Motion Planning for Automated Vehicles

Considering Motion Prediction and Run-Time Risk Assessment

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Description

The focus of my research will lie on investigating algorithms and architectural patterns that can close the gap between state of the art robotic vehicle motion planning and novel methods for predicting motions of adjacent traffic agents. The aim is to also include investigation of how motion planning algorithms can act upon uncertainties in the predictions, i.e performing and acting on run-time risk assessment. In the longer term, we aim to investigate architectural patterns for integrating such functionality in a larger scale ITS, where trajectory predictions may be complemented with the actual intended trajectory communicated between vehicles, when available.

Background & Motivation

Automated transportation systems is a promising development towards providing safe, sustainable and efficient mobility for people and goods in the not too distant future. Massive progress have been made in recent years, both in industry and in academia. The motion planning problem for autonomous vehicles is a central technical challenge. As pointed out by Broadhurst et al [2] already in 2005, it is not sufficient for safe and efficient operation to know only that there is an object at position x at time t. Similar to how experienced human drivers operate, the automated vehicle needs to predict trajectories of adjacent traffic agents in a probabilistic manner, to account for the non-deterministic behaviour of human drivers and pedestrians.

The field resides on the intersection between optimal control, machine learning and automotive safety and is very active. Results on isolated performance of novel combinations of algorithms are published continuously, a brief overview and categorization is provided by Lefevre et al in[4]. However, less attention is given to integration aspects and implications of the algorithms on system wide properties.

Methods & Preliminary Results

My research is done to a large extent in collaboration with the at the Integrated Transport Research Lab (ITRL) at KTH. I use their Research Concept Vehicles (RCV) as primary experiment platform.

Figure 1: *The KTH Research Concept Vehicle*

Preliminary Results
My time as a PhD student started by taking part in the KTH team participating in the Grand Cooperative Driving Challenge (GCDC) 2016 [3], which generated some implementation oriented results on collaborative automated driving, which were submitted to a special issue of IEEE Transactions on Intelligent Transportation Systems.

In parallel to the GCDC I took part in a project course, in which rudimentary autonomous functionality for the RCV was developed (using ROS) at the ITRL.

I took part in the control design and system integration work. The control design work generated some interesting results on the utilization of 4-wheel-steering for autonomous path tracking control, that we aim to submit to IEEE Intelligent Vehicles Symposium 2017.

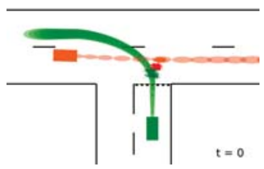

Figure 2: *Screenshot from the visulisiation of the simulation environment, illustrating the probaabilistic prediction of the adjecent (red) vehicle as well as the possible collision points*

Also, a preliminary framework for integration of a probabilistic collision estimation system was developed together with two Msc thesis students. They evaluated the framework using Monte Carlo simulations in a ROS environment, with results [1] published at ITSC 2016.

Going forward
In its present state, the RCV is capable of autonomous navigation and avoiding static objects. A planning framework inspired by Werling et. al. [6] is in place, but is not considering predictions of dynamic object trajectories at this point.
In the coming months I will be focusing on the the planning functionality of the RCV, with the aim to incorporate the concept of dynamic risk from [1] into the Werling style framework.
Also, we will collaborate with a visiting Phd student in a project where the aim is to extract requirements for a safety monitor, [5] applied to the RCV ROS system. Hopefully this will increase our understanding of what aspects of the motion planning framework are important for the safety monitoring concept to be effective.

Roadmap & Milestones

My research is partially funded by the Connected Mobility Arena (CMA) project at ITRL and as such I will contribute to the project by working with the demonstrative capability of the RCV.

MS1: Mar -17 Possible submission to ITSC 2017

MS2: Jun -17 Initial results on predictive planning with RCV (CMA demo)

MS3: Dec -17 Initial results on run-time risk assessment in planning

MS4: Jun -18 Functional risk aware planning framework (CMA demo)

Research Goals & Questions

Research Goals:

- ◊ Contribute to an open framework for safe motion planning in a human-robot mixed traffic environment

Research Questions:

- ◊ What challenges are associated with integrating trajectory prediction based motion planning in a larger scale ITS (where V2V is sometimes available)?
- ◊ How does state-of-the-art methods of predicting trajectories compare to V2V communicated intention?
- ◊ How does algorithm A compare to algorithm B in terms of performance measure X?
- ◊ (To what degree can 4-wheel steering improve performance in path tracking for autonomous vehicles?)

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