RECRUITMENT NEAR WORKSITES FACILITATES ROBUSTNESS OF FORAGING E-PUCK SWARMS TO GLOBAL POSITIONING NOISE

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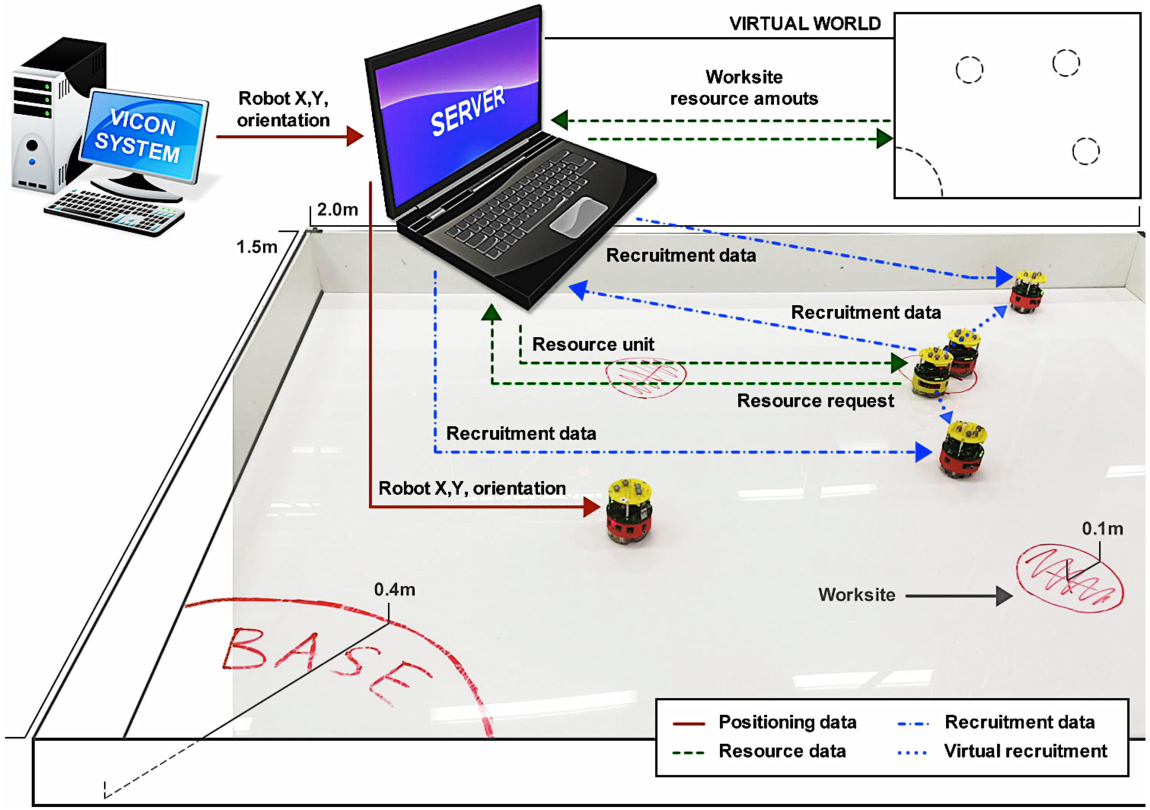
THALES

Overview

- □ Five e-pucks need to search the arena and find randomly-distributed worksites
- □ They then carry virtual resource units from worksites to the base until all worksites are depleted
- □ Do robot swarms where robots recruit each other perform better?
- □ How does noise in the GPS affect the swarms?

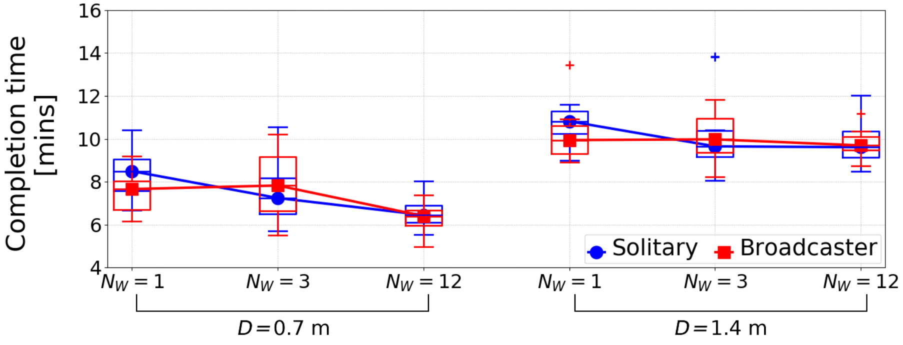
Semi-virtual environment

- Physical interactions
- Data handled by a server
  - Robot tracking and positioning
  - World state
  - Communication



Outcomes

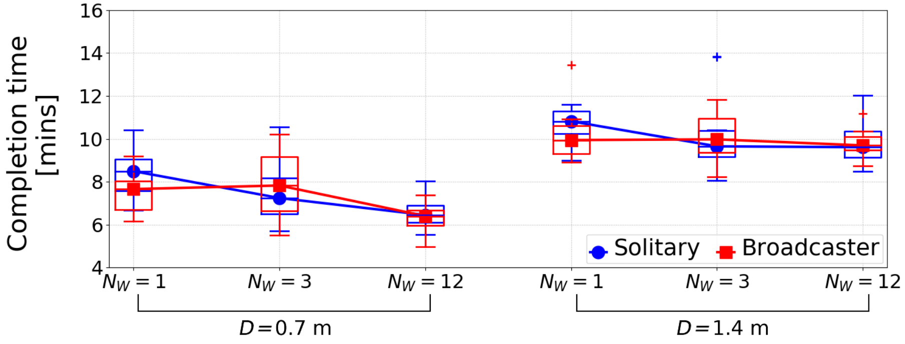
- □ In small noiseless environments, the choice of a foraging strategy does not matter
- □ When GPS noise is added, robots may loose track of foraging sites



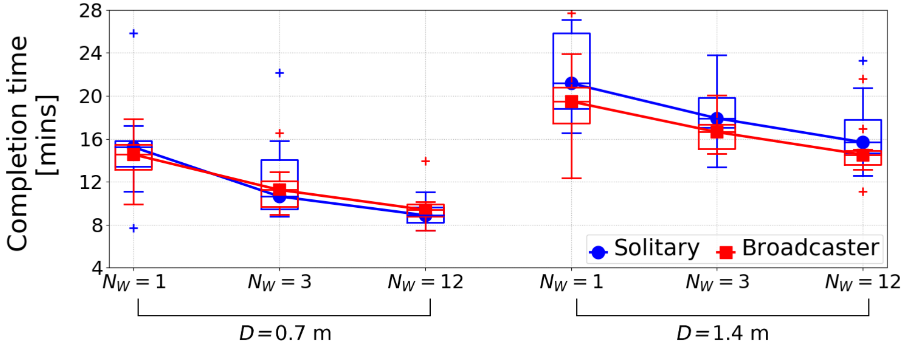
Without noise

Outcomes

- □ Recruitment near worksites helps the swarm maintain correct information about worksite locations
- □ Inherent sensory-motor noise makes obstacle avoidance harder in reality than in simulation



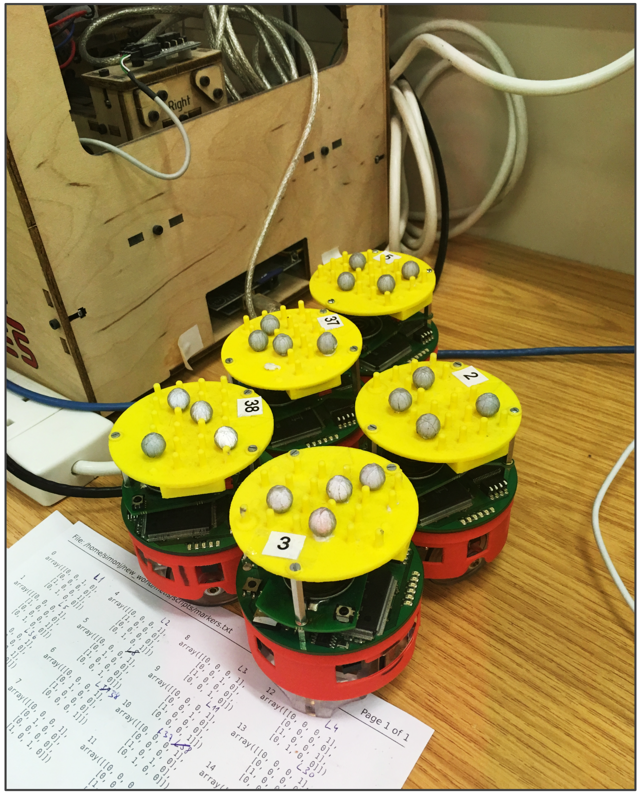
Without noise



With noise

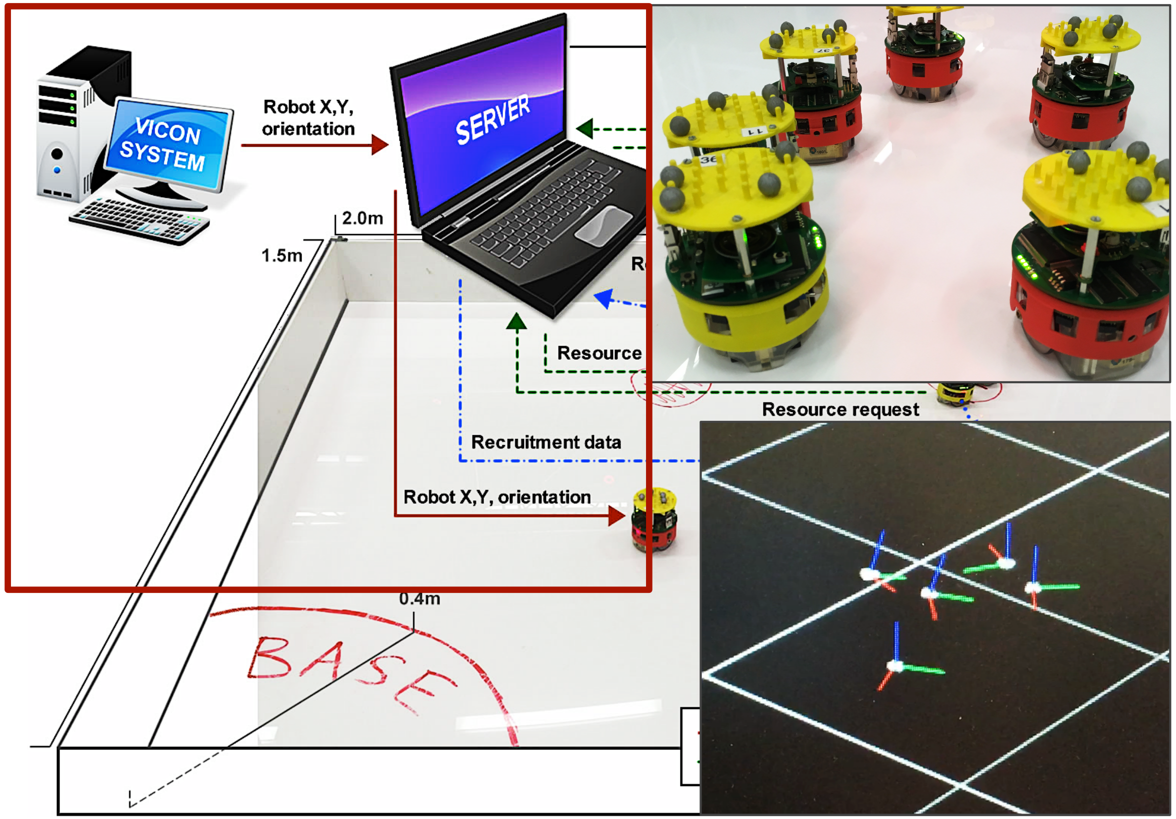
Experiment details

Parameter	Value
Number of robots	5
Arena size	2 × 1.5 m
Base radius	0.4 m
Worksite radius	0.1 m
Number of worksites	{1,3,12}
Min. worksite distance from base edge	{0.7,1.4} m
Total reward	48
Robot worksite sensor range	0.25 m
Robot communication range	1.25 m



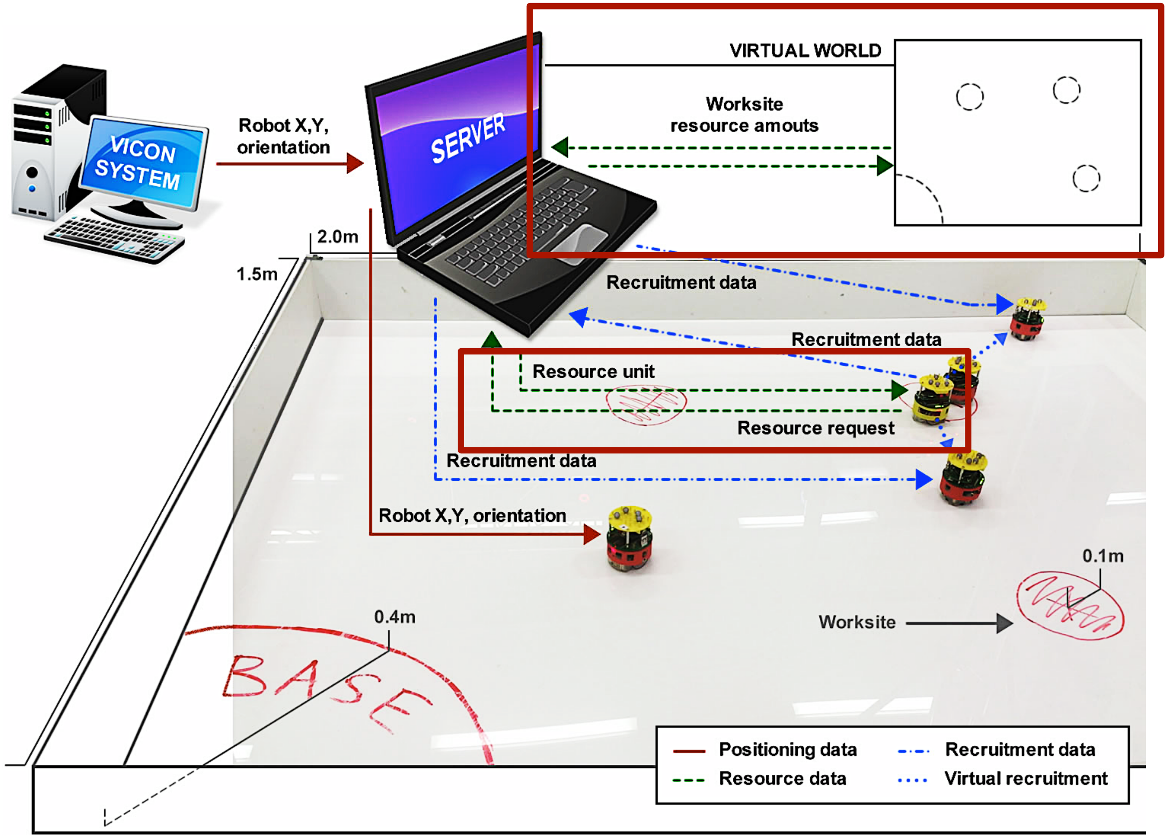
Semi-virtual environment: Positioning

- □ Vicon tracking system connected to the Server
- □ Server sends X,Y position to each robot every 1/10 seconds



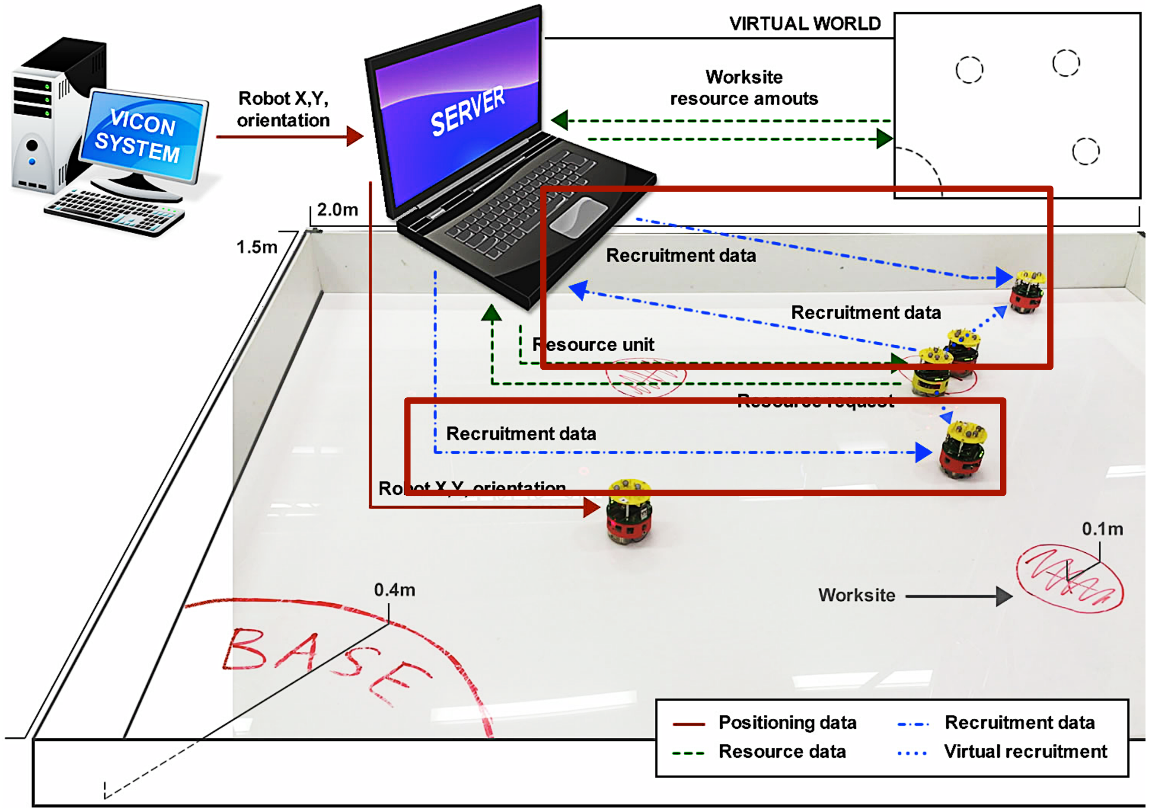
Semi-virtual environment: World state

- The Server knows worksite locations and resource left
- Robots that think they are at worksites request resource units from the Server



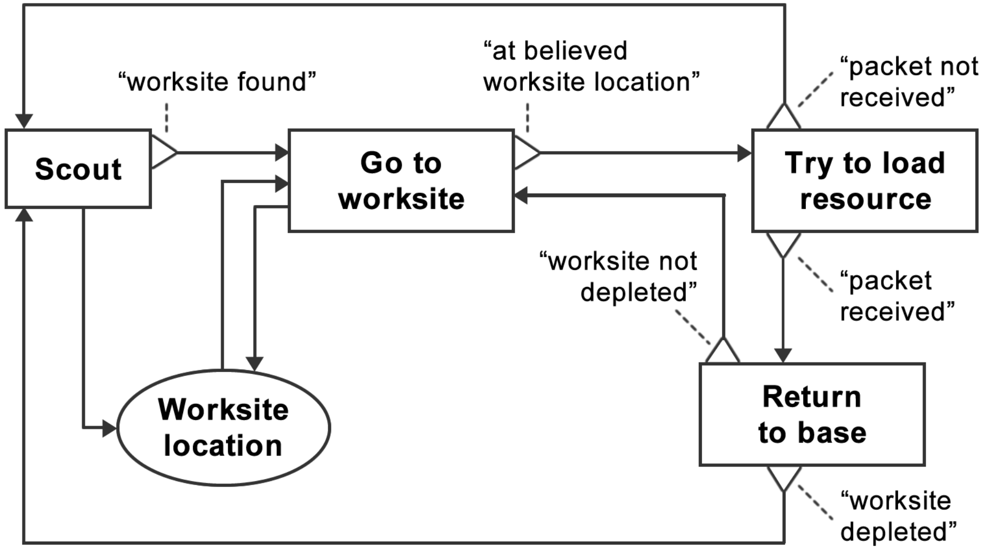
Semi-virtual environment: Recruitment

- □ Recruiters send recruitment signals and worksite location to the Server
- □ The Server sends the data to robots near the recruiter



Robot control algorithms: Solitary

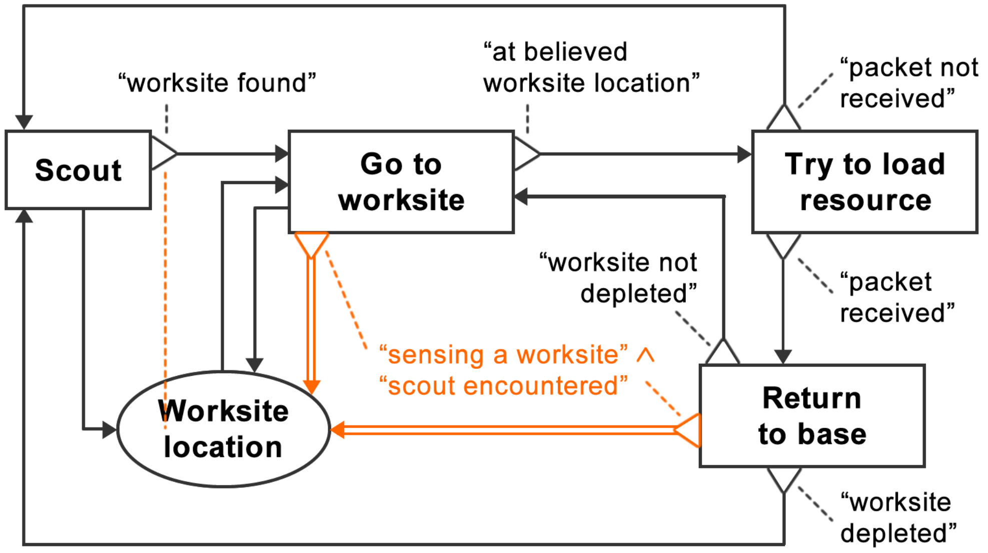
- □ Robots start in the base and scout for worksites
- □ When a robot finds a worksite, it tries to load resource from it
- □ The robot delivers resources to the base until the worksite is depleted or not found



BDRML representation of the Solitary controller

Robot control algorithms: Broadcaster

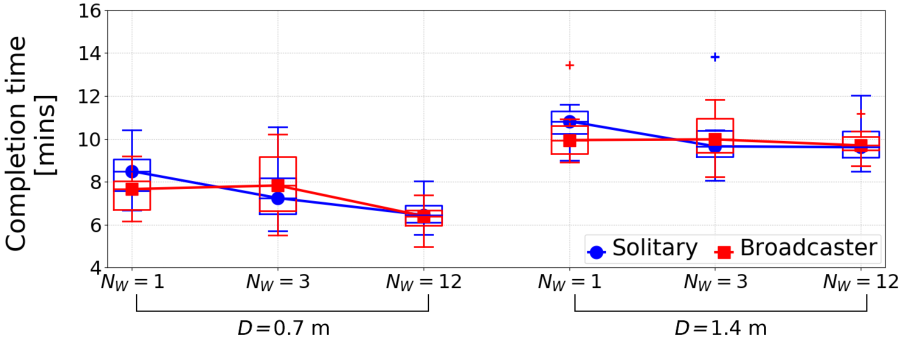
- □ Based on the Solitary controller, but robots also recruit each other
- □ While a robot is near a worksite, it sends recruitment signals with believed worksite location to nearby scouts



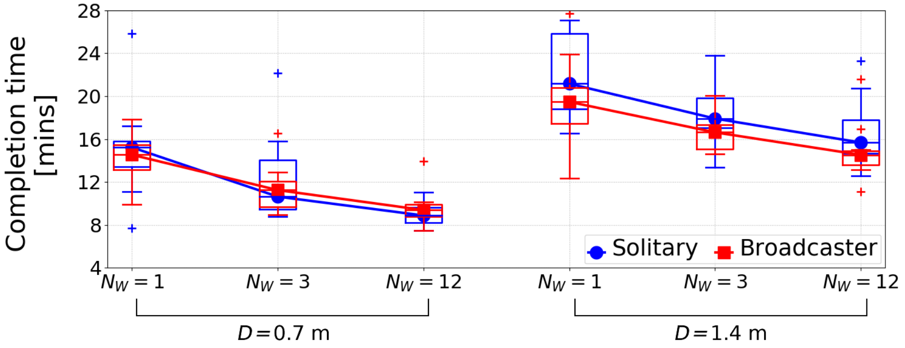
BDRML representation of the Broadcaster controller

Foraging performance

- □ Environments with different number of worksites (N_W) and worksite distance from the base (D)
- □ When there is no noise, both controllers perform similarly
- □ Noise increases completion time. The Solitary swarm is more affected.



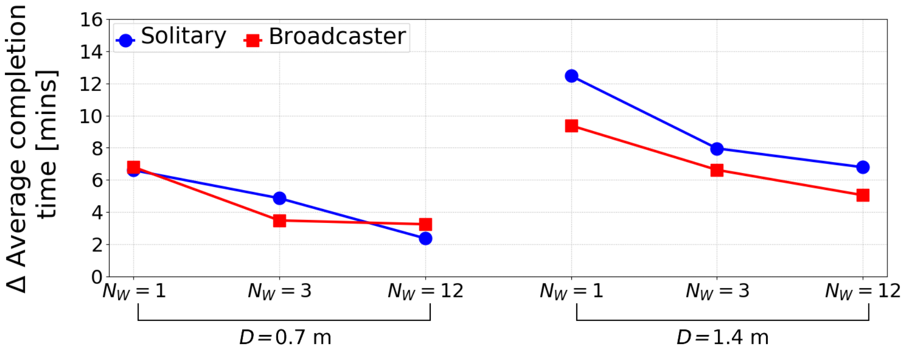
Without noise

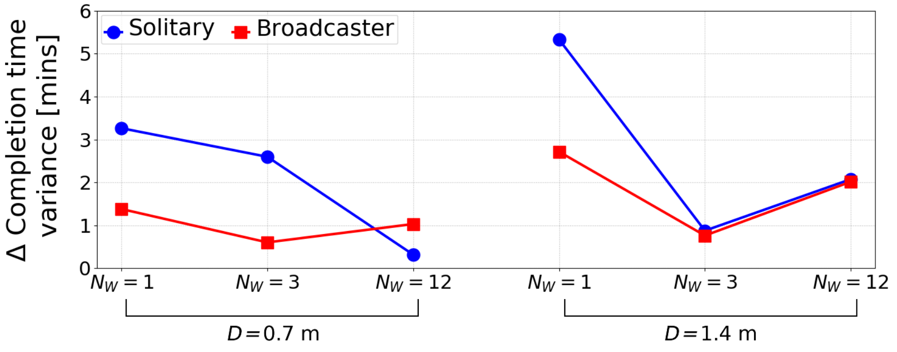


With noise

Foraging performance

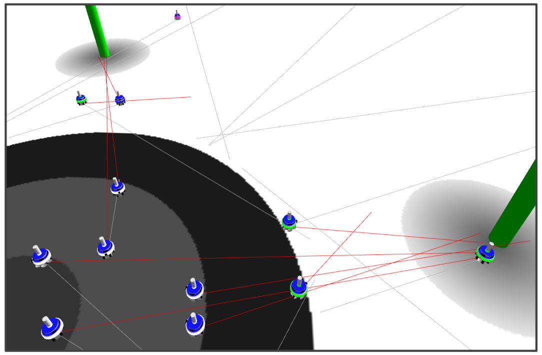
- As a result of noise, Solitary swarm exhibits a larger increase in:
  - Average completion time when *D* is large
  - Completion time variance when N_W is small

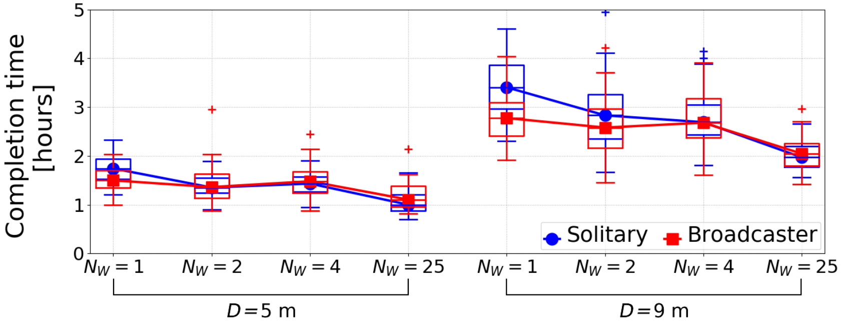




Relation to previous work

- Similar results than in larger simulated environments
- Obstacle avoidance and dealing with congestion are more difficult in real world due to inherent noise
- Controller type affects what kind of noise a swarm can be robust to





Task completion time in a larger simulation

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Find out more:

Designing Robot Swarms project:
https://rebrand.ly/designingSwarms

The BDRML language
https://rebrand.ly/bdrml

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Acknowledgements

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