


TEMPO Spring School (3 ECTS) on

# Theory and Numerics for Nonlinear Model Predictive Control

March 26-April 2, 2015

University of Freiburg

For industrial and academic researchers, in particular PhD and master students in engineering, mathematics, physics, and computer science.

Teachers: **James B. Rawlings** (U Wisconsin, Madison), Joel Andersson, Mario Zanon and Moritz Diehl (U Freiburg & KU Leuven)

The aim of this intensive 6-day course is to give a complete overview on Nonlinear Model Predictive Control (NMPC). On the one hand, the theoretical foundations for this control technique will be treated from the point of view of systems theory. On the other hand, participants will be taught how to efficiently and reliably formulate and solve numerically NMPC problems for practical applications.

**Content:** The course covers all topics relevant for the theory and numerical solution of nonlinear model predictive control (NMPC) problems. It starts by recalling concepts from systems theory in continuous and discrete time as well as concepts from nonlinear optimization with equalities and inequalities, and the computation of derivatives. The major focus of the course is on the stability theory of NMPC and what impact it can have in control engineering practice. Topics treated are Lyapunov stability theory, robustness and economic MPC. A second focus is on the numerical solution of nonlinear model predictive control and moving horizon estimation problems. All lecture topics are accompanied by intensive computer exercises, for which we use the computational optimization environments Python and CasADi (both open-source), and participants are recommended to bring a laptop. Towards the end of the course, each participant will also start to work on a self-chosen application problem and the results will be presented in a short report and presentation, after the written exam.






**Prerequisites, Workload and Evaluation:** The course is self-contained and can be followed by all quantitative scientists with basic mathematical background (calculus and linear algebra). It is recommended for both industrial and academic practitioners of control and optimization as well as for master and PhD students of engineering, computer science, mathematics, and physics.

The theory part of the course is based on the recent graduate text by Rawlings and Mayne (2009), which is available on the web for free download:
http://jbrwww.che.wisc.edu/home/jbraw/mpc/electronic-book.pdf
Familiarity with this material is not a prerequisite for the course, but would aid in learning the course material. A basic knowledge of Python is required for the exercises. A one-day Python course will be organized on March 25, 2015 by Joris Gillis.

The total workload is 90 hours including lectures, project work and self-study, and the course gives 3 ECTS credits. The final course evaluation is based 50% on the written exam and 50% on the projects. A certificate of attendance can be given to participants not wishing to participate in the exam and/or project.

**Location and Schedule:** The course takes place from Thursday, March 26, to Thursday April 2, 2015, from 9:00-18:00, in the main historical university building in the city center of Freiburg (Kollegiengebäude I, HS 1015, Platz der Universität 3 , D-79098 Freiburg).

**Registration:** Participation in the course is free of charge, while food and coffee and the optional excursion will require minor cost contributions. To apply for a place in the course, or obtain additional information, please write an email to Christine.Paasch@imtek.uni-freiburg.de with subject "TEMPO NMPC School Registration" before February 15, 2015.

**Organizers and Sponsors:** Prof. Dr. Moritz Diehl, Mario Zanon, Robin Verscheuren, Christine Paasch, University of Freiburg and University of Leuven. Support by the EU via the ITNs TEMPO (607957) and SADCO (264735), and the ERC Project HIGHWIND (259166) is gratefully acknowledged.

http://www.imtek.de/laboratories/systemtheorie

***NEWS: Two open PhD positions in Computational Control and Optimization in Freiburg*,** submission deadline February 28, 2015: https://www.imtek.de/professuren/systemtheorie/stellenangebote/awesco/openposition