MECHANICAL ENGINEERING SEMINAR

Hierarchical Model Predictive Control for Energy Management

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Abstract

Electrification of power systems is a societal megatrend, especially for vehicle systems such as aircraft, on- and off-road vehicles, and ships. This talk explores the exciting opportunities for achieving higher performance and efficiency of electro-thermal systems through modeling and advanced control. Managing the heat generated by electric power systems is currently a major limiting factor in the design and operation of these systems, and power requirements are only expected to increase over the next several decades. In the absence of costly system redesign, cooperative control of electrical and thermal systems is the key to overcoming these barriers and maximizing the capability of these systems.

In particular, this talk discusses the development of hierarchical Model Predictive Control (MPC) formulations for aircraft energy management. The first half of this talk focuses on the coordination of electrical and thermal management systems, where a hierarchical control approach decomposes the multi-energy domain, constrained optimization problem into smaller, more computationally efficient problems that can be solved in real-time. A Hardware-In-the-Loop (HIL) experimental testbed is used to evaluate the proposed hierarchical MPC for a scaled, laboratory representation of an aircraft electro-thermal system. The second half of this talk presents the recent development of a novel set-based hierarchical MPC approach that aims to maximize the performance of the system while guaranteeing the ability to satisfy state and input constraints throughout operation. With guaranteed satisfaction of constraints, such as the upper temperature limits of critical electronic devices, the controller can safely utilize the full capabilities and performance of a system while maintaining the reliability and integrity of the system.

Biography

Justin Koeln is an Assistant Professor in the Department of Mechanical Engineering at UT Dallas, where he directs the Energy Systems Control Laboratory. Prior to joining UT Dallas in January 2018, he was a postdoctoral research associate at the University of Illinois at Urbana-Champaign (UIUC) where he was a member of the NSF Engineering Research Center for Power Optimization of Electro-Thermal Systems (POETS) with the long term goal of increasing power density of mobile electrified systems by 10–100 times greater than the current state-of-the-art. Dr. Koeln received his B.S. degree in 2011 from Utah State University in Mechanical and Aerospace Engineering. He received M.S. and Ph.D. degrees in 2013 and 2016, respectively, from UIUC in Mechanical Science and Engineering. He was a Summer Faculty Fellow at the Air Force Research Laboratory (AFRL) in 2018 working on hierarchical mission-based model predictive control strategies for aircraft energy management. His research interests include dynamic modeling and control of thermal management systems, model predictive control, and hierarchical and distributed control for electro-thermal systems.