Numerical Methods for NMPC Based Operation of Hybrid Electric Vehicles

C. Kirches[1], **F. Ding**[2], **C. Xiang**[2], **and R. Longman**[3]

Abstract: Hybrid vehicles are considered as a viable development direction in the automotive industry to address environmental concerns and increasing energy cost. Optimal operation of hybrid vehicles however involves a number of degrees of freedom not present in conventional cars. This in particular includes discrete decisions on which subset of the available engines (combustion, electrical, generator) to run at what respective torque loads.

Contrary to implementations found in present-day cars on the open market, to harness the full potential for energy savings this decision must be taken repeatedly and in view of future changes of road and traffic conditions, operational loads, and environmental conditions such as ambient temperature. This decision space is generally accepted to be too large to be operable even by an experienced driver, mandating the adoption of automated control strategies.

Mixed-integer nonlinear model predictive control is a promising optimization based control strategy to this end. In this paper, a numerical methods for real-time hybrid vehicle control method is presented. The method is based on a direct method for mixed-integer optimal control and state-of-the-art NMPC techniques. It is used to realize a nonlinear model predictive controller (NMPC) for hybrid vehicles. Using the example of a simplified vehicle model, we conduct numerical studies of typical scenarios to investigate the method's behavior in various settings.

[1] Interdisciplinary Center for Scientific Computing (IWR), Heidelberg University
Im Neuenheimer Feld 368, 69120 Heidelberg, GERMANY
christian.kirches@iwr.uni-heidelberg.de

[2] School of Mechanical Engineering, Beijing Institute of Technology
5 Zhongguancun South Street, Haidian District, 100081 Beijing, CHINA
dingdfdfdf4@gmail.com, xiangcl@bit.edu.cn

[3] Department of Mechanical Engineering, Columbia University
116th Street and Broadway, New York, NY 10027, USA
rwl4@columbia.edu