Supplementary Course (EVA) in the MSE programme

Title: Applied optimisation and control for automotive systems

Short Code: rEVA_AOCAS

Credits	3
Profile	Mechatronics & Automation (MA)
Responsible Institute /Centre	Institute of Energy Systems and Fluid Engineering (IEFE)
Responsible lecturer and contact informtion	**Giovanni Beccuti, becc@zhaw.ch**
Type and duration of examinations	Oral examination, 30 minutes
Start date and duration	Semester: Spring 2027 Detail: Course to take place over 14 semester weeks
Location	Zürich
Course type	rEVA
Language of instruction	English
Short description (max. 300 characters)	The course addresses applied optimisation techniques for the advanced control and operation of modern automotive systems. The focus will be on electric, hybrid electric, and plug-in hybrid electric vehicles, but combustion-based technologies will also be considered, as they will foreseeably still be employed in the future, e.g. for long distance freight applications. Accordingly, a broad overview of different vehicle architectures, powertrains, engine types, batteries, and associated features, specifically accounting for energy flow and conversion efficiency, will be presented in the first part of the lectures. An overview of optimisation algorithms and modelling techniques will also be included, so that students can at least gain an intuitive feeling for the underlying approach, without delving into mathematical intricacies. To achieve the full potential of modern vehicles, energy optimisation strategies are necessary, which can reduce fuel consumption and emissions in comparison to traditional control approaches by explicitly accounting for motor modelling and limitations in a systematic manner, including the presence of a reversible energy storage device and one or more electric machines. This can be formulated as a multi-objective, multi-variable optimisation problem, which in turn translates into the

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	need of finding the most efficient way of exploiting the associated dynamics and degrees of freedom to satisfy the final demand. Additionally, the anticipated widespread deployment of these vehicles represents both a problem as well as an opportunity for the secure operation of the electric grid, as electric cars act as mobile batteries that can be used for a variety of purposes, such as peak-shaving, frequency regulation, renewable absorption, price-based charging, and congestion management. Accordingly, vehicle-to-grid (V2G) approaches will also be investigated. The overarching focus consists in presenting a systematic model-based approach and proposing an operational framework to cast the energy control problem using optimisation-based methods and tools.
Contents and Learning Objectives	The objective is to give an overview of applied optimisation methods for the specific case of automotive systems. Emphasis is placed on the underlying physical problem, the real-world operational setting, and an overall understanding of the applied method and the end-application. Students should be able to formulate, implement and solve optimisation problems of this kind with the knowledge acquired throughout the module.
Prerequisites	Students are expected to have fundamental knowledge of physical systems, specifically with regard to energy conversion and conservation, as can be acquired with the completion of a bachelor degree course on basic engineering thermodynamics. Previous experience with modelling and programming languages such as Matlab or Python is an advantage. Specific previous knowledge of optimisation algorithms or applied optimisation is not required, but fundamental knowledge of linear algebra (vector and matrix algebra, linear spaces) and calculus (with functions of single and multiple variables) is necessary.
Literature	Model Building in Mathematical Programming. H.P. Williams, Wiley 2013. Electric and Hybrid Vehicles - Design Fundamentals I. Husain, CRC Press 2021. Nonlinear Model Predictive Control of Combustion Engines. T. A. Rajasingham, Springer 2021 Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives. C. Mi, M. A. Masrur, Wiley 2025 Electric and Plug-in Hybrid Vehicle Networks: Optimization and Control. E. Crisostomi, R. Shorten, S. Stüdli, F. Wirth, CRC Press, 2018.

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Special requirements	None			
Offer for profiles	Aviation (Avi)	☐	Business Engineering (BE)	☐
	Computer Science (CS)	☐	Data Science (DS)	☐
	Electrical Engineering (EIE)	☒	Energy & Environment (EnEn)	☒
	Mechanical Engineering (ME)	☒	Mechatronics & Automation (MA	☒
	Medical Engineering (Med)	☐	Photonics (Pho)	☐
	Information and Cyber Security (ICS)	☐	Civil Engineering (CE)	☐