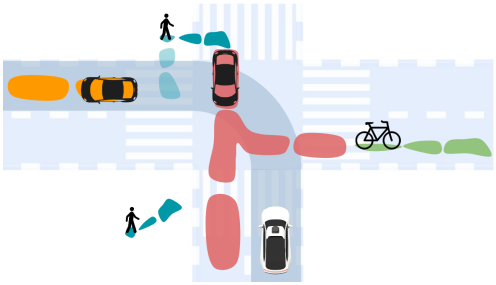
Risk-Aware Motion Planning for Autonomous Driving

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



Brief Description: Ensuring the safety of autonomous vehicles in uncertain traffic scenarios poses a significant challenge. Robust optimization approaches are able to provide safety guarantees by rigorously accounting for all possible realizations of the uncertainty, yet they sacrifice efficiency in dense traffic due to conservative driving [8]. Typically, humans balance safety and efficiency in dense traffic by accepting *a probabilistic risk* of violating the safety constraints. Inspired by human behavior, stochastic optimization allows for the violation of constraints as long as the probability of this violation is below an acceptable upper bound, which is specified through chance constraints [9]. The focus of this thesis is to build up on the quantification of the risks associated with the uncertain predictions of other road users, and integrate them into a motion-planning framework. To achieve this task, two possible research directions are proposed.

Research direction 1: Risk Assessment for Probabilistic Planners
Scenario-based MPC [3] is a non-convex optimization approach that can be applied within a motion planning framework by sampling chance constraints from the obstacles' uncertainty. One of the challenges in the scenario-based MPC is to determine the upper bound of the specified risk, e.g., by using a repetitive scenario design [2]. The thesis shall explore a criterion to adapt the chance constraint bounds online based on the perceived risk. In addition, in our previous work [6], we assumed that the robot can well capture the uncertain pedestrian motion distributions. However, in reality, this is not the case. Thereby, this thesis shall explore elaborated risk metrics in case the robot has a biased prediction for obstacle motion uncertainty [4].

Research direction 2: Reachability Analysis for Contingency Planning
Reachability analysis is used extensively in literature to analyze safety for robotic systems by computing invariant sets. With these sets, one is able to detect when the robot performs trajectories that are close to violating safety constraints, simply by checking the distance to the boundary of the

set [7]. Yet, it is difficult to incorporate uncertainties in the generation of these sets or to estimate the probability of leaving the set in uncertain traffic scenarios. Therefore, this thesis shall tackle the problem of integrating the probabilistic predictive model into the estimation of reachable sets [1], and how to incorporate the estimated reachable sets in the contingency planning context, e.g. in estimating branching time [5].

Desired Qualities:

- Motivated and independent
- Good problem-solving skills
- Experience with ROS (knowledge of CARLA simulator is a plus)
- Experience in Python and C++ programming

Start Date: June to November 2023

For further questions or to apply, please contact Khaled Mustafa (k.a.mustafa@tudelft.nl) or Dr. Xinwei Wang (xinwei.wang@qmul.ac.uk). When applying, please provide a short motivation, an up-to-date CV, a transcript of your current degree program, and the intended start date.

Group information: www.autonomousrobots.nl

References:

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