Agile Flying Robots Fully Protected Against GNSS Spoofing and Communication Jamming



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Multi-Robot Systems at CTU in Prague



42 employees

> 50 MSc. & Bc. Students

> 70 FLYING ROBOTS



3/2017 – MBZIRC 3rd challenge:
1st place $330.000





2019-2021 - DARPA SubT: 2x 1st place among self-funded teams. 2nd place in virtual ch. finals $200k & $500k & $500k





2/2020 – MBZIRC 2rd challenge:
1st place $250.000, TOTAL WINNERS



FLY4FUTURE

Forming the future of unmanned flights

Development and prototyping of autonomous aerial systems

Customized platforms for areal research and development

R&D projects



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- Close collaboration with MRS group at CTU in Prague (spin out)
- 30 R&D engineers for technology transfer from research to products
- 4 new positions starting 11/2024

Fundamental research topics in 9/2023-9/2024

- Agility – flying robots can be faster
  - nonlinear control
  - fast perception (ego navigation & relative localization)
- Reliability of GNSS-denied localization
  - Robustness against jamming and spoofing of GNSS and communication
- Applications require also global localization
  - Long-range missions (huge maps)
- Scalability in real world (perception)
  - Scalable and secured mesh communication
- Heterogenous systems with different dynamics





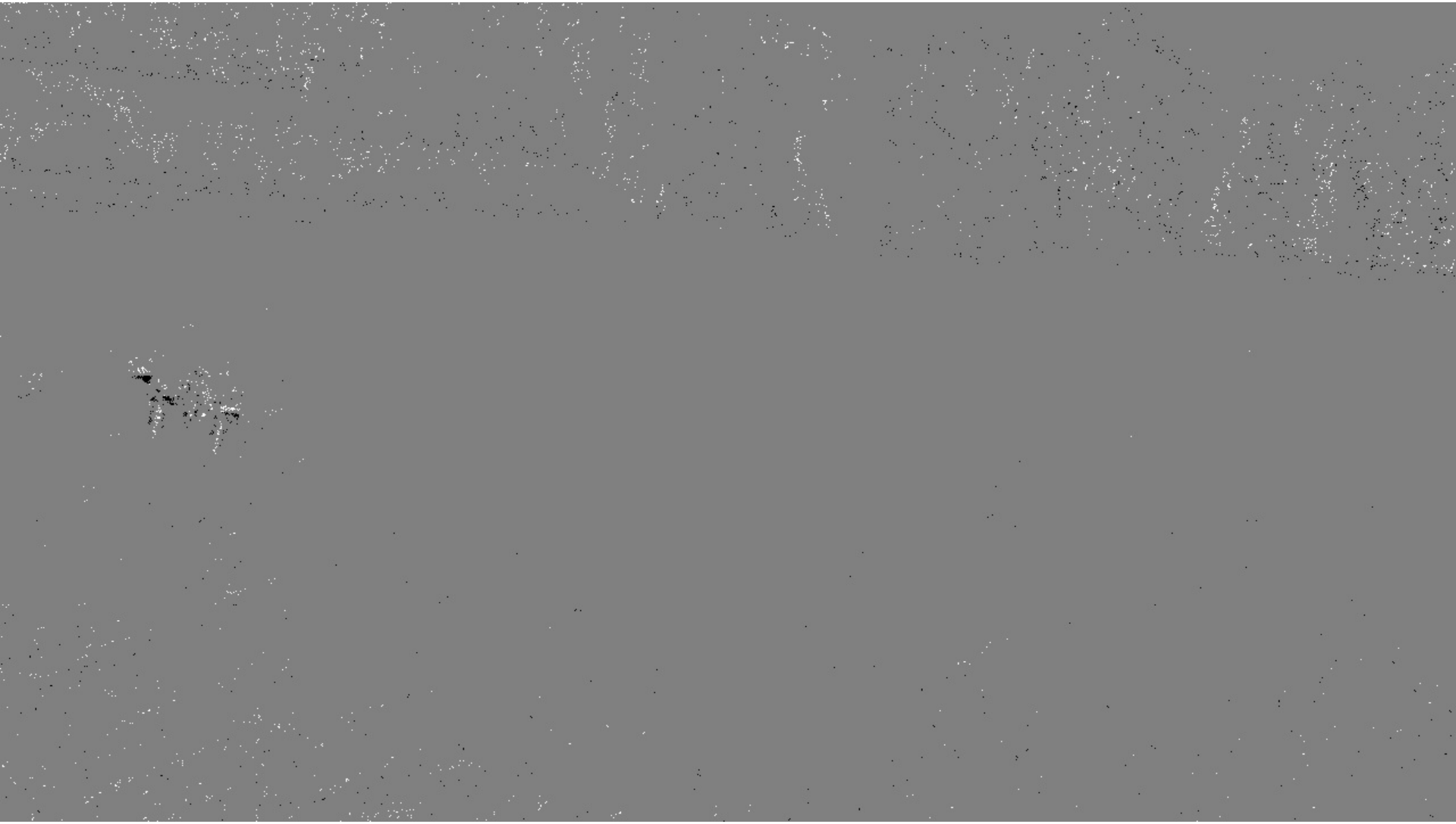




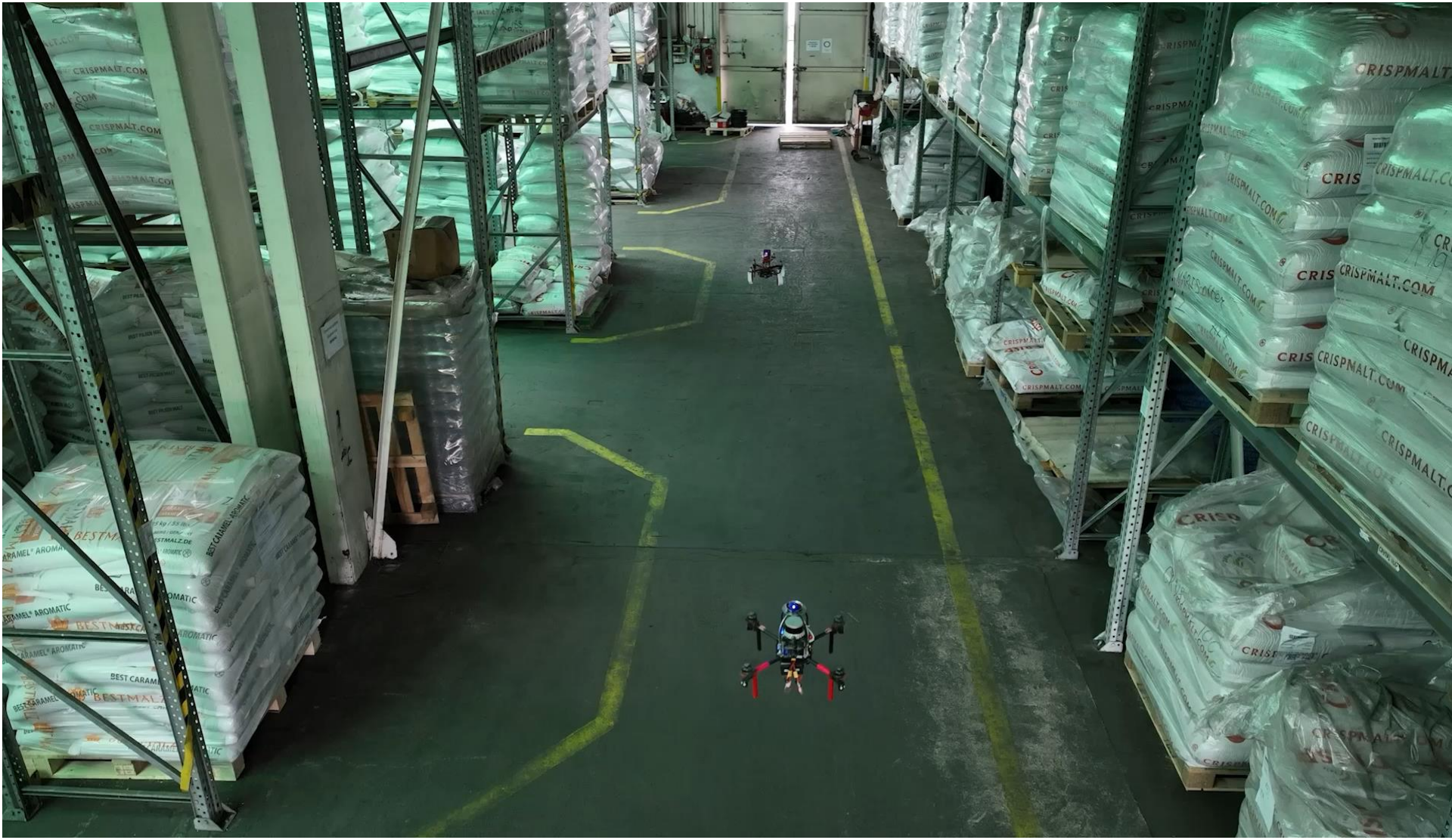
Model Predictive Path Integral Control for Agile UAVs



Agile swarms: super fast onboard relative localization



Cooperative navigation of a less-equipped UAV by an accompanying UAV



Teams of Cooperating UAVs and autonomous boats (USVs)

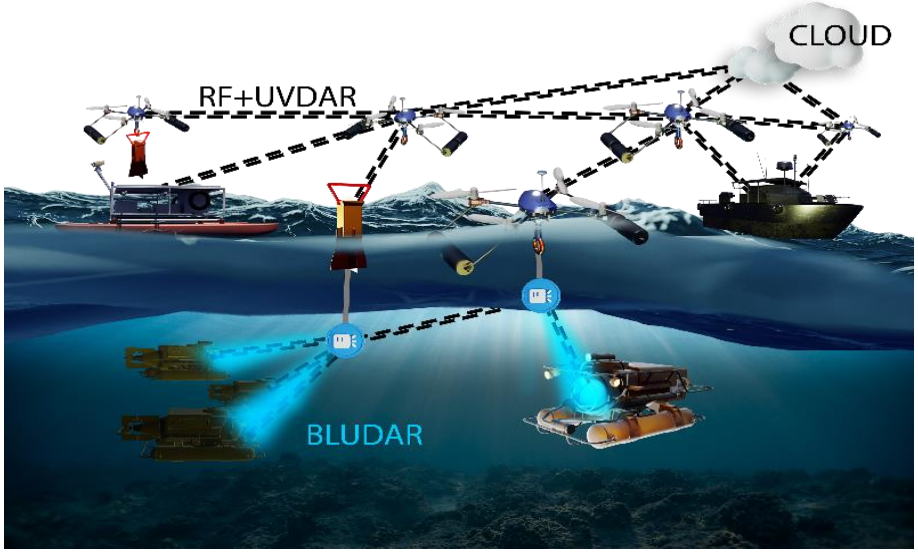
Marine operations: cargo delivering to ships, autonomous monitoring and surveillance (on the surface and under water), inspection of ships, water surface monitoring and cleaning











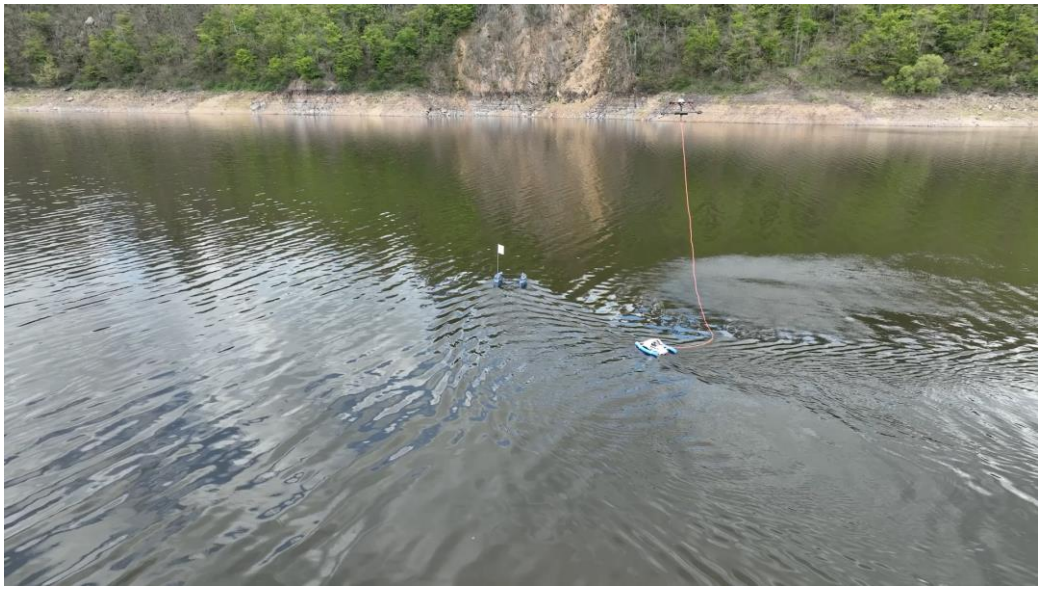
Coordination of robots with different dynamics

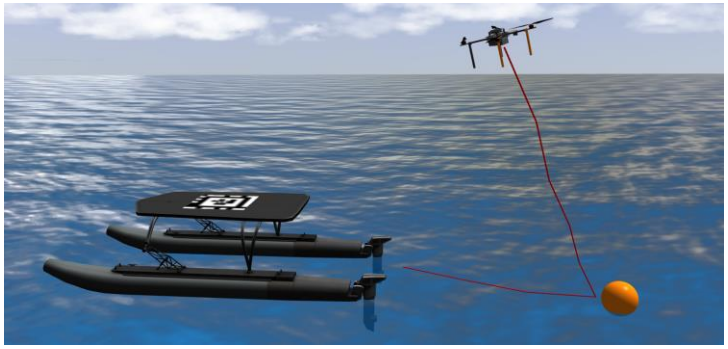


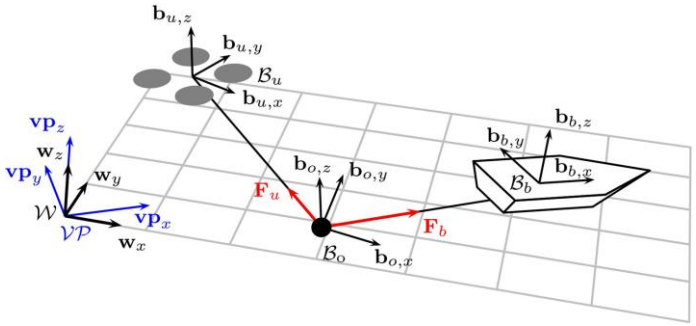
Collaborative Object Manipulation by a UAV-USV Team Using Tethers

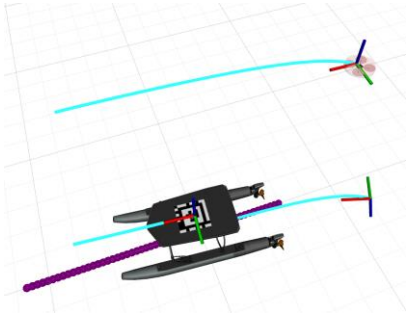
- Novel 6DOF mathematical model of UAV-USV; UVDAR and AprilTag localiz.
- Optimal control using MPC



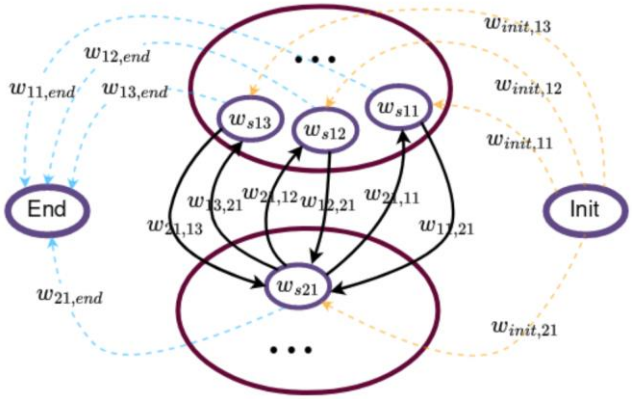




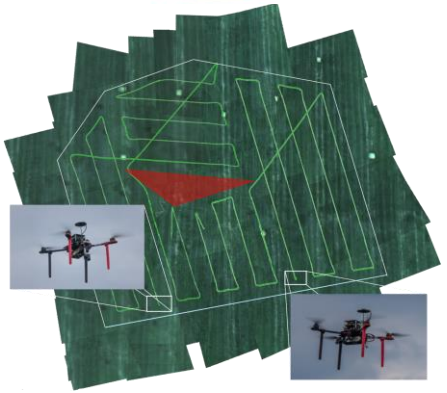


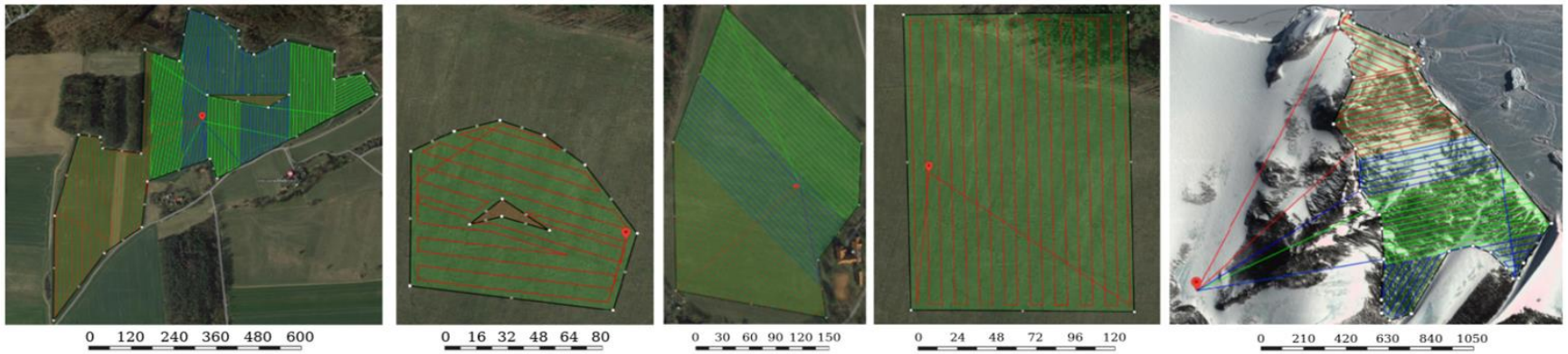


Energy-aware Multi-UAV Coverage Mission Planning with Optimal Speed of Flight



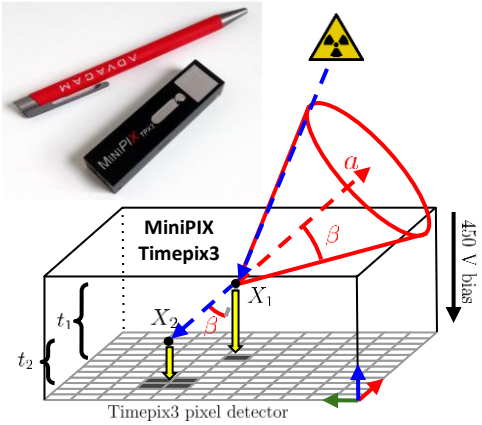
- Energy consumption used as an optimization objective.
- Efficient energy estimation from flight paths during planning
- Coverage Path Pplanning formulated as Multiple Set TSP (MS-TSP)

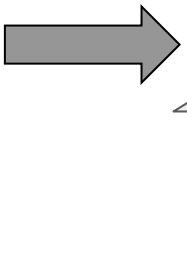


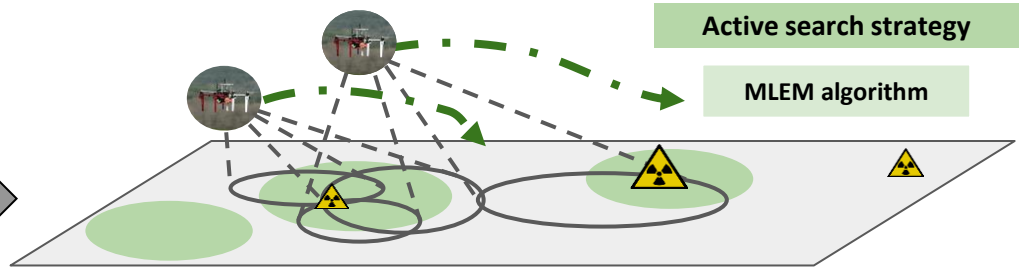


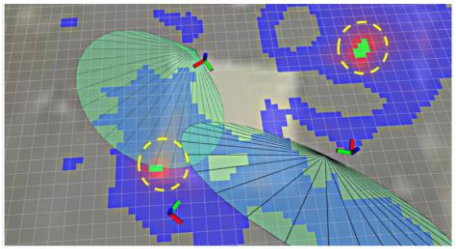
Autonomous localization of multiple ionizing radiation sources using miniature single-layer Compton cameras onboard a group of MAVs

Compton camera





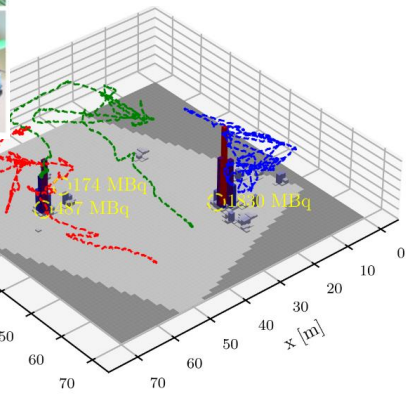




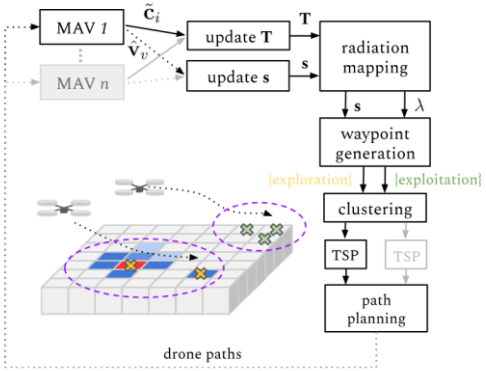
Real-world evaluation using 3 fully-autonomous aerial robots.







Maximum likelihood expectation maximization (MLEM)



discretize the area of interest into *J* bins

introduce λ - our hidden parameters

optimize using EM approach

$$\hat{\lambda}_j^{(l+1)} = \frac{\hat{\lambda}_j^{(l)}}{s_j} \sum_{i \in I} \frac{t_{ij}}{\sum_k t_{ik} \hat{\lambda}_k^{(l)}}$$

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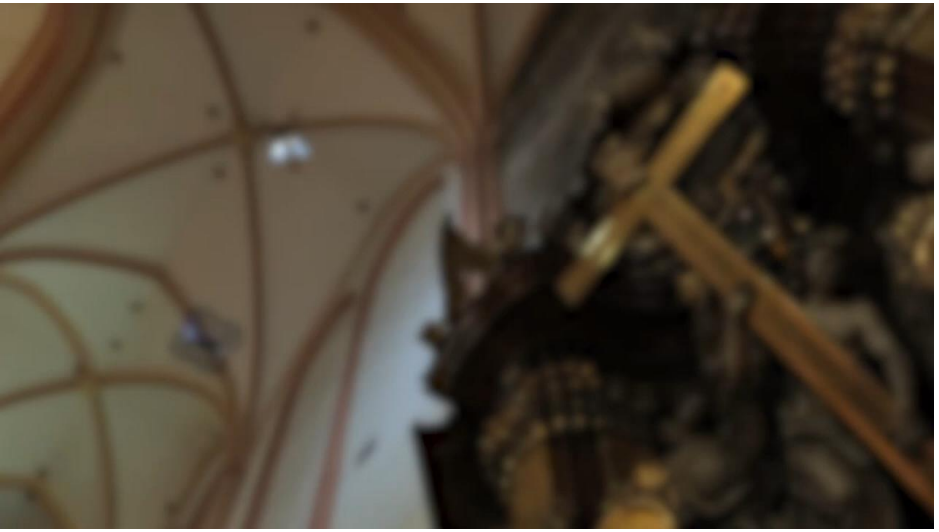
Applied research of autonomous aerial robots



Machine learning and target behavior estimation



Multi-robot high level planning



Vision-based indoor navigation (VIO)



Human-robot interface

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Applied research of autonomous aerial robots



Autonomous inspection in greenhouses



Flying robots in agriculture



Teams of robots for surveillance and security



24/7 inventory and inspection in industrial halls

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How to cooperate with us

- Autonomous robots can solve (almost) any of your technical problems
- We are happy to see new applications and innovative ideas
- The Czech Republic has one of the best mechanisms for supporting good R&D challenges and applied research and development

- Research contracts
- National public funded projects
- EU projects
- Bilateral projects with none EU countries

The IEEE RAS Summer School on Multi-Robot Systems
30.7.-5.8.2025, Prague, Czech Republic
https://mrs.fel.cvut.cz/summer-school-2025/

