Data-Enabled Predictive Control

Prof. Florian Dofler (ETH Zurich, Automatic Control Lab IfA)

چکیده

We consider the problem of optimal and constrained data-driven control for unknown systems. A novel data-enabled predictive control (DeePC) algorithm is presented that computes optimal and safe control policies driving the unknown system along a desired trajectory while satisfying system constraints. Using a finite number of data samples from the unknown system, our algorithm is grounded on insights from subspace identification and behavioral systems theory. In particular, we use raw unprocessed data assembled in a matrix time series for data-driven estimation and prediction. In case of deterministic linear time-invariant (LTI) systems, the DeePC algorithm is equivalent to standard Model Predictive Control (MPC). To cope with stochasticity and nonlinearity, we robustify the objective and constraints of DeePC by means of distributionally robust stochastic optimization resulting in regularized problem formulations. Finally, we relate our direct data-driven control approach to the indirect approach consisting of sequential system identification and certainty-equivalence control. We conclude that the direct approach can be derived as convex relaxation of the indirect approach, where the regularizations account for an implicit identification step. Our comparisons suggest that the direct approach is superior for control of nonlinear systems, whereas the indirect approach excels for stochastic LTI systems. Our results are illustrated with experiments and simulations from aerial robotics, power electronics, and power systems.

Bio: Florian Dörfler is an Associate Professor at the Automatic Control Laboratory at ETH Zürich and the Associate Head of the Department of Information Technology and Electrical Engineering. He received his Ph.D. degree in Mechanical Engineering from the University of California at Santa Barbara in 2013, and a Diplom degree in Engineering Cybernetics from the University of Stuttgart in 2008. From 2013 to 2014 he was an Assistant Professor at the University of California Los Angeles. His primary research interests are centered around control, optimization, and system theory with applications in network systems, especially electric power grids. He is a recipient of the distinguished young research awards by IFAC (Manfred Thoma Medal 2020) and EUCA (European Control Award 2020). His students were winners or finalists for Best Student Paper awards at the European Control Conference (2013, 2019), the American Control Conference (2016), the Conference on Decision and Control (2020), the PES General Meeting (2020), the PES PowerTech Conference (2017), and the International Conference on Intelligent Transportation Systems (2021). He is furthermore a recipient of the 2010 ACC Student Best Paper Award, the 2011 O. Hugo Schuck Best Paper Award, the 2012-2014 Automatica Best Paper Award, the 2016 IEEE Circuits and Systems Guillemin-Cauer Best Paper Award, and the 2015 UCSB ME Best PhD award.