Master thesis
for
Mr. Shengya Guo

TECHNISCHE UNIVERSITÄT DARMSTADT

Optimal Input Excitation for Parameter Estimation in Electromechanical Brake Actuators

Optimale Eingangsanregung zur Parameterschätzung bei elektromechanischen Bremsen

With the ongoing electrification of passenger vehicles, the transition from hydraulic to electromechanical brake (EMB) systems becomes attractive. This new kind of braking system promises advantages, as it removes bulky hydraulic components, enables fast wheel individual brake actions, and integrates seamlessly with the X-by-wire paradigm, but it also poses new challenges which need to be overcome. To enable the reliable operation of EMB systems, exact knowledge about system parameters e.g., actuator motor torque constant, friction coefficients or the brake pad stiffness, is essential [1]. Due to aging and wear or manufacturing imperfections these quantities are uncertain and may vary over the component‘s lifetime. Therefore, a method which reliably estimates system parameters is of great importance. An example of such a method in the context of EMB is presented in [2], where a genetic algorithm is used to obtain a control input which maximizes an information gain criterion (D-Optimality). In other engineering domains, the optimal excitation problem is tackled with Reinforcement Learning (RL) [3] and Chance Constraints [4]. The aim of the offered master's thesis is to investigate how optimal excitation strategies can be realized (open- or closed-loop, with RL or other optimization techniques, etc.) for a mechatronic system such as the electromechanical brake.

Tasks:

- Literature research on parameter estimation for mechatronic systems
- Formulation of a simplified system model for analysis of excitation strategies
- Implementation of a suitable excitation strategy
- Evaluation based on simulation results and optionally also on prototype hardware

This thesis is offered in cooperation with Robert Bosch GmbH (Corporate Research).

[1] C. Line. Modelling and control of an automotive electromechanical brake. PhD thesis, The University of Melbourne, Melbourne, 2007.
[2] C. F. Lee and C. Manzie. Rapid parameter identification for an electromechanical brake. In 2013 Australian Control Conference, pages 391–396, 2013.
[3] R. Huang, J. Fogelquist and X. Lin. Reinforcement Learning of Optimal Input Excitation for Parameter Estimation With Application to Li-Ion Battery. In IEEE Transactions on Industrial Informatics, vol. 19, no. 11, pp. 11160-11170, Nov. 2023.
[4] A. Mesbah and S. Streif. A Probabilistic Approach to Robust Optimal Experiment Design with Chance Constraints. In IFAC-PapersOnLine, vol. 48, no. 8, pp. 100-105, Nov. 2015

Institut für
Automatisierungstechnik
und Mechatronik

CCPS Control and Cyber-Physical Systems

Prof. Dr. Ing. Rolf Findeisen

Landgraf-Georg-Str. 4
64283 Darmstadt

Tel. +49 6151 16 25201
Fax +49 6151 16 25172
rolf.findeisen@iat.tu-darmstadt.de
www.ccps.tu-darmstadt.de

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