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Title of the course: Model Predictive Control

Summary: Model Predictive Control (MPC) is a well-established technique for controlling multivariable systems subject to constraints on manipulated variables and outputs in an optimized way. Following a long history of success in the process industries, in recent years MPC is rapidly expanding in several other domains, such as in the automotive and aerospace industries, smart energy grids, and financial engineering. The course is intended for students and engineers who want to learn the theory and practice of Model Predictive Control (MPC) of constrained linear, linear time-varying, nonlinear, stochastic, and hybrid dynamical systems, and numerical optimization methods for the implementation of MPC. The course will make use of the MPC Toolbox for MATLAB developed by the teacher and co-workers (distributed by The MathWorks, Inc.) for basic linear MPC, and of the Hybrid Toolbox for explicit and hybrid MPC.

Syllabus: General concepts of Model Predictive Control (MPC). MPC based on quadratic programming. General stability properties. MPC based on linear programming. Models of hybrid systems: discrete hybrid automata, mixed logical dynamical systems, piecewise affine systems. MPC for hybrid systems based on on-line mixed-integer optimization. Multiparametric programming and explicit linear MPC, explicit solutions of hybrid MPC. Stochastic MPC: basic concepts, approaches based on scenario enumeration. Linear parameter- and time-varying MPC and applications to nonlinear dynamical systems. Selected applications of MPC in various domains, with practical demonstration of the MATLAB toolboxes.

References:

- A. Bemporad, M. Morari, V. Dua, and E.N. Pistikopoulos, "The explicit linear quadratic regulator for constrained systems", *Automatica*, vol. 38, no. 1, pp. 3–20, 2002
- A. Bemporad, "A multiparametric quadratic programming algorithm with polyhedral computations based on nonnegative least squares", *IEEE Trans. Automatic Control*, vol. 60, no. 11, pp. 2892–2903, 2015.
- A. Bemporad and M. Morari, "Control of systems integrating logic, dynamics, and constraints", *Automatica*, vol. 35, no. 3, pp. 407–427, 1999
- F.D. Torrisi and A. Bemporad, "HYSDEL - A tool for generating computational hybrid models", *IEEE Trans. Contr. Systems Technology*, vol. 12, no. 2, pp. 235–249, Mar. 2004
- D. Bernardini and A. Bemporad, "Stabilizing model predictive control of stochastic constrained linear systems", *IEEE Trans. Automatic Control*, vol. 57, no. 6, pp. 1468–1480, 2012