Adaptable and Robust Multi-Robot Decision Making through Generalized Sequential Stochastic Task Assignment

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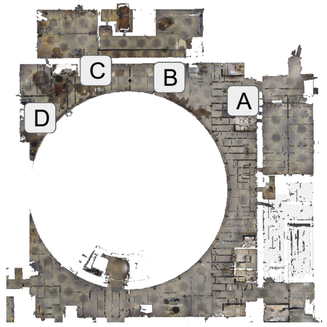
Overview:

The goal of this project is to maximize the probability of correctly deploying the heterogeneous passengers of a marsupial robot team (e.g. aerial vehicles mounted on a ground robots or underwater vehicles mounted on surface vehicles). At each possible decision point, a decision must be made regarding which, if any, of the heterogeneous passengers will be deployed based on the multi-task reward gained from deployment. Multiple deployment decisions are made based on sequentially revealed random variables.

Challenges:

- Prior work cannot be easily extended to solve this problem
- Sequential decision making under uncertainty
- Deployment decisions must be made before uncertainty is resolved
- Multiple tasks with uncertain rewards; reward distributions vary by task
- More decision points than resources to deploy



Left: Carrier robot capable of launching aerial robots (photo: CMU and OSU)
Right: Example from DARPA Subterranean challenge of deployment locations

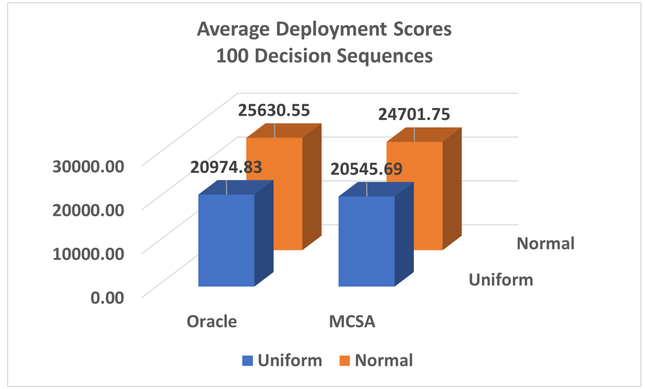
Education and Outreach:

- OSU Robots in the Real World Research Experience for Undergraduates
- ASE High School Summer Scholars program
- Graduate-level Sequential Decision Making course in OSU Robotics curriculum

Solution:

We formulate the multi-robot deployment decision as a sequential stochastic assignment problem (SSAP):

- Use Monte Carlo Simulation to incorporate the reward distributions
  - For all tasks
  - For all remaining decision points
- Determine optimal remaining deployments for each simulated trial
- Choose solution that maximizes the probability of an optimal deployment at each decision point
- Repeat for each decision point



Oracle vs. proposed Monte Carlo Simulation Algorithm (MCSA): 10 resources, 20 decision points.

Scientific impact:

- Establishes a general approach for multi-task sequential decision making with heterogeneous resources under uncertainty
- Possible extensions include:
  - Deploying the same heterogeneous resources multiple times
  - Deploying multiple heterogeneous resources to the same task
  - Updating reward distributions in the middle of a decision sequence

Societal impact:

- Exploration
- Search and rescue
- Long-term deployments for autonomous teams
- Maintenance and repair
- Deployments in unsafe environments
  - Industrial accidents
  - Natural disasters
  - Harsh environments (deep ocean, desert, etc.)
  - Remote spaces

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