A Novell Magnetic Indoor Positioning System for Indoor Location Services

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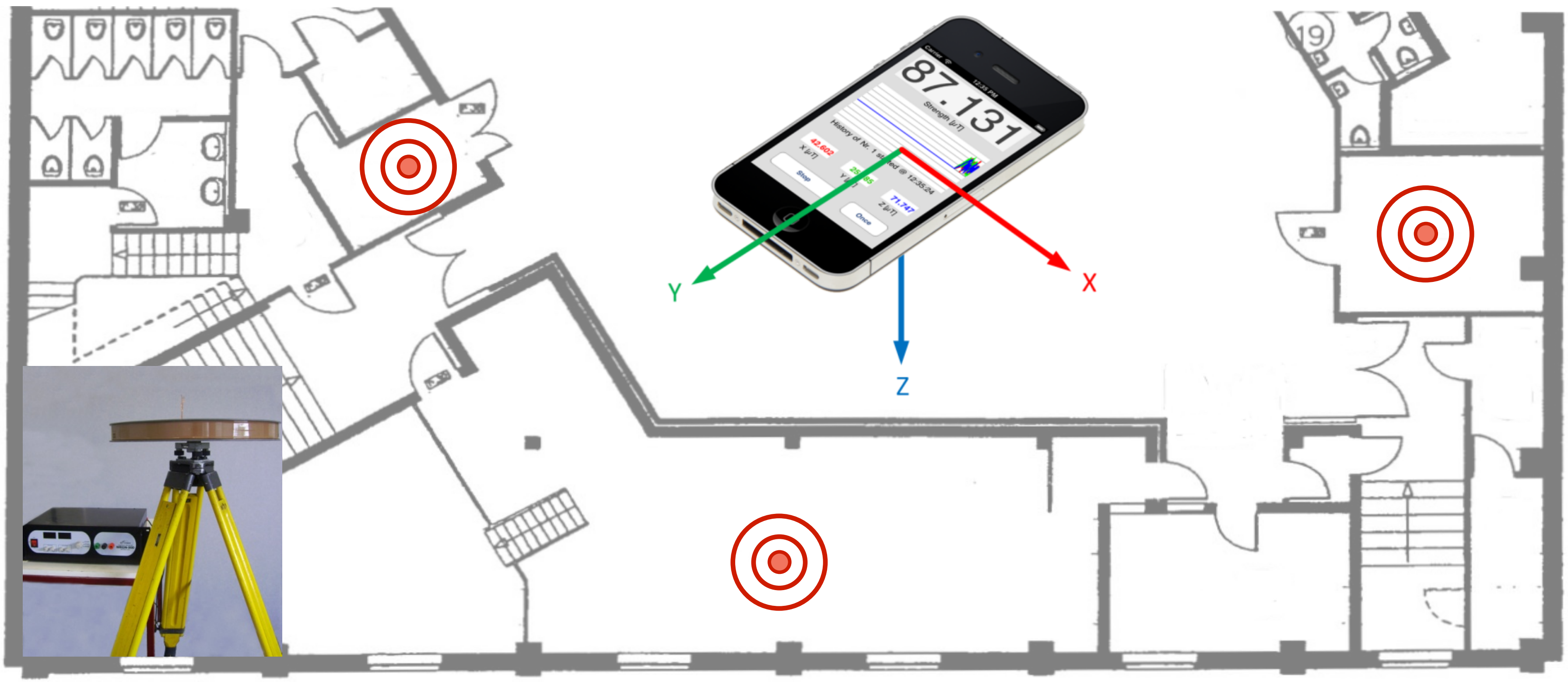

Introduction

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- Localization is essential for Location-based applications

  → Satellite based localization (GNSS)

- GNSS only works outdoor, although numerous indoor applications exists which could benefit from the possibility of positioning
  - Navigation of pedestrians
  - Maintenance & inspection of objects
  - Catastrophe management

  → Indoor Location Services

- Use of local positioning systems

  → Indoor Positioning

Indoor positioning

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- Although many efforts have been done in the last years, an overarching technology of positioning is still not available
- Problems of infrastructur based positioning systems
  - shading, absorption
  - multipath
  - signal delay
- Solution
  - Coupling of different technologies (IMU, WLAN, compass)
  - Searching for alternative technologies

Magnetic Indoor Local Positioning System
Motivation

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Introduction

MILPS

Conclusion

- Use of magnetic fields
- Advantages
  - Unbiased diffusion of any building material
  - Detection of magnetic fields by “passive sensor systems”
    - No communication protocols required
    - No user management required
- Creation of artificial magnetic fields by using induction of electromagnetic coils

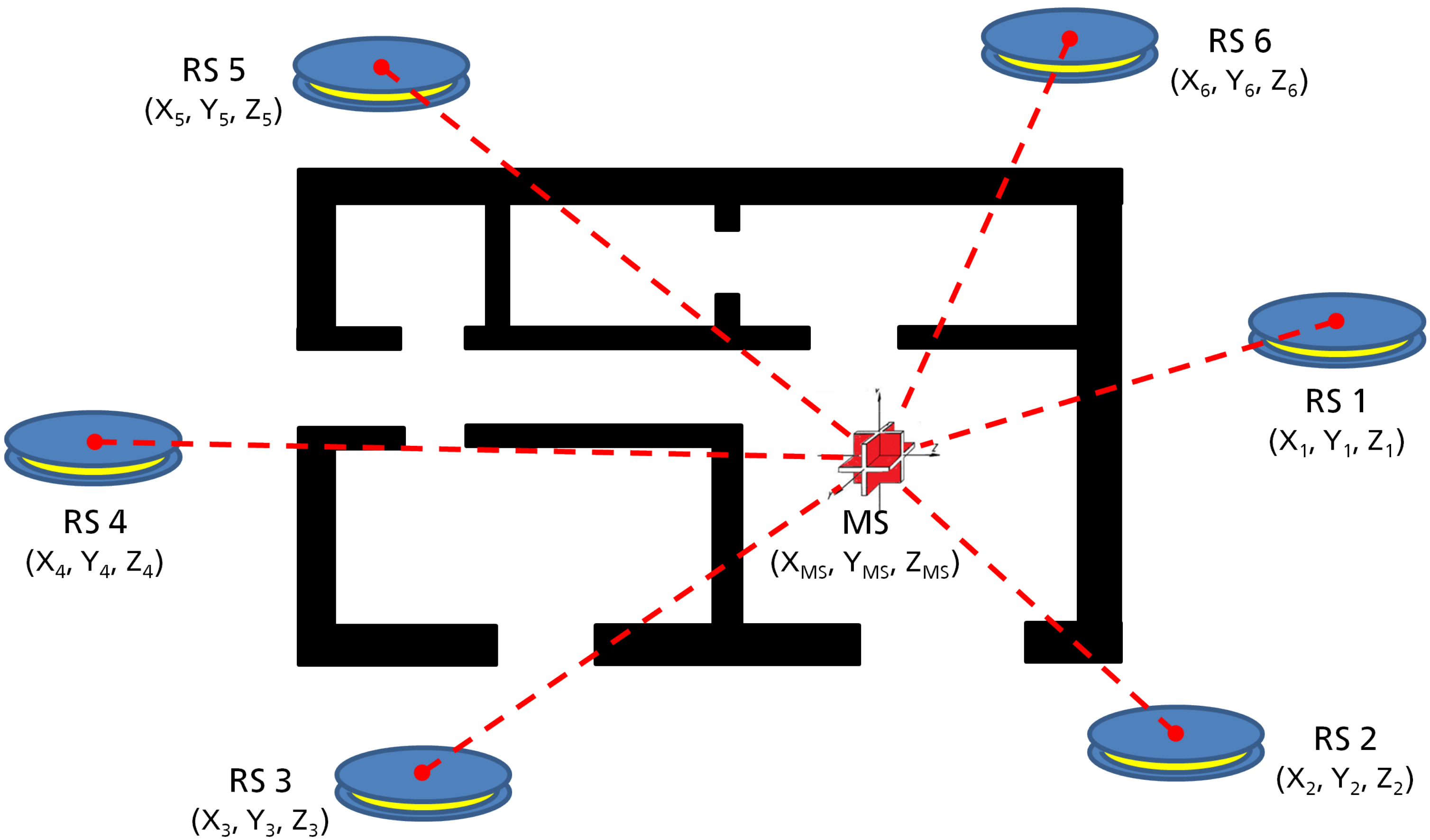
  → Simple local positioning system

  → Magnetic Indoor Local Positioning System (MILPS)

Deutsche Forschungsgemeinschaft DFG

MILPS

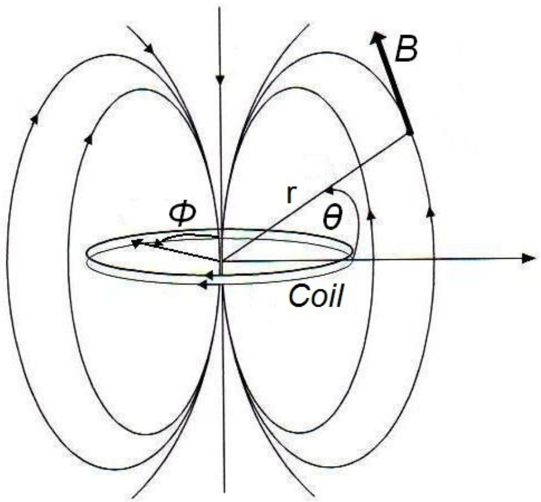
Architectur

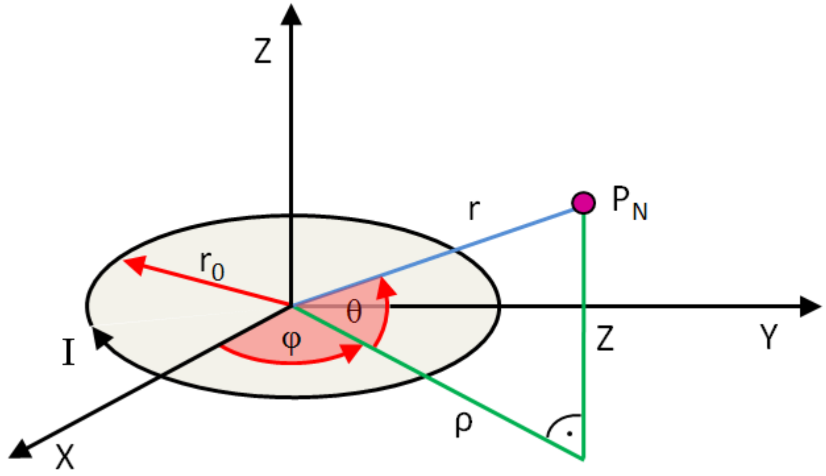


MILPS

Magnetic field theory[7]

- **Introduction**
- MILPS
- Conclusion





$$B_r = \frac{\mu_0 NIF}{2\pi r^3}\sin(\theta)$$

$$B_\varphi = 0$$

$$B_\theta = \frac{\mu_0 NIF}{4\pi r^3}\cos(\theta)$$

F : Surface area

I : Current strength

N : Number of windings

$\mu 0$: Magnetic permeability

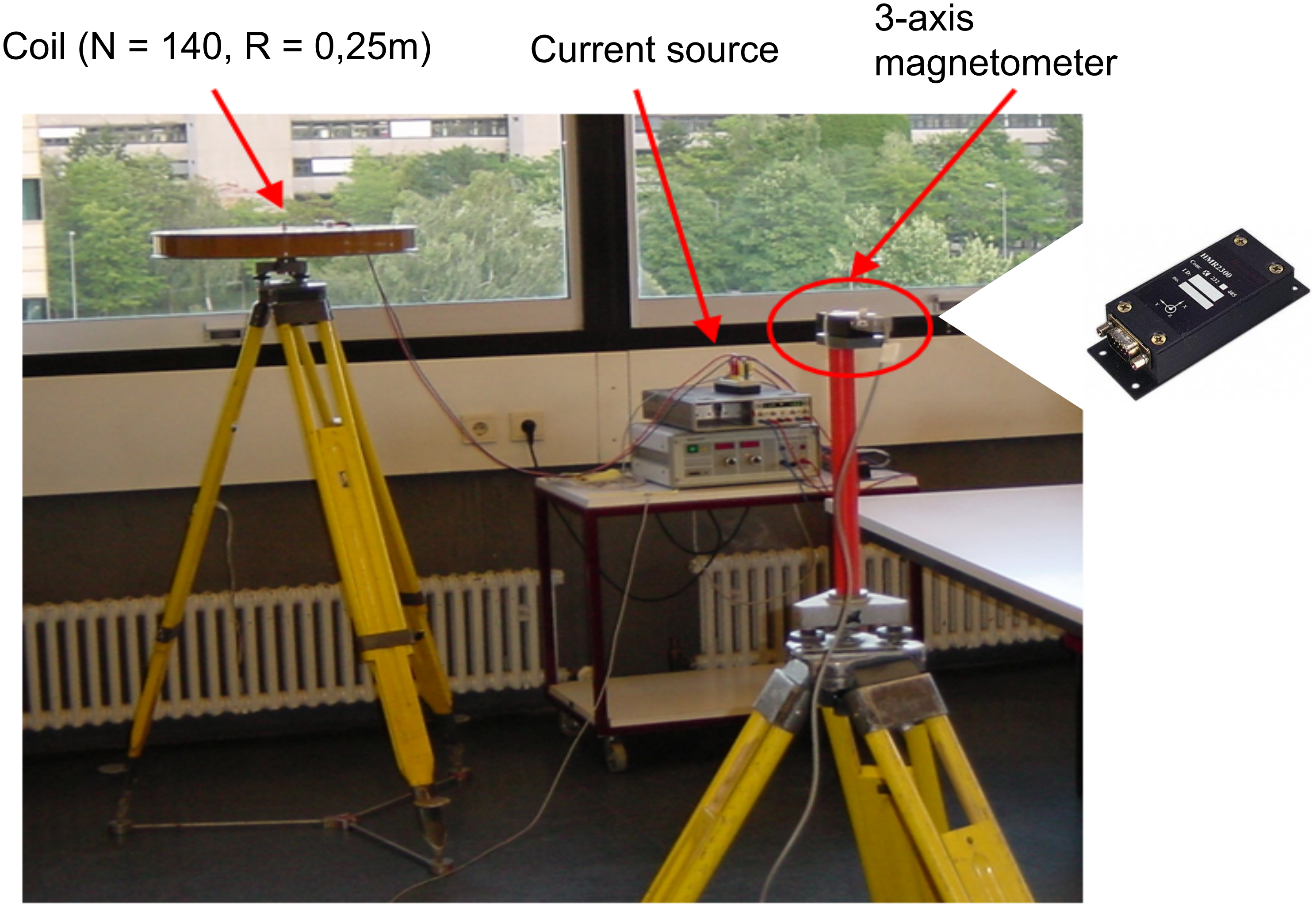
θ : Elevation angle

r : Distance

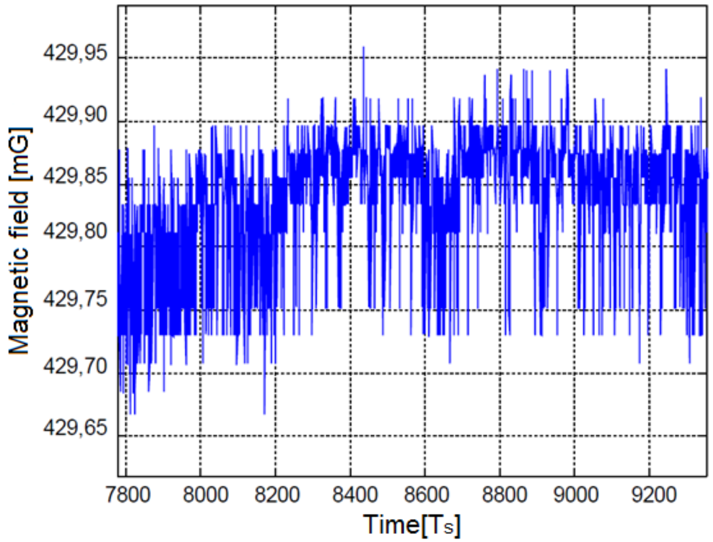
$$B = \frac{\mu_0 NIF}{4\pi r^3}\left(1 + 3\sin^2(\theta)\right)^{\frac{1}{2}}$$

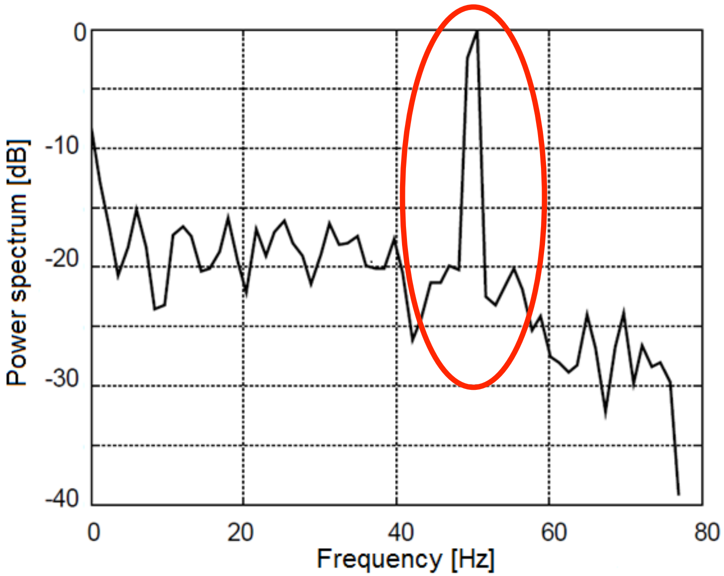
$$r = \sqrt[3]{\frac{\mu_0 NIF}{4\pi B}\left(1 + 3\sin^2(\theta)\right)^{\frac{1}{2}}}$$

MILPS
Experimental system



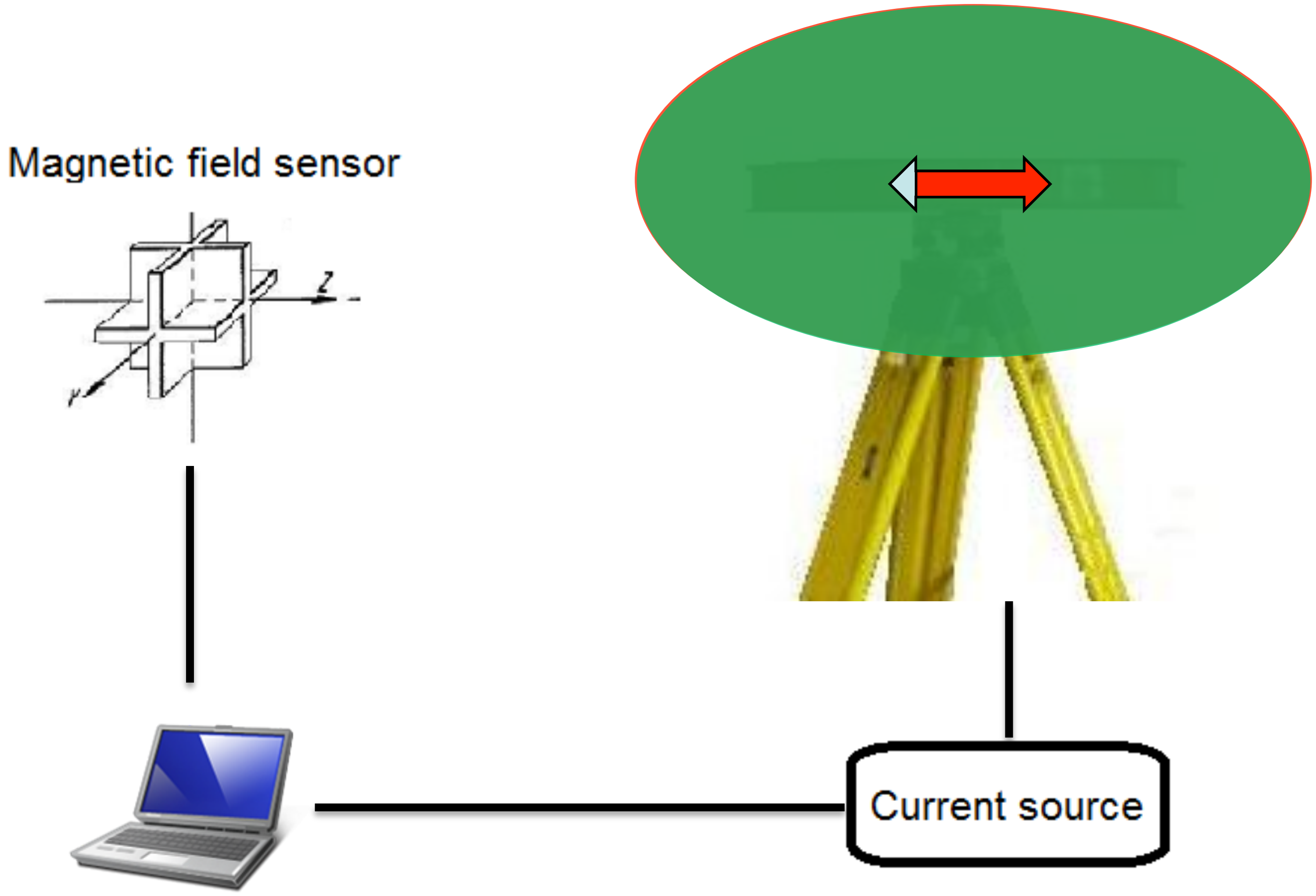
MILPS
Test measurements





- Interference fields
  - Earth magnetic field
  - Electricity network
  - Domestic appliance

MILPS
Differential Measurement principle



Signal Processing

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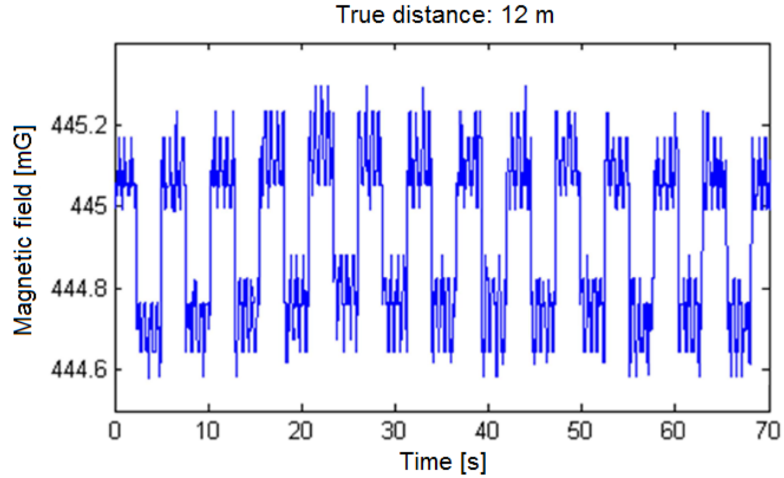
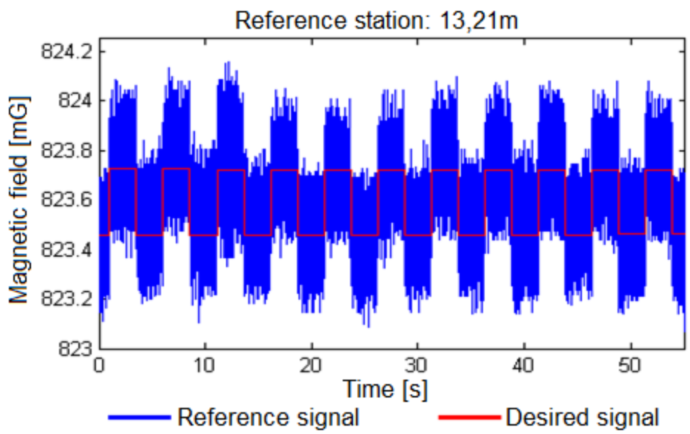
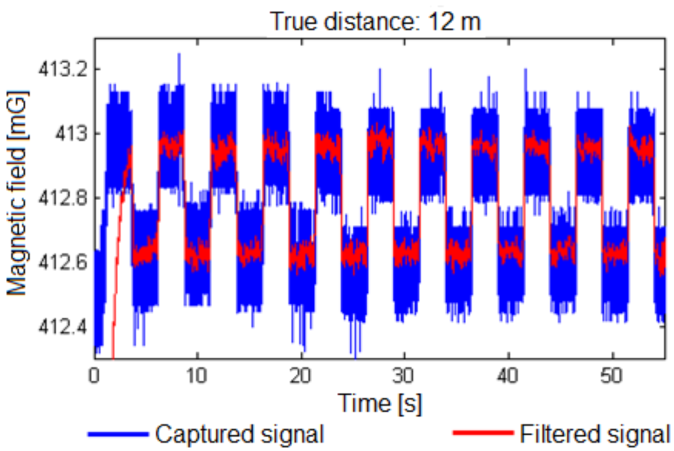


$$2B_{Sp} = \left(B_E + B_n + B_{Sp}\right) - \left(B_E + B_n - B_{Sp}\right)$$

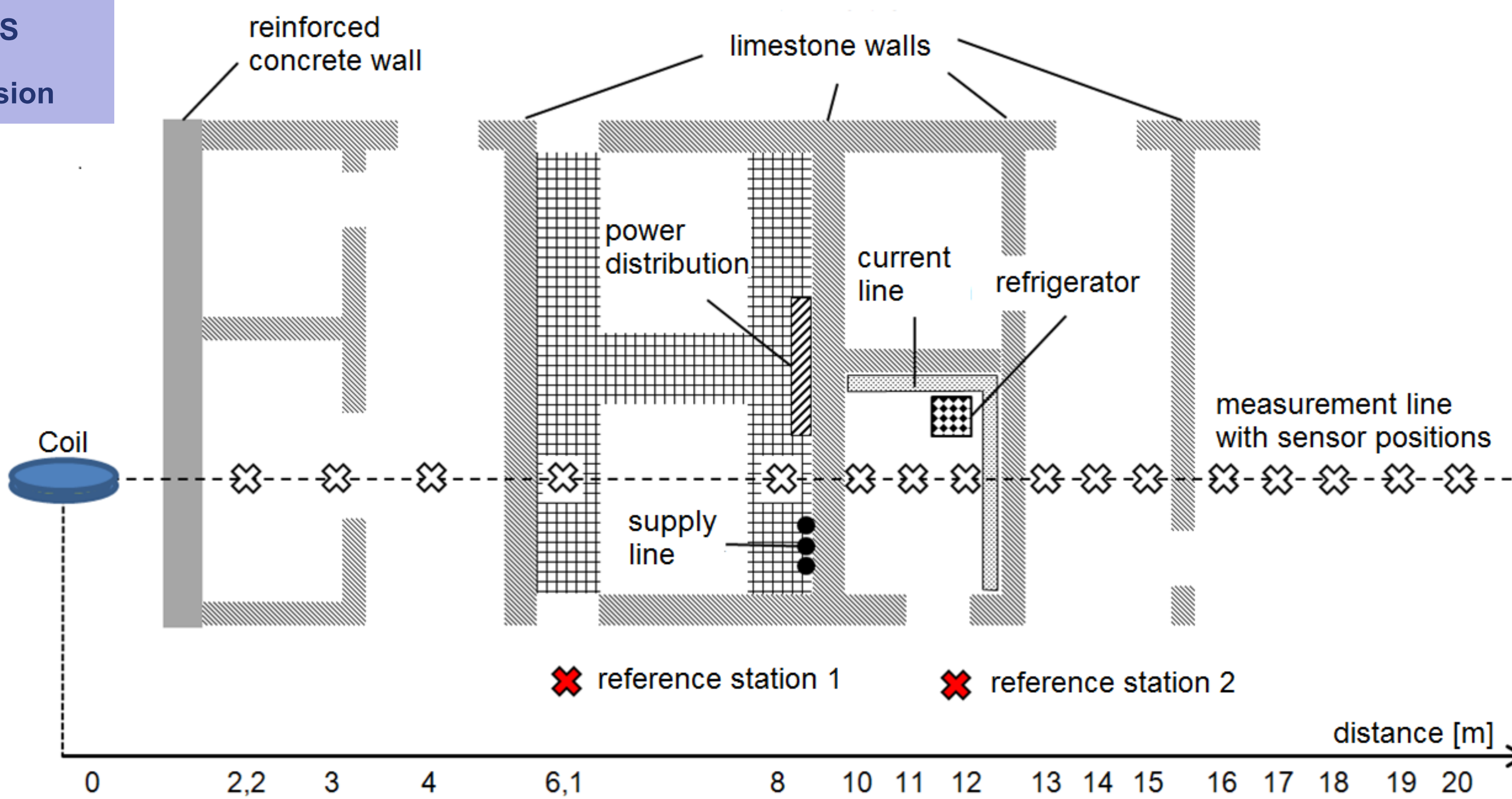
Adaptive Filter





Measurement example
Horizontal distances (θ=*0*)

- **Introduction**
- **MILPS**
- **Conclusion**



Measurement example
Accuracy

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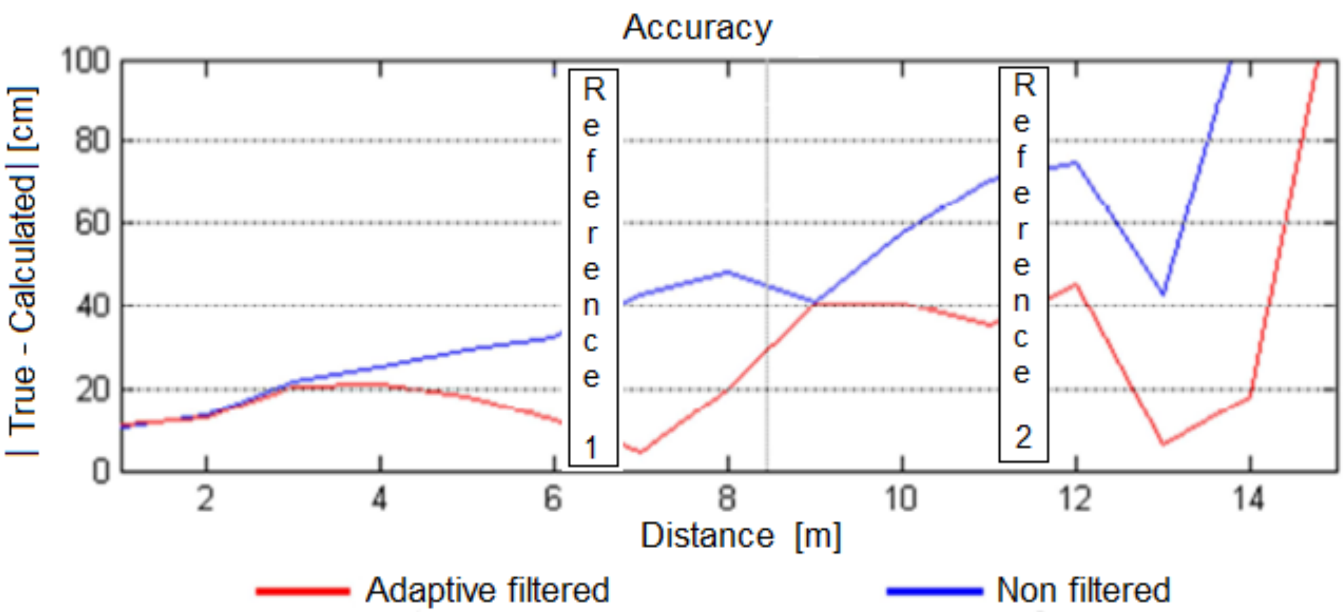
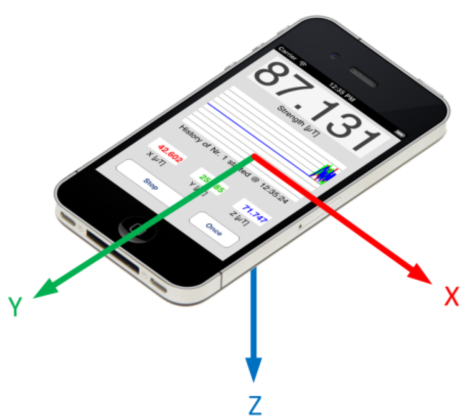
$$r = \sqrt[3]{\frac{\mu_0 NIF}{4\pi B_{Sp}} \left(1 + 3\sin^2(\theta)\right)^{\frac{1}{2}}} \xrightarrow{\theta = 0} r = \sqrt[3]{\frac{\mu_0 NIF}{4\pi B_{Sp}}}$$

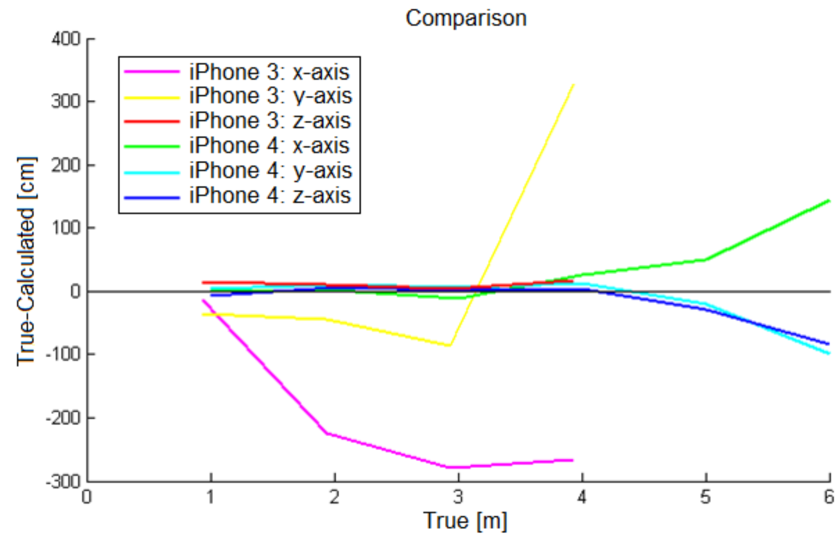


Measurement example
iPhone

Introduction
MILPS
Conclusion

- Todays smartphones include multiple of sensors, amongst others a *magnetometer*
- Example: iPhone





→ Coil field (N=140; R=0,25) detectable till a distance of 6 m

→ Accuracy: 0,02 – 0,15 m (iPhone 4)

Conclusion

Introduction
MILPS
Conclusion

- MILPS is able to provide a submeter localization in indoor areas, but...
- …there are still some things to do:
  - Calibration (Magnetic Field)
  - Kinematic positioning
  - Determination of all 6DoF

    → Integration of other sensors
  - Extension of range (magnetic field)
  - Establishing of applications regarding to positioning

→ Development of a three-dimensional Building Information System → Indoor Location Services

Thank you for your attention!