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Localization of Interferences Using Drones in Spectrum Monitoring

Yifeng Zhou, Louise Lamont, Paul Astell, and David Kidston

Communications Research Centre

December 2021

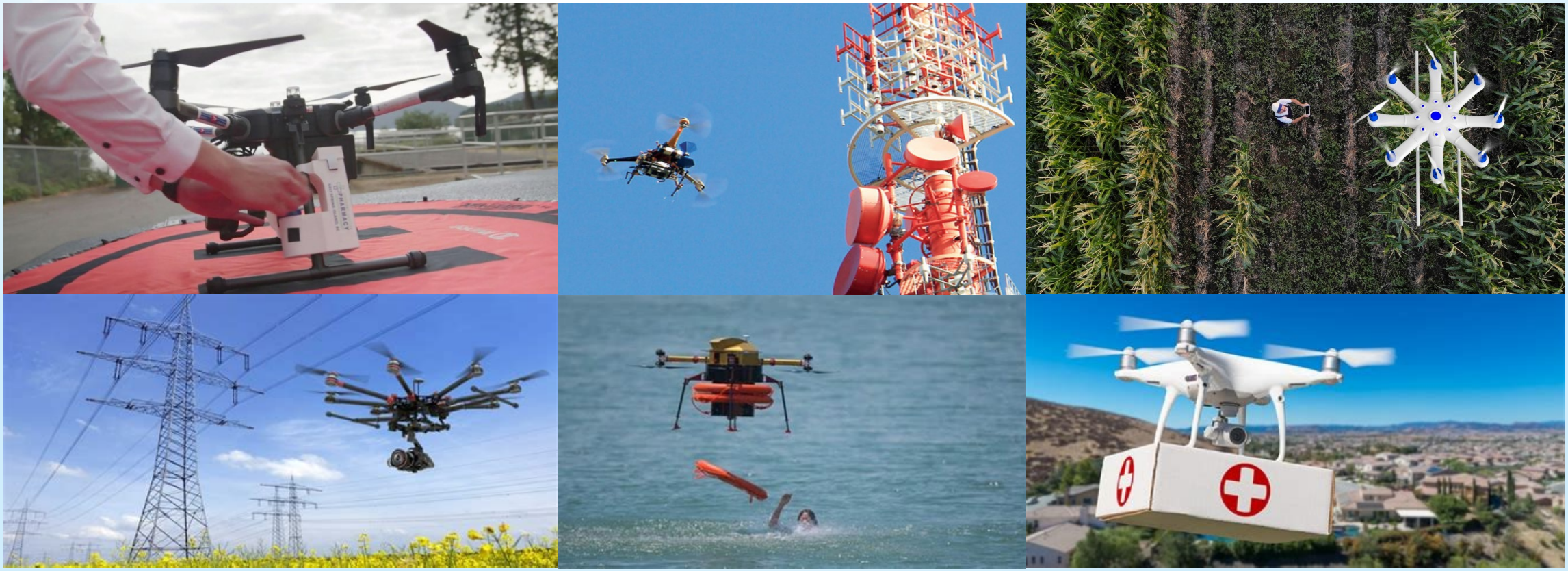
Canada

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

Background

- 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

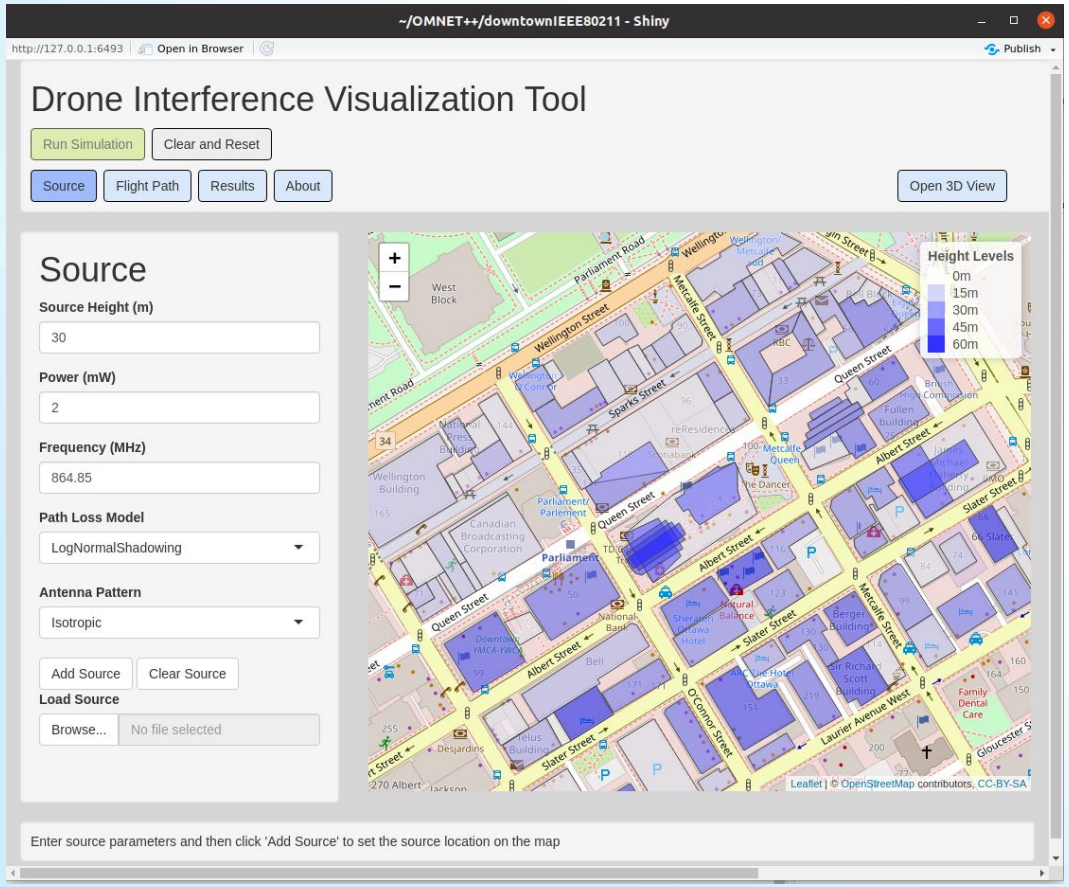
- A drone with RF sensor payload flies around in the area of interest using different pre-determined flight path
  - The area is pre-determined based on other information sources
  - typically has dimensions of a few kilometers.
  - The flight path are also pre-determined depending the scenario
- The drone collects RSS measurements and record measurement location coordinates.
- After the measurements collected, localization techniques will be applied to determine the interference location.

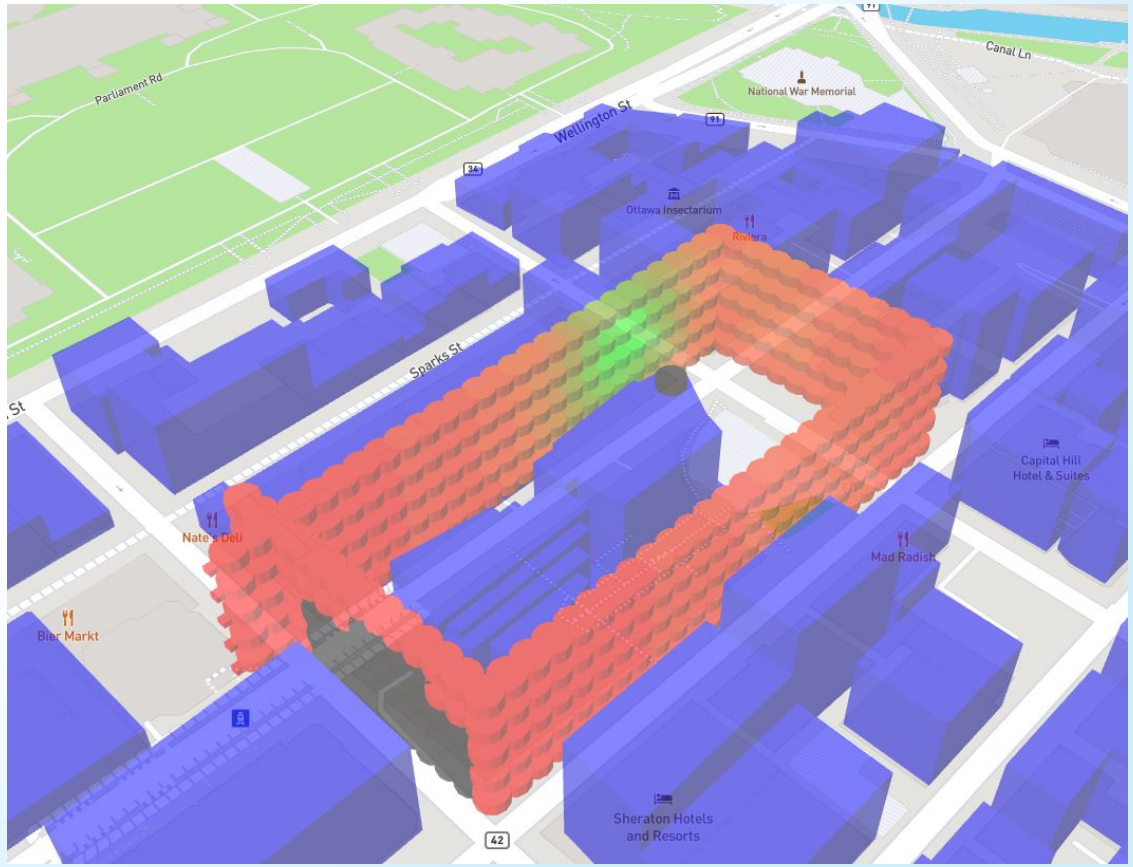
The Proposed Localization Technique

- 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

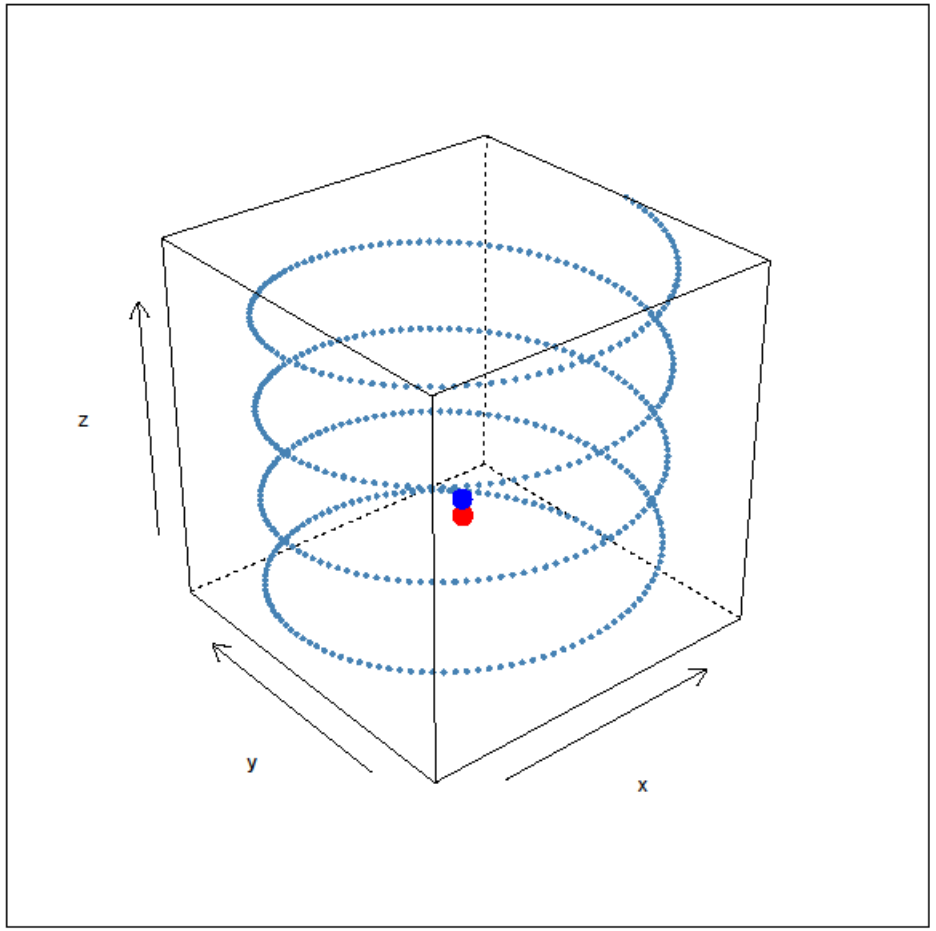
- A tool is under development for demonstrating the performance of drone use for interference detection and localization.

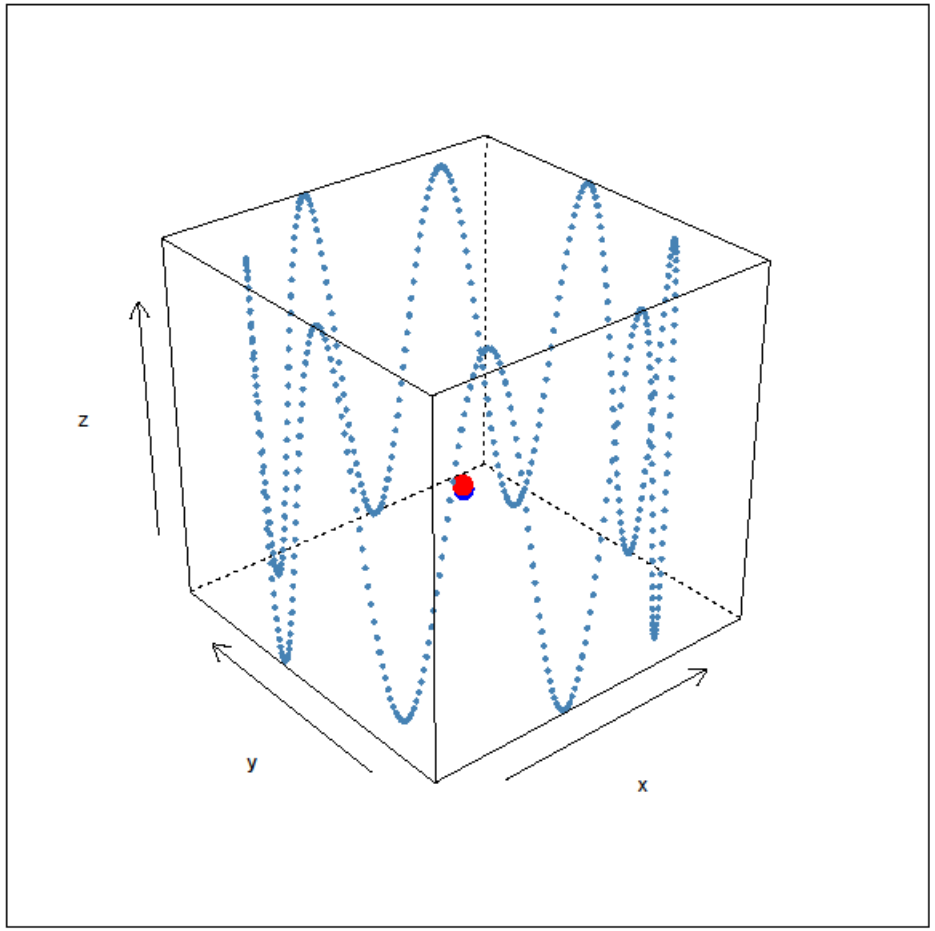




Initial Localization Results

- 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