Swarms of drones - from theory to real applications





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Multi-robot Systems group

16 employees: 5 senior researchers,
9 researchers, 2 engineers
+ >25 MSc. & Bc. students



1. Experimental camp



2. Experimental camp



7. Experimental camp



11. Experimental camp

MRS group in years

2015 – 3 employees

2016 – 5 employees

2017 – 8 employees

2018 – 12 employees

2019 – 16 employees

2020 - ?

NEW positions available: 2 postdocs + 2 PhDs + 2 engineers

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MBZIRC Challenge

- UAV team designed for autonomous search, grasping, and delivering
- Autonomous landing on a moving vehicle with UAV
- 1st place, 2nd place, and 3rd place in different challenges: $350 000 prize










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DARPA Subterranean Challenge

- Multi-robot team designed for exploration underground environment
- DARPA SubT Tunnel Circuit - 8/2019: 1st place among self-funded teams, 3rd place in total. $200 000 prize







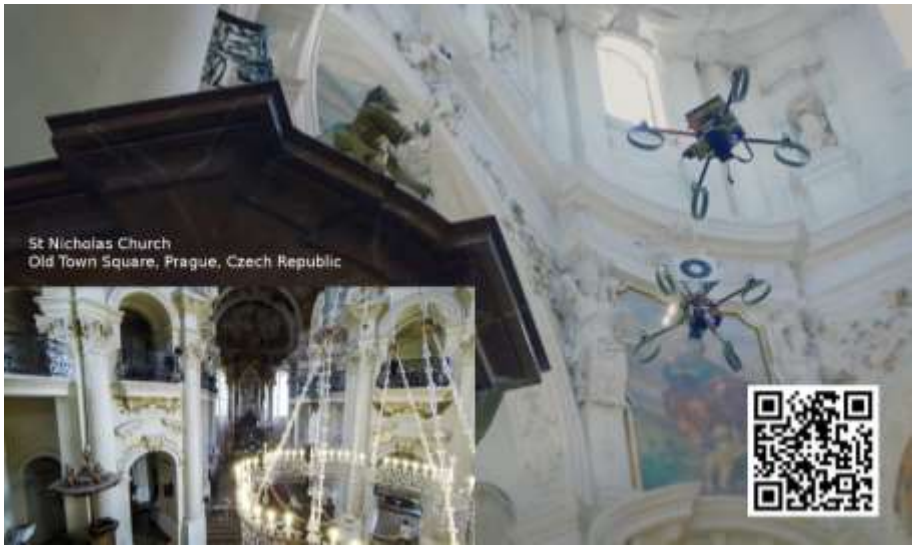






Documentation of dark areas of large historical buildings by a formation of unmanned aerial vehicles









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EAGLE.ONE®

MARK II April 2019









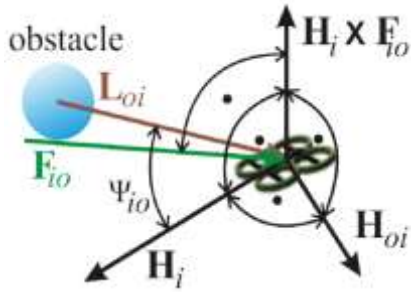


Nature inspired swarms

- Sensing abilities like in swarms in nature
- Inspired by Reynold's BOIDS model
- The Reynold's rules interpreted for relatively stabilized MAVs
  - ***Separation* –** avoid crowding neighbours
  - ***Cohesion* –** keep swarm compact
  - ***Alignment* –** attract swarm particles along a common path
  - ***External avoidance* –** avoid obstacles (a short range repulsion based on flight direction) – in a cooperative way

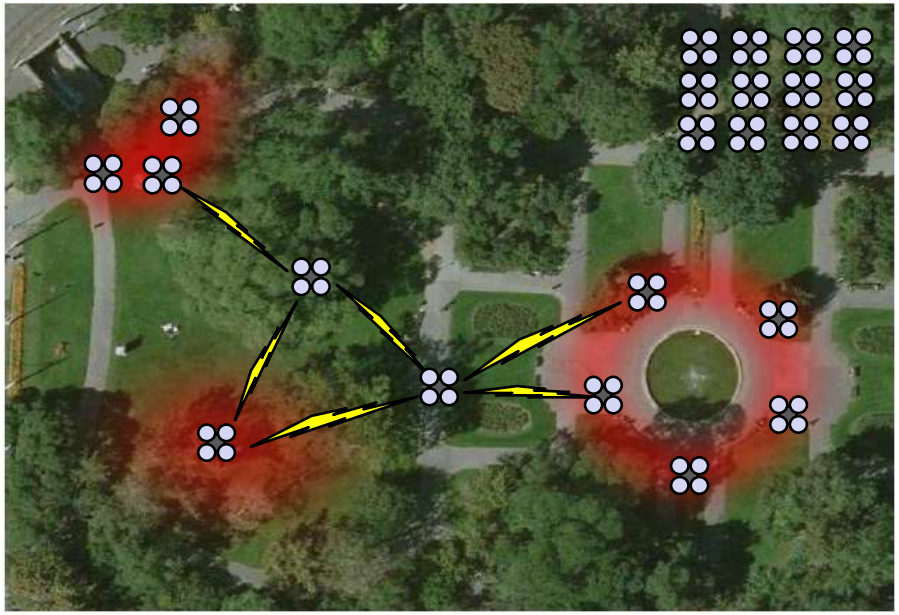






Multi robot systems: Swarm coverage

- Deployment of swarms (MAVs) in real outdoor applications
- Surveillance task – locations of interest with different priorities

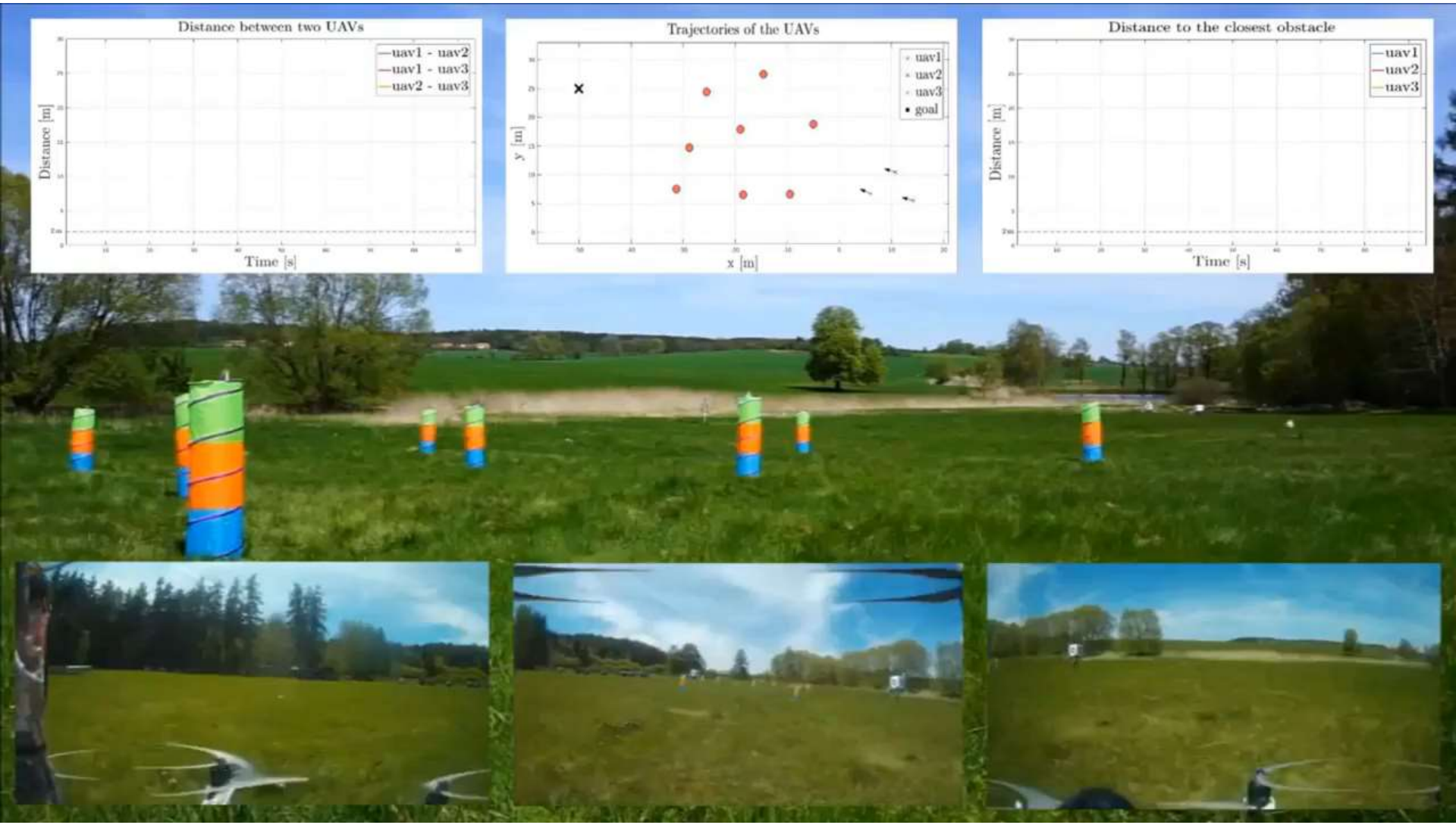




M Saska, T Baca, J Thomas, J Chudoba, L Preucil1, T Krajnik, J Faigl, G Loianno, V Kumar. System for stabilization of micro aerial vehicle swarms using onboard visual relative localization. Autonomous Robots, 2017.

M Saska, V Vonasek, J Chudoba, J Thomas, G Loianno and V Kumar. System for cooperative surveillance by compact swarms of micro-aerial vehicles. Journal of Intelligent & Robotic Systems, 2017.

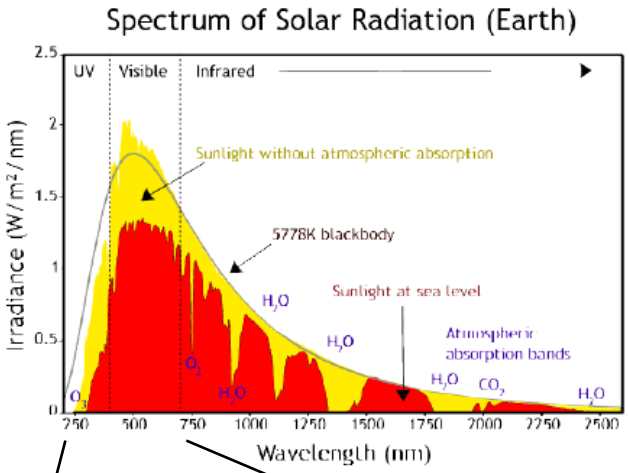
M Saska, J Chudoba, L Preucil, J Thomas, G Loianno, A Tresnak, V Vonasek and V Kumar. Autonomous Deployment of Swarms of Micro-Aerial Vehicles in Cooperative Surveillance. International Conference on Unmanned Aircraft Systems (ICUAS), 2014. .....

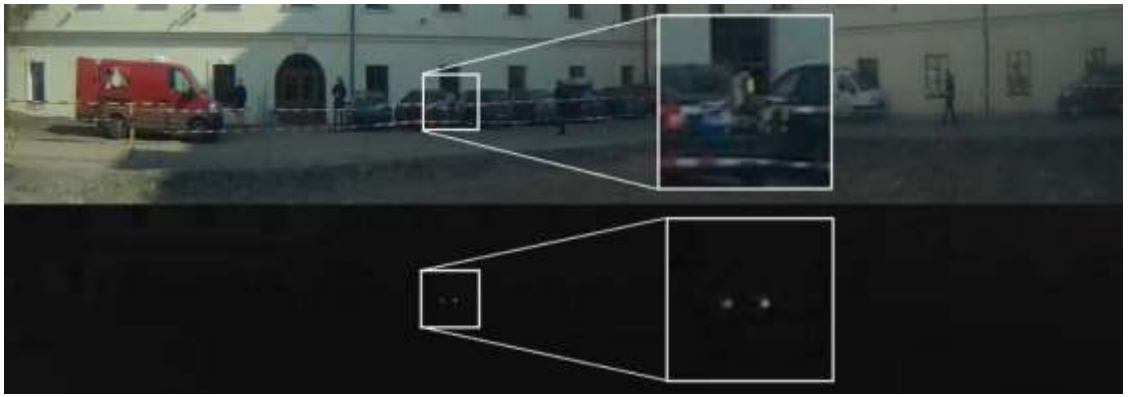

Distance between two UAVs
uav1 - uav2
uav1 - uav3
uav2 - uav3
Distance [m]
Time [s]
Trajectories of the UAVs
uav1
uav2
uav3
goal
y [m]
x [m]
Distance to the closest obstacle
uav1
uav2
uav3
Distance [m]
Time [s]

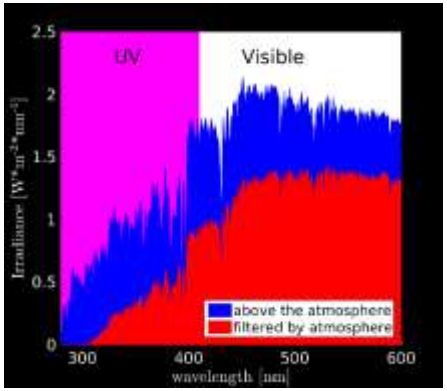
Mutual Localization of UAVs using Ultraviolet Markers

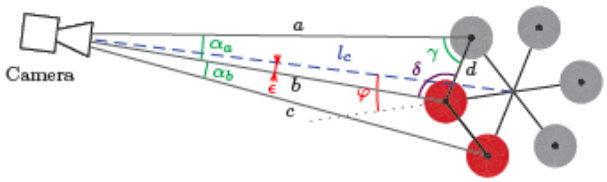
- Reduced size of markers, computational complexity
- Increased reliability

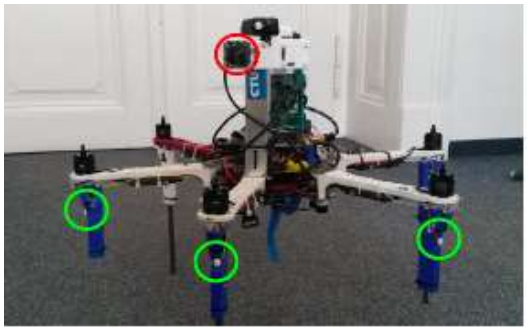






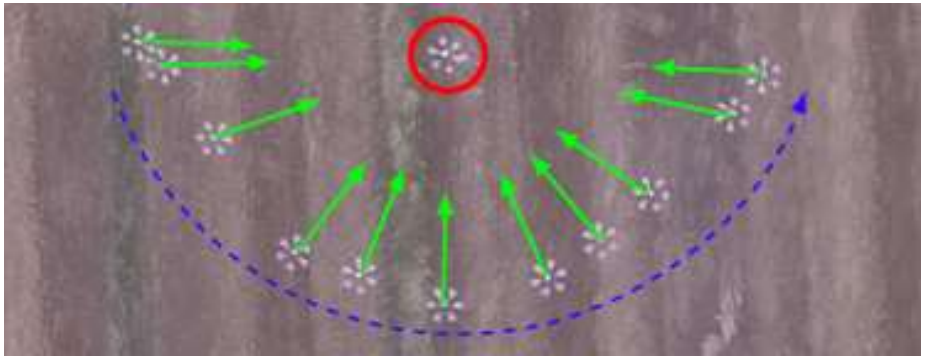


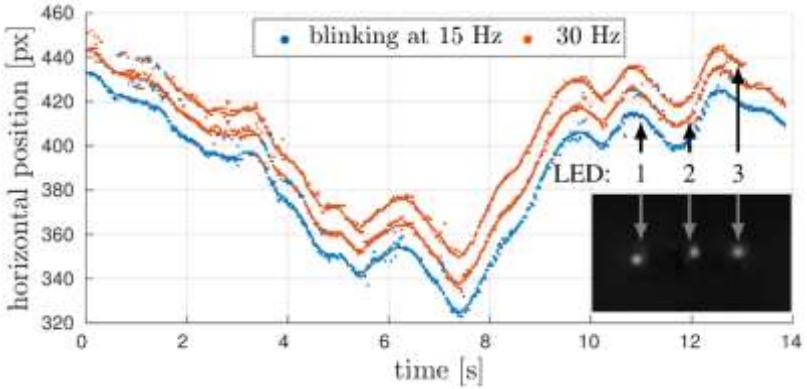




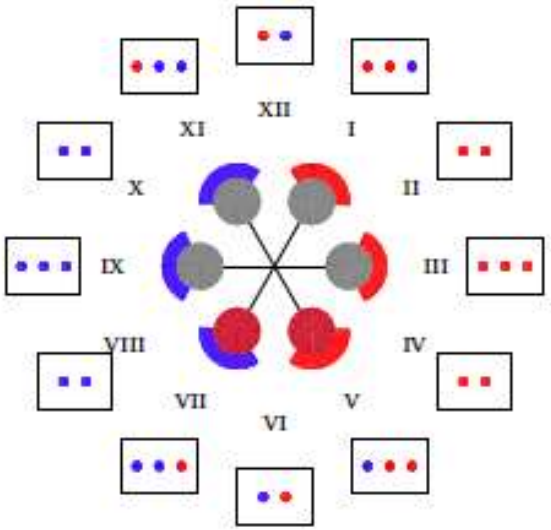
Blinking UV markers

- ID encoding and observation
- Relative orientation estimation
- 3D time-position Hough transform
- Directed leader-follower approach











RAL 2019, CASE 2018, ICUAS 2018


uav2
uav4
uav3
uav5
x [m]
>> 3x



Thank you for your attention ☺

Any questions?





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