Localization of Interferences Using Drones in Spectrum Monitoring

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Outline

• Using Drones for Spectrum Management
• Advantages of Drones for Spectrum Management
• Spectrum Interference
• Localization and RSS-based Localization
• Localization Techniques Developed by CRC
• Simulation Tool and Initial Results
• Future Work
Drones are increasingly being used in various domains including agriculture, energy, health care, search and rescue, etc. due to their advanced capabilities and benefits. Technology improvements and safety capabilities in drones are also contributing to a mature market for drones. As a result, there has been interest in applying drones to spectrum monitoring.
Drones for Spectrum Monitoring

- Super-mast that moves fast and flexibly.
- Good complement for existing sensors.
  - Allowing elevation far above ground-based sensors to provide better line of sight.
  - Flying to locations inaccessible to ground-based or vehicular sensors
  - Supports 3-dimensional localization and compliance testing
  - Drones are portable, easily launched and collected
Spectrum Interference

• Spectrum regulators establishes technical and non-technical requirements in licenses, standards, and operating conditions to ensure efficient use of spectrum in a no-harmful interference environment for all users.
  • regulators have responsibilities in resolving harmful interference to radio communication systems

• Interference occurs in different bands and services,
  • Internal (due to system itself)/external (due to other sources)
  • Intentional (jamming)/unintentional (unauthorized or non-compliance)

• The interference issue is an increasing challenge as new technologies allow the greater exploitation of spectrum.
Typical Localization Use Cases

• Interference Localization for 4G/5G networks
• Interference Localization in public safety LMR system.
• High-Power Tower to Tower Interference
• Interference to aircraft, localizing around the back of buildings, courtyards, top of buildings
• Urban scenarios are difficult for ground-based sensors because of blockage and multipath, but the use of drones can provide some unique benefits.
Localization Techniques

- Localization refers to the process of estimating the locations of objects based on various types of measurements by sensors.
  - AOA (Angle of Arrival) based techniques requires DF capability (e.g., spinning DF, amplitude comparison, and interferometer etc.) or an antenna array and has limited performance in urban scenarios due to multipath.
  - TDOA (time-difference-of-arrival) based localization requires multiple mobile sensors and clock synchronization among them. Time measurement accuracy is a major challenge for TDOA estimation.
  - RSS (received signal strength) based localization is based on signal power level measurements in multiple locations and is cost-effective because it does not require additional hardware or sensors.
Challenges of RSS based localization

• RSS measurement has the reputation of unpredictability and requires large number of measurements to reduce modeling errors.
• Signal vs distance curves flatten with increasing distance, which would severely degrade the localization performance.
• Not appropriate for fixed ground sensors due to the lack of measurements in space.
How RSS-based Localization Works

• A drone with RF sensor payload flies around in the area of interest using different pre-determined flight path
  • The area is pre-determined based on other information sources
  • typically has dimensions of a few kilometers.
  • The flight path are also pre-determined depending the scenario

• The drone collects RSS measurements and record measurement location coordinates.

• After the measurements collected, localization techniques will be applied to determine the interference location.
The Proposed Localization Technique

- RSS based localization.
- Use the popular log-distance path model
  - Used vertical partition of the measurements and local path loss component.
- Formulated using the maximum likelihood method
  - can handle the cases of known or unknown noise variance.
- Optimization is implemented by dividing the volume of interest into a cubic lattice of square cells, and cell attaining the maximum likelihood indicates the interference.
  - each cell is associated with a probability measure indicating the probability that the emitter is located within this cell.
Visualization Tool for Interference Detection and Localization

- A tool is under development for demonstrating the performance of drone use for interference detection and localization.
Initial Localization Results

- Computer simulations to evaluate the performance of using drones for interference localization.
- Two flight paths were simulated: spiral and sine.
Future Work

• Further algorithm development including
  • the case of unknown noise variance and others
  • Application of clustering to clustering
  • Finger-printing localization approach.
  • Flight path optimization
  • Performance Analysis for the developed localization techniques under various conditions.

• Improve the capabilities of the simulation tool.

• Set up trials to explore and demonstrate the effectiveness and performance of the developed localization techniques for drones in spectrum monitoring applications in real life.
Questions / Discussion