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Study and Simulations of an Angle of Arrival Localization System for Indoor Multipath Environments

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Outline

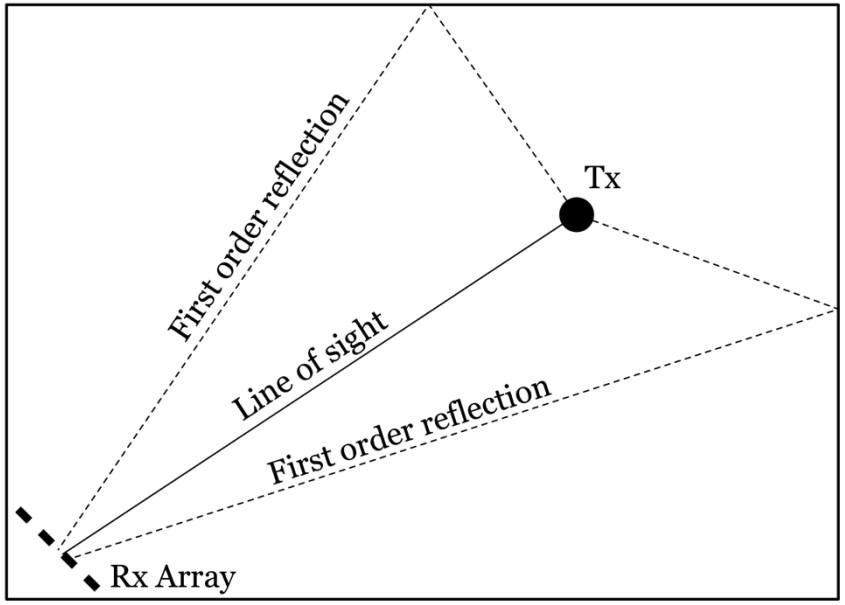
- Introduction
- Proposed system
- Virtual test bench
- Simulations:
  - Antenna array elements
  - AOA algorithms
- Conclusions

Introduction

- Indoor RF localization:
  - Received Signal Strength: RSS
  - Time (Difference) Of Arrival: T(D)OA
- Problems:
  - Ad hoc tuning
  - Multipath (non-line-of-sight)
    - Reflections
    - Scattering
    - Fading
    - …

Proposed System

- Rectangular room with reflecting walls
- Omnidirectional mobile transmitter
- Receiving antenna array
  - Angle Of Arrival (AOA) estimation
    - Line of sight
    - Reflections
  - Ray tracing
  - Estimate Tx position



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Virtual Test Bench

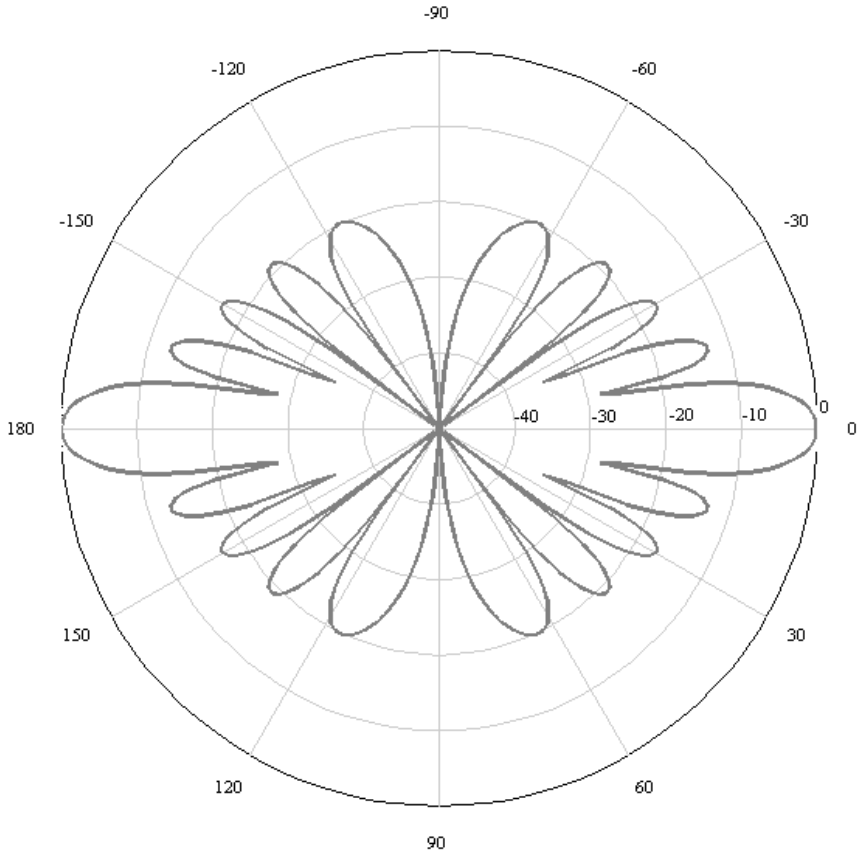
- Dimensioning & evaluating antenna array (ULA)
  - Number of elements
  - Inter element spacing (standard λ/2)
  - Operation frequency (standard 2.4 GHz or 5.8 GHz)
  - Antenna type (radiation pattern)
  - Impinging signals
    - Angle of arrival
    - Signal strength
    - Delay
  - AOA algorithms
    - Non-parametric: MVDR/Capon, Beamscan
    - Parametric: MUSIC, ESPRIT
  - Spatial smoothing

Simulations: array elements

- Evaluation of array response
- Incoming signal: 0º azimuth, 0º elevation
- 10 array elements with λ/2 interspacing
- Evaluated types:
  - Isotropic radiator
  - (half) wavelength dipole
  - Microstrip patch antenna

Simulations: array elements

- Isotropic & (half) wavelength dipoles:
  - Symmetry around 90º azimuth axis
  - Impossible to distinguish signals from front/back



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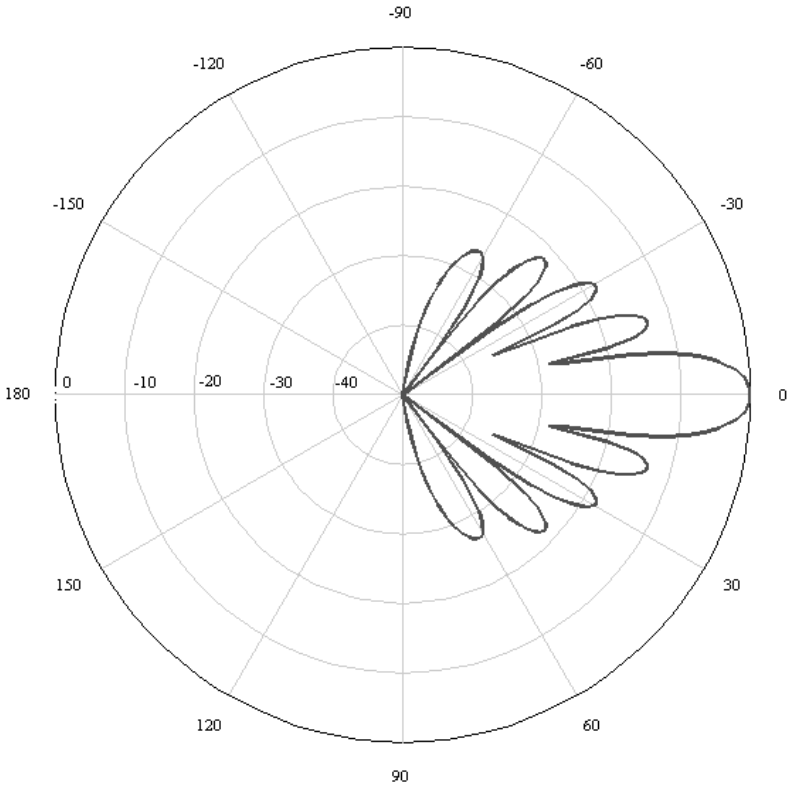
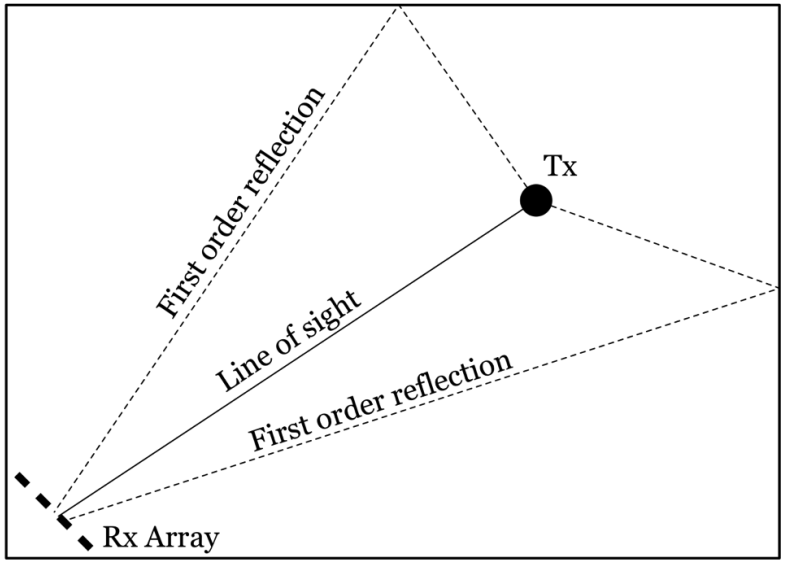
Simulations: array elements

- Microstrip patch antenna
  - Less sensitive for signals at angles >45º
  - Receives no signals from the backside





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Simulations: AOA algorithms

- Performance of AOA algorithms for reflections
- Influence of spatial smoothing (decorrelation)
- Test setup:
  - Incoming signal + reflection at 2 different angles
  - Search for smallest signal with correct AOA estimation

	Beamscan	MVDR	MUSIC	ESPRIT
No spatial smoothing	-5.2 dB	-5.5 dB	-	-
Spatial smoothing	-6.6 dB	-53 dB	-63 dB	-55 dB

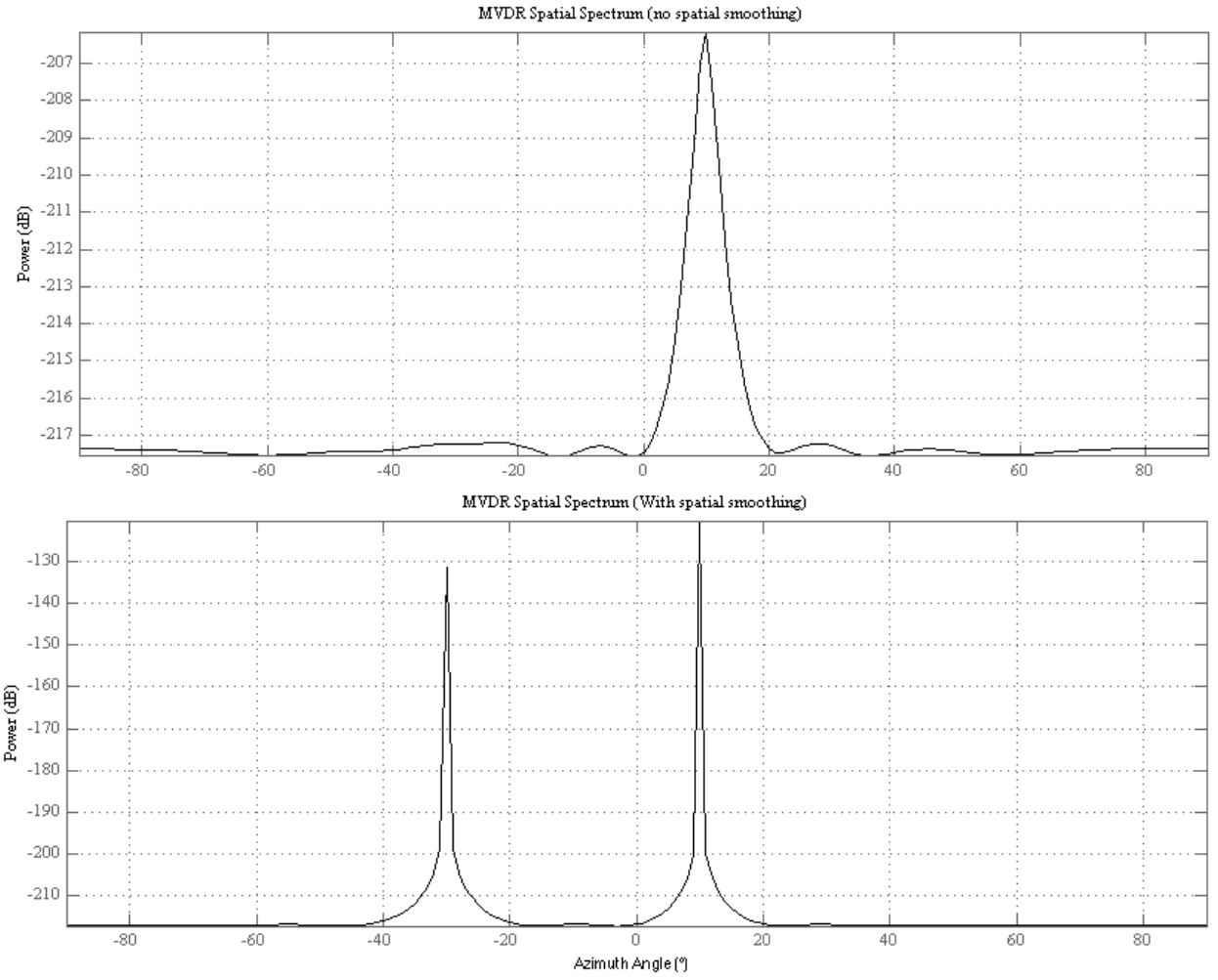
Simulations: AOA algorithms

- Beamscan performs worst
- MVDR performs well
- MUSIC & ESPRIT only perform well with spatial smoothing

	Beamscan	MVDR	MUSIC	ESPRIT
No spatial smoothing	-5.2 dB	-5.5 dB	-	-
Spatial smoothing	-6.6 dB	-53 dB	-63 dB	-55 dB

Simulations: AOA algorithms

- Example: MVDR before & after spatial smoothing



Conclusions

- New type of indoor positioning system: AOA + ray tracing
- Virtual test bench for evaluation & dimensioning

- Microstrip patch antennas are the best option
- Spatial smoothing is necessary for AOA of reflections
- MVDR has an overall good performance

Thank you for your attention!

Questions?

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