Active Perception for Robot Teams: From Visual Search to Videography

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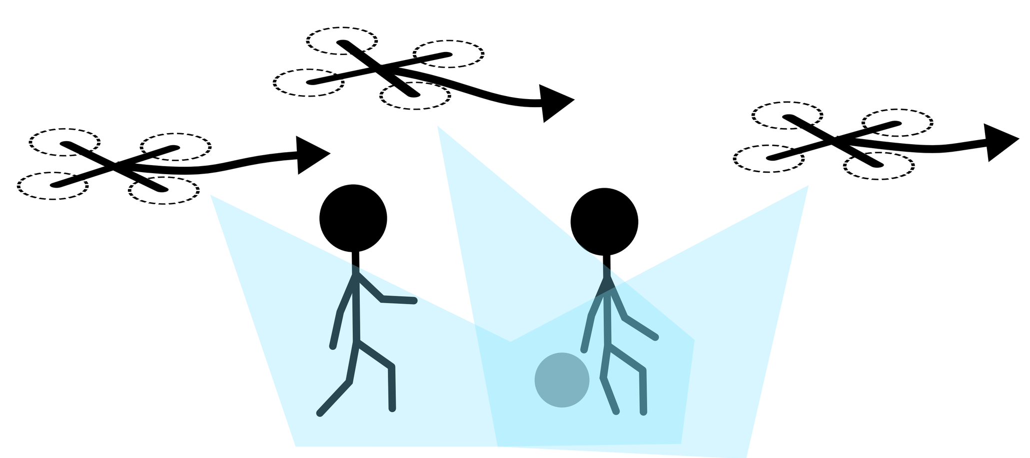
Interests

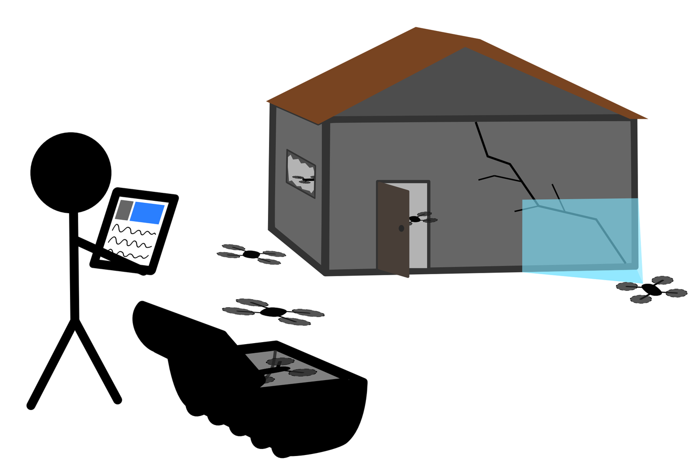
- Aerial vehicles
- Multi-robot systems
- Active perception

Research Topics

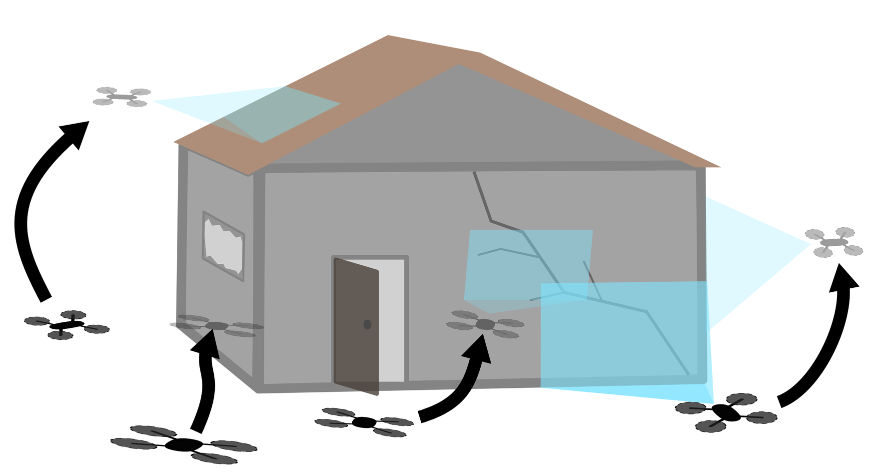
Aerial Videography



Search and Inspection



Perception Planning

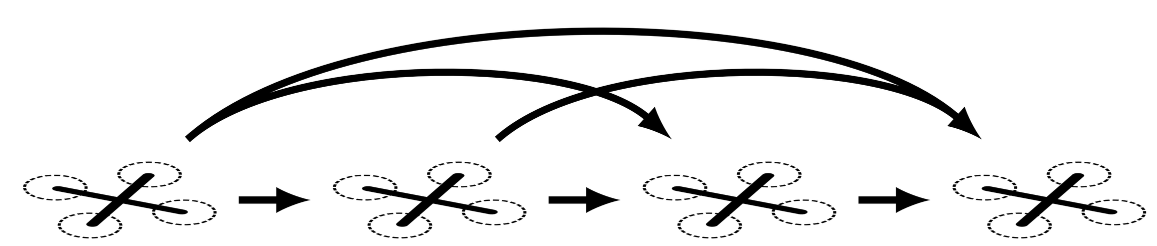


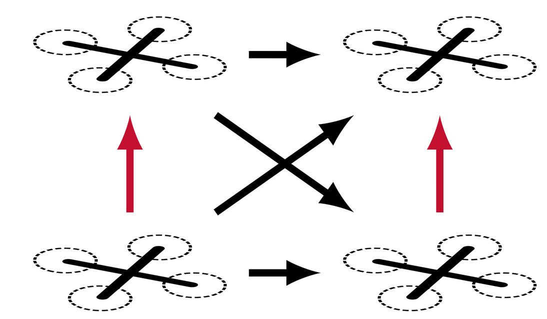
Safe Navigation

Multi-Robot Perception Planning

Receding-horizon maximization of **view coverage** and **information gain** jointly across teams of robots

Scalable, Distributed, Parallel Perception Planning





Greedy planners (Sequential or Parallel):

- **Both:** Extend single-robot planners to multi-robot settings. *Robots plan greedily given prior decisions **(edges)***
- **Sequential methods:** Induce temporal constraints
- **Parallel methods:** Ignore some decisions to plan in parallel

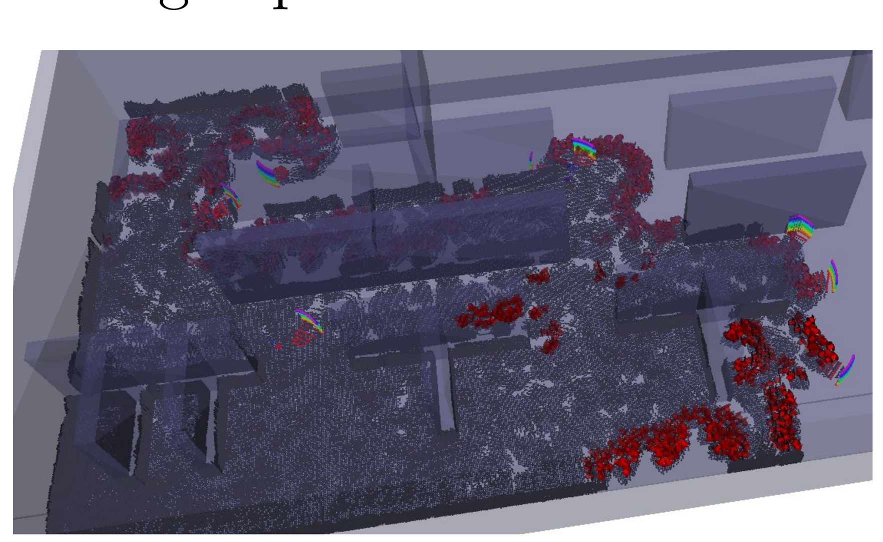
Randomized Sequential Partitions (RSP) provides *distributed*, *parallel* solutions to many multi-robot perception problems in *constant time*.

Monotonicity and Suboptimality for Active Perception

- **Monotonic (1-increasing), submodular (2-decreasing) objectives:** Greedy sequential planners within 1/2 optimal
- **3-increasing:** Scalable, parallel planning via **RSP** *Suboptimality guarantees approach 1/2 optimal* (can ignore decisions with fixed edge costs)

Search, Inspection, and Exploration

Contributions: Volumetric and view-based methods for exploration of large environments, with multi-robot teams, and at high speed

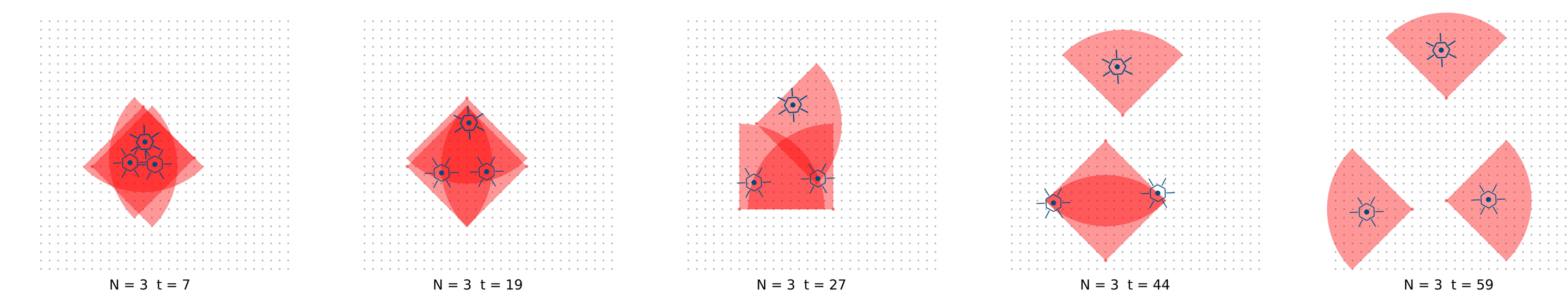


Direction:
Perception planning for:

- Disaster and emergency response
- Infrastructure inspection
- Environment monitoring

Aerial Videography

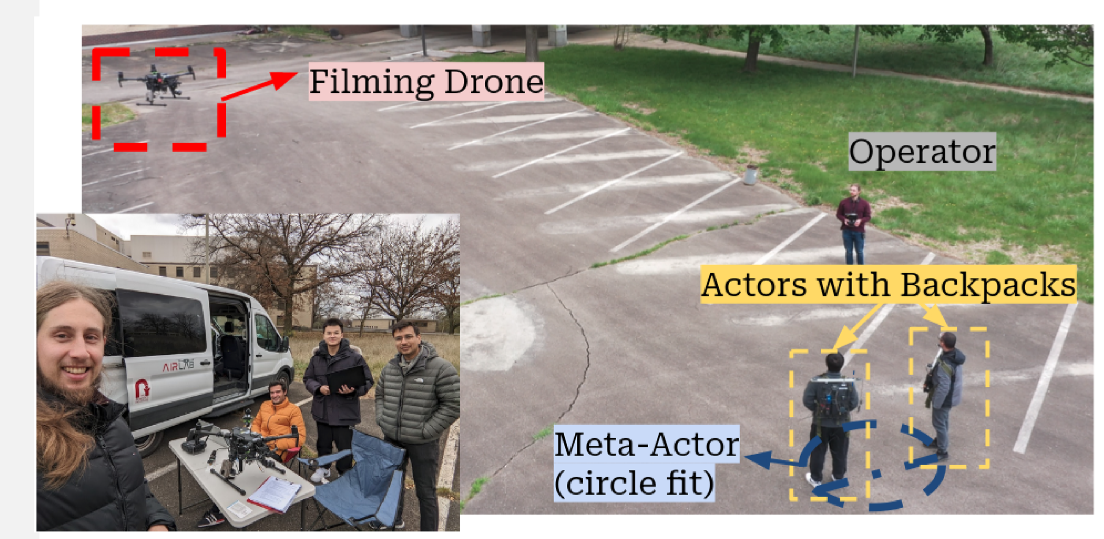
Planning and Coordination



- **Diverse views:** Maximize sum of square-root pixel density over discretized target surface
- **Optimize trajectories:** Plan for individual robots via value iteration (single-pass over planning horizon)
- **Coordination:** Jointly optimize views & trajectories via greedy submodular optimization

Systems and Field Experiments

Developing proof-of-concept filming system:



- **System:** 3–4 robots (DJI M210) with gimbal cameras operating
- **Localization:** RTK GPS on robots and actors
- **Communication:** Mesh network (Rajant Breadcrumb)
- **Baseline:** Formation around meta-actor (bounding circle)

Opportunities for Collaboration

- **Computer Vision:** Compute-constrained tracking and prediction; Dense reconstruction and neural rendering
- **Human Robot Interaction:** Interfaces and control for multi-robot filming; Studying social interaction between drones and athletes being filmed
- **Media & Arts:** Filming performance and study of multi-robot filming as new media

Selected References

[1] **M. Corah** and N. Michael. Distributed matroid-constrained submodular maximization for multi-robot exploration: theory and practice. *Auton. Robots*, 43(2):485–501, 2019.

[2] **M. Corah** and N. Michael. Distributed submodular maximization on partition matroids for planning on large sensor networks. In *Proc. of the IEEE Conf. on Decision and Control*, Miami, FL, December 2018.

[3] **M. Corah**, C. O'Meadhra, K. Goel, and N. Michael. Communication-efficient planning and mapping for multi-robot exploration in large environments. *IEEE Robot. Autom. Letters*, 4(2):1715—1721, 2019.

[4] **M. Corah** and S. Scherer. On performance impacts of coordination via submodular maximization for multi-robot perception planning and the dynamics of target coverage and cinematography. In *RSS 2022 Workshop on Envisioning an Infrastructure for Multi-Robot and Collaborative Autonomy Testing and Evaluation*, 2022.

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