Model Predictive Control of Connected, Autonomous Cars in a Road Network using Optimal Control Methods

A. Britzelmeier[1] **and M. Gerdts**[1]

Abstract: In the aspiring field of autonomous driving the interaction of cars plays an important role. In particular finding optimal paths for each car whilst avoiding collision raises many problems whose resolutions are significant to ensure the safety of the passengers. This common problem can be couched as the collision free optimal driving of N autonomous cars through a known road network and can be tackled by the formulation of an optimal control problem which considers a collision criterion as a constraint. Such an optimal control problem is formulated with respect to minimize the time or fuel consumption of each car through the road network. To this end, we apply a nonlinear model predictive control (MPC) scheme in combination with a driving hierarchy. Herein, for every car an optimal control problem with state constraints, needs to be solved. During each MPC-step the hierarchy among the cars is redefined and adapted depending on the current state with respect to set rules which were derived from common traffic guidelines. To this end at each time and state the position of each car needs to be known.

The car with the highest priority can freely roam the road network without taking into account collisions with other participants, whilst every other car has to take into account the behaviour of every superordinate car. Thus, the computational cost increases with descending priority, which needs to be handled in view of real time applications. Furthermore, in order to keep the dimensions of the optimal control problem small, we prescribe the geometric path, which is given by a shortest path algorithm, and use the acceleration as a control. This leads to a comperatively small optimal control problem, but with complicated state constraints. These problems can be handled well by the dynamic programming approach even with respect to real time applications.

We present numerical studies for selected road networks and car pool constellations, specifically concering varying number of cars and the real time implementability.

[1] Department of Applied Mathematics and Computer Application
Institute of Aerospace Engineering, Munich University of the Federal Armed Forces
Werner-Heisenberg-Weg 39, Neubiberg, 85579 Munich, Germany
{*andreas.britzelmeier, matthias.gerdts*}*@unibw.de*