Risk-Aware Motion Planning for Autonomous Vehicles: Probabilistic Risk Metrics in Sampling-Based MPC

MSc. Project Proposal at the Autonomous Multi-Robots Lab, Cognitive Robotics, TU Delft and Queen Mary University of London (QMUL), UK

Description: While autonomous vehicles are slowly being developed, their motion-planning algorithms are still an active field of research. A relevant problem is that most motion planning algorithms assume deterministic future motions for the other vehicles in the environment while, as any driver knows, there is always a degree of uncertainty in what other people might do on the roads/canals.

Probabilistic risk metrics, given a planned future trajectory for the ego agent, can assess the risk of incurring in a collision accounting for uncertain future actions of the other agents in the scene [1]. However, this only works if you already have a planned trajectory in the first place, which makes it hard to account for these risk metrics at the planning stage when using conventional optimization-based planners.

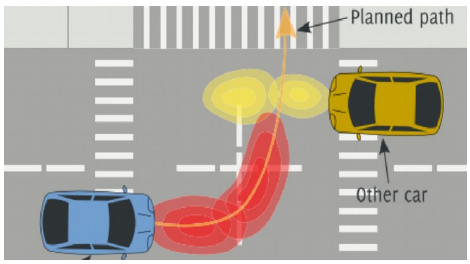
Recently, sampling-based MPC algorithms have been applied to autonomous driving in urban canals [2]. Instead of relying on constrained optimization, these algorithms sample and simulate thousand of possible future trajectories leveraging parallel computations. They then approximate the optimal control input sequence weighting the samples against a cost function, allowing for a gradient-free optimization of the control input.

Therefore, a promising research direction could be to implement probabilistic risk metrics in the motion planner by evaluating the risk for each sampled trajectory and appropriately assigning cost based on such risk. You will first apply your work to simulated cars and vessels, with the possibility of real-world robotics experiments. You will need to apply your research with parallelizable and computationally efficient code, so programming experience is a big plus.

Desired qualities:

- Motivated and independent
- Good problem-solving skills
- Experience/interest in motion planning, autonomous cars/vessels
- Experience in Python/C++ programming and Robot Operating System (ROS)

For further questions or to apply, please contact Ir. Elia Trevisan <e.trevisan@tudelft.nl> or Dr. Xinwei Wang <xinwei.wang@qmul.ac.uk>. When applying, please provide a short motivation, up to date CV, a transcript of your current degree program and intended start date.



References:

[1] X. Wang, J. Alonso-Mora, M. Wang, "Probabilistic Risk Metric for Highway Driving Leveraging Multi-Modal Trajectory Predictions", in IEEE Transactions on Intelligent Transportation Systems, 2022.

[2] L. Streichenberg, E. Trevisan, J. J. Chung, R. Siegwart, J.Alonso-Mora "Multi-Agent Path Integral Control for Interaction-Aware Motion Planning in Urban Canals," *IEEE International Conference on Robotics and Automation (ICRA)*, 2023.