Distributed Lloyd-b
Uncertainty-Aware
Under-Canopy Floo

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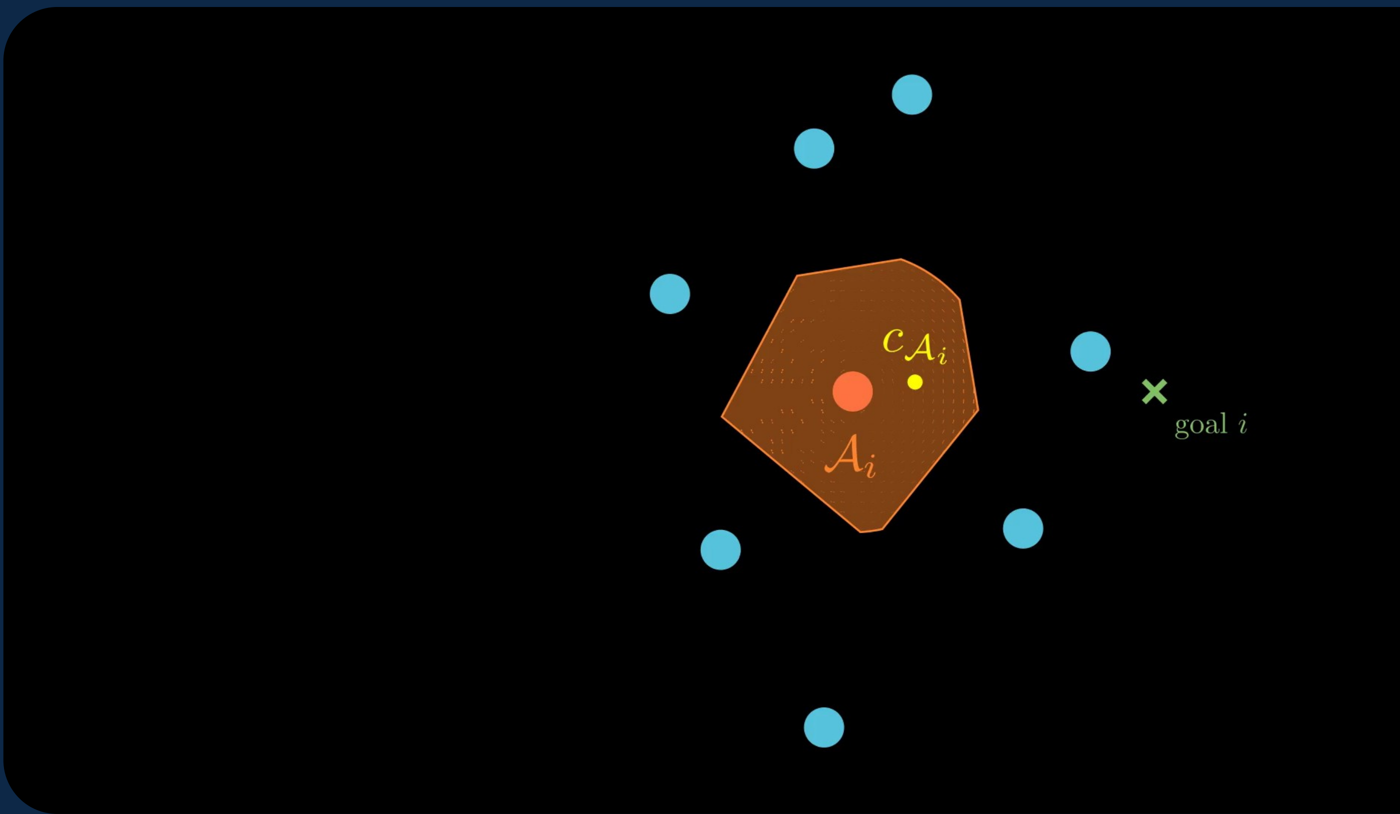
Three UAVs flocking under the forest canopy — no GNS

1 The basic idea

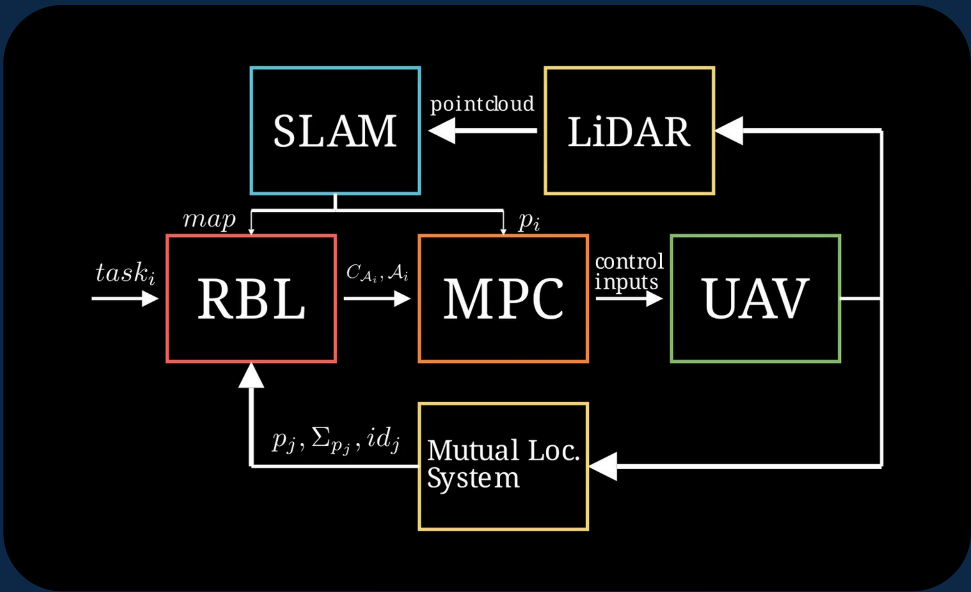


The Lloyd-based algorithm

- Each robot computes its cell A_i from sensed neigh obstacles

- …and moves towards the cell centroid

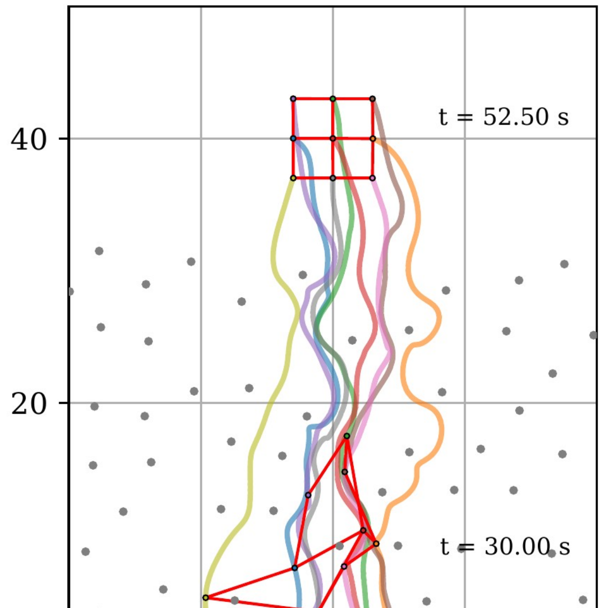
$$\dot{p}_i = -k_{p,i}\,(p_i - c_{\mathcal{F}_i})$$

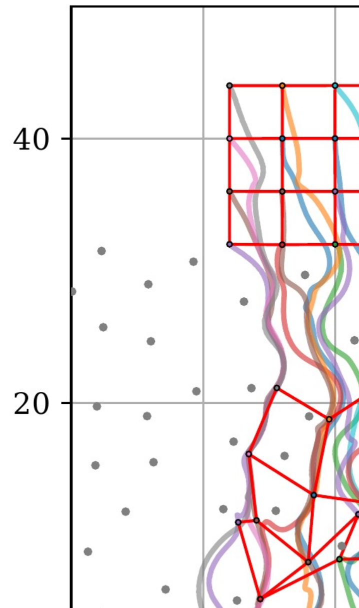


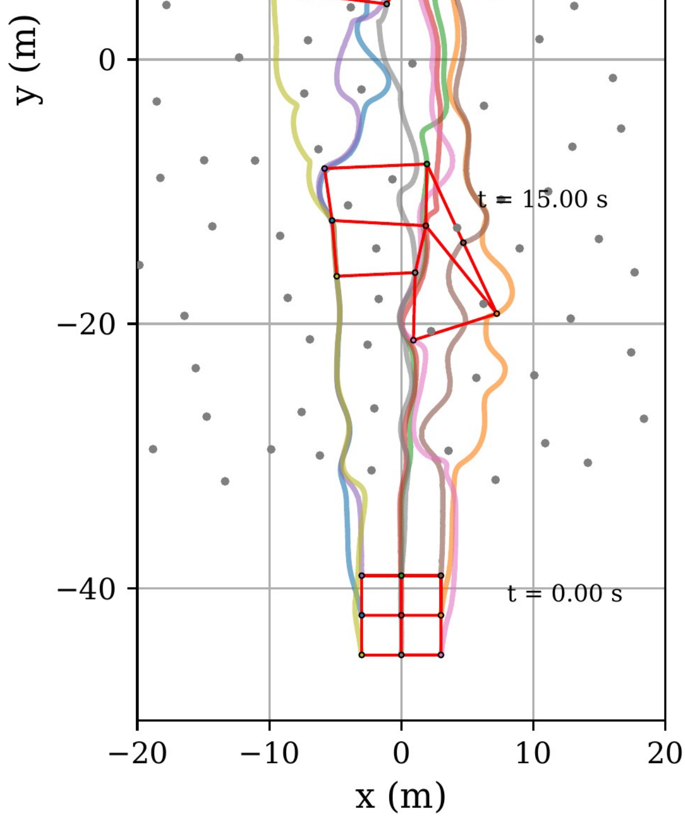
On-board

RBL outputs t
2-D LiDAR + S
localization s

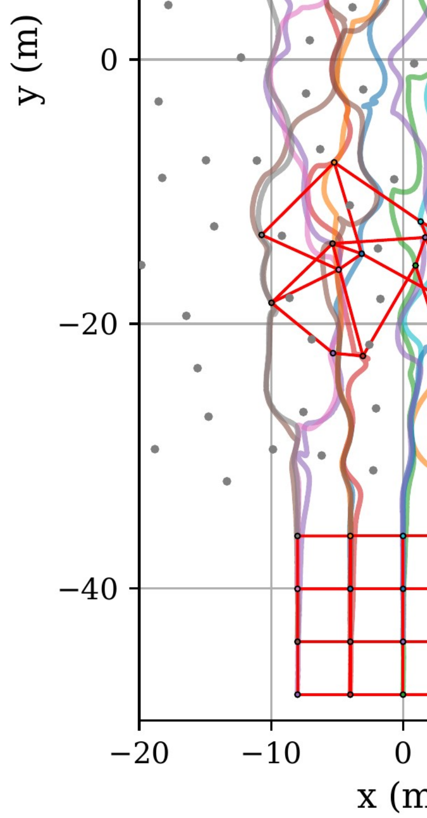
2 Simulation



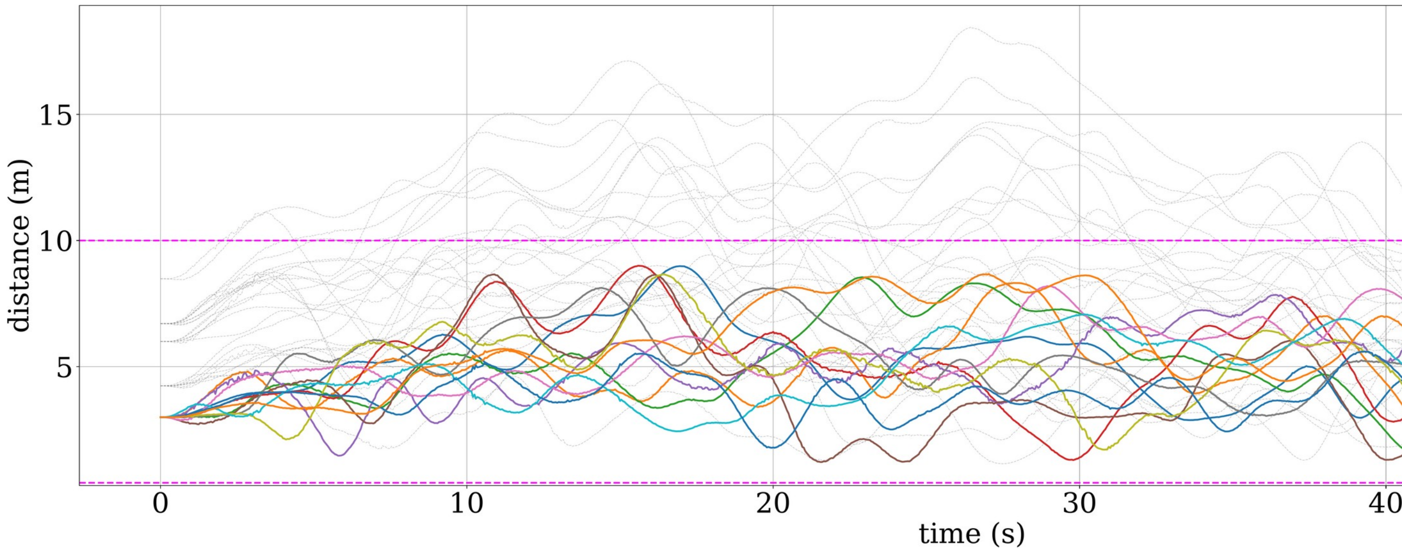




N = 9



N = 16



Inter-robot distances (N = 9) stay between the safety and flo
(magenta).

Next steps Minimal communication for

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based Algorithm for
Multi-Robot
cking

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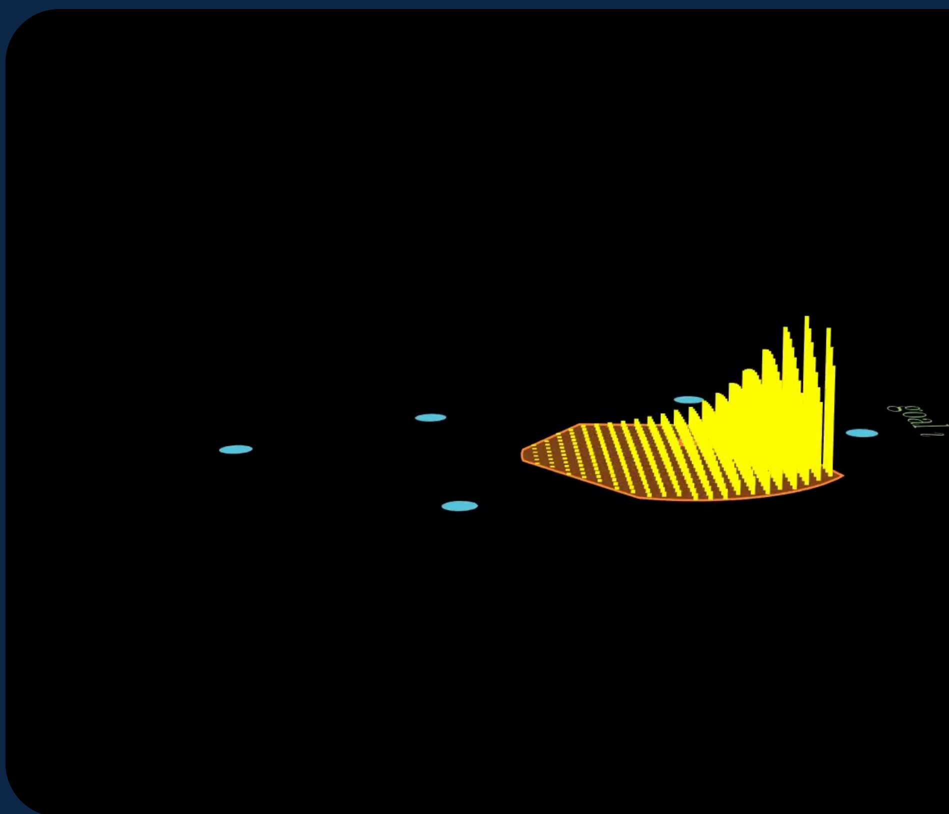
SS, no communication, only on-board sensing.



Manipulating the dens

nbours &

- Affects convergence and perforn

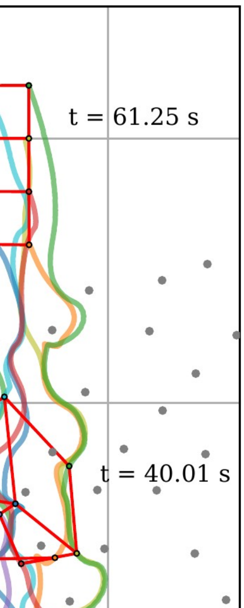
- Accounts for tracking errors and

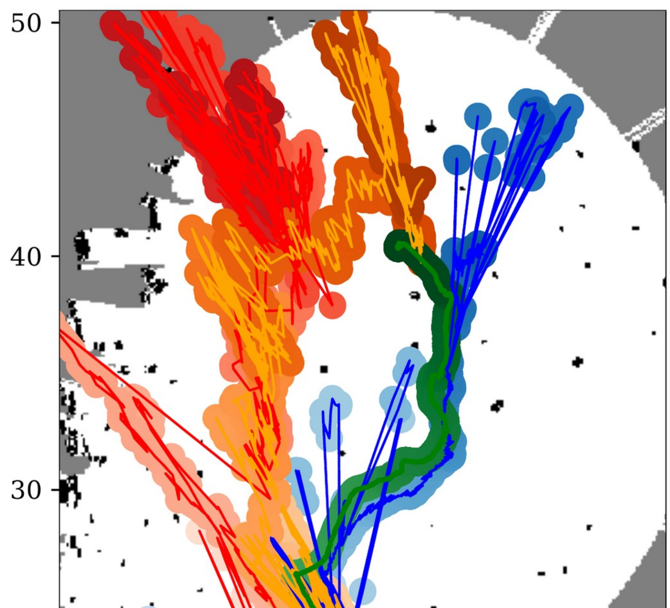
$$\varphi_i(q) = \exp\left(-\right.$$

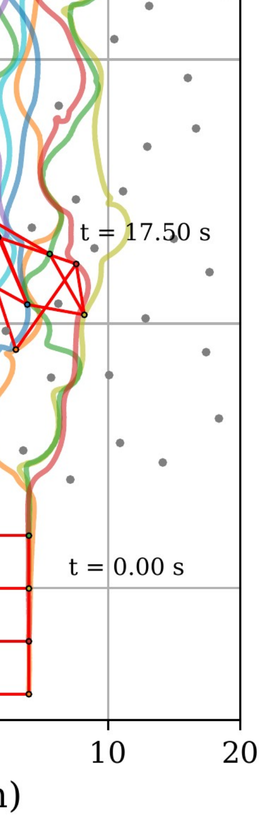
d perception and computation

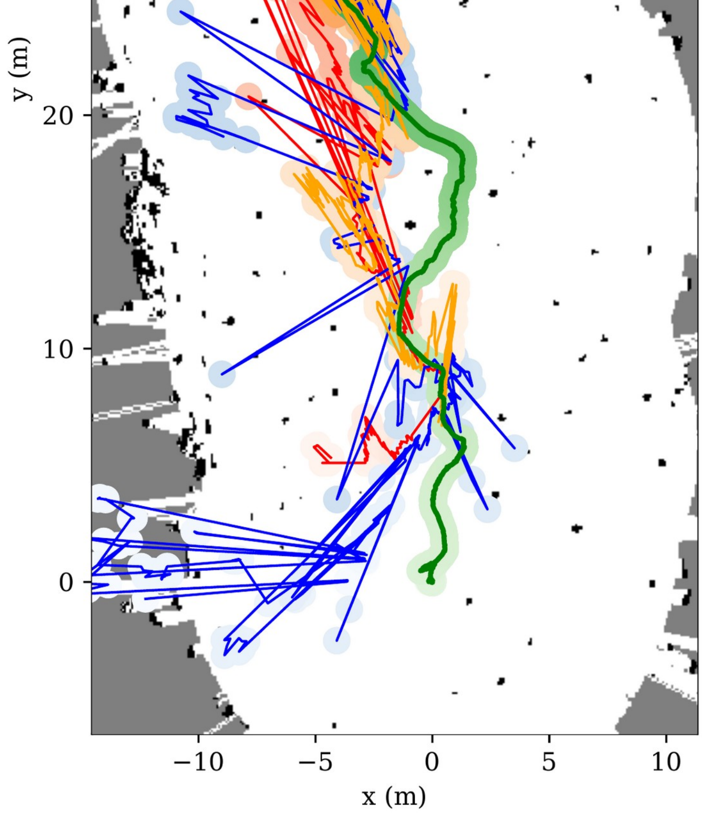
the cell and its centroid to an MPC. Obstacles come from SLAM; neighbours (p_j, Σ_j, id_j) from the UVDAR mutual ystem.

3 Forest expe

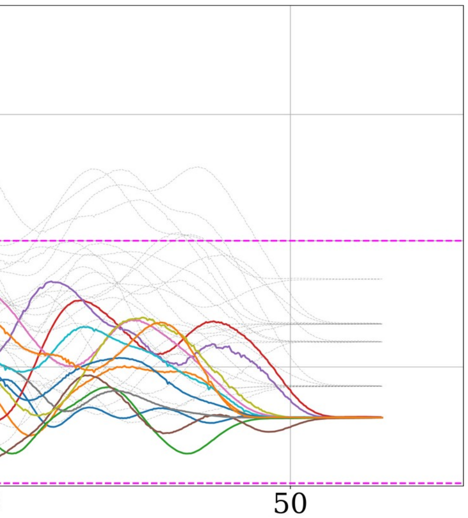




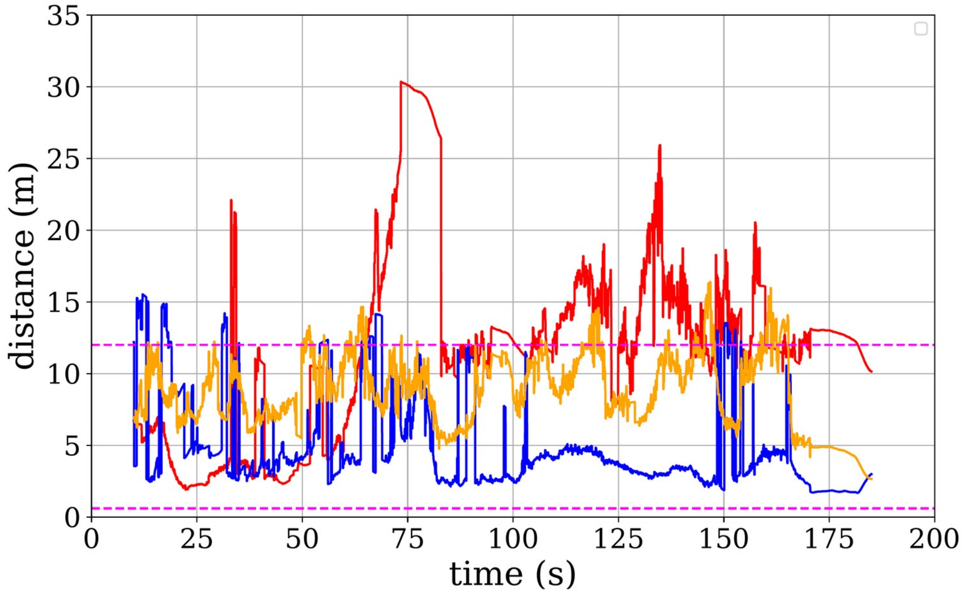




UVDAR view



ocking limits

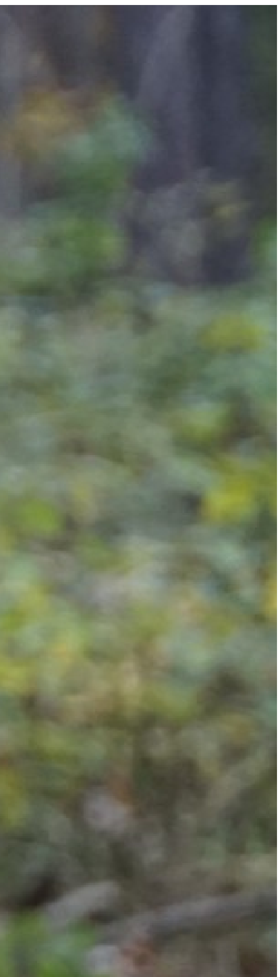


Distances measured by UVDAR (UAV 2).

higher-level decisions. Human decision at the mission

d the EU project Robotics and advanced industrial production (CZ.02.01.01/00/22_

a[1]



Problem

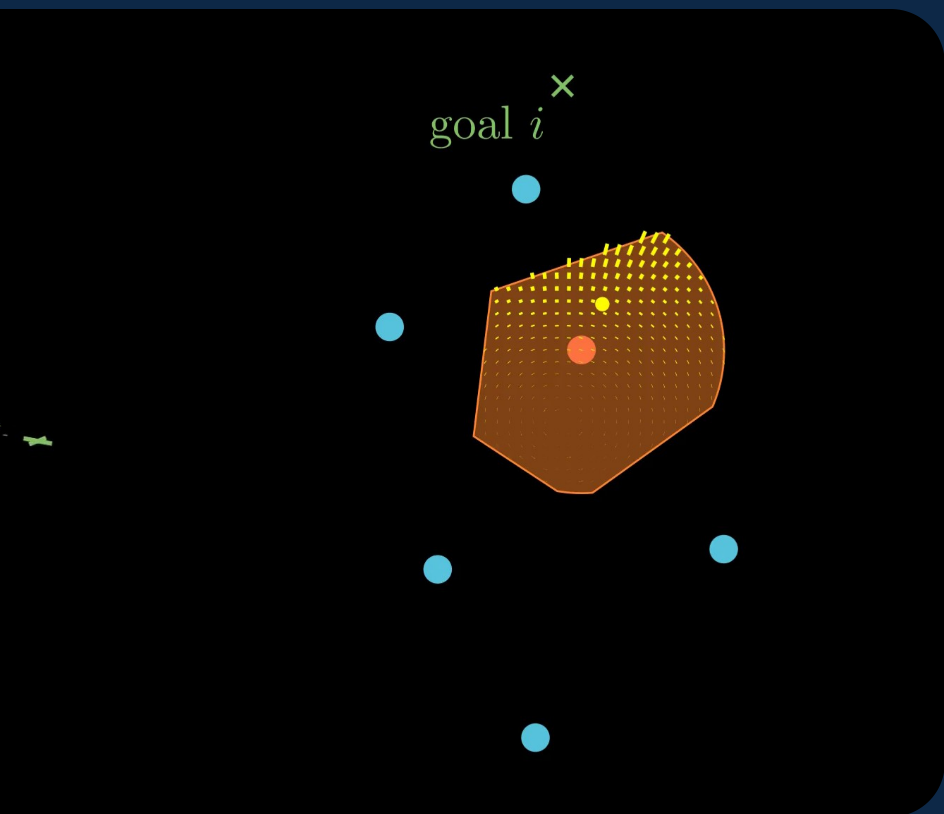
Steer N robots towards their goal lo
fish: no leader, each robot decides f

✓ Safety (collision & obstacle avoidance)

✓ **Distributed & asynchronous control**

✓ **Dealing with uncertainties**

Each robot only needs relative p



sity function

mance to the goal

Reshaping

$A_i = \tilde{\mathcal{V}}_i^p \cap \tilde{\mathcal{V}}_i^o \cap S$

uncertainties

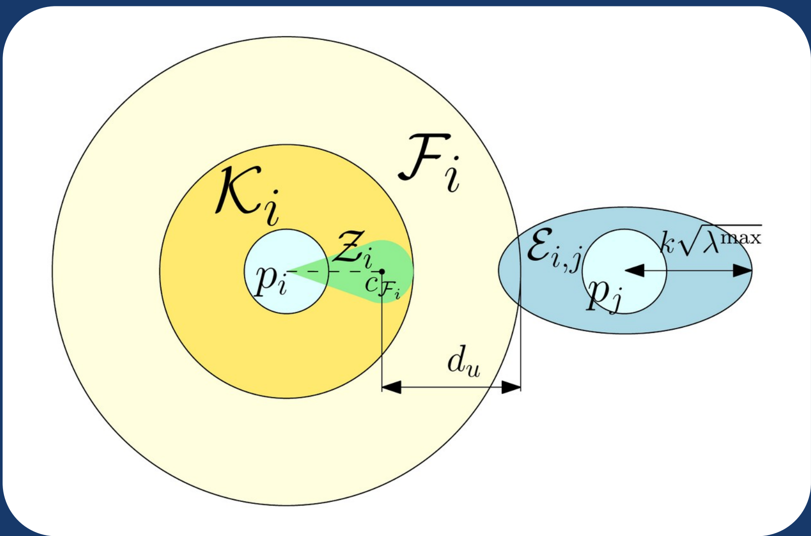
$\tilde{\mathcal{V}}_i^p, \; \tilde{\mathcal{V}}_i^o$

$\mathcal{S}_i$

$\mathcal{M}_i$

$-\|q - \bar{p}_i\| \,/\, \beta_i)$

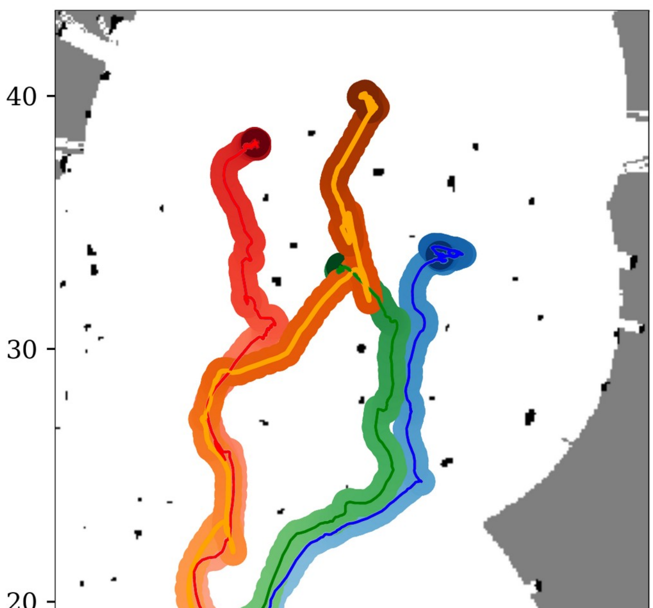
$\mathcal{F}$



Dealing with un

Centroid kept ≥ d_u from t
and the neighbours' mea

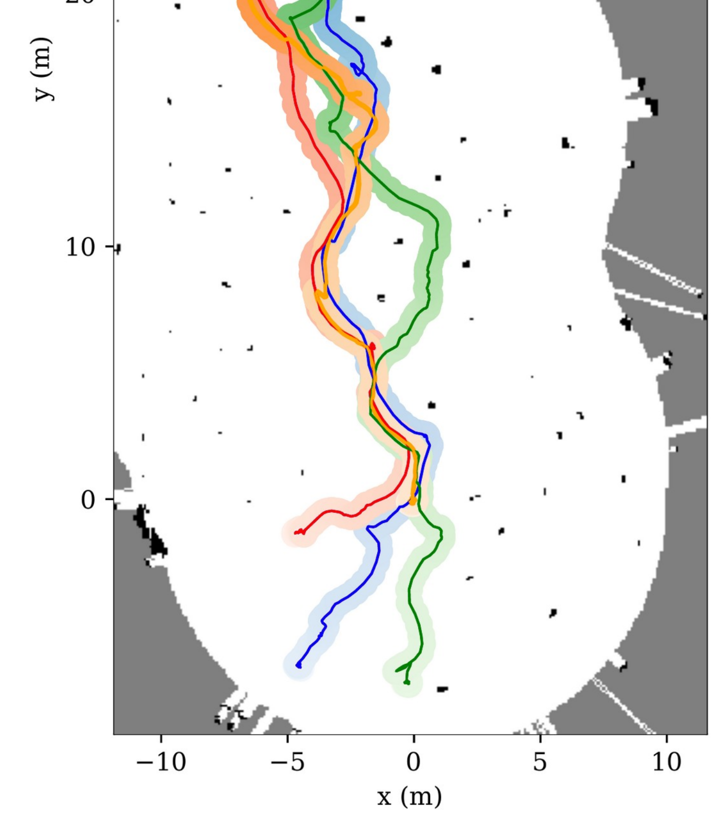
eriments



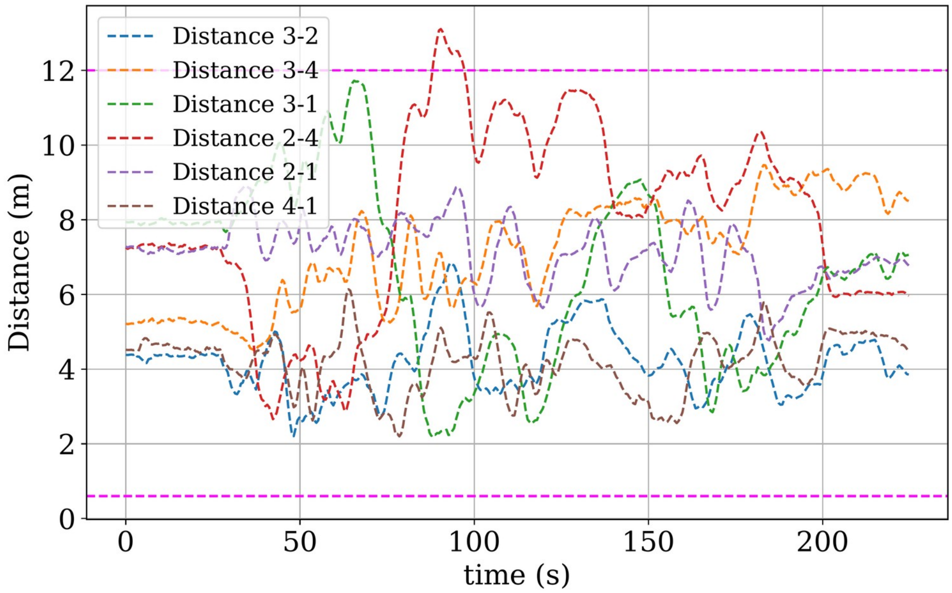
NEW ON ARXIV

Perceptio
Coordinat

M. Boldrer, M.



All tracks



True distances (aligned odometry).

Full 3-D coordina
UAV for SLAM, o
planner for its lir

Paper · arXiv

n level

_008/0004590).

Video
mrs.fel.cvu

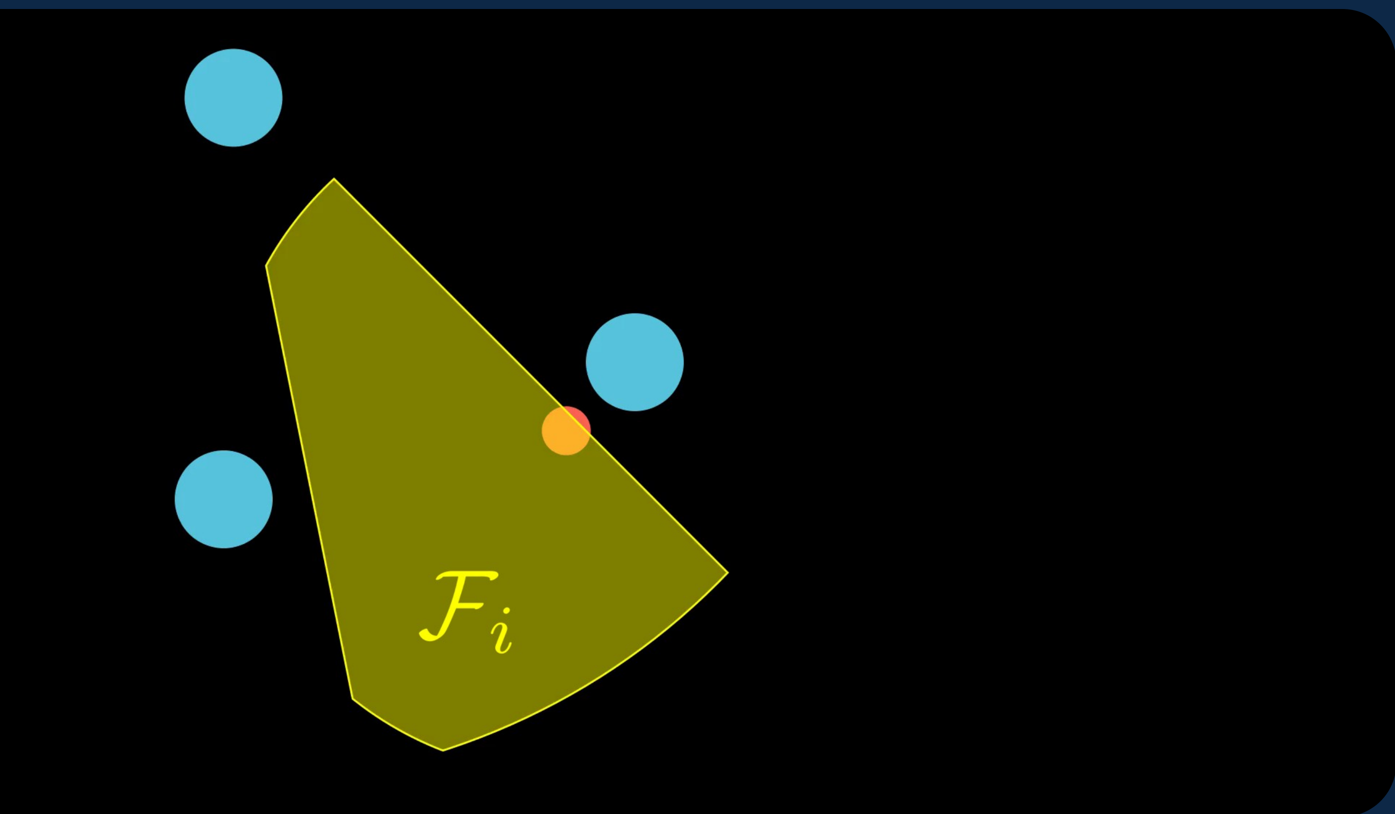
cations — like a flock of birds or a school of
rom what it senses.

✓ **Without explicit communication**

✓ Proximity maintenance

✓ On-board localization only

ositions of what it perceives.



the cell

safe cell, collision-free by convexity

safe cell, collision-free by convexity
convex weighted Voronoi cells w.r.t. neighbours / obstacles (inflated by size)
disc of radius half the sensing range
proximity: $\|q - p_j\| \leq \Gamma_{ij}$ (flocking)

$$\mathcal{F}_i = \tilde{\mathcal{V}}_i^p \cap \tilde{\mathcal{V}}_i^o \cap \mathcal{S}_i \cap \mathcal{M}_i$$

ncertainties

the cell boundary, accounting for both the tracking error
asurement uncertainty.

• FOLLOW-UP WORK

n-Aware Multi-UAV Implicit ion in the Wild

Kamler, A. Ahmad, M. Saska

ation, no communication: one anisotropic LiDAR per
bstacles and neighbours, with a perception-aware
mited field of view.

Video

Code

ut.cz/rbl

Code
github.com/ctu-mrs/rbl