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Resource Allocation and Path Planning for Multi-Vehicle Autonomous Source Localization and Mapping

Sam Kemp
Jonathan Rogers
School of Aerospace Engineering
Georgia Institute of Technology

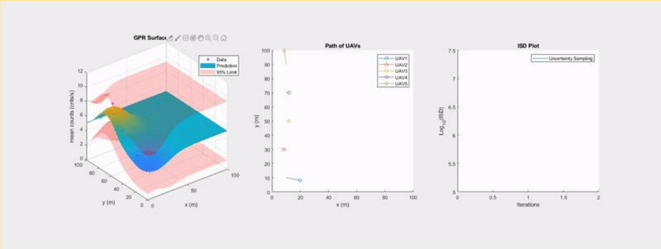
Introduction:

Radiological search and mapping missions are typically performed by human agents or, in some cases, remotely piloted vehicles. Because radiation intensity falls off with distance squared, effective radiation scans with small, low cost detectors must be performed near the ground and other obstacles. As a result, human operators are typically closely involved in operating vehicles to ensure safety. Our work involves development of multi-agent, information-driven, active search algorithms for **source localization and mapping** that can identify areas of interest and effectively cover the search area much quicker than humans or human-piloted vehicles. Even using **path planning with obstacle avoidance** algorithms, obstacles lengthen search times in general, if a multi agent search were able to dynamically assign agents (through dynamic **resource allocation**) to areas with high obstacle density, it could lead to significant improvement in search times.

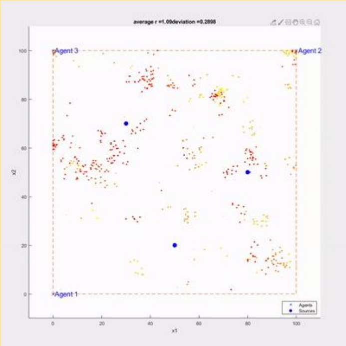
The goal of this work is to develop algorithms that combine information-driven active search and dynamic resource allocation to rapidly perform radiological search and mapping, with significantly reduced time to completion compared to human-piloted missions.

Source Localization and Mapping:

There are many different inference schemes to help visualize and understand data from the environment. One family of algorithms is the Gaussian Process (GP) which includes **Gaussian Process Regression/Prediction (GPR)** or Kriging. GPR is nonparametric and provides real time estimates of uncertainty to aid a search algorithm. It is a great tool for multi-agent information driven search.

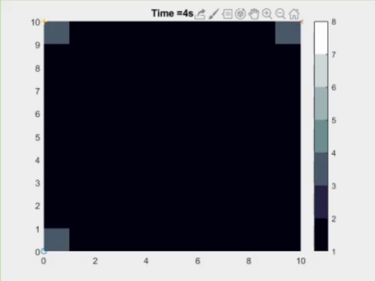


Another common family of algorithms are forms of Recursive/Sequential Bayesian Estimation (RBE). Such examples are Sequential Monte Carlo Filters (SMC) and Kalman Filters (KF, EKF, etc.) **Particle Filters (PF)** are a form of SMC and are what is most used in radiation source localization as well as multi target track before detect problems. They are effective at finding states for Partially Observable Markov Decision Processes (POMDP).



Resource Allocation:

Obstacles slow down the speed at which we can measure a given area. **Dynamic Resource Allocation** will enable us to assign more agents to areas with difficult obstacles to accelerate the source localization and mapping process.



Path Planning with Obstacle Avoidance:

The information driven active search protocol will try and send the agents to areas where they will have the most utility. The path planning with obstacle avoidance algorithms will be responsible for ensuring agents efficiently visit assigned waypoints via the optimal pathway while navigating difficult terrain and avoiding obstacles.

Collaborators: Andrew Torgesen and Jon How from the Department of Aeronautics and Astronautics, Massachusetts Institute of Technology and Brian Quiter with Lawrence Berkeley National Laboratory