Planning and Coordination for Unmanned Aerial Vehicles

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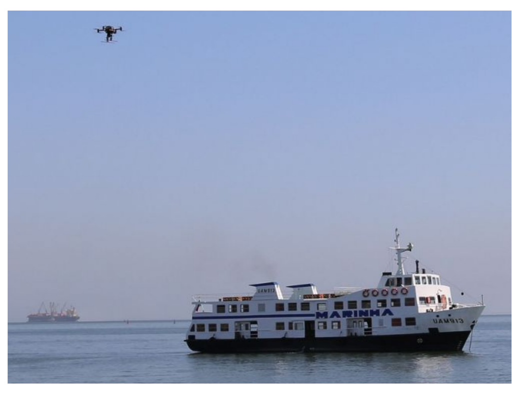
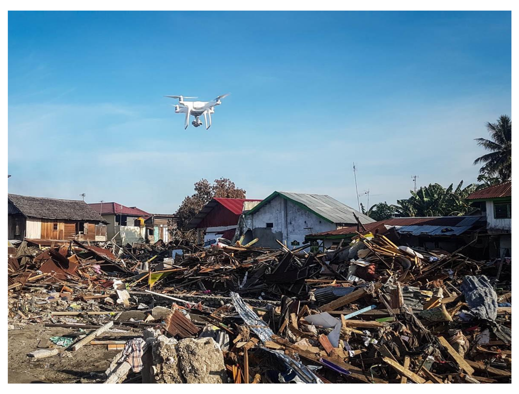
Research Theme

Unmanned Aerial Vehicles (UAVs) are a versatile platform that can be used for many data collection applications

Learn more about my work!



Maritime Search and Rescue



Disaster Response

Forest Fire Monitoring

Get a digital copy of the poster

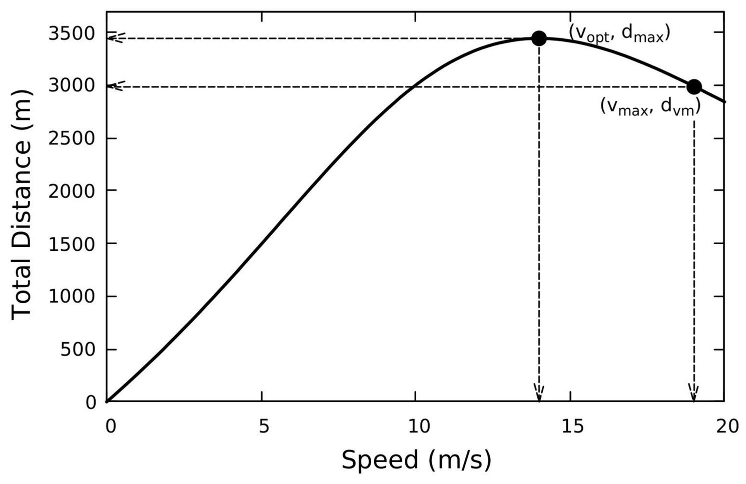
This poster presents recent research on UAV path planning, with a focus on drones

Energy-aware UAV Path Planning with Adaptive Speed

Problem setup

Background Work: Related works showed drone speed impacts power consumption

Building on this, we derived speed to distance relationship

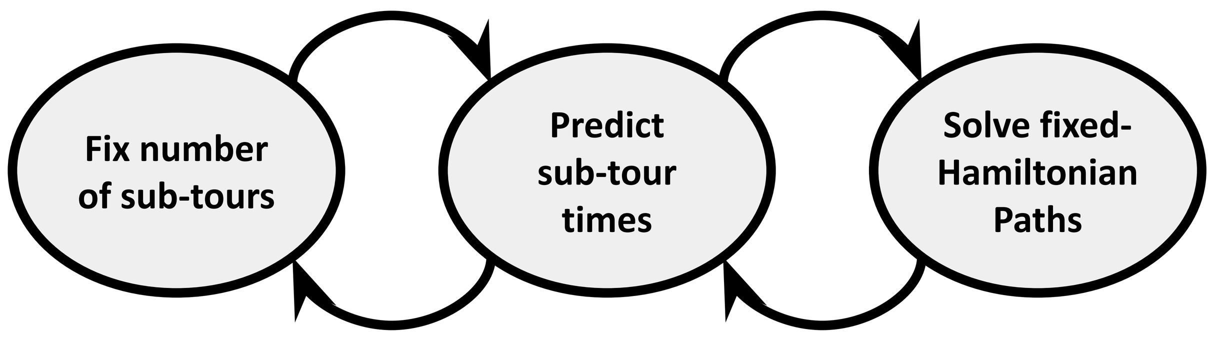


Problem Definition: Given a single energy constrained drone and unstoppable ground vehicle with known movement pattern, plan a route for the drone that visits a series of waypoints while being launched/received at the ground vehicle

Goal: Minimize mission completion time

Constraints: UAV has limited on-board energy storage, limited velocity

Our Approach

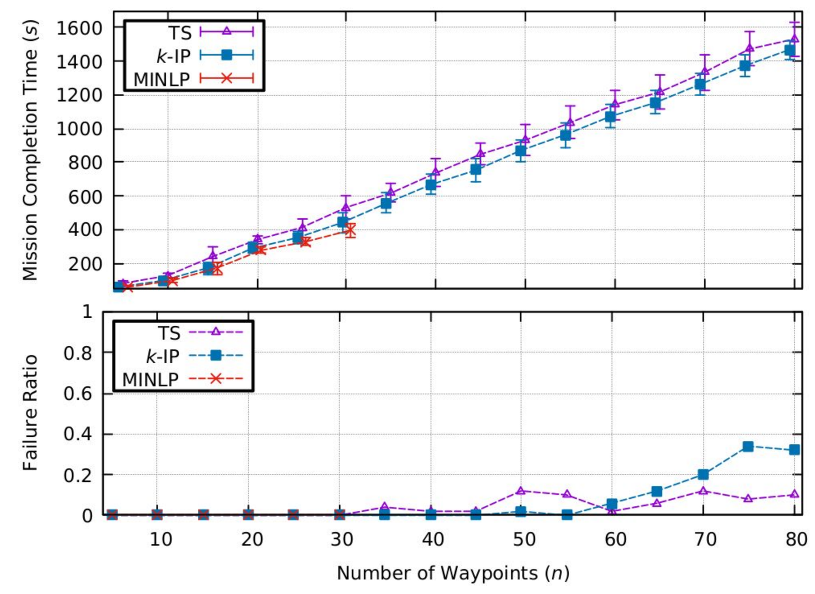


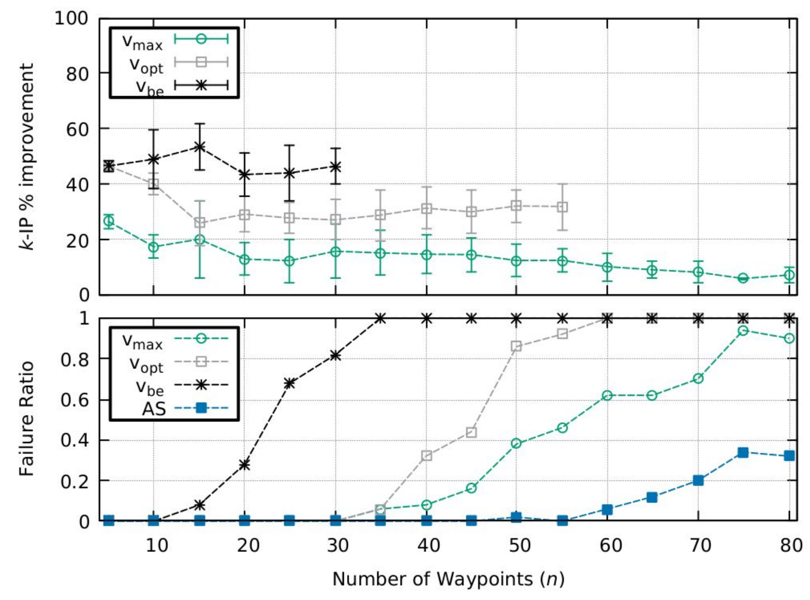
We propose two methods for solving fixed-Hamiltonian paths:

- Clustering + TSP solver (k-IP)
- Mixed-Integer Nonlinear Program (MINLP)

Major Results:

- MINLP, k-IP provide 23.8%, 14.5% improvement in mission completion time over baseline approach, respectively
- Adapting speed improves mission completion time 11.9% ~ 47.1% compared to fixing speed (depending on approach)





Holistic Path Planning for Multi-Drone Data Collection

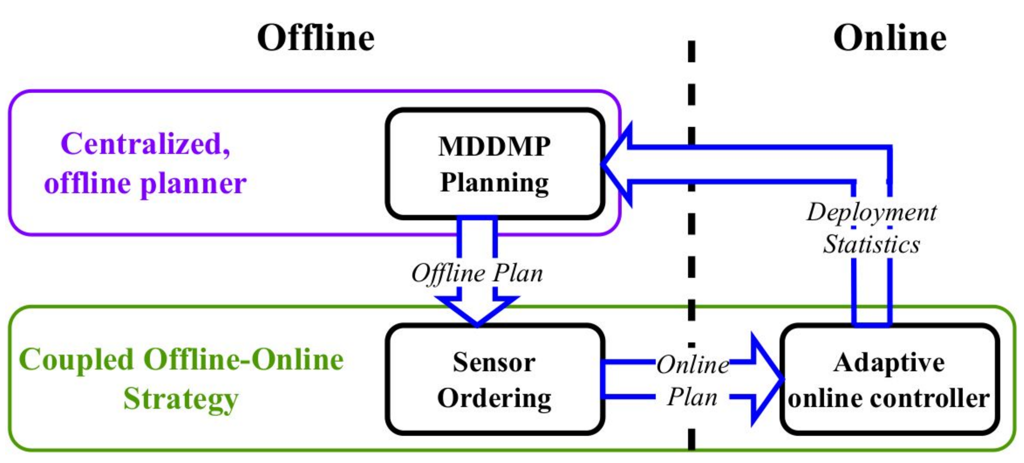
Problem setup

Problem Definition: Given a team of energy constrained drones and set of sensors, plan data collect routes for the drones such that the drones come within communication range of each sensor

Goal: Minimize total time required to collect all data

Constraints: Drones have limited on-board energy storage, limited communication range

We need: Offline algorithm to divide-up work, drone route planning, and online strategy to adapt actions during deployment



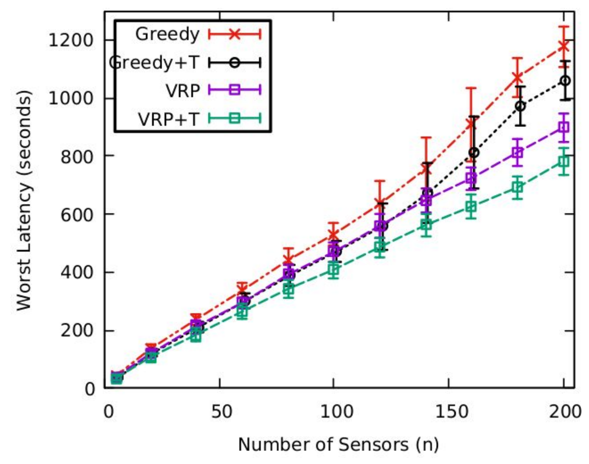
Our Approach

Offline algorithm:

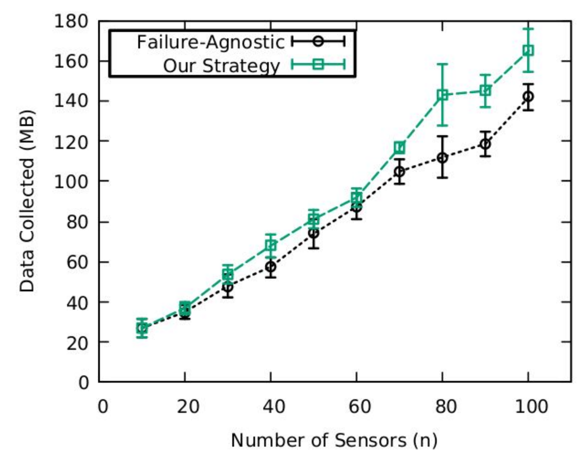
1. Assume a single sub-tour can solve problem
2. Ignore communication ranges, solve VRP on sensor locations
3. Improve sub-tours using heuristics while considering communication ranges
4. Run job-scheduling algorithm to assign drones to sub-tours
5. Increase number of sub-tours, repeat 2-4 until solution stops improving

Online strategy: What should a drone do if it stops at a hovering location but cannot connect to a sensor on the ground?

- Create pre-assembled sensor ordering before deploying to enable drone to visit non-responsive sensors without intensive computations during deployment
- Manage energy budget while adapting route during deployment



Offline algorithm outperforms greedy approach by 20.7% when increasing number of sensors



Online strategy shows 12.8% increase in total data collected compared to failure-agnostic approach

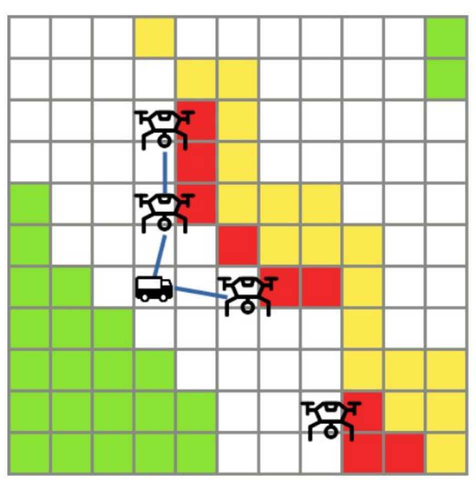
Future Work in Path Planning & Coordination

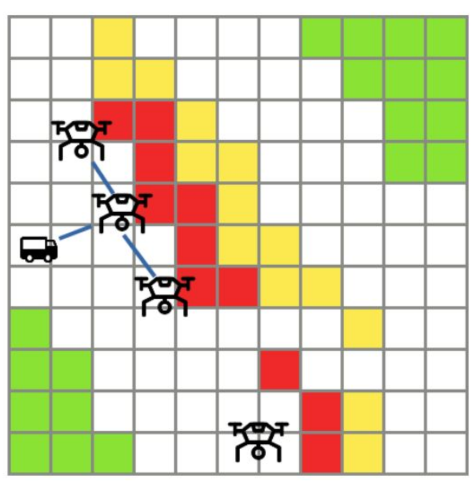
Future Directions

We are considering two new directions for future work:

- Distributed multi-UAV path planning
- Distributed multi-UAV task assignment

Our focus is on real-time decision making and consensus for mixed, partially connected teams





Envisioned Problem Setup

Envisioned Setup: A team of partially connected UAVs and ground vehicles must coordinate actions while performing a monitoring task

Goal: Balance task accomplishment and staying connected to a central ground vehicle

Possible Constraints: limited energy, limited communication ranges, limited computation power