IT UNIVERSITY OF COPENHAGEN

Risk-averse Planning and Plan Assessment for Marine Robots

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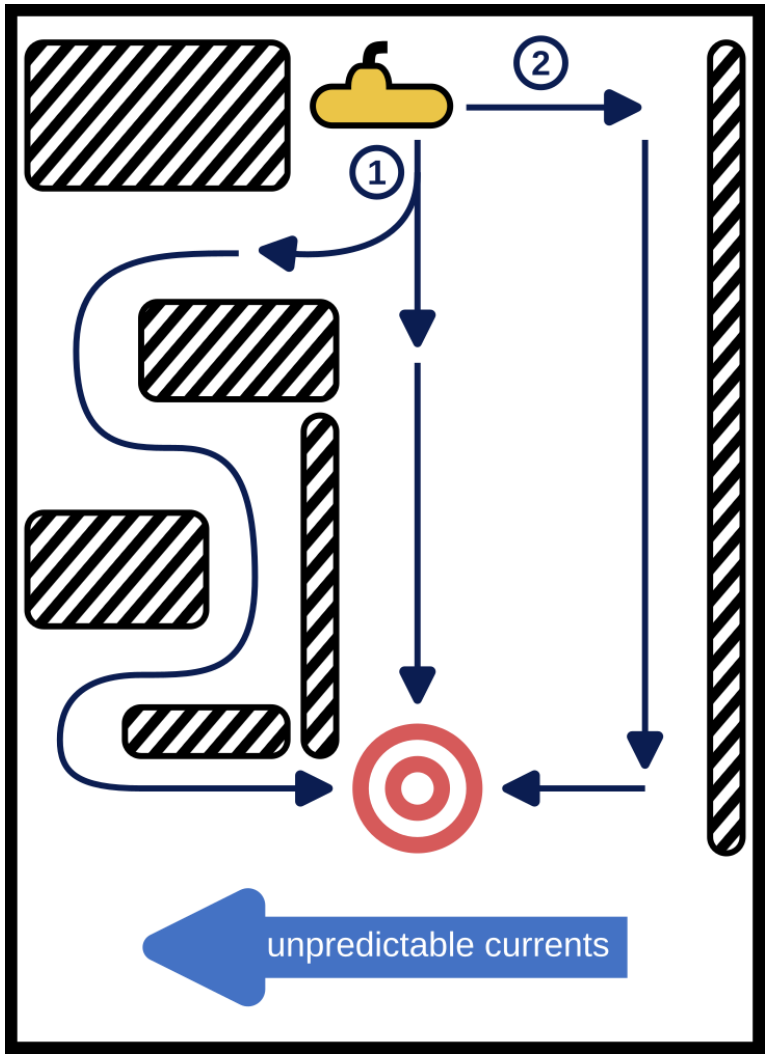
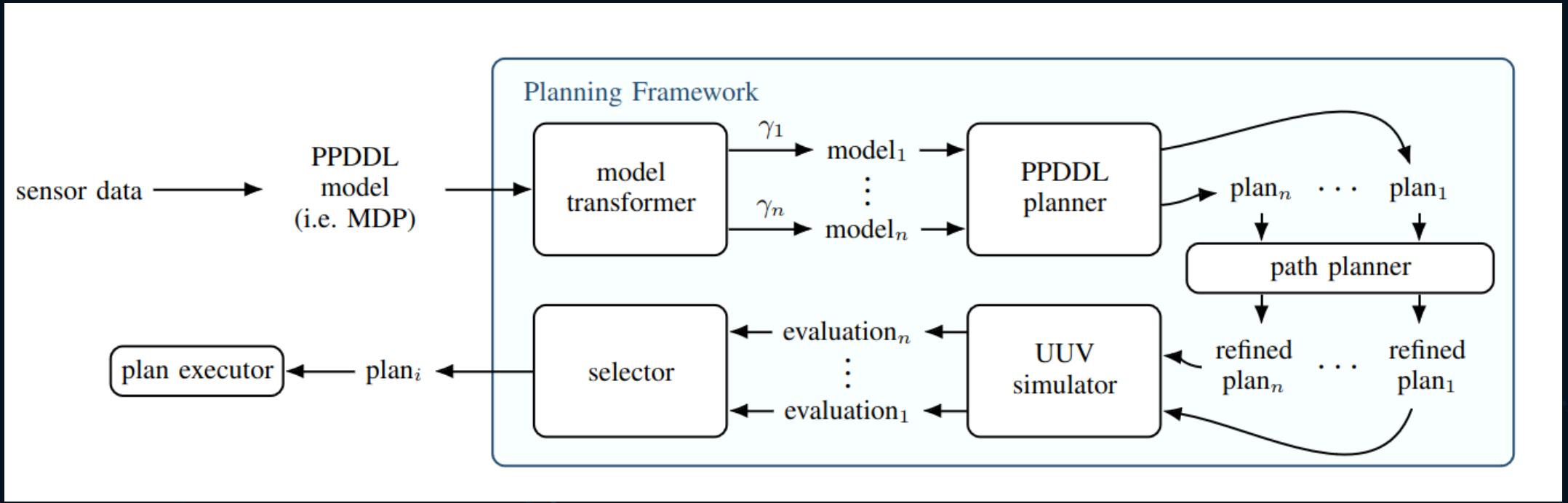
REMARO
RELIABLE AI FOR MARINE ROBOTICS

Risk-sensitive Planning

- **Scenario**: subsea infrastructure inspection
- **Problem**: we need multiple plans and select safest one among them
- **Solution**: Risk-sensitive planning (high-level), sonar probabilistic mapping (low-level)





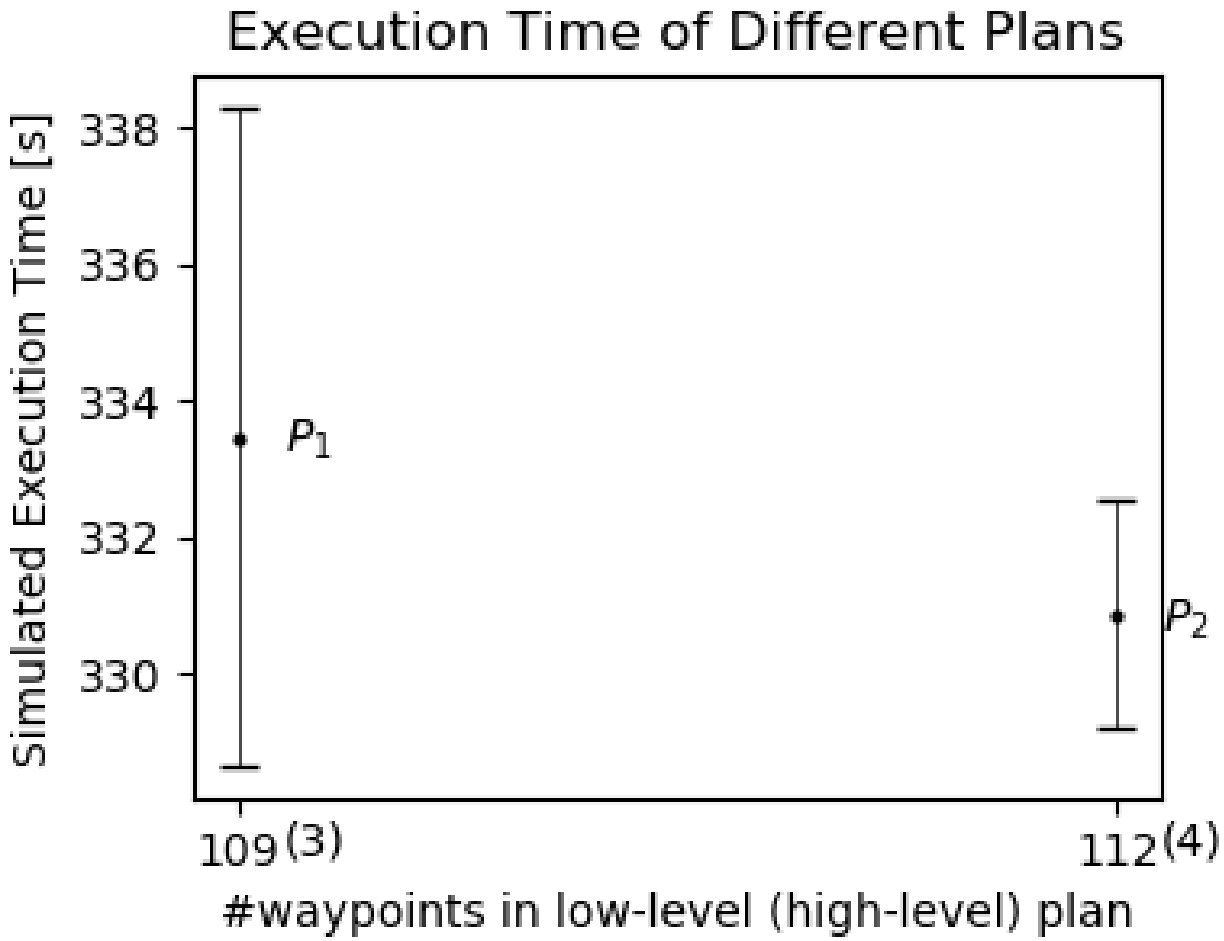
Proposed Framework

- **Plan Generation**
- Plan Evaluation
- Plan Execution (Simulation)

Risk-sensitive vs Risk-neutral Planner

P1: shortest but dangerous

P2: longer but safest



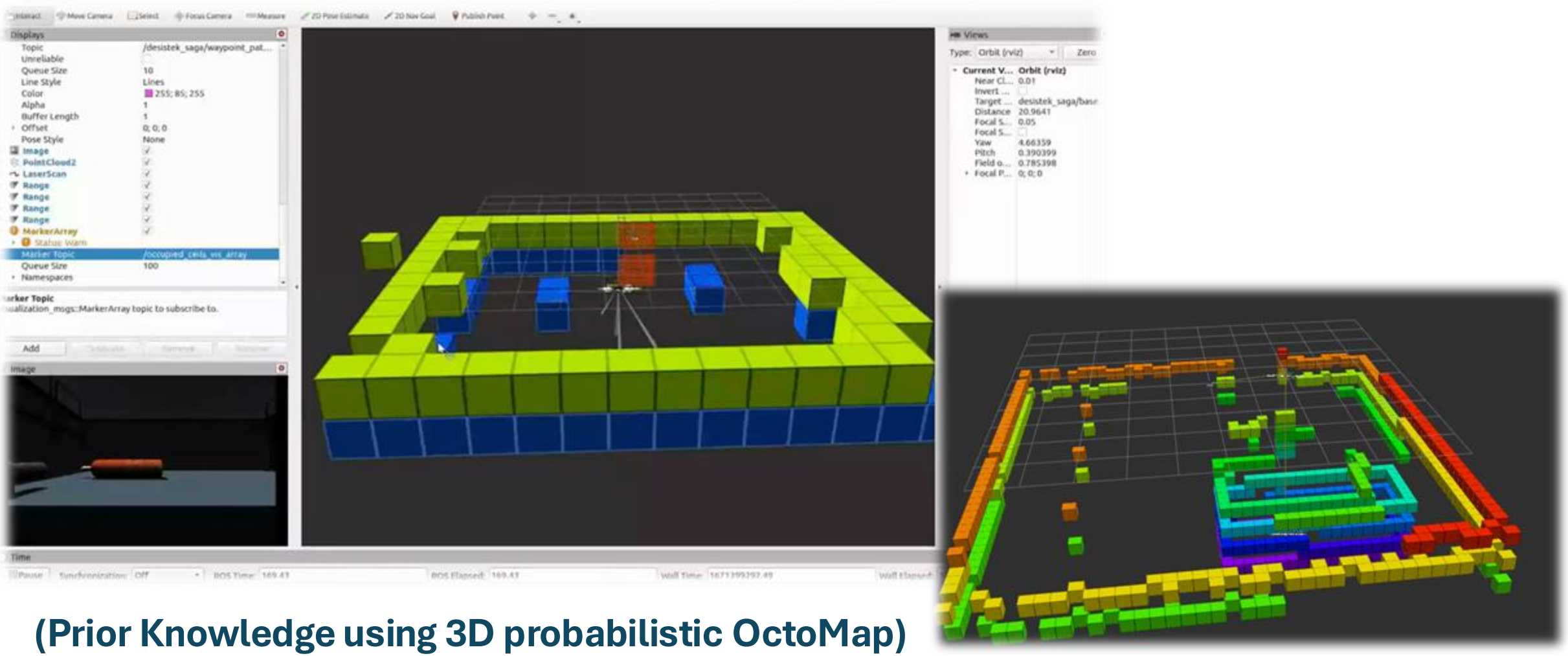
Generated plans using risk-averse planning

ID	Plan schema	planning time [s]	high-level length	low-level length	assessment (exec. time) mean [s]	variance	entropy
P_1	lg tank → quad tank → sm tank	0.09	3	109	332	13.8	2.3
P_2	lg tank → tank pairs → platform → quad tank → sm tank	0.11	5	114	297	1.6	2.3
P_3	lg tank → tank pairs → lg tank → platform → quad tank → sm tank	0.15	6	115	351	0.3	2.3
P_4	lg tank → quad tank → lg tank clone → sm tank	0.07	4	112	294	0.2	2.3
P_5	lg tank → tank pairs → lg tank → quad tank → sm tank	0.11	5	114	305	0.2	2.3

Different scenarios for risk-averse planning

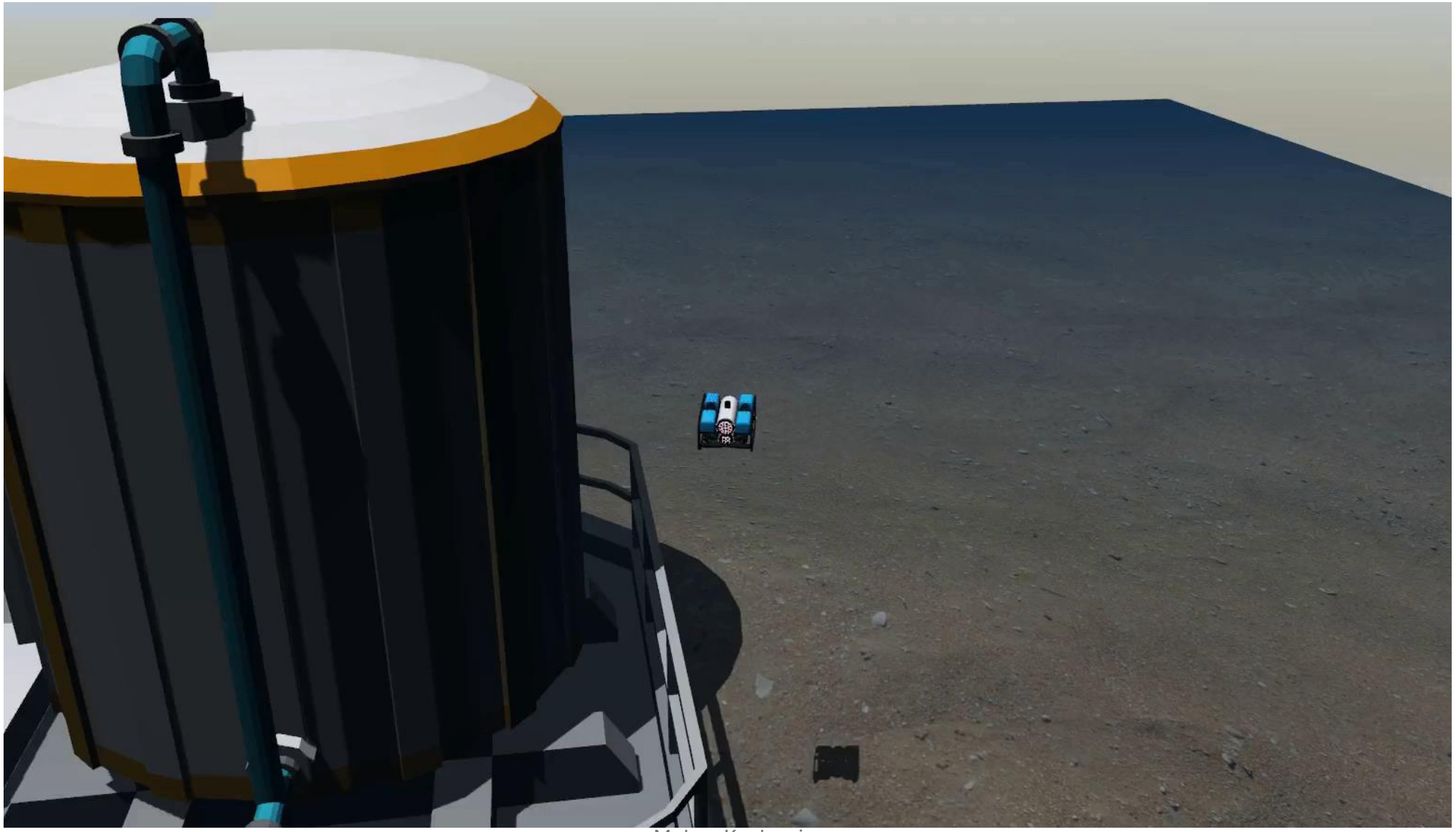
	Problem properties		Properties of the safest plan		
ID	depth [state]	#crit. states	length	risk (γ)	planning time [s]
1	3	3	5	0.95	0.05
2	4	4	5	0.74	0.06
3	5	5	6	0.40	0.11
4	6	6	17	0.57	0.10
5	10	5	13	0.67	0.11
6	15	5	13	0.49	0.14
7	20	6	17	0.84	0.08
8	30	10	52	0.58	0.13
9	40	15	66	0.84	0.16
10	50	15	86	0.96	0.21
11	60	15	106	0.97	0.29
12	70	15	126	0.95	0.40
13	80	15	146	0.59	0.54
14	90	15	166	0.57	0.93
15	90	25	166	0.42	0.98
16	90	35	166	0.75	1.04

Sonar Mapping



(Prior Knowledge using 3D probabilistic OctoMap)

Simulation (4x times)



Conclusion

- Common risk-neutral planners' issue is those optimize planning problem w.r.t. time step
- Modeling transformed MDP with risk-sensitive utility
- Utilizing new model in PPDDL programming language format
- Developing and leveraging an integrated risk-sensitive plan selection in risk-neutral probabilistic planner
- Evaluating generated plans using introduced metrics

Publications

1. John, T., Kashani, M.M., Coffelt, J.P., Johnsen, E.B. and Wasowski, A., 2023. Reliable Plan Selection with Quantified Risk-Sensitivity. In *NWPT 2023-34th Nordic Workshop on Programming Theory*.

2. Kashani, M.M., John, T., Coffelt, J.P., Johnsen, E.B. and Wasowski, A., 2024. Risk-averse Planning and Plan Assessment for Marine Robots. Submitted to IEEE/RSJ International Conference on Intelligent Robots and Systems.

Https://github.com/remaro-network/risk-averse_planning
Https://github.com/remaro-network/remaro_scenarios