Active search in agricultural fields

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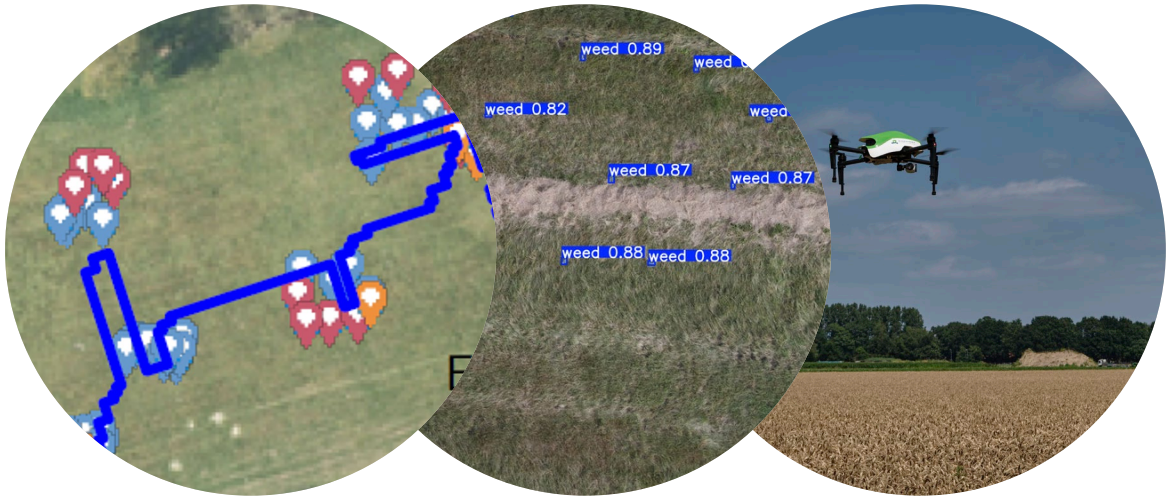
Wageningen University and research



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UAV-based monitoring of fields

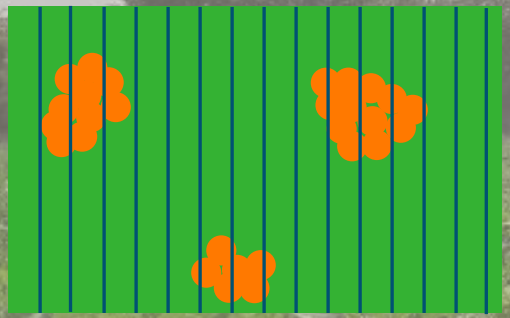
- UAVs can be useful to monitor agricultral fields
- To monitor growth and development of the crop, UAVs typically cover the whole field
- But some weeds/pest/diseases are located in patches in specific locations

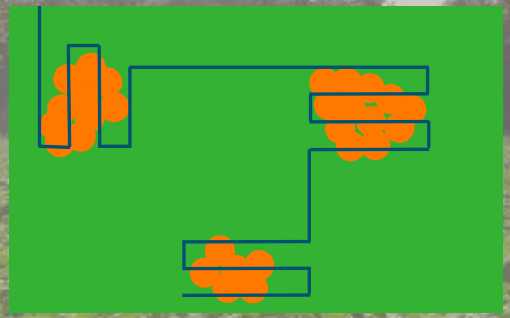


The technical challenge

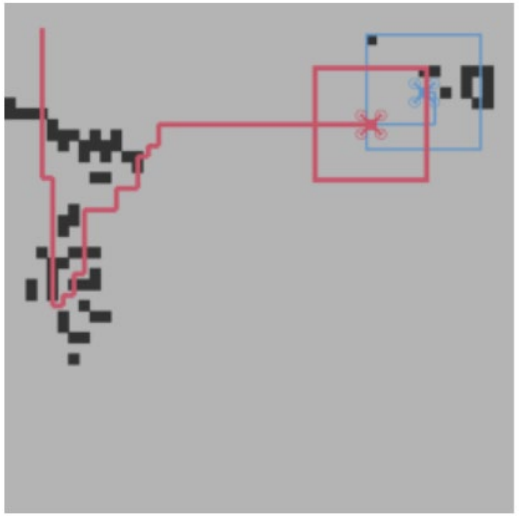
The challenge
- Large fields
- Searching for specific (small) objects
- Limited flight time

The objective
- Efficient flight paths





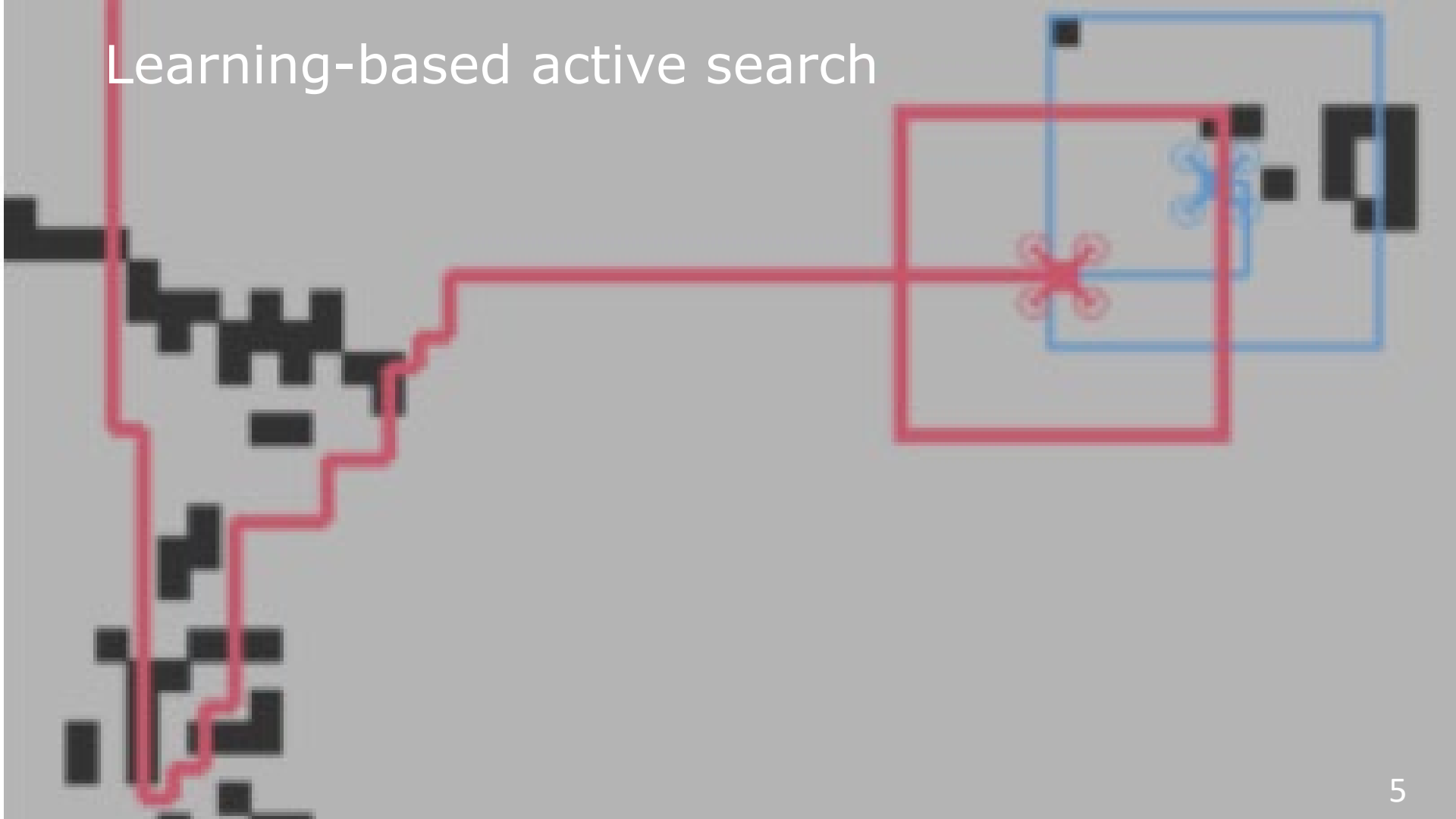
Overview of Rick's PhD work



Learning-based

Rule-based

Learning-based active search



Reinforcement learning to find objects

State

Local map (egocentric)

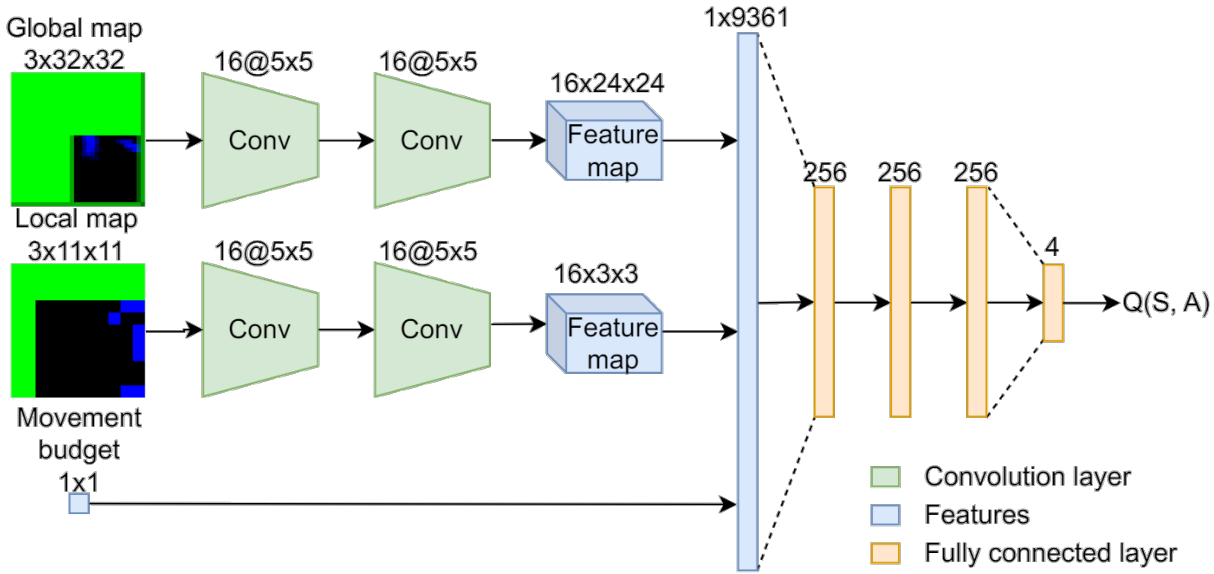
- Current view
- Already detected weed
- No fly zone

Global map (egocentric)

- Prior knowledge weed
- Detected weeds
- No fly zone

Action

Predicts a Q value for four actions (U,D,R,L)

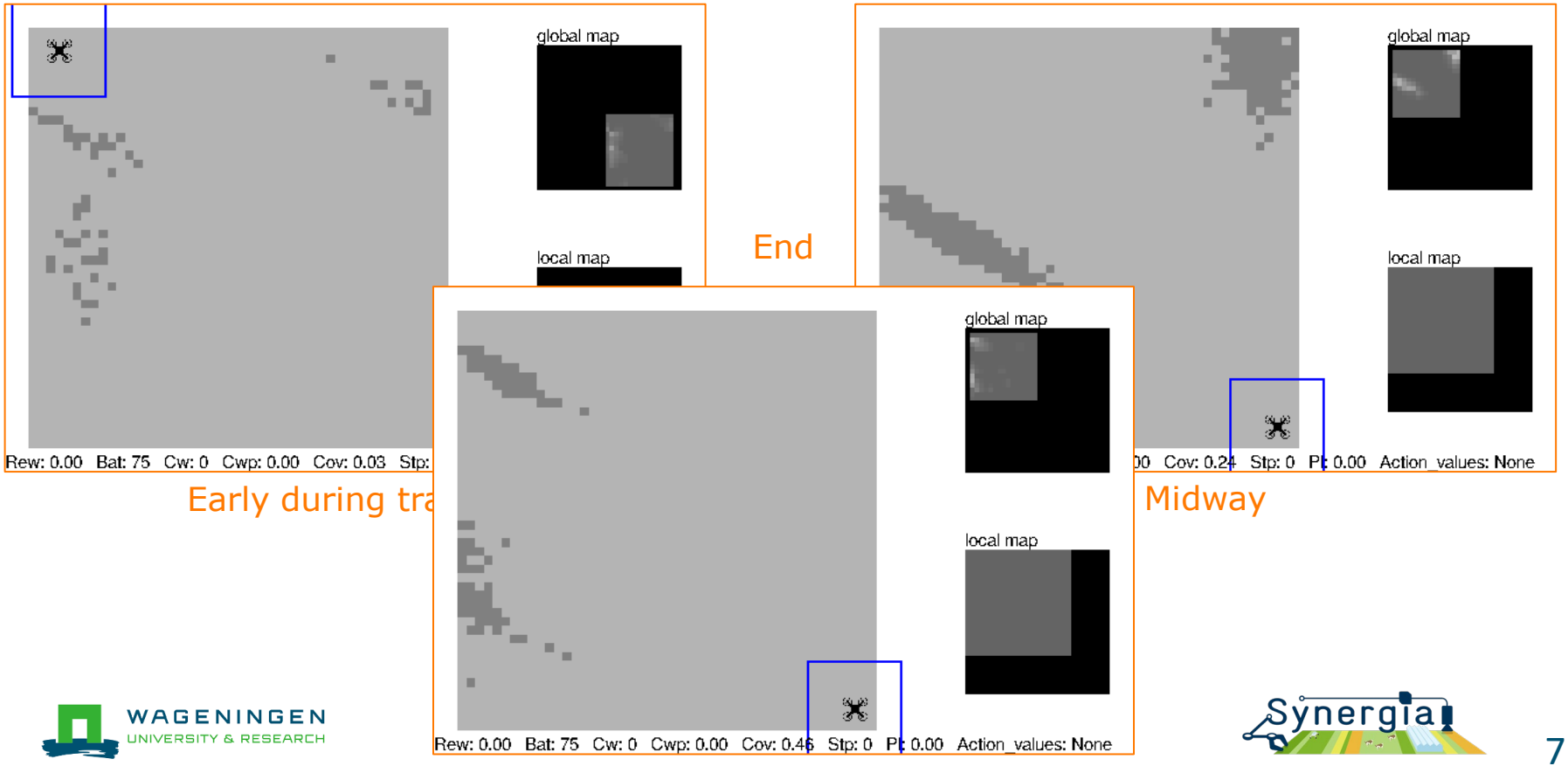


Reward

- Nr actions, detected weeds

Essen, R., Kootstra, G., & van Henten, E. J. (2025). UAV-based path planning for efficient localization of non-uniformly distributed weeds using prior knowledge: A reinforcement-learning approach. *Computers and Electronics in Agriculture*, 237, 110651

Learning to search a field for weed patches



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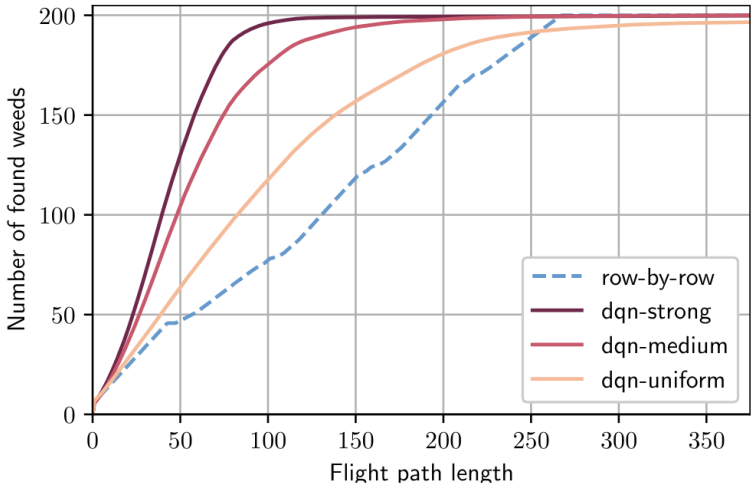
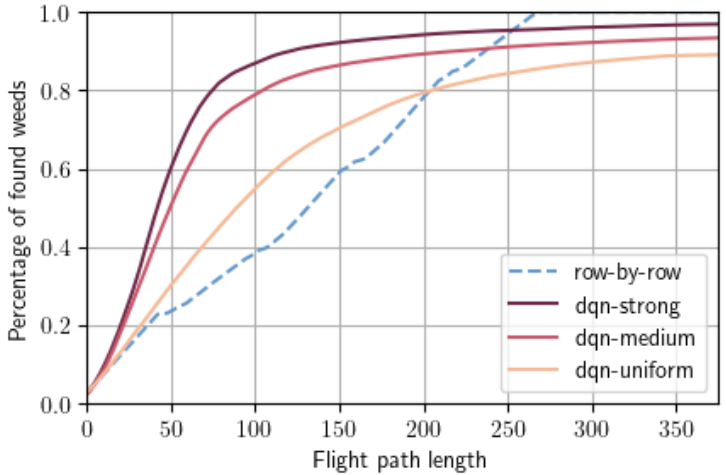
Reinforcement learning to find objects

Full prior knowledge



Incomplete/erroneous prior knowledge



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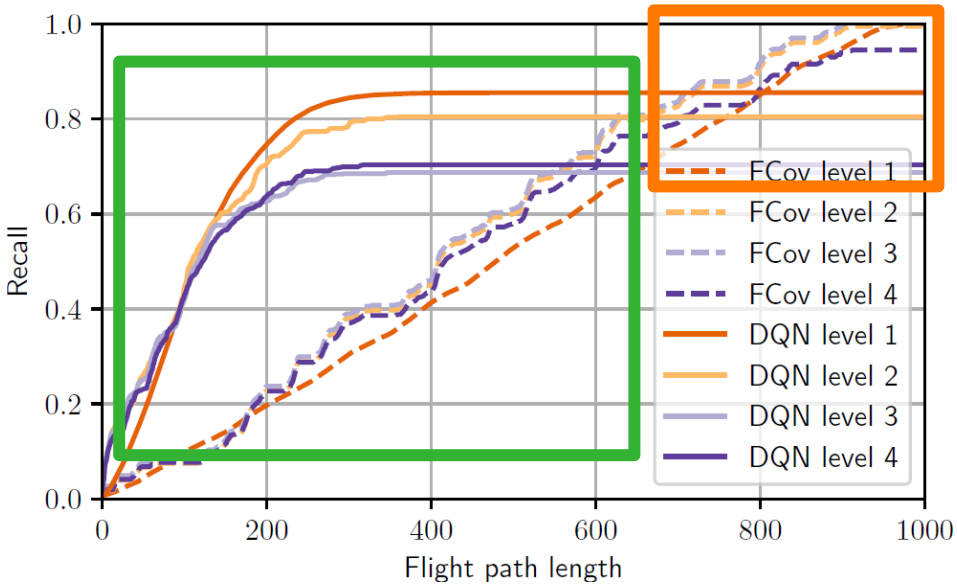
Results: from simulation to real-world data

Level 1: full simulation

↓

Level 4: real-world data



Faster than coverage flight path

Not all objects were found

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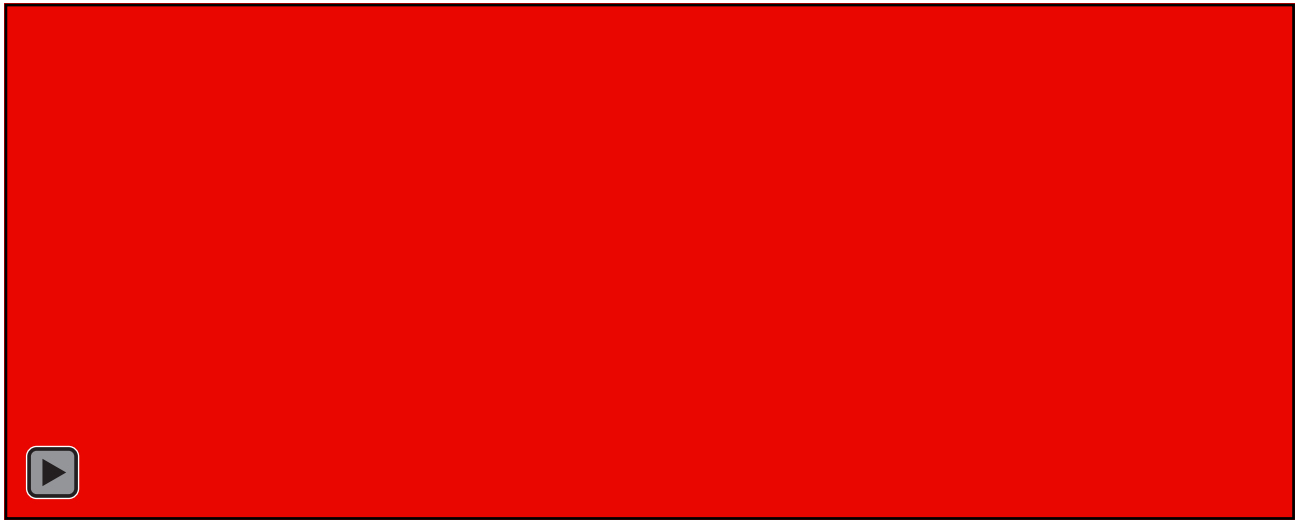
RL-agent on real-world data



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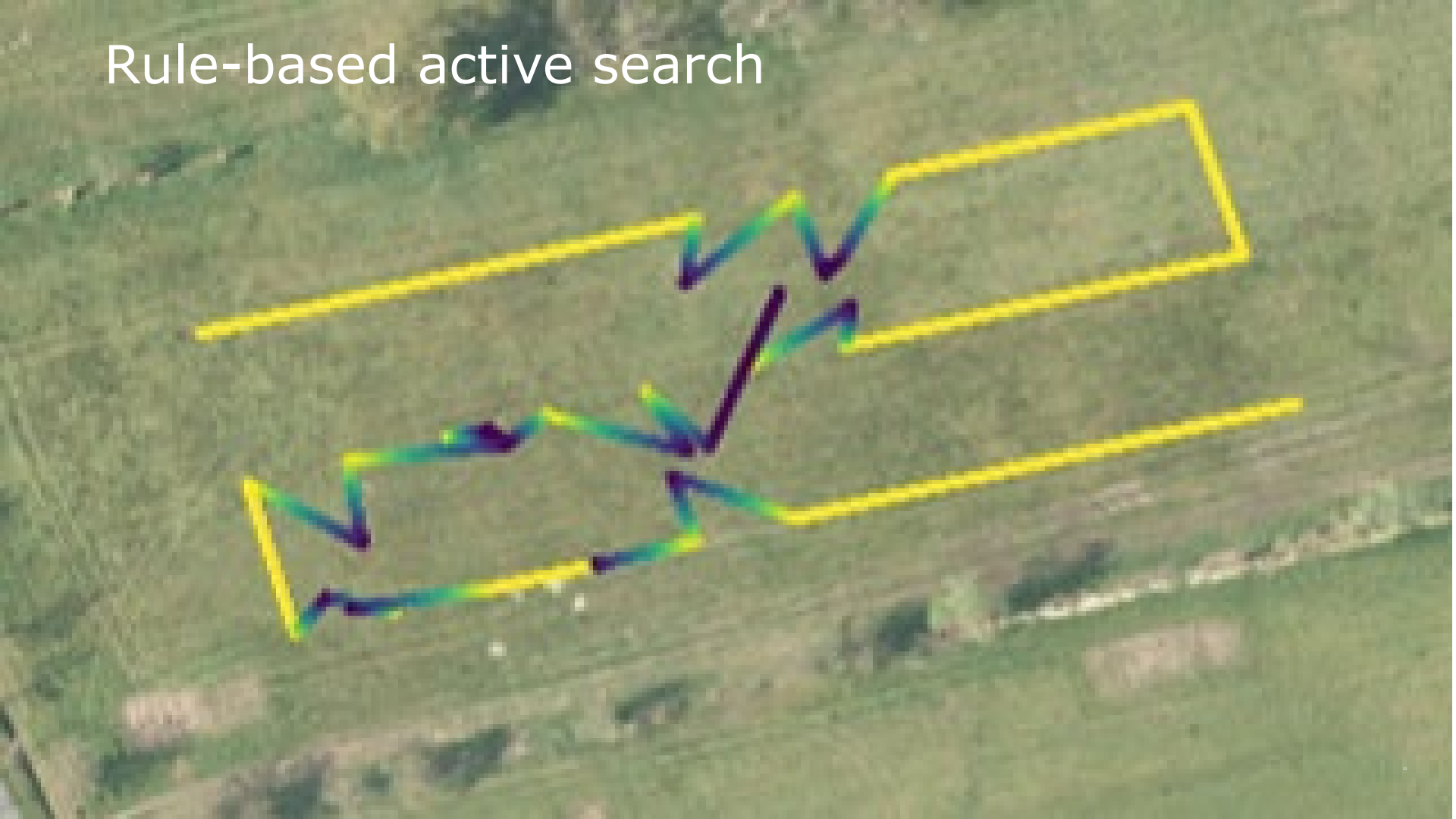
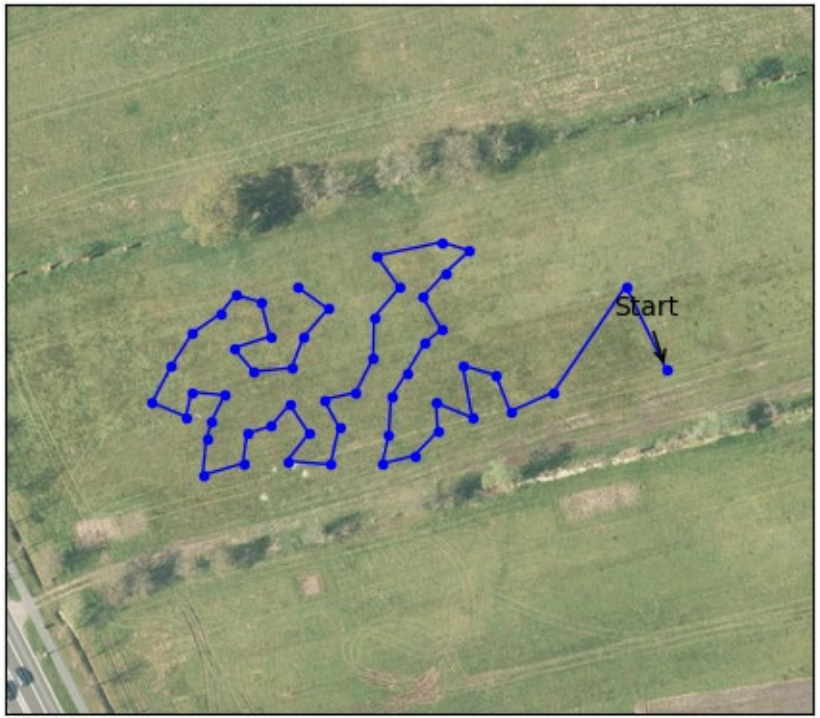
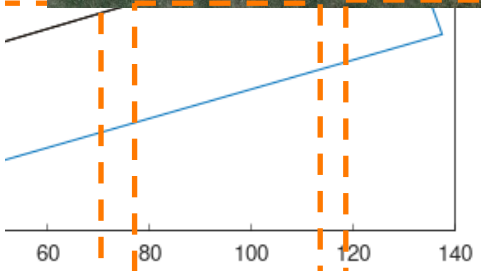
Rule-based active search

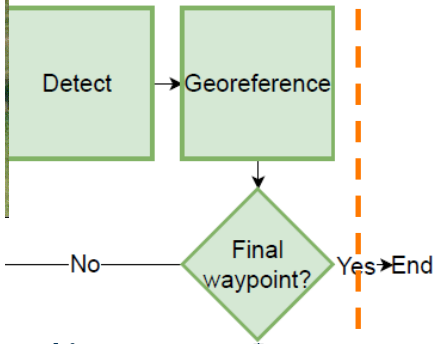


Taking a closer look



Start





overlap

waypoint

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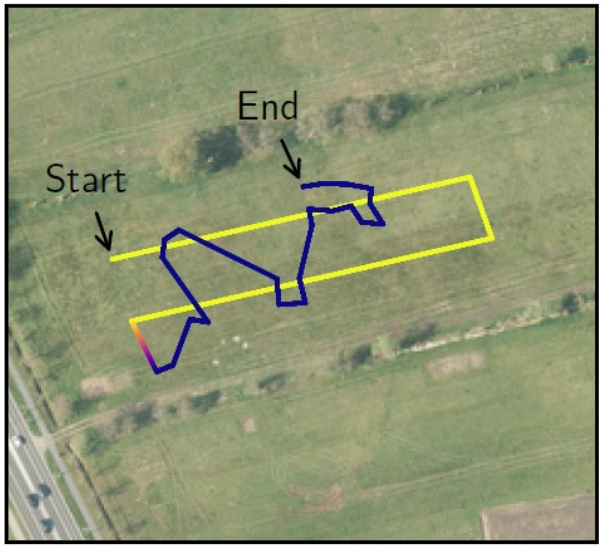
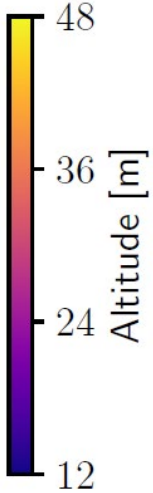
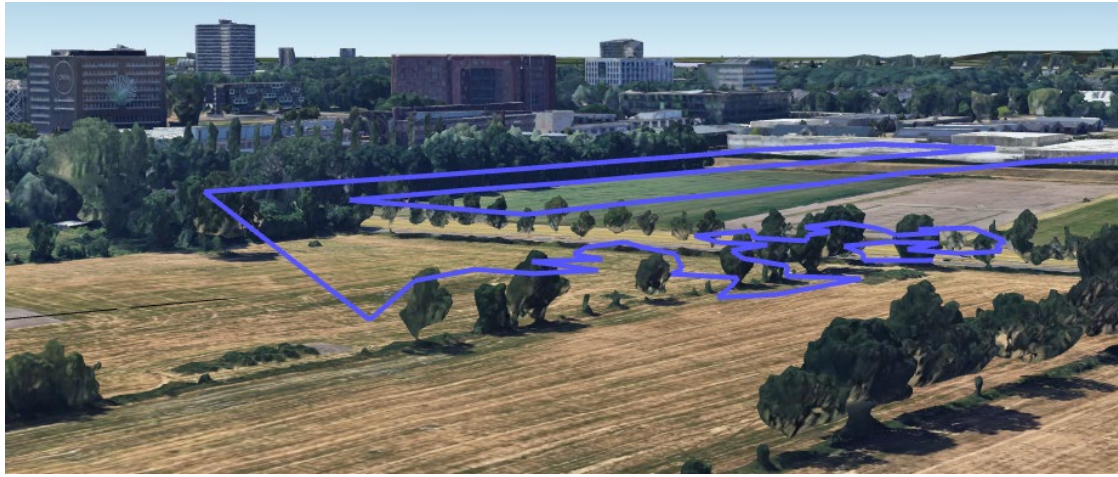
Example of a planned path at different altitudes





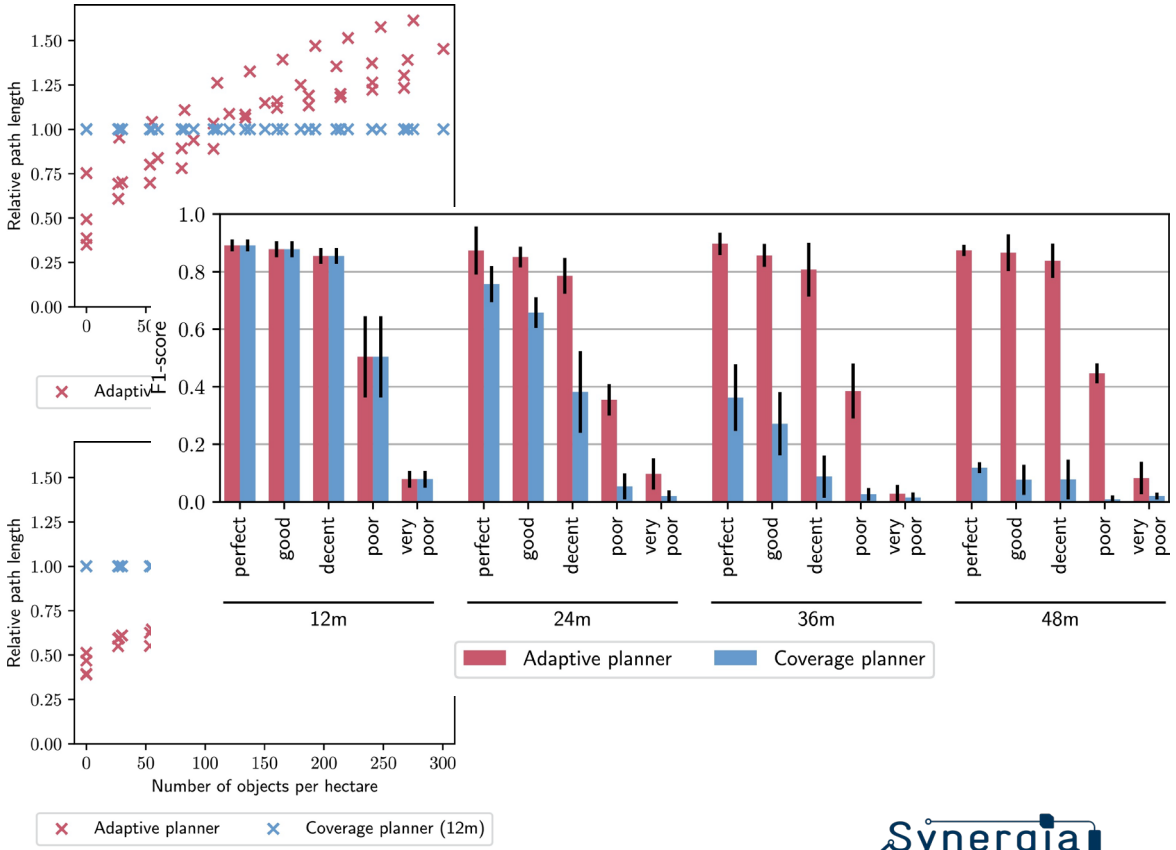


van Essen, R., van Henten, E., Kooistra, L., & Kootstra, G. (2025). Adaptive path planning for efficient object search by UAVs in agricultural fields. *Smart Agricultural Technology*, 101075.

Some results

(a)

(b)



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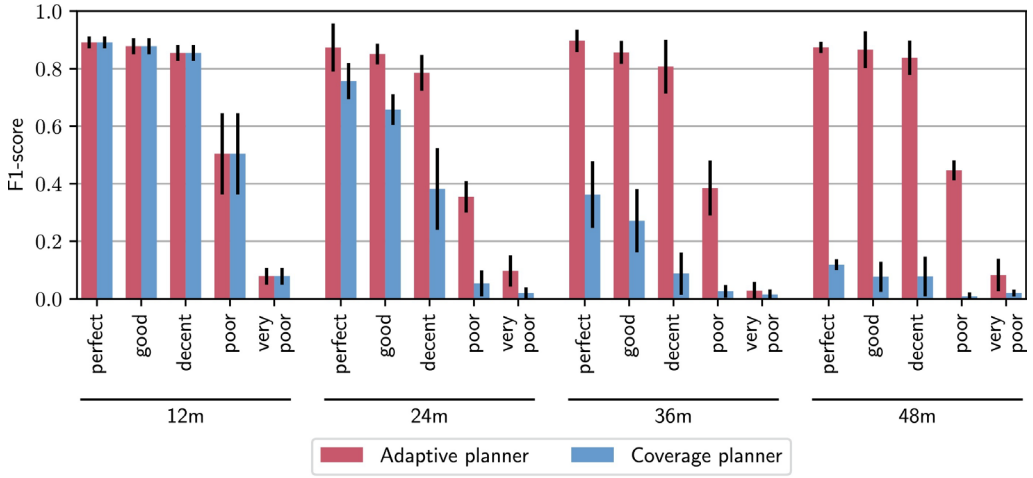
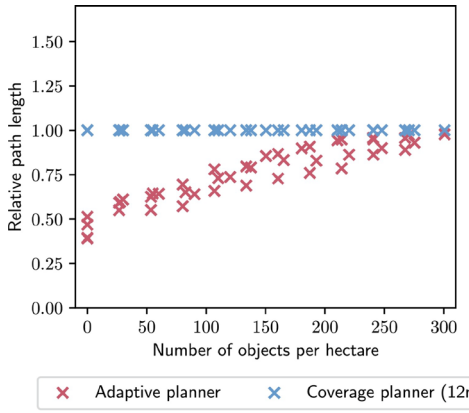
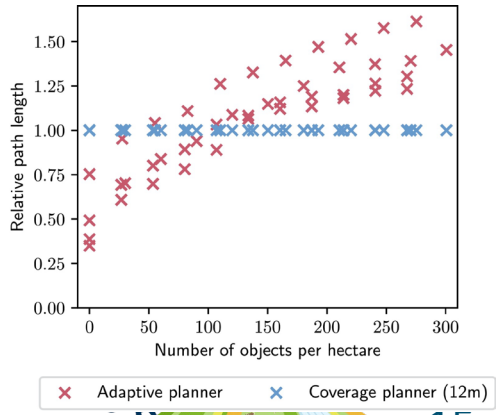
Some results

- The adaptive path planner detects more objects
- When number of objects is limited, path length is much shorter
- Most effective when objects are in patches







Thank you for you attention

Efficient UAV flight using adaptive path planning

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