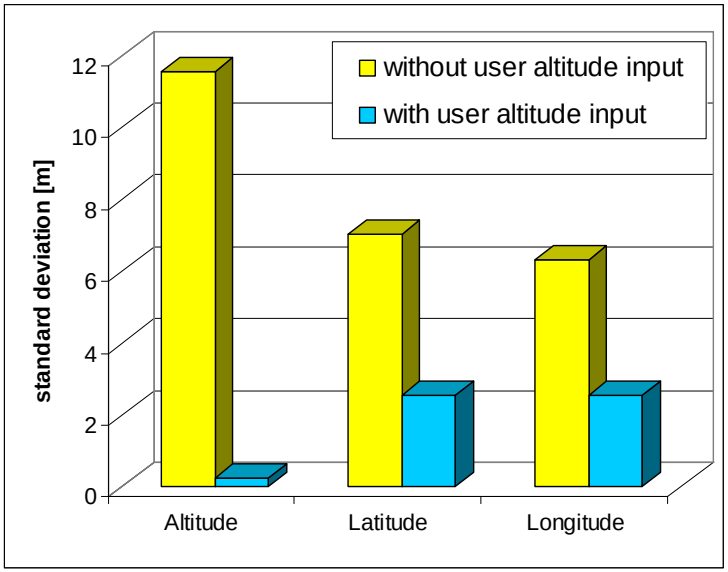
Improve vertical positioning by BMP085
→ Indoor navigation

Good GPS conditions, reliable altitude:
→ BMP085 weather re-calibration by Kalman filter

Weak GPS conditions / multipath (e.g. urban canyon):
→ Provide BMP085 altitude as input to GPS chipset to improve positioning

Improvement of horizontal precision with BMP085

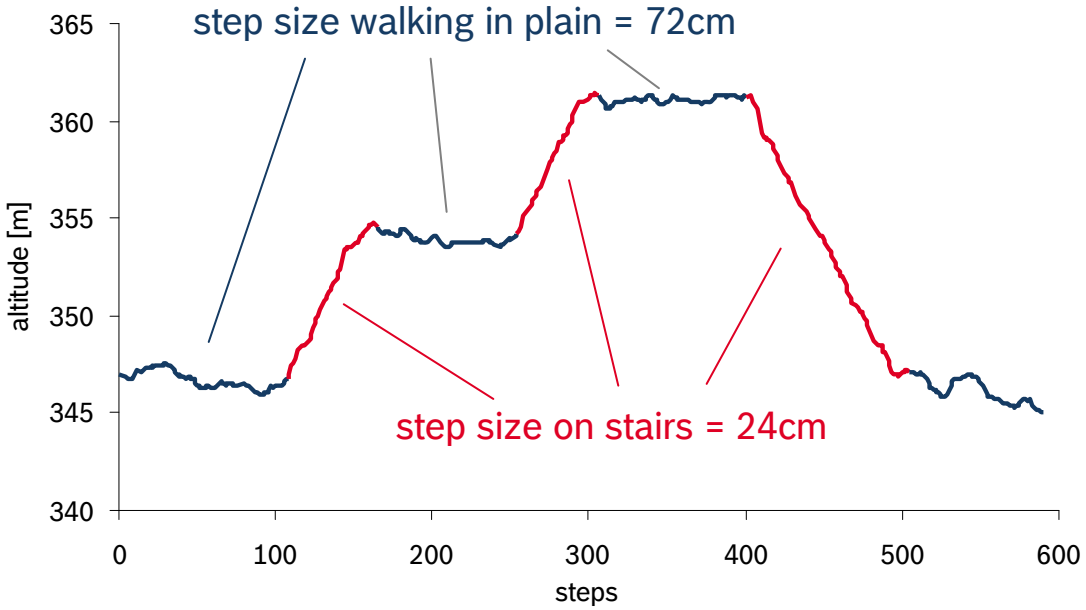
- GPS chipsets have **external data input for altimeter.**
- SiRFstarIII + BMP085 and improves not only the **vertical** accuracy significantly, but also the **horizontal** accuracy by a **factor of 2** in urban canyons with multipath GPS signals!



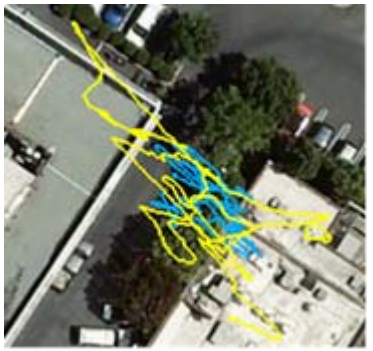
Positioning error next to a 6-story building in urban canyon. True position is fixed.

Adaptive step counter with stair detection

- Acceleration sensor counts the number of steps of the user.
  - Distance = steps × step-length
- On stairs: shorter step length, calculated distance too long
- If altimeter detects stairs, algorithms reduces step length is automatically
  -> **correct path length !**



Synergy of GPS + altimeter



- Improvement of horizontal and vertical GPS precision
- Combination of pressure sensor and step counter allows 3D indoor navigation without GPS signals
- MEMS sensors are key components for location based services (LBS) based upon mobile devices

Summary

- MEMS sensors already offer and will even expand a huge potential for new applications in mobile consumer devices
- For accelerometers most use cases are related to the user interface for offering convenient, intuitive ways when interacting with the mobile device
- Pressure sensors can open up new application fields and help where existing technologies have shortcomings
- The fusion of different MEMS sensors with existing technologies and all of these linked by intelligent software is the next goal

Thank you!

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