TEMPLE UNIVERSITY
Department of Mathematics

Applied Mathematics and Scientific Computing Seminar

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Multi-Robot Active Information Gathering Using Random Finite Sets

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Abstract. Many tasks in the modern world involve collecting information, such as infrastructure inspection, security and surveillance, environmental monitoring, search and rescue, and mapping. All of these tasks involve searching an environment to detect, localize, and track target objects, such as damage to roadways, suspicious packages, plant species, victims of a natural disaster, or landmarks. In any of these tasks the number of target objects is often not known at the onset of exploration. Teams of robots can automate these often dull, dirty, or dangerous tasks to decrease costs and improve speed and safety.

This talk will address the problem of automating data collection processes, so that a team of mobile sensor platforms is able to explore an environment to determine the number of target objects and their locations. In real-world scenarios, robots may fail to detect objects within the field of view, receive false positive measurements to clutter objects, and be unable to disambiguate true objects. This makes data association, i.e., matching individual measurements to targets, difficult. To account for this, we utilize estimation algorithms based on random finite sets to simultaneously estimate the number of objects and their locations within the environment without the need to explicitly consider data association.

Using the estimated object locations along with motion and sensor models, robots must choose where to move next. We explore two methods for doing this. One is decentralized, where robots select actions over a long time horizon that maximize the mutual information between the set of targets and the binary events of receiving no detections. This effectively hedges against uninformative actions and leads to a closed form equation to compute mutual information. The second is distributed, where each robot moves to the weighted centroid of its Voronoi cell, using the output of the estimation algorithm to weight the relative importance of each location. This allows robots to effectively detect and track stationary and moving targets. Our extensive hardware and simulated experiments validate the unified estimation and control framework, using robots with a wide variety of mobility and sensing capabilities to showcase the broad applicability of the framework.