Ultra-low-power Angle-of-Arrival Estimation Using a Single Antenna

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**Overview**

Traditional antenna array approach:

- Power hungry

**Low-power Reconfigurable Antenna**

- Reconfigurable antenna
- Passive envelope detector
- Small AI model

**Collision Detection**

- Unequal duty cycles

**Beacon Identification Algorithm**

\[
y(t) = A_1 e^{j 2 \pi f_1 t} + A_2 e^{j 2 \pi f_2 t}
\]

\[
y_{envelope}(t) = |y(t)|
\]

**Implementation**

- Antenna array
- I/Q Demodulation
- Digital signal processor

**Evaluation**

- Error (deg)
- Location ID
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- Passive envelope detector
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Sirius:

- Reconfigurable antenna
- Passive envelope detector
- Digital signal processor

Low-power Reconfigurable Antenna

- PIN Diodes
- MUX

Collision Detection

Beacon Identification Algorithm

- Anchor Beacon (A1, F1)
- Anchor Beacon (A2, F2)

Implementation

Evaluation

- Ground truth angles (deg)
- Estimated angles (deg)
- Error (deg)

Testing environment:

- University of Maryland College Park

Diagrams and graphs showing antenna array, reconfigurable antenna, and various signal processing elements.
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Reconfigurable Antenna

- PIN Diodes
- LNA
- MUX

Collision Detection

Unequal duty cycles

Anchor Identification

Case 1

- Anchor 1
- Anchor 2
- Received signal

Case 2

- Anchor 1
- Anchor 2
- Received signal

Evaluation

- Location ID
- Median Error (deg)
- Direct-path LOS
- Multi-path LOS
- Direct-path NLOS
- Multi-path NLOS

Prototype

- US Quarter
- Lipo battery
- MSP430FR5969

Applications

- Precision Farming
- Wildlife Monitoring
- Asset Tracking
- Climate Sensing
- Space Localization