POMDP Planning at Roundabouts

IV2021 Workshops

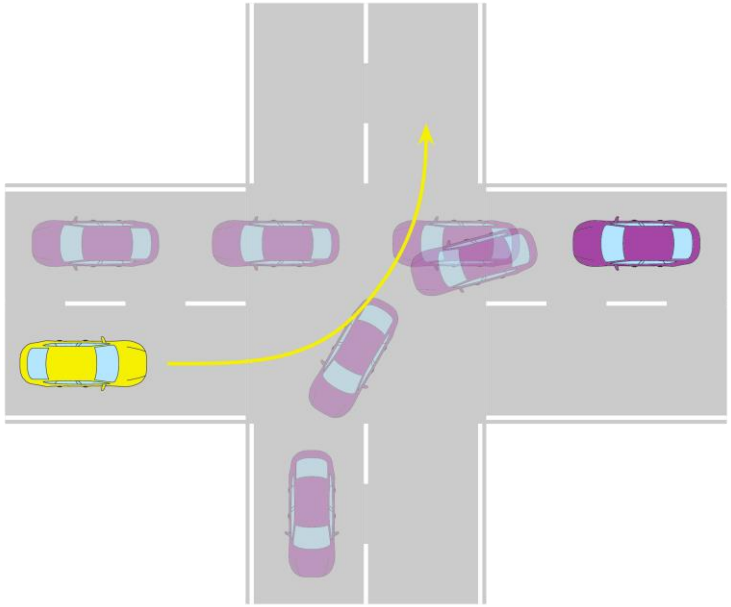
Henrik Bey

henrik.bey@fau.de
Friedrich-Alexander-Universität Erlangen-Nürnberg
Institute of Information Technologies (LIKE)
In cooperation with Pre-Development of Automated Driving, AUDI AG

FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

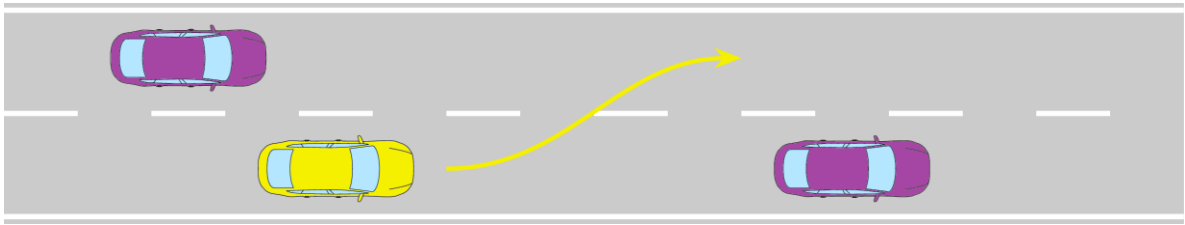
POMDPs in Automated Driving

Crossroads [1]



› Unknown route choice

Highway [2]

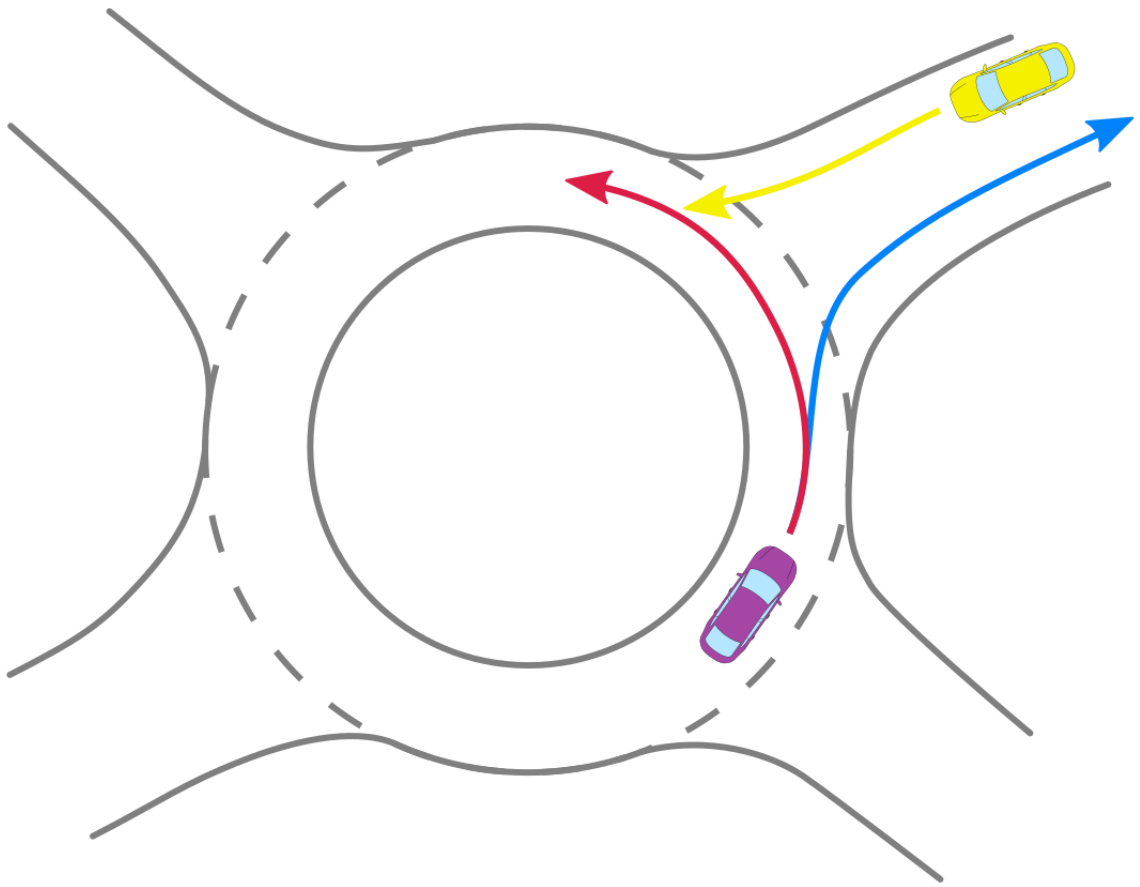


› Unknown driver characteristics

[1] Hubmann et al. (2018) Automated Driving in Uncertain Environments. *Transactions on IV*

[2] Sunberg et al. (2017) The value of inferring the internal state of traffic participants for autonomous freeway driving. *ACC*

Scenario



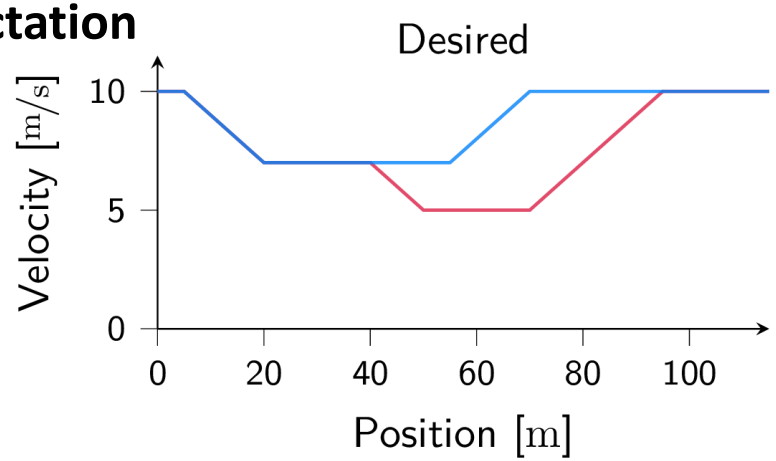
Roundabouts

- Controlled by interaction
- Indications on route choice
- No mandatory stopping → highly dynamic

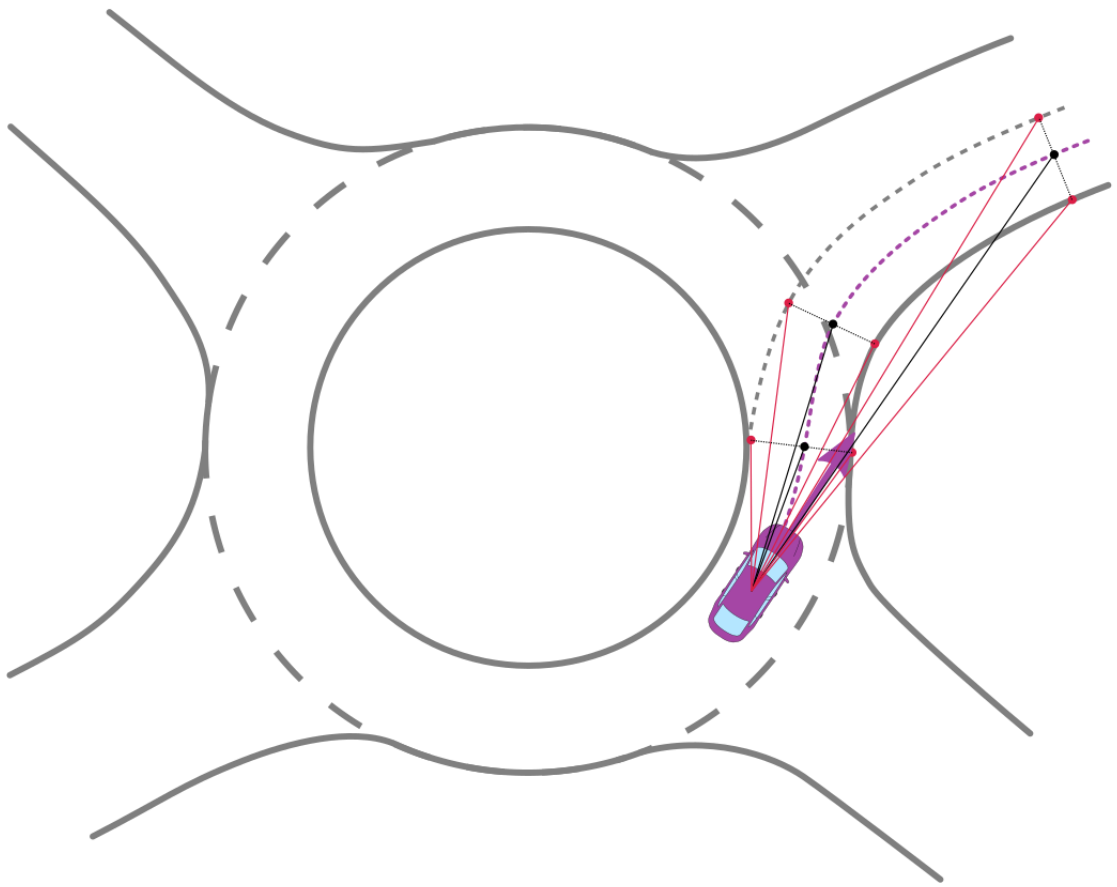
Modelling

- Fixed path for ego, choosing accelerations
- Noisy position of other vehicle as observation

Expectation



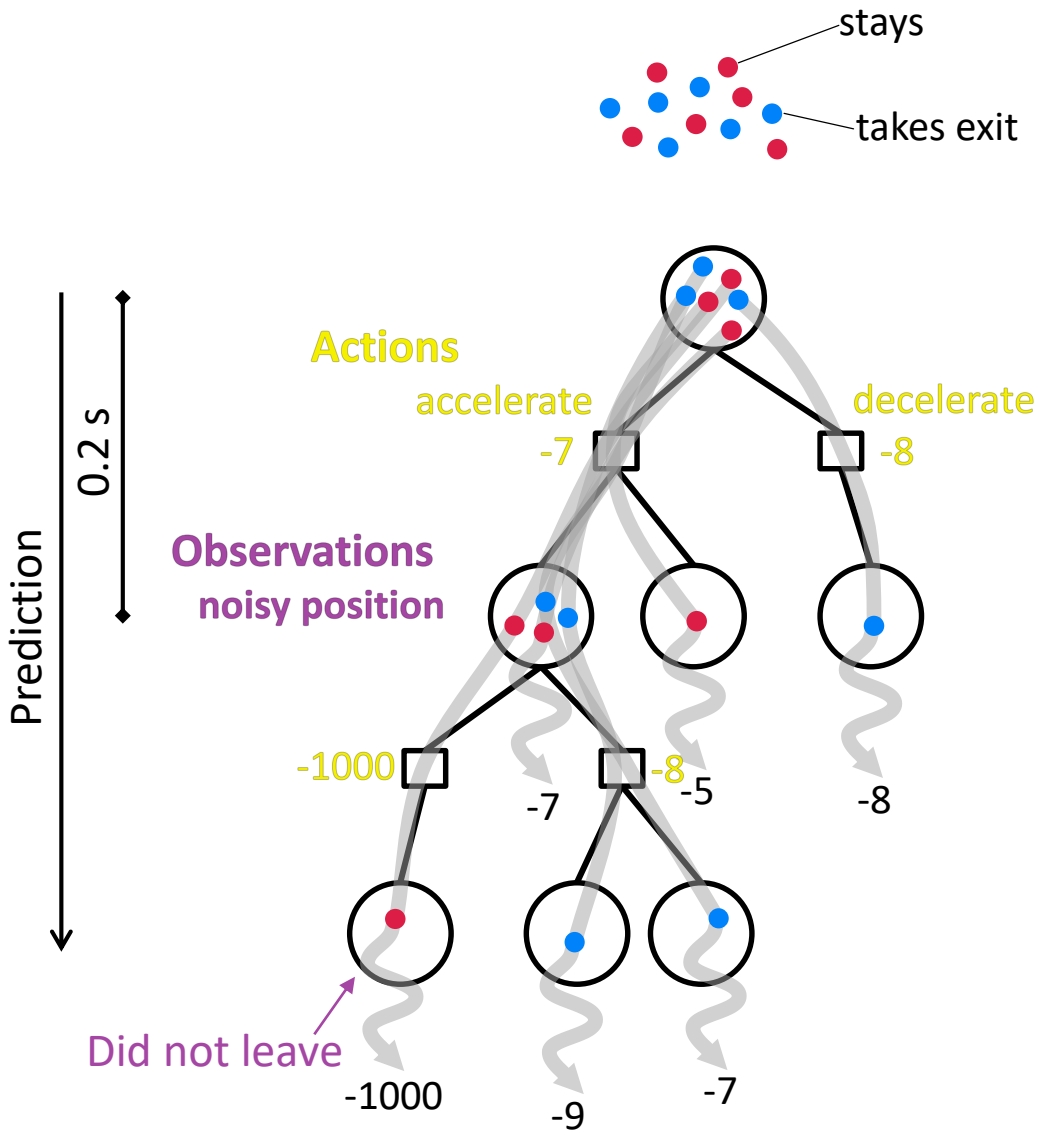
Prediction with Learned Model [1]



- Inputs to Neural Network:
  - Current velocity
  - Relative angles to 9 key points ahead on route (in 5, 10, 20m)
- Outputs:
  - Acceleration
  - Curvature
  - Overlaid with noise to reach different trajectories

[1] Sackmann et al. (2020) Prediction Error Reduction of Neural Networks for Car-Following Using Multi-Step Training. *IV*
Sackmann et al. (2020) Classification of Driver Intentions at Roundabouts. *VEHITS*

Sampling-Based POMDP Solving [1]

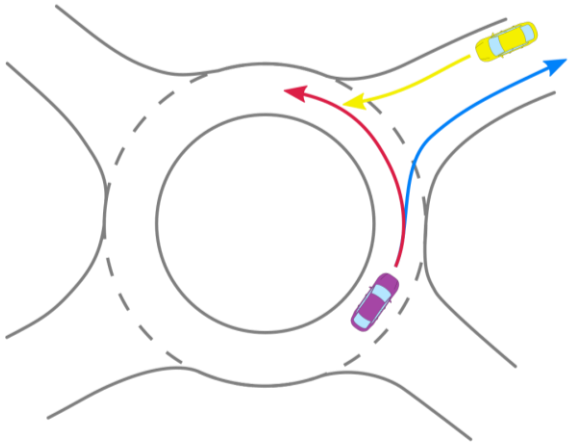


Particle filter

Sample state

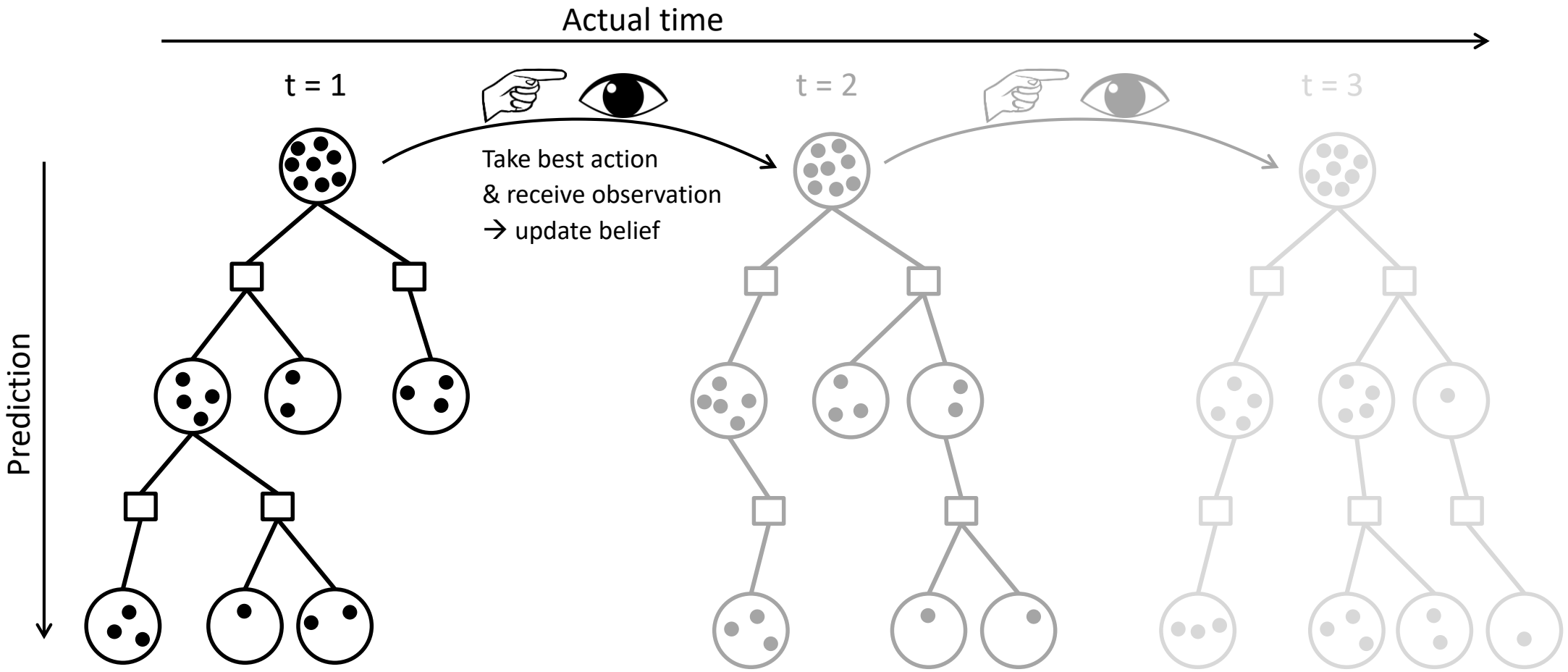
Transition model,
Observation model,
Reward function

Rollout,
Update Q-values



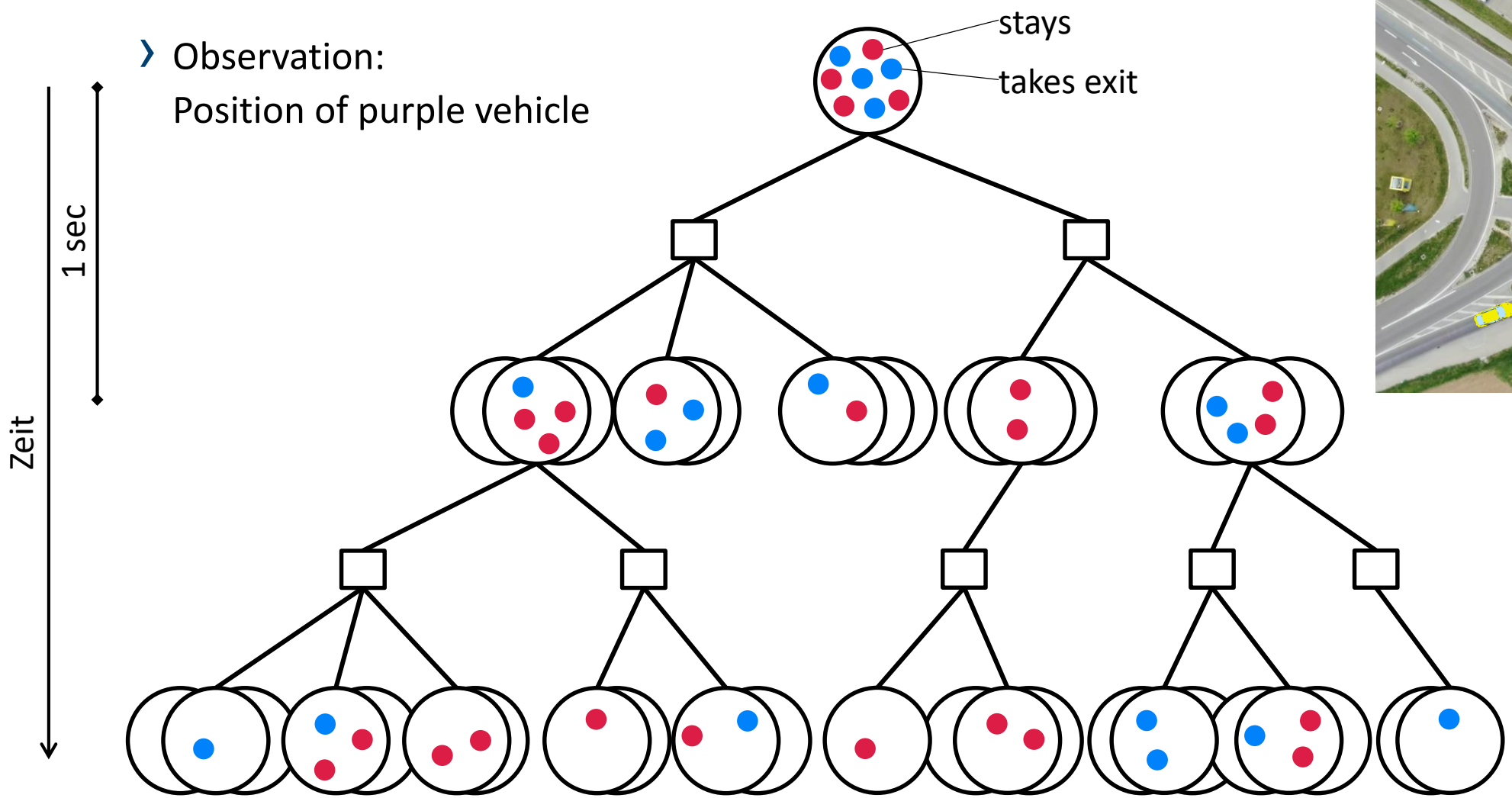
[1] Silver and Veness (2010) Monte-Carlo Planning in Large POMDPs

Planning Procedure



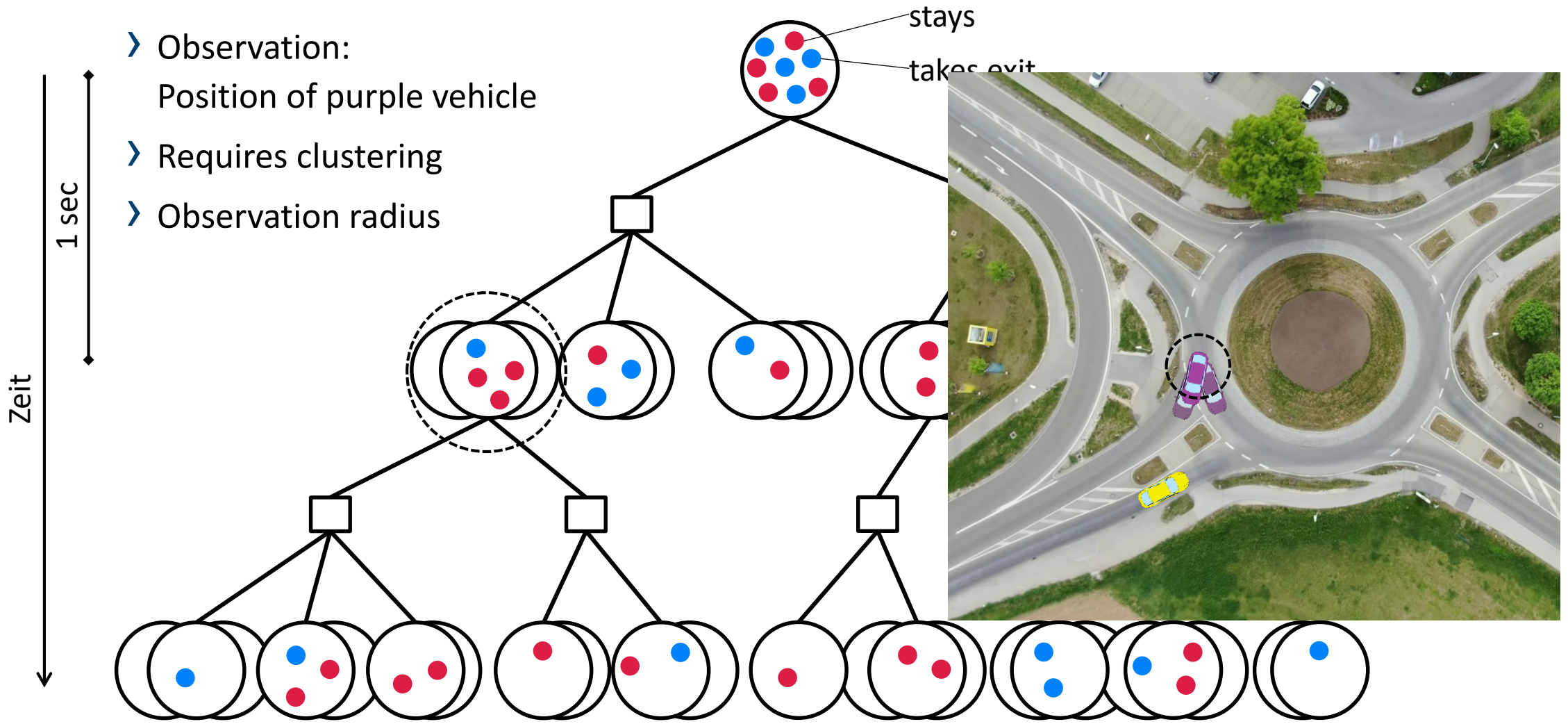
Continuous Observations

- Observation:
  Position of purple vehicle

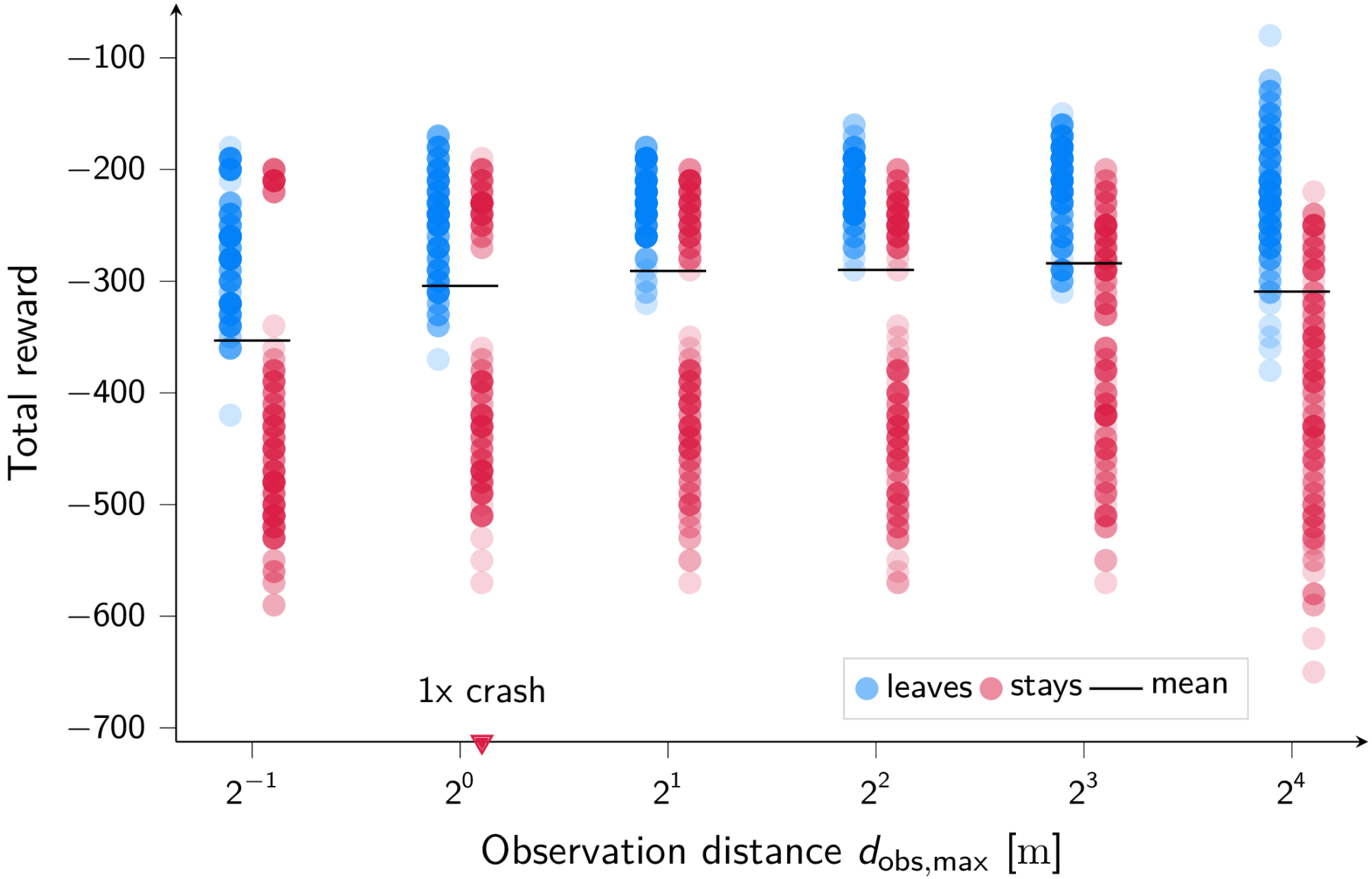


Continuous Observations

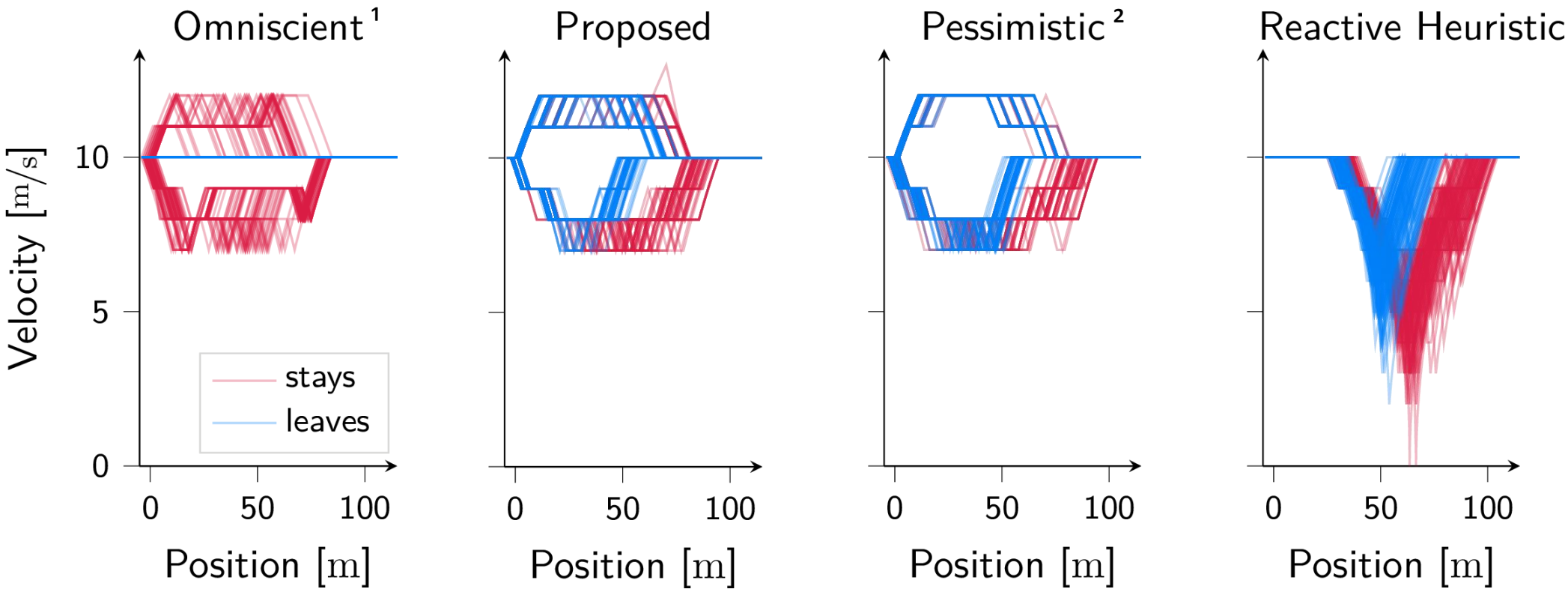
- Observation:
  Position of purple vehicle
- Requires clustering
- Observation radius



Results Observation Clustering



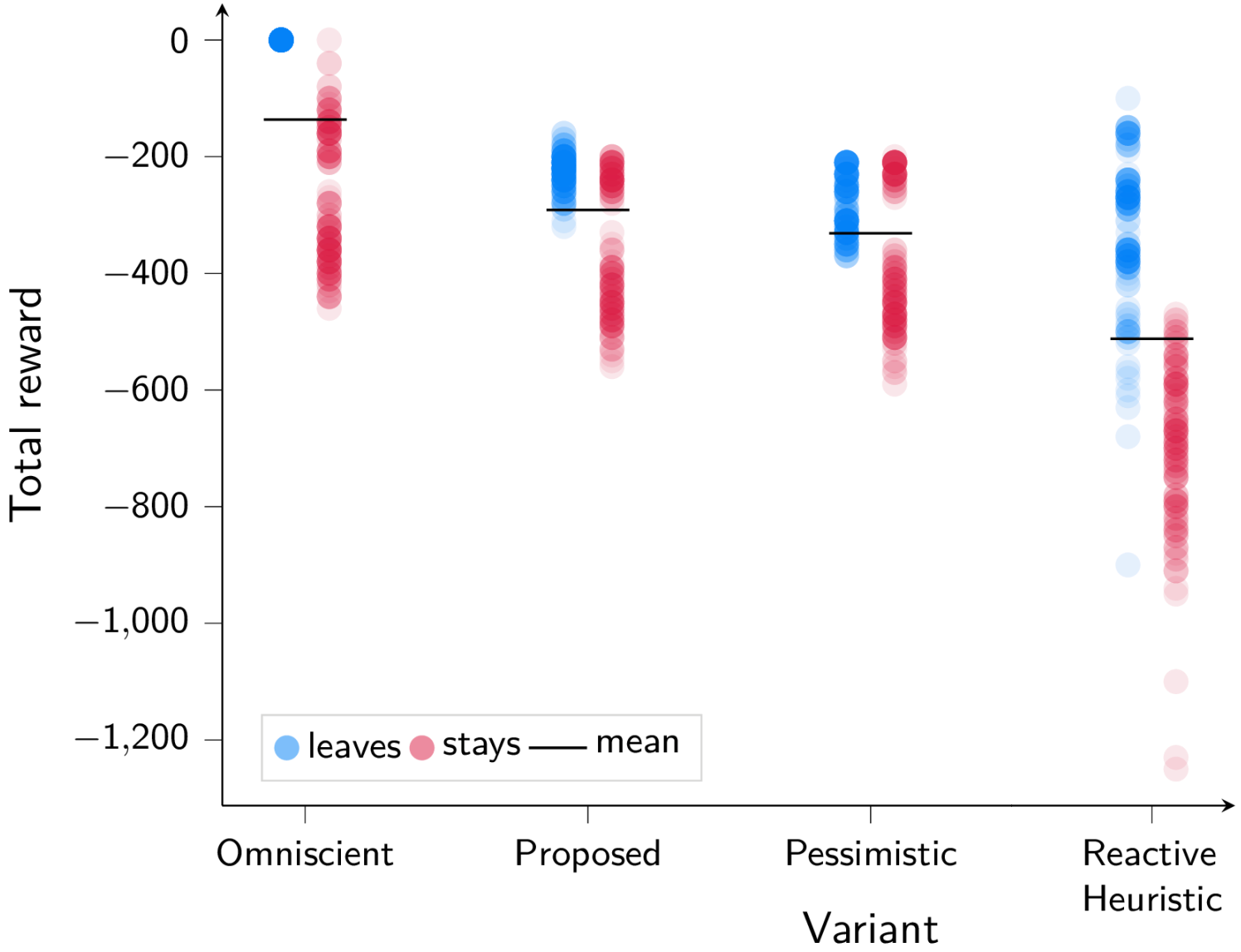
Resulting Trajectories of Different Variants



[1] All particles initialized with the ground-truth trajectory → cheating

[2] Assumes „staying“ until 100% sure

Total Rewards of Different Variants



Conclusion & Outlook

Promising combination of POMDPs and learned models

- Prediction may consider subtle driving cues
- But still transparent planning

Remaining challenges

- Calling a Neural Network 100.000 times is expensive
- → Better (native) integration
- → Parallelization