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:
  o Antenna array elements
  o AOA algorithms
• Conclusions
Introduction

• Indoor RF localization:
  o Received Signal Strength: RSS
  o Time (Difference) Of Arrival: T(D)OA

• Problems:
  o Ad hoc tuning
  o 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
Virtual Test Bench

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

- Evaluation of array response
- Incoming signal: 0° azimuth, 0° 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 90° azimuth axis
  - Impossible to distinguish signals from front/back
Simulations: array elements

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

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<th>Beamscan</th>
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<th>MUSIC</th>
<th>ESPRIT</th>
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Simulations: AOA algorithms

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

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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?