Artificial Intelligence in Operations Research

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Publication date:
2019

Artificial Intelligence in Operations Research

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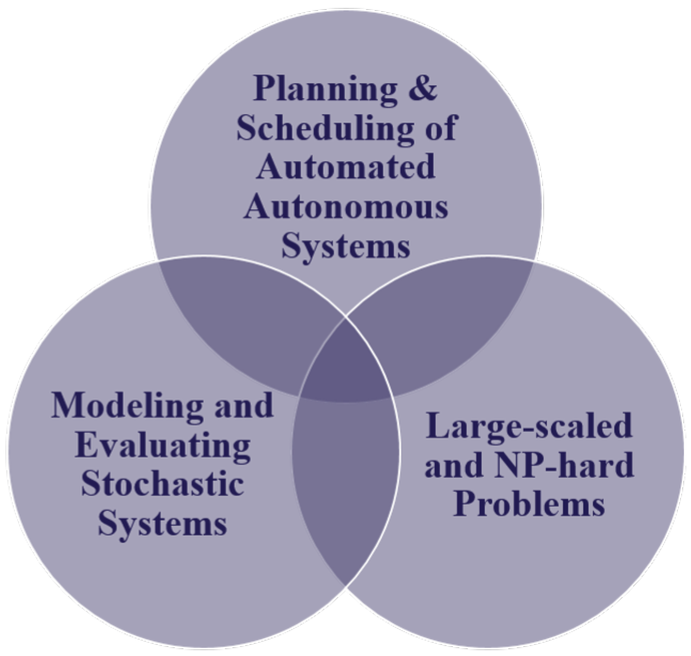
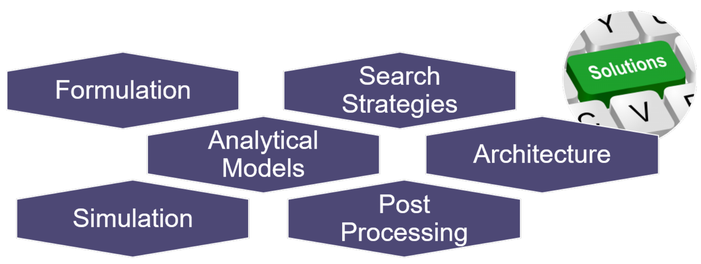
Operations Research Group

- Our research interest is primarily focused on fully **autonomous system** using automated guided vehicles, unmanned aerial vehicles and other mobile robots.
- We solve various complex decision problems using various solution approaches, mainly based on **Operations Research** techniques

Nature of Target Challenges



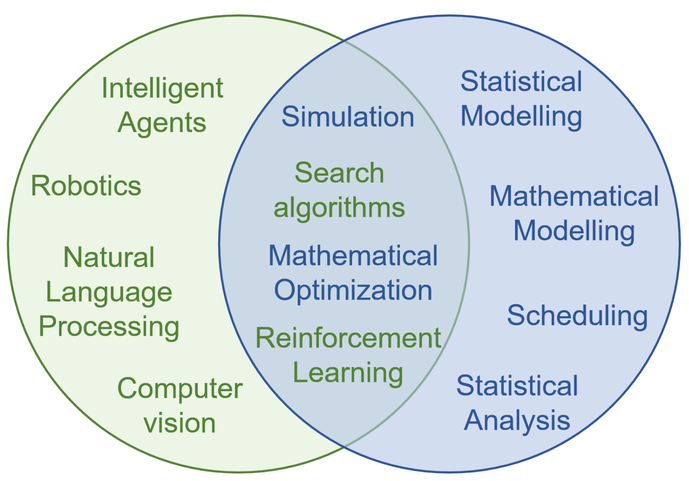
Solutions



AI Challenges Addressed

- Very large scale decision problems
- Very large data sets
- Real-time (or near real-time) reaction needs

AI meets OR



Coverage Path Finding

- Coverage Path Finding is to seek a path that guides a vehicle to cover an area of interest in a cost and time effective manner

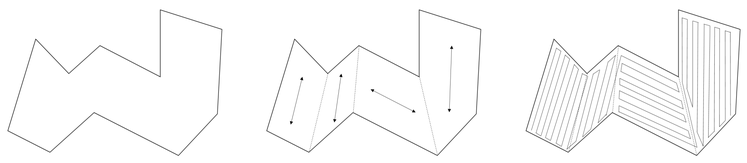


Fig. 1: Illustration of coverage path finding

- We have proposed a new convex decomposition method (a component algorithm for the coverage path finding) that can manage any shape of area of interest in a short time

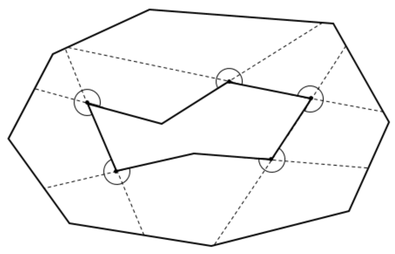


Fig. 2: The concept of the proposed convex decomposition

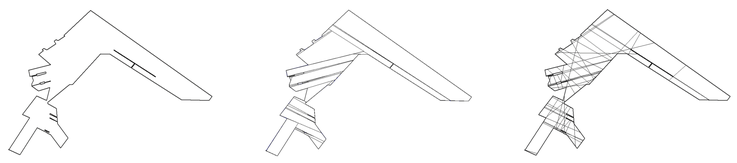


Fig. 3: Output of the method for a port in Antwerp

UAV Routing under Threats

- We study the algorithms for UAV path finding in the presence of threats
  - Dijkstra, A* algorithm, RL, etc.
- Collision between UAVs should be avoided

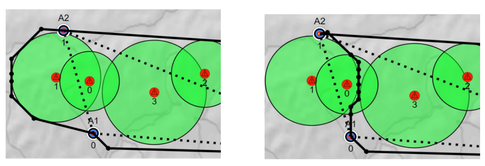


Fig. 4: Paths with different weights for threats

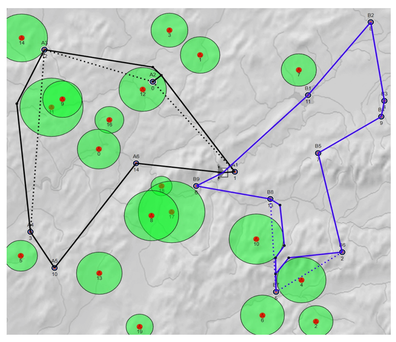


Fig. 5: A screenshot of an simulation environment and paths for multiple UAVs

Routing with Speed Selection

- Routing + Speed optimization
- Time-dependent speed selection options
- Solutions: Determine multiple promising paths and optimize speeds over the paths

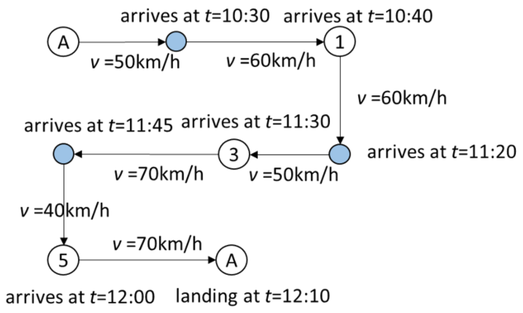


Fig. 6: Solution structure

Satellite Image Acquisition

Assigning image acquisition tasks to multiple satellite

- Multiple criteria to prioritize tasks
- Inter-dependencies in requests due to operational constraints and request specifications
- Weather uncertainty
- Finding solutions in real time

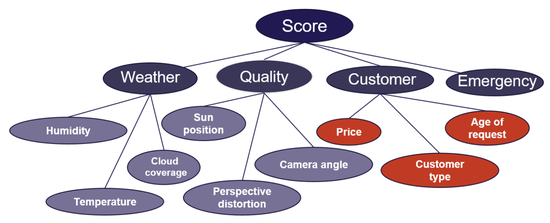


Fig. 7: List of criteria for prioritization

Solution Approach

- Decompose a continuous problem, i.e. to compute all discrete feasible attempts
- Score all attempts
- Consider Weather uncertainty
- Find optimal task assignment scheme for multiple satellites based on scores and operational constraints

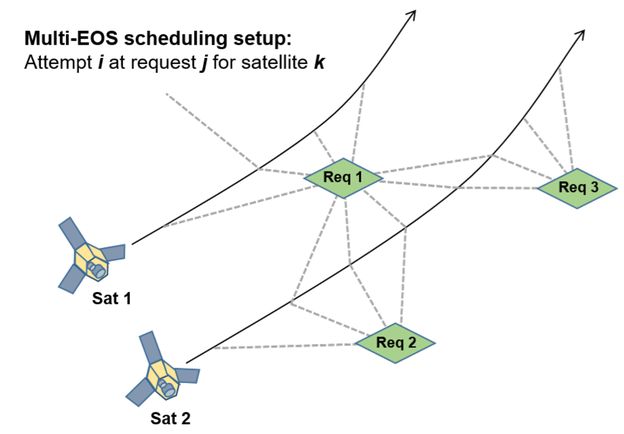


Fig. 8: Illustration for task assignment to satellites

Implementation

- Scoring mechanism
- Binary linear programming problem and the operational constraints
- Prototype of a decision-support system for satellite operators

RL in Project Management

- We formulate the resource allocation problem during a project execution as an Markov decision process
- We test the feasibility and performance of Deep Q-learning in the resource allocation

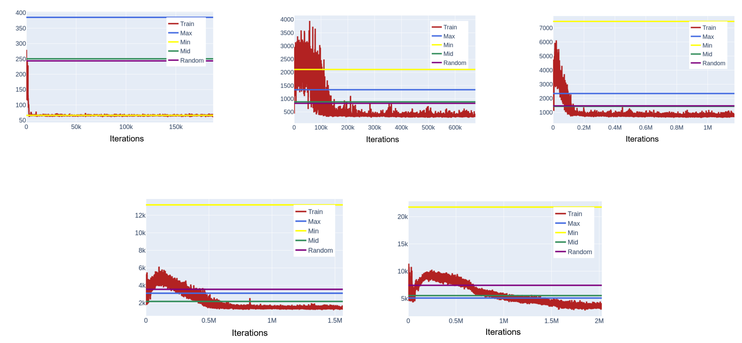


Fig. 9: Q-network training over iterations

- Open issues in RL for project management
  - Parameter tuning for different project setting
  - Representation of an environment for future projects
  - Interpretation of a policy from reinforcement learning