

# Online Grey-Box Identification and Adaptive Nonlinear Model Predictive Control for Autonomous Vehicles

## Český název

## Online grey-box identifikace a adaptivní nelineární prediktivní řízení autonomních vozidel

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**Study program:** Automatic Control and Informatics

### Abstract:

Accurate vehicle models are essential for high-performance model-based control, but developing and maintaining such models is challenging due to the nonlinear nature of vehicle dynamics and their dependence on operating conditions. This dissertation topic aims to develop an online grey-box system identification method that combines physical knowledge of vehicle dynamics with real-time measurement data to continuously adapt and update the vehicle model.

The identified and continuously updated model will be integrated into a Nonlinear Model Predictive Control (NMPC) framework, enabling the controller to adapt its predictions and control actions to changing vehicle dynamics and operating conditions. The research will investigate the potential of this adaptive approach to improve trajectory tracking, vehicle stability, robustness, and overall control performance.

The proposed methodology will be evaluated using simulation-based studies. Particular attention will be given to the accuracy and computational efficiency of the online identification method and to the resulting impact on NMPC performance.

The research will build on established methods of system identification and predictive control while addressing their integration in an adaptive control framework for autonomous vehicles.

The main research objectives of the dissertation are therefore to:

1. develop an online grey-box system identification methodology for vehicle dynamics that combines physical knowledge of the vehicle with real-time measurement data;
2. develop methods for online adaptation and parameter estimation of the vehicle model under changing operating conditions, including variations in vehicle speed, road conditions, tire characteristics, and loading conditions;
3. investigate the integration of the online identified model into a Nonlinear Model Predictive Control (NMPC) framework, with particular emphasis on prediction accuracy and computational tractability;
4. investigate the influence of online model adaptation on NMPC performance, particularly in terms of trajectory tracking accuracy, vehicle stability, robustness, and constraint handling under changing and uncertain conditions;

5. develop and evaluate methods for ensuring the computational efficiency and numerical robustness of the combined online identification and NMPC framework with respect to real-time implementation; and
6. validate the proposed methodology through simulation studies and compare its performance with conventional fixed-model and/or non-adaptive NMPC approaches.

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