FRR: Sequential Stochastic Multi-Task Assignment for Multi-Robot Deployment Planning

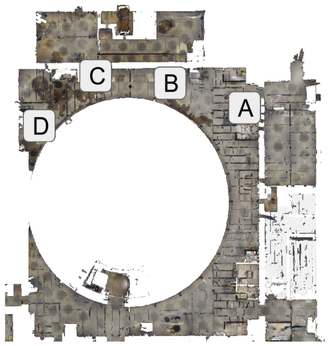
Geoff Hollinger (PI), Colin Mitchell (PhD Student), Graeme Best (Collaborator)
Collaborative Robotics and Intelligent Systems Institute, Oregon State University, http://research.engr.oregonstate.edu/rdml/
Geoff.Hollinger@oregonstate.edu

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 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
- 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
- Sequential decision making under uncertainty

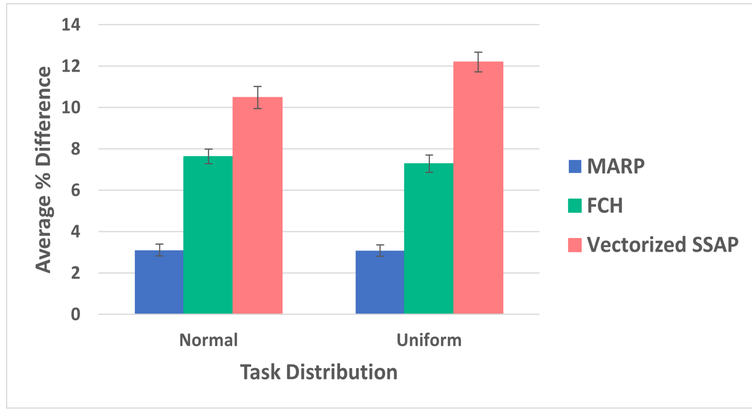


Left: Carrier robot has capability to launch aerial robots
Right: Example from DARPA Subterranean challenge
Image Credit: DARPA SubT Team Explorer (Carnegie Mellon and Oregon State)

Solution:

We formulate the multi-robot deployment decision as a Multi-Robot Multi-Task Sequential Stochastic Deployment Problem (MRMT-SSDP):

- Use Monte Carlo Simulation to incorporate the reward distributions for all tasks and 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



Maximize Aggregate Reward Probability (MARP) vs.
Comparison methods: 10 resources, 30 decision points

Scientific Impact:

- Establishes a basic 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

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

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