Temasek Defence Systems Institute

A Simulated Annealing Algorithm for Detecting Moving Target

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Objectives:

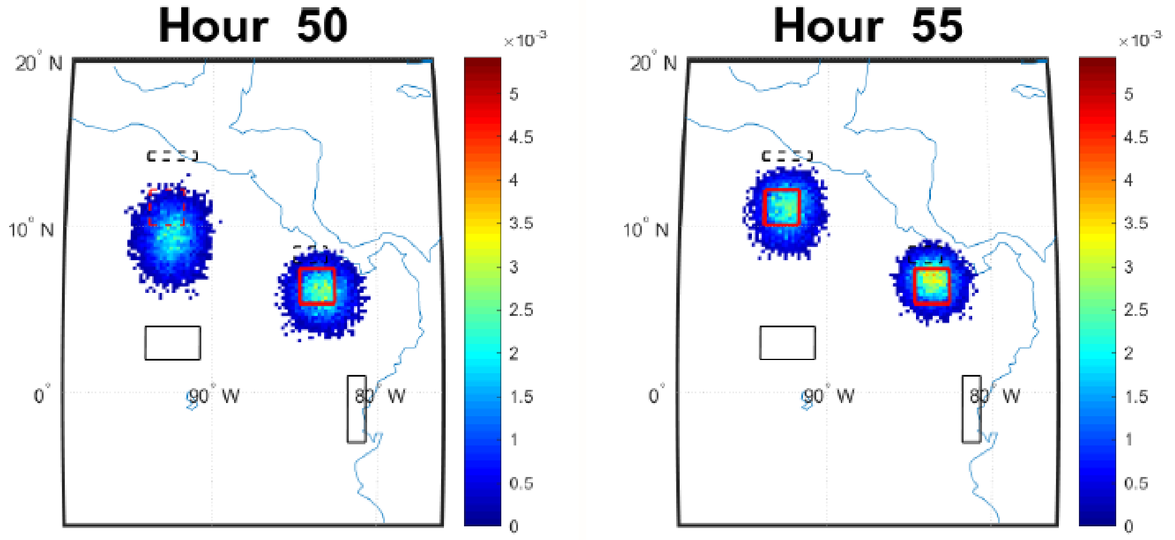
- Use simulation methods to estimate the probability of finding a target.
- Use the Simulated Annealing (SA) algorithm for static sensor placement to choose and place the sensors prior to the beginning of target's journey that maximises target detection probability.

Generate Probability Heat Map:

- Use Temporal Brownian bridge model to model target movement that aggregates weather and tactical behaviours using variance parameter, and allows
  - Uncertain start and end points
  - Multiple path
  - Waypoints during travel
- Simulation obtains detection probability by integrating probability density over sensor area in a single see time.

Simulated Annealing (SA):

- Random search algorithm that generates new candidate point randomly using a candidate point generator
- Exploration with exploitation
  - Accepts all improving points
  - Accepts some non-improving points probabilistically
- Temperature controlled
  - Initial high temp, more exploration
  - Ending low temp, more exploitation



In this scenario, sensors are turned on at hour 50 and 55, as shown by the change of dotted red boxes to solid red boxes. The black boxes represents the start point, end point and the waypoint of the target. The different colours of the heat map represents the probability of target being present in the area.

Results:

- Variance parameter is the dominant factor
- SA algorithm performs better than heuristic methods when
  - Variance parameter is low
  - Sensor size is large
  - Scenario is multipath

Benefits:

- Use in search and detection scenarios for a moving target given highly uncertain target behavior, such as:
  - Drug trafficking
  - Terrorist attacks
  - Search for missing objects

Follow-up research activities:

- Modify and improve convergence and stopping conditions of the SA algorithm.
- Use the SA algorithm to implement a dynamic sensor placement strategy.

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