Distributed Control of Autonomous Space Vehicles

Elias Krantz

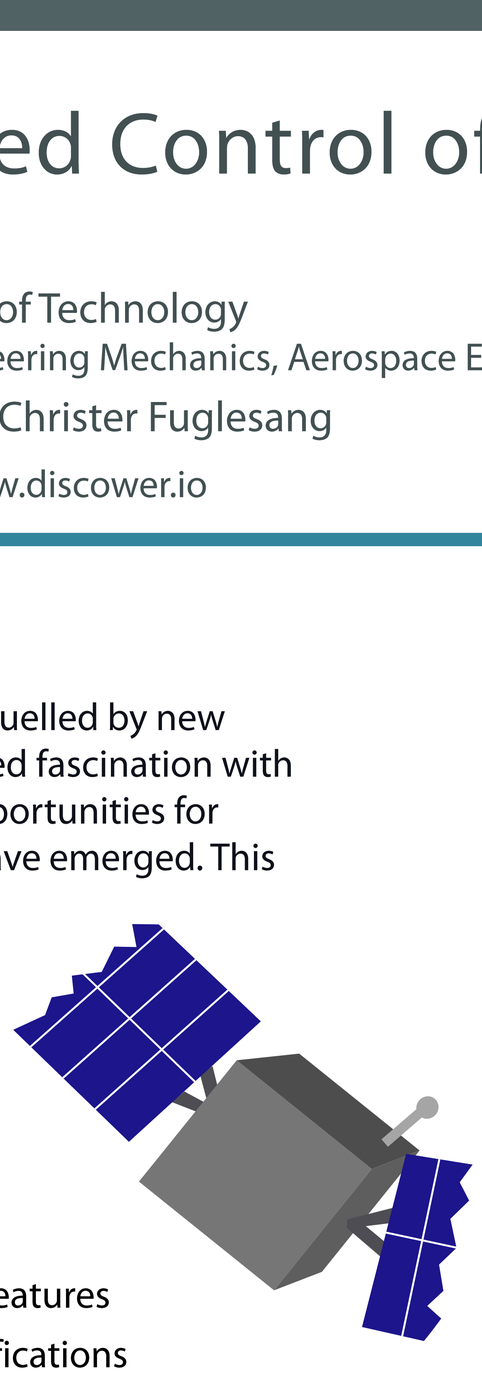
KTH Royal Institute of Technology
Department of Engineering Mechanics, Aerospace Engineering

Supervised by Prof. Christer Fuglesang

eliaskra@kth.se www.discower.io

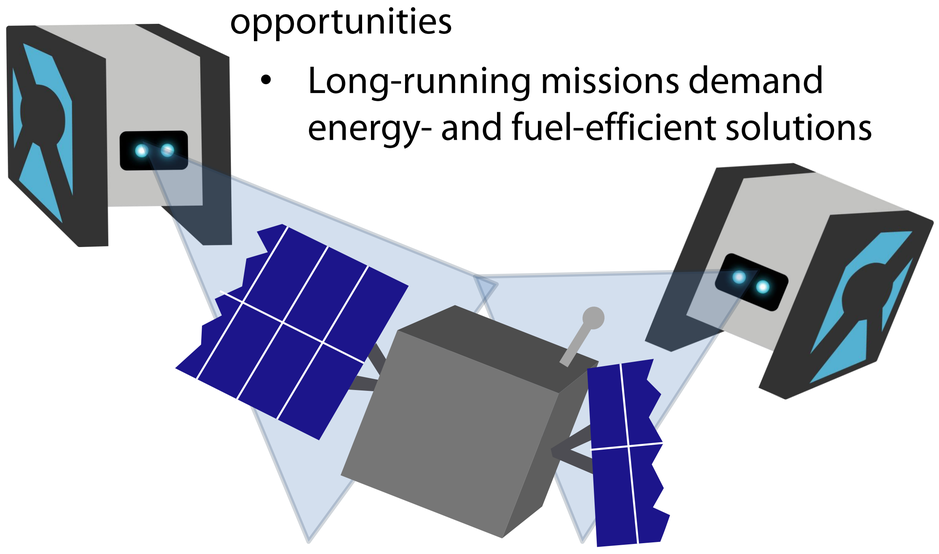
Introduction

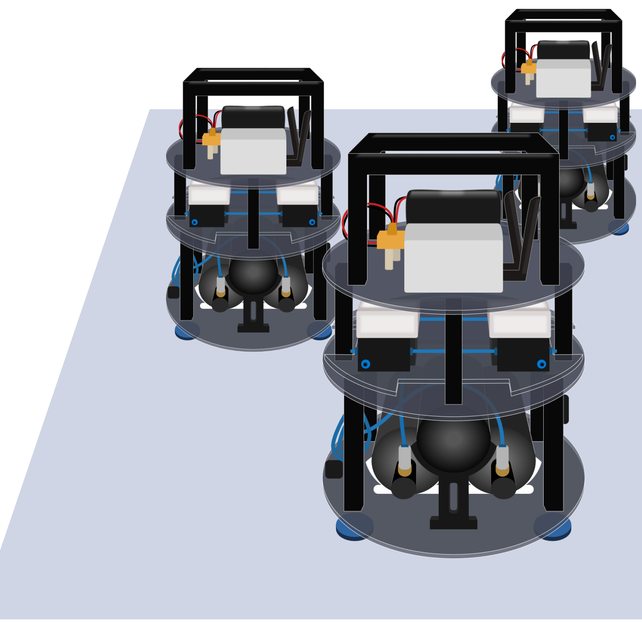
The space industry is experiencing a resurgence, fuelled by new technologies, commercial interests, and a rekindled fascination with space exploration. As such, a growing array of opportunities for multi-agent autonomous vehicles and robotics have emerged. This research aims to capitalize on this momentum by developing innovative distributed control and planning strategies specifically designed for the extreme conditions of outer space.



Challenges

- Weightlessness impacts standard robotic features
- Expensive and safety-critical mission specifications
    - Limited accessibility, testing and validation opportunities
        - Long-running missions demand energy- and fuel-efficient solutions





Validation

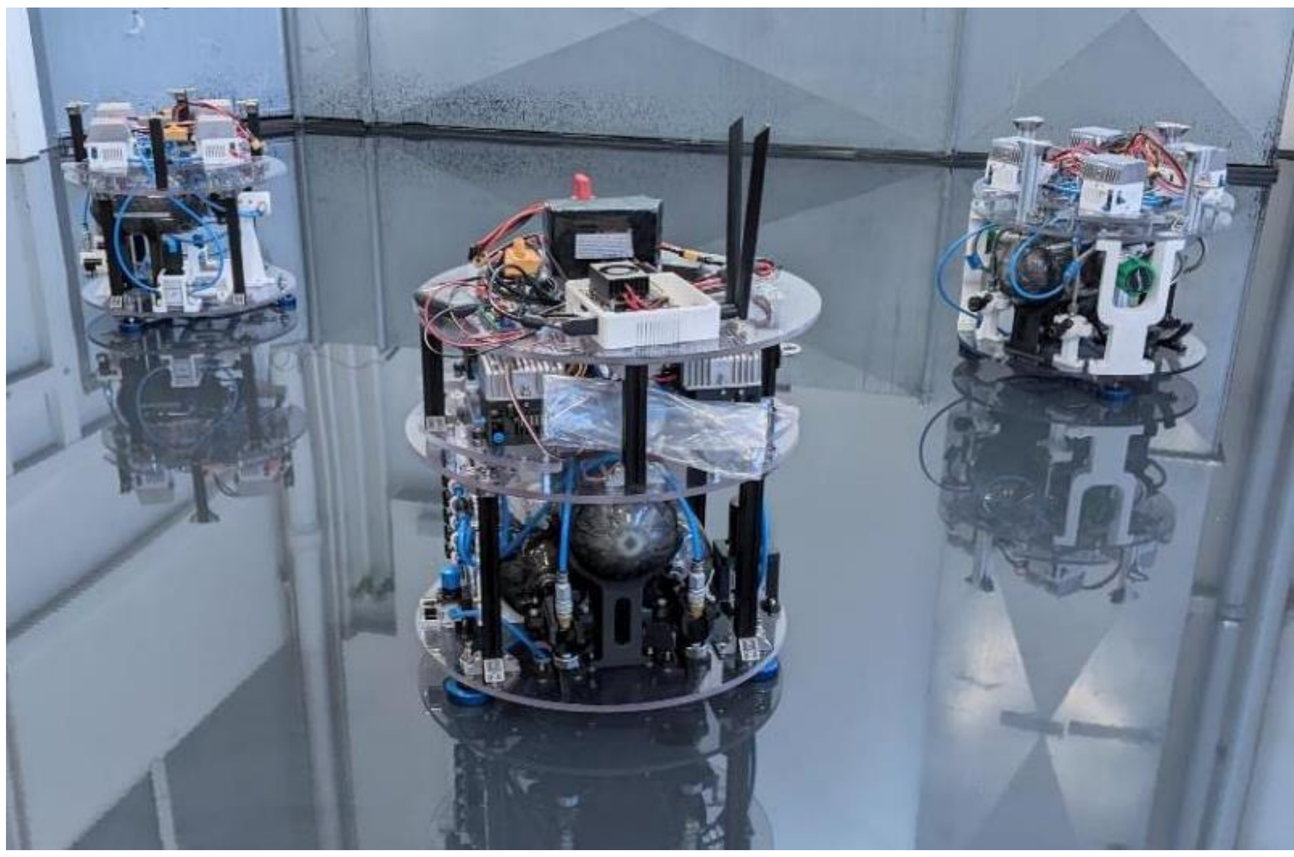
The problematic accessibility of the space environment enforces the need for on-Earth testing and validation. Through the collaboration of the DISCOWER project, developed control and planning strategies are validated in-lab (2D) and subsea (3D), using frictionless and underwater robots for realistic simulation.

Simulated Microgravity Robotics

The project has established a new space robotics lab at KTH, equipped with robotic platforms for testing and validating controllers and planners in a 2D-microgravity setting.

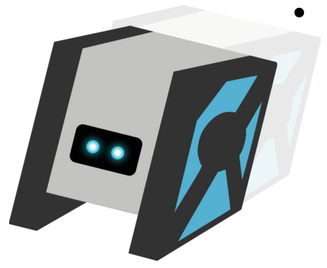
Robots host onboard computing, flight controllers, sensors, cold gas thrusters, communication, mocap, and diverse subsystems.

Levitation via air bearings mimics microgravity in a two-dimensional plane.



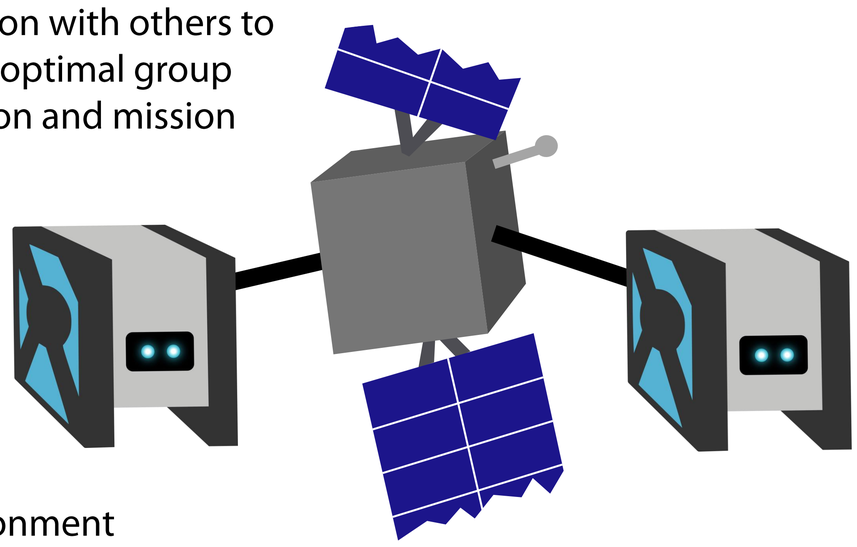
Technologies

- Multi-agent coordination, scalable for swarm control
- Robust control and safe recovery under actuation and communication failures
- Rendezvous, docking and proximity operations
- State estimation, manipulation and load transportation of non-cooperative objects



Methods

We propose centralized, decentralized and distributed Model Predictive Control schemes for multi-agent autonomous space vehicles where each agent independently predicts and optimizes its trajectory and actions, while also adjusting in collaboration with others to guarantee optimal group coordination and mission success.



DISCOWER

WASP WALLENBERG AI, AUTONOMOUS SYSTEMS AND SOFTWARE PROGRAM