**Learning and Control using Gaussian Processes**

This talk is about bridging Machine Learning and Control for physical systems. Building physics-based models of complex physical systems like buildings and chemical plants is extremely cost and time prohibitive for applications such as real-time optimal control, production planning and supply chain logistics. Machine learning algorithms can reduce this cost and time complexity, and are, consequently, more scalable for large-scale physical systems. However, there are many practical challenges that must be addressed before employing machine learning for closed-loop control. In this talk, I describe the use of Gaussian Processes (GP) for learning control-oriented models: (1) We develop methods for the optimal experiment design (OED) of functional tests to learn models of a physical system, subject to stringent operational constraints and limited availability of the system. Using a Bayesian approach with GP, our methods seek to select the most informative data for optimally updating an existing model. (2) We also show that black-box GP models can be used for receding horizon optimal control with probabilistic guarantees on constraint satisfaction through chance constraints. (3) We further propose an online method for continuously improving the GP model in closed-loop with a real-time controller. Our methods are demonstrated and validated in a case study of building energy control and demand response.

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Rahul is an Associate Professor in the Dept. of Electrical & Systems Engineering and Dept. of Computer & Information Science at the University of Pennsylvania. His interests are in cyber-physical systems at the intersection of formal methods, machine learning and controls. He is the Penn Director for the Department of Transportation's $14MM Mobility21 National University Transportation Center [2017-2022] which focuses on technologies for safe and efficient movement of people and goods. Rahul received the 2016 US Presidential Early Career Award (PECASE) from President Obama for his work on Life-Critical Systems. He also received the 2016 Department of Energy’s CleanTech Prize (Regional), the 2014 IEEE Benjamin Franklin Key Award, 2013 NSF CAREER Award, 2012 Intel Early Faculty Career Award and was selected by the National Academy of Engineering for the 2012 and 2017 US Frontiers of Engineering. He has won several ACM and IEEE best paper awards.

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