Optimal Energy Control of Hybrid Vehicles

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Abstract: This work is a part of the common project "RESY" (route based energy-efficient control of hybrid vehicles) supported by the Federal Ministry of Education and Research (BMBF). In recent years navigation systems in vehicles have become a major support for the challenging task to navigate around the road network. While initially the length of the track or the predicted travel time were the aim of optimization, the desire for resource-efficient traveling is significantly increased.

We consider a dynamic model system for a hybrid vehicle including the navigation system to determine the most economical route in terms of fuel consumption and driving time. Due to the consideration of both objective criteria (energy and time optimized control) the mathematical model provides different challenges in comparison to existing models. For example, with respect to the current state restrictions, we have to verify whether a direct method is more suitable than an indirect one.

In a first step the optimal control problem associated with the energy management in a parallel hybrid was solved numerically for a simplified motor model. Transcribing the control problem into a programming problem it was solved by an SQP method and first fundamental results with respect to optimal energy management strategies were achieved: It became clear that the mathematical model is actually realized the expected behavior of the motor control. While driving downhill the energy produced when braking is recuperated and is used for drive purposes again with the electric motor, for example as drive support when driving uphill. Horizontal rides usually accompanied by a slight charging of the battery. These information should be used in order to integrate them into a route planner.

The aim of this part of the project is the development of optimization algorithms with real-time capability for a practical implementation. To this end, appropriate approaches for a nonlinear model based predictive control (NMPC) should be developed. The sensitivity and stability analysis of NMPC leads to a class of infinite horizon optimal control problems.

We will present a first model system for a hybrid vehicle with its numerical results and point out the mathematical challenges and open problems with regard to the treatment of control problems with infinite horizon.

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