Data-driven Probabilistic Motion Planning using Model Predictive Contouring Control with Scenario Replay

MSc. Project Proposal at the Autonomous Multi-Robots Lab and the group of Dr. L. Ferranti, Cognitive Robotics, TU Delft

Brief description: Autonomous vehicles are moving closer to becoming part of our every-day lives, with the safety and trust in these vehicles being the biggest hurdle to overcome. To operate in urban environments, they need to understand of the motion of other road users (pedestrians, cylists, etc.). However, the intentions of other road users are not observable, which makes predicting their future motion difficult. A common approach is to estimate not only the expected future motion, but also the uncertainty associated with those predictions. Using this information we can in theory constrain the risk of our motion plan. Recent advances in `scenario optimization' [1], have shown that the risk can be assessed by first sampling uncertain constraints, then counting the relevant constraints. In light of this result, [2] developed a framework for probabilistic safe trajectory generation using a model of the uncertainty. The scenario optimization framework, however, offers a fully data-driven perspective where a model of the uncertainty is not required and the constraints may be obtained directly from previous observations. The goal of this project is to explore this direction by I) investigating how we can 'label' previous experiences such that we replay conditioned observations online and II) implementing the approach in an MPCC framework to safely navigate among pedestrians.

Main activities:

1. *Literature study on scenario optimization and MPCC (~3 months)*
   - *Nonconvex scenario optimization and the notion of risk*
   - *Stochastic MPC*
   - *Formulate the research question for the MSc project*
2. *Setup a simulation to collect data (e.g., using the Carla simulator)*
3. *Extend the framework of [2] for fully data-driven scenario optimization*
4. *Implement the approach in C++ on top of the existing motion planner*
5. *Validate the approach with a mobile robot (Jackal) at the CoR Lab and the Cyberzoo at TUD.*

Desired qualities:

- Motivated and independent
- Loving Math or Control Theory
- Experience/interest in optimization algorithms, stochastic control and/or autonomous navigation
- Strong programming skills and experience with C++/ROS

For further questions or to apply, please contact O. de Groot <o.m.degroot@tudelft.nl>. When applying, please provide a short motivation, up to date CV, a transcript of your current degree program and intended start date.

Group information: http://www.alonsomora.com/

References:

[1] Campi, M., Garatti, S., and Ramponi, F., "A General Scenario Theory for Nonconvex Optimization and Decision Making." IEEE Transactions on Automatic Control (2018).

[2] de Groot, O., Brito, B., Ferranti, L., Gavrila, D., and Alonso-Mora, J., "Scenario-Based Trajectory Optimization in Uncertain Dynamic Environments." Submitted to RA-L (2020).