Aalborg Universitet

Artificial Intelligence in Operations Research

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Publication date:
2019

Link to publication from Aalborg University

Artificial Intelligence in Operations Research

Operations Research Group

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https://www.mp.aau.dk/researchgroups/operations-research

AALBORG UNIVERSITY
DENMARK

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

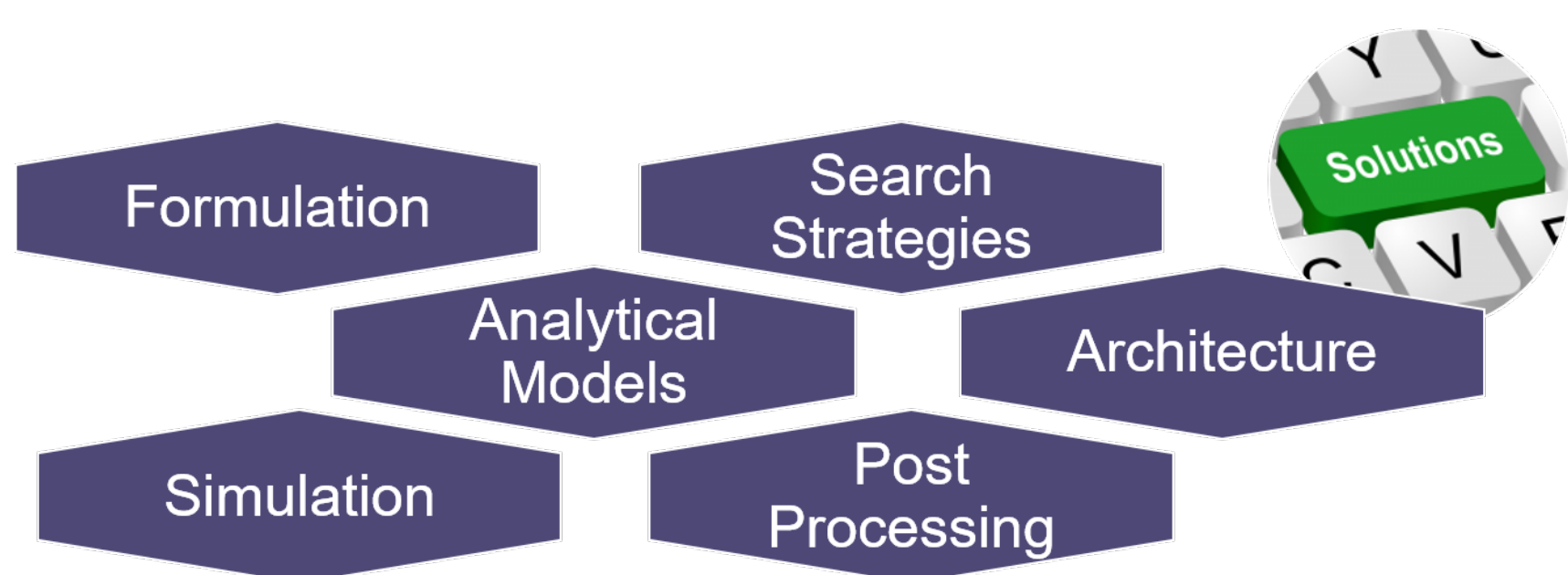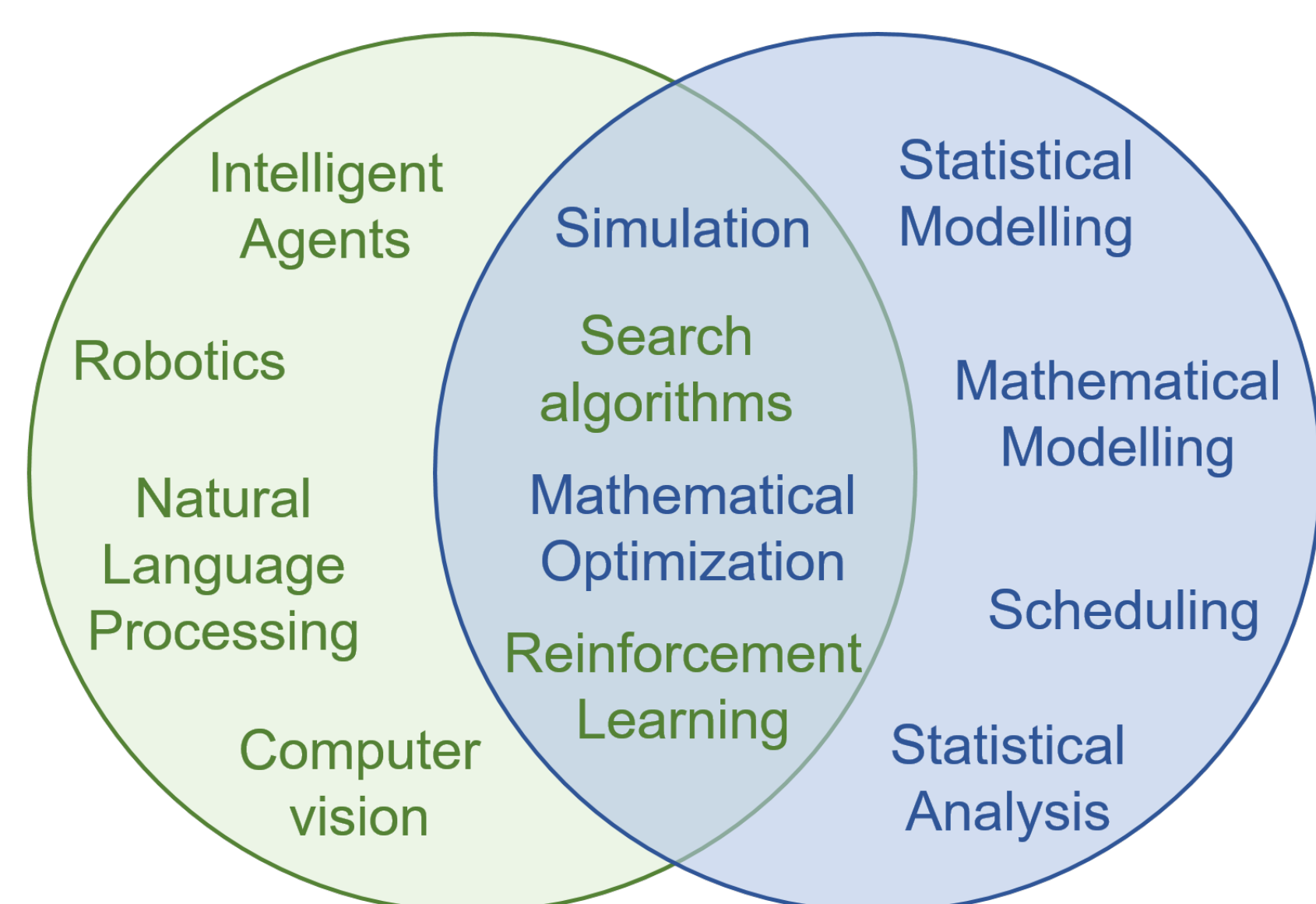- Planning & Scheduling of Automated Autonomous Systems
- Modeling and Evaluating Stochastic Systems
- Large-scaled and NP-hard Problems

Solutions
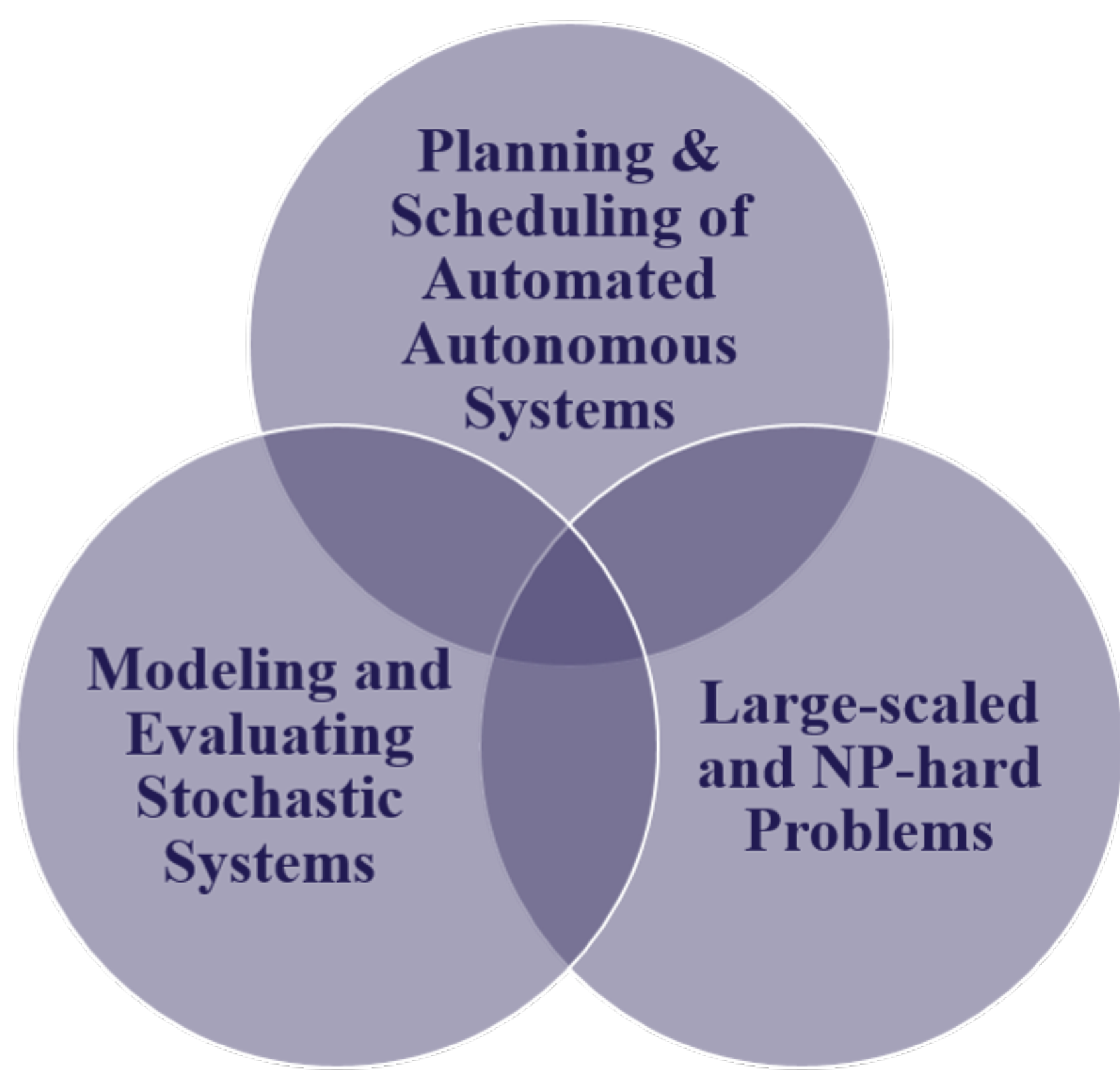
- Formulation
- Search Strategies
- Analytical Models
- Architecture
- Simulation
- Post Processing
- Solutions

AI Challenges Addressed

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

AI meets OR

- Intelligent Agents
- Robotics
- Natural Language Processing
- Computer vision
- Simulation
- Search algorithms
- Mathematical Optimization
- Reinforcement Learning
- Statistical Modelling
- Mathematical Modelling
- Scheduling
- Statistical Analysis

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
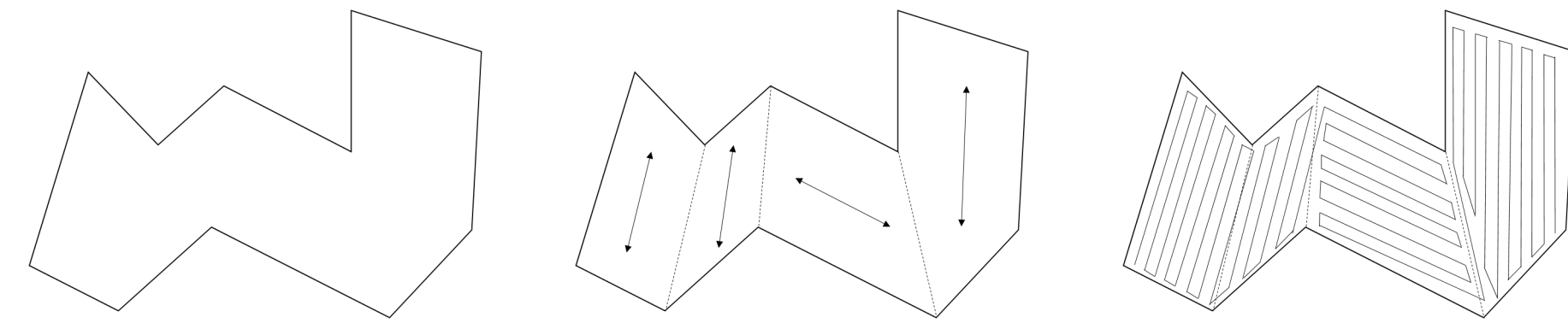
Fig. 1: Illustration of coverage path finding

► 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
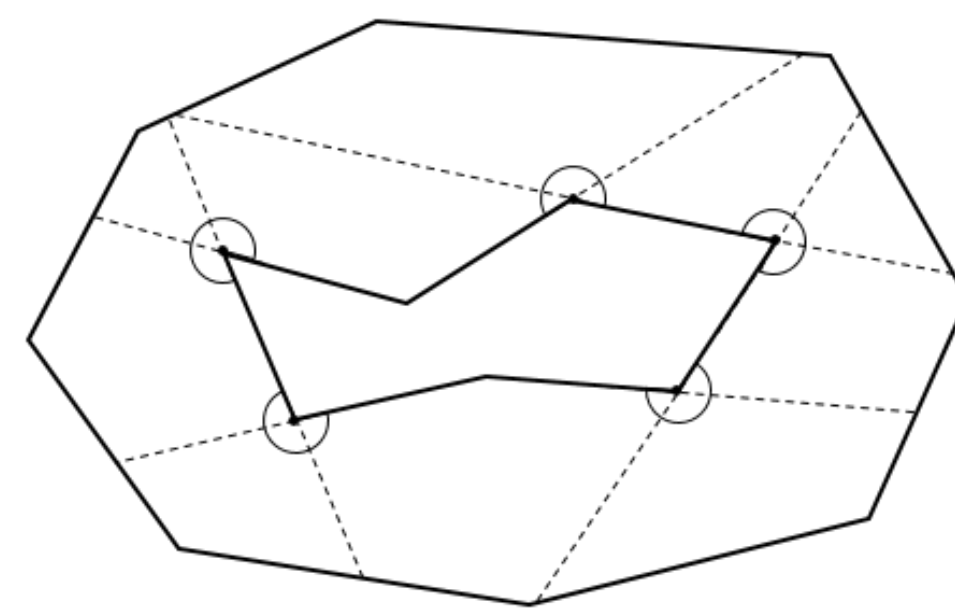
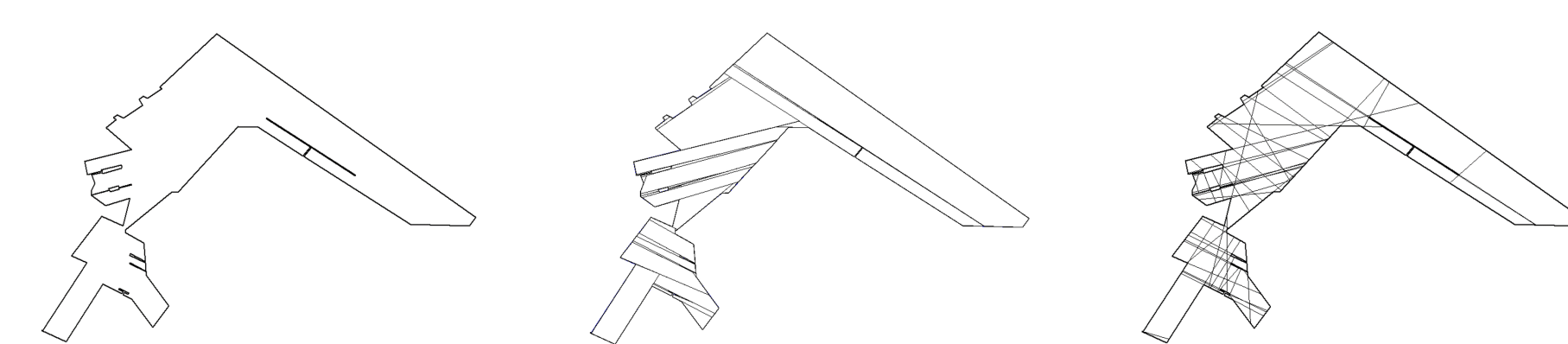**Fig. 2:** The concept of the proposed convex decomposition

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.
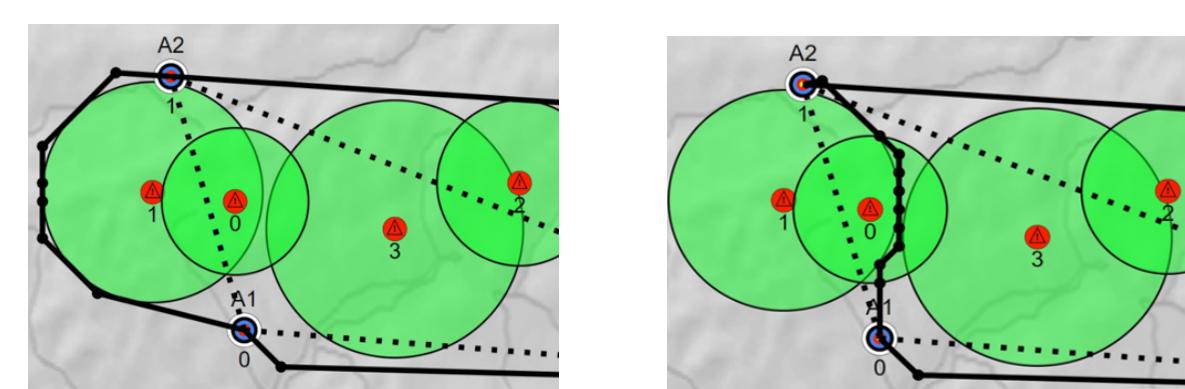► Collision between UAVs should be avoided

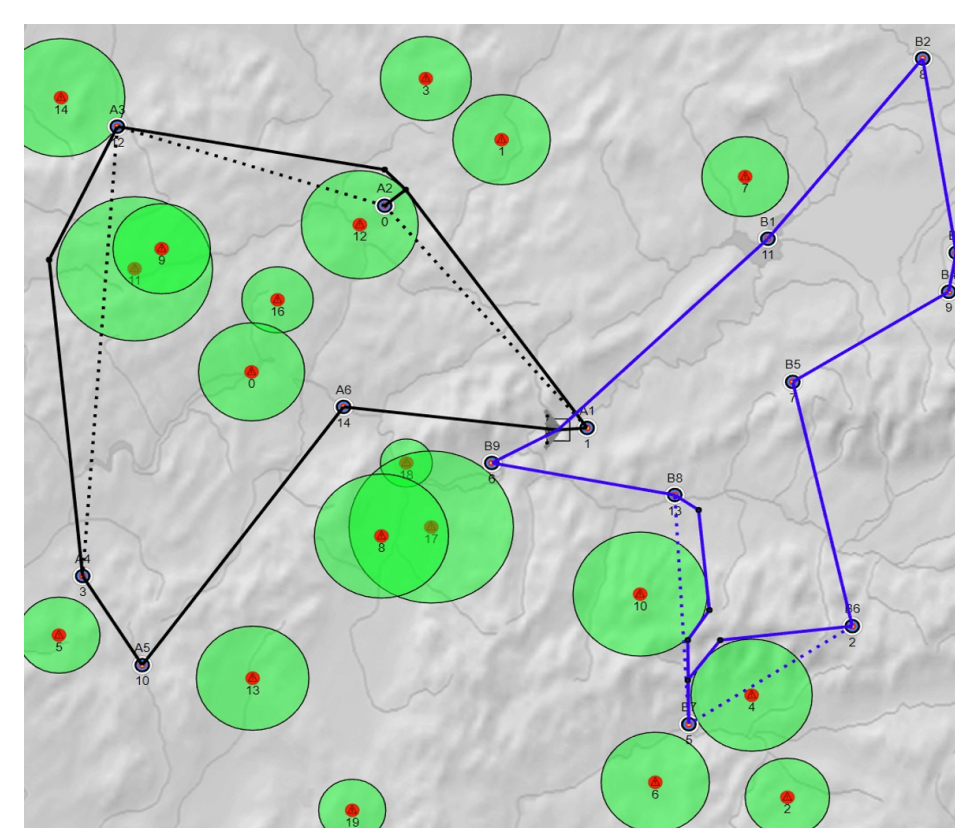**Fig. 4:** Paths with different weights for threats

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
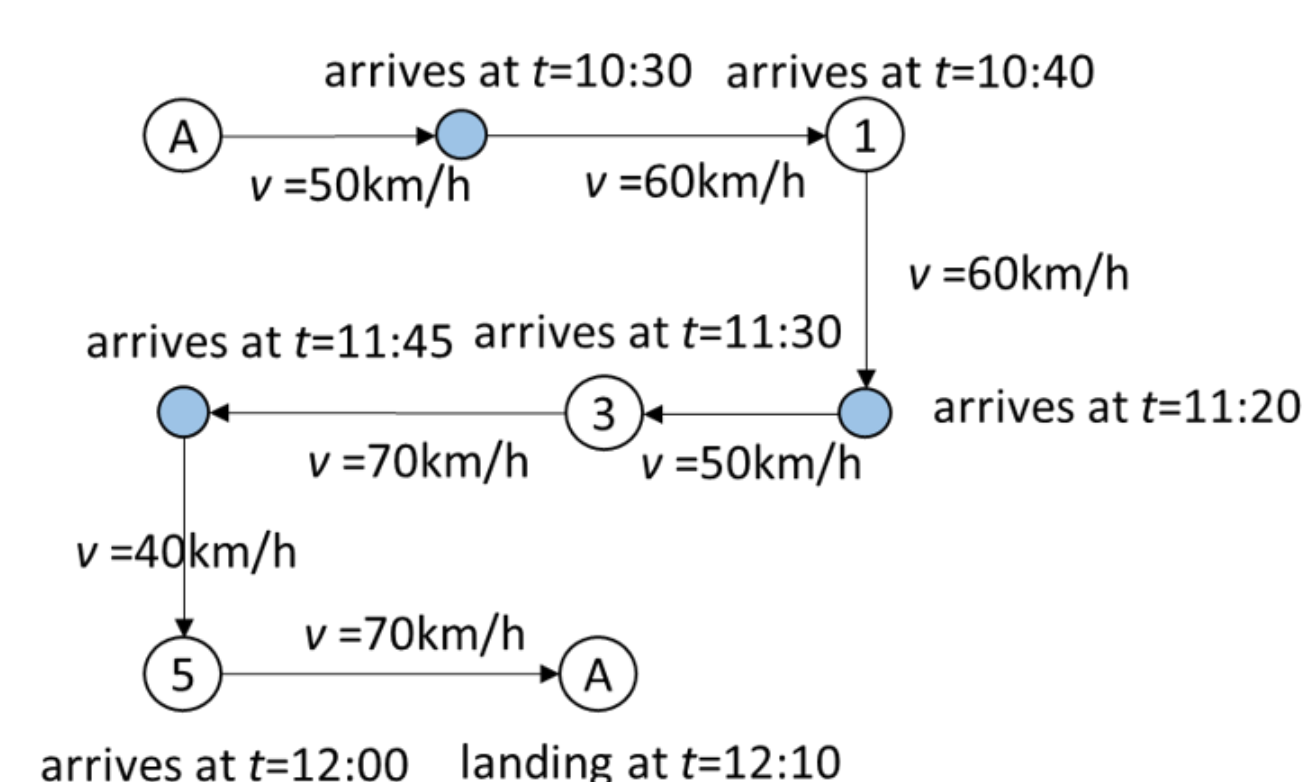
arrives at t=10:30   arrives at t=10:40
A → v=50km/h → 1 ; v=60km/h

v=60km/h

arrives at t=11:45   arrives at t=11:30
v=70km/h → 3 ← v=50km/h ← arrives at t=11:20

v=40km/h

v=70km/h
5 → A

arrives at t=12:00   landing at t=12:10

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
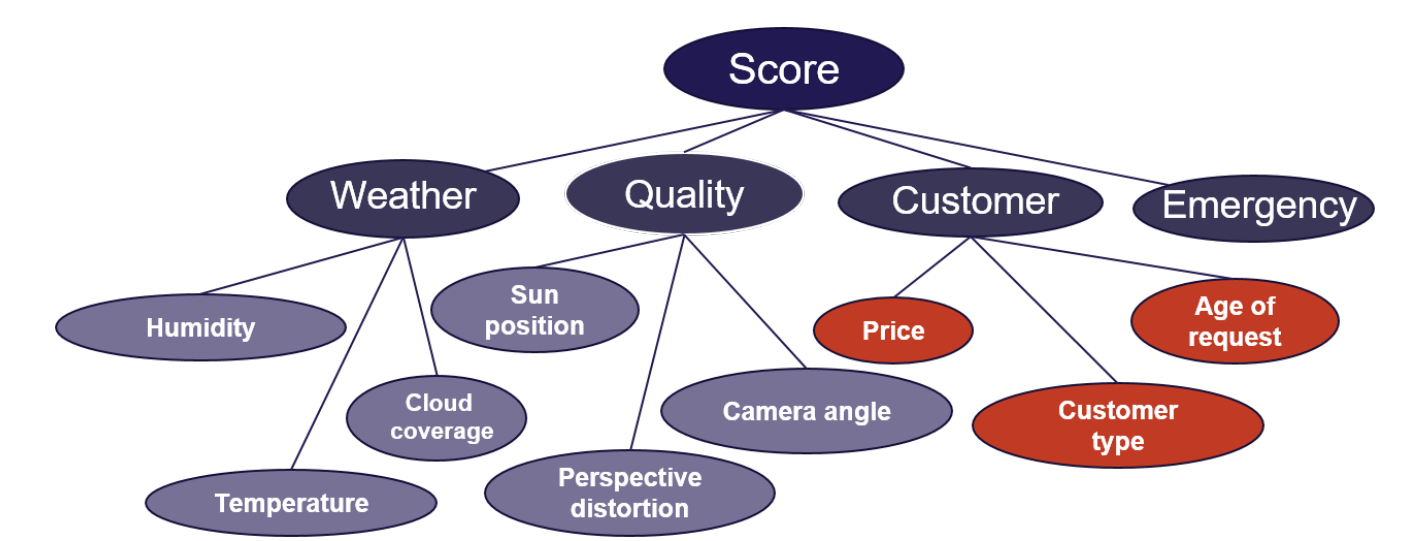► Finding solutions in real time

- Score
  - Weather
    - Humidity
    - Cloud coverage
    - Temperature
    - Sun position
    - Perspective distortion
  - Quality
    - Camera angle
  - Customer
    - Price
    - Customer type
  - Emergency
    - Age of request

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
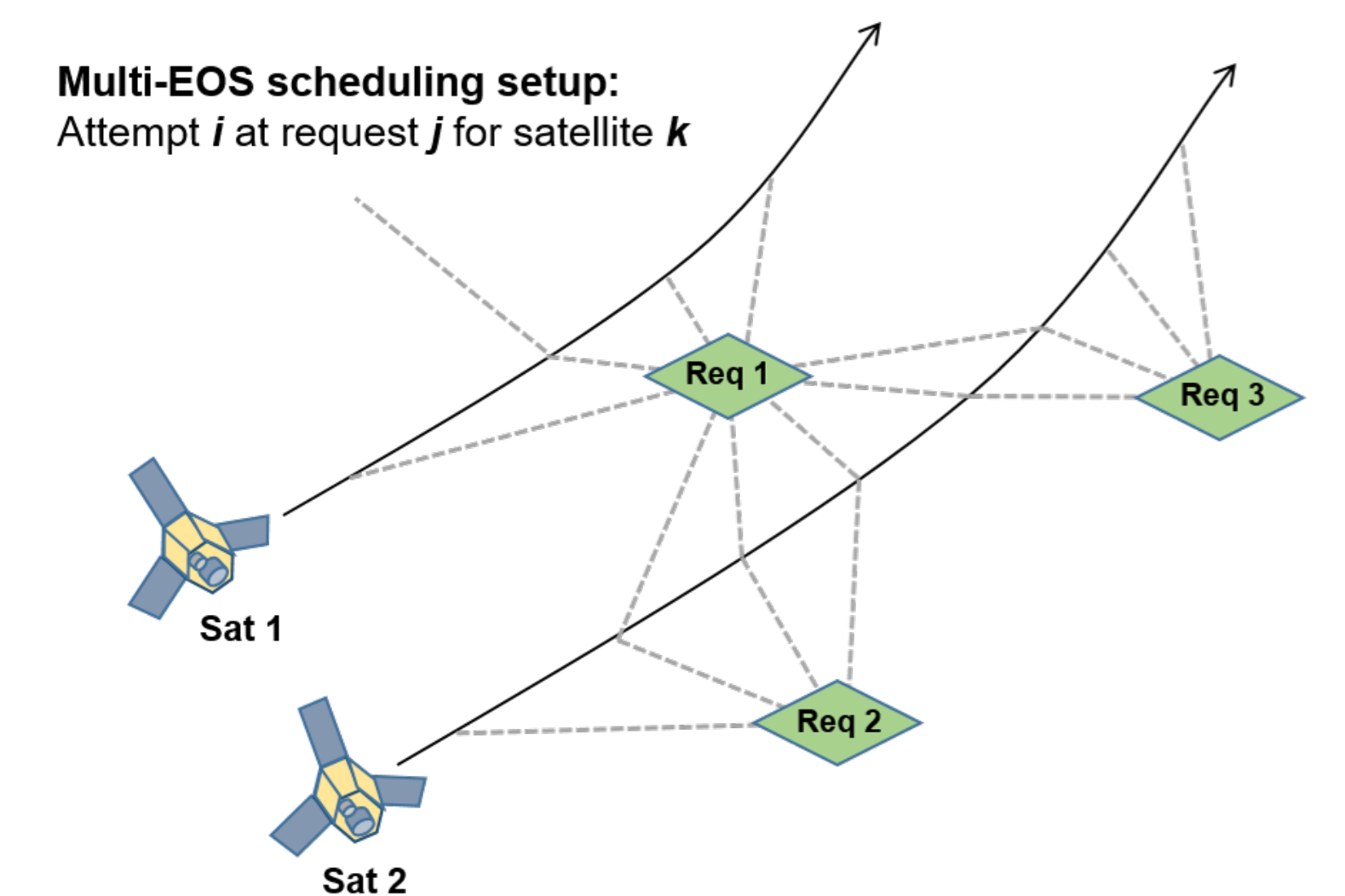
Multi-EOS scheduling setup:
Attempt *i* at request *j* for satellite *k*

Req 1, Req 2, Req 3, Sat 1, Sat 2

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
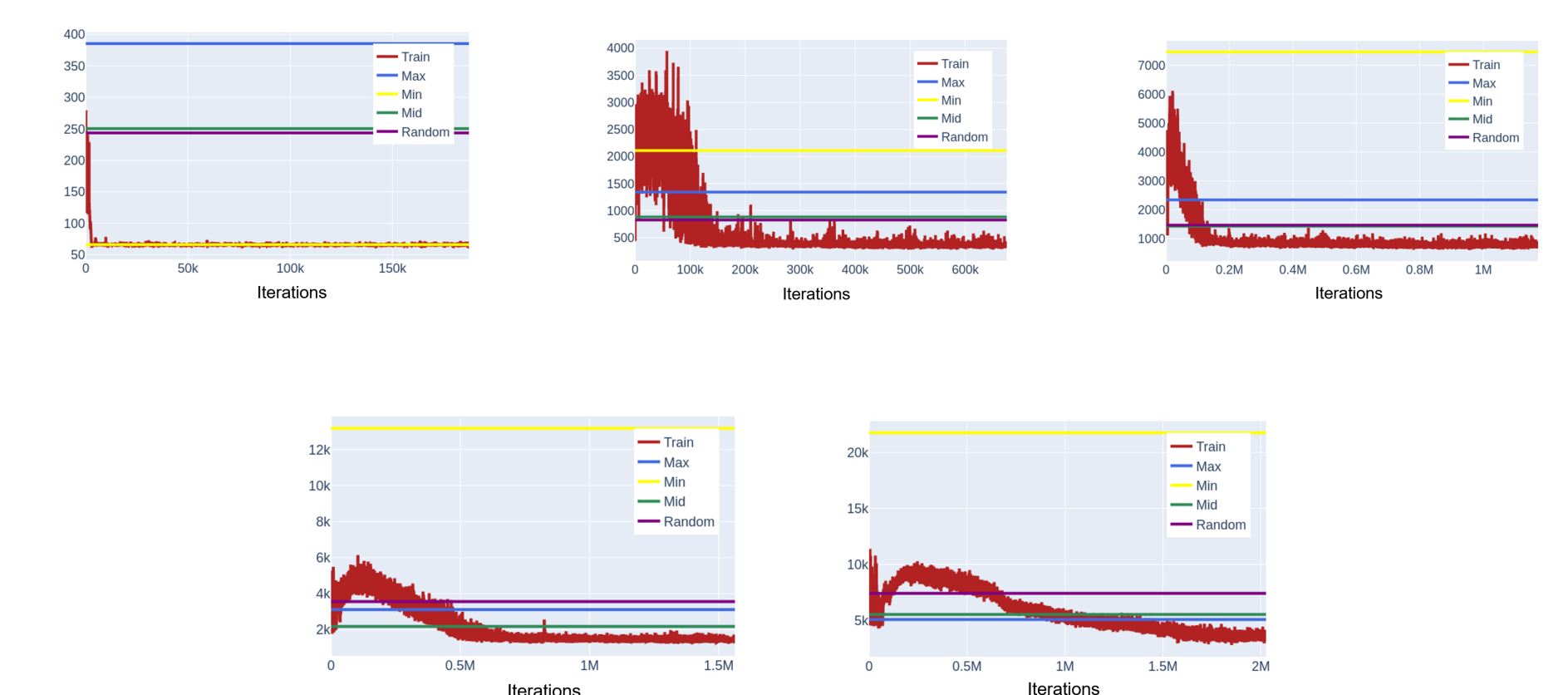► We test the feasibility and performance of Deep Q-learning in the resource allocation

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