Control Part of Power Electronic Devices and Circuits

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Systems Control and Optimization Laboratory
Department of Microsystems Engineering (IMTEK) and
Department of Mathematics
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some videos are from 2006-2013
when MD was the PI of the
Optimization in Engineering Center (OPTEC) at
KU Leuven University

Freiburg, June 1, 2017

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Aims and Topics of Control Part

Aims:

- know about control concepts in state space
- be able to design state space controllers on a computer

Topics:

- State Space Control for Linear Time Invariant (LTI) Systems
- Linear Quadratic Regulator (LQR)
- State Estimation and Kalman Filter (KF)
- Model Predictive Control (MPC)
- Exercises in MATLAB (incl. homework)

Introduction of Teachers

Lecturers:

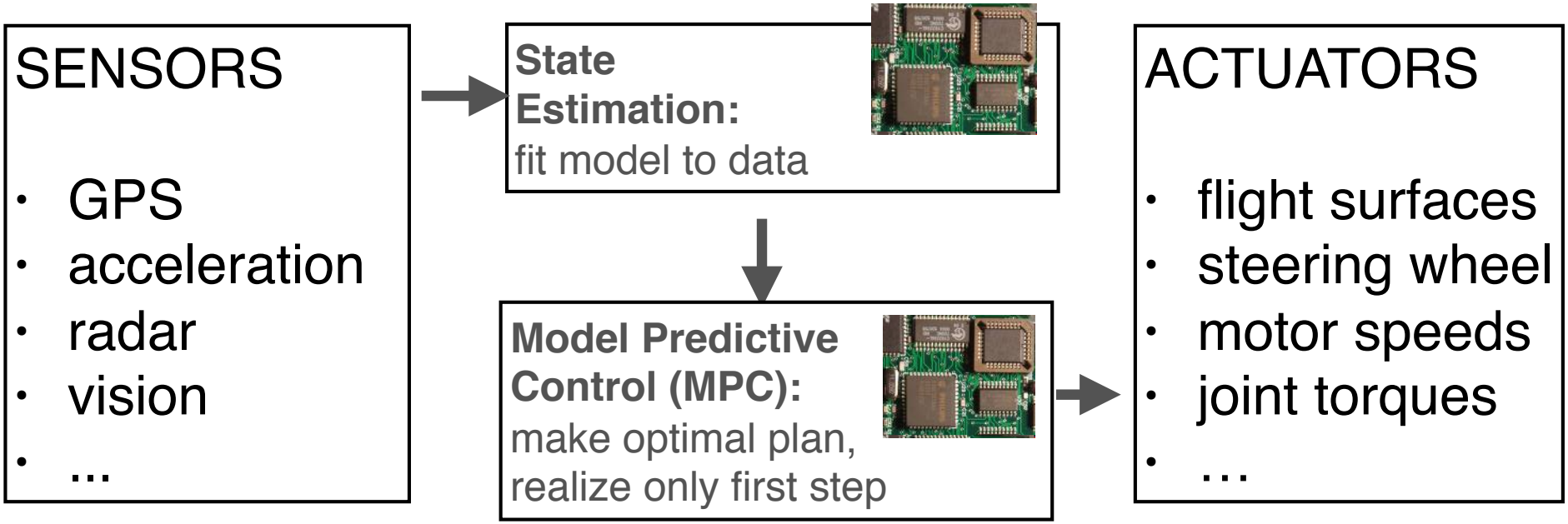
- Moritz Diehl (Professor for Systems, Control and Optimisation at IMTEK)
- Gianluca Frison (Postdoc, expert on embedded model predictive control)

Tutor:

- Benjamin Stickan (PhD student at ISE Fraunhofer and IMTEK)

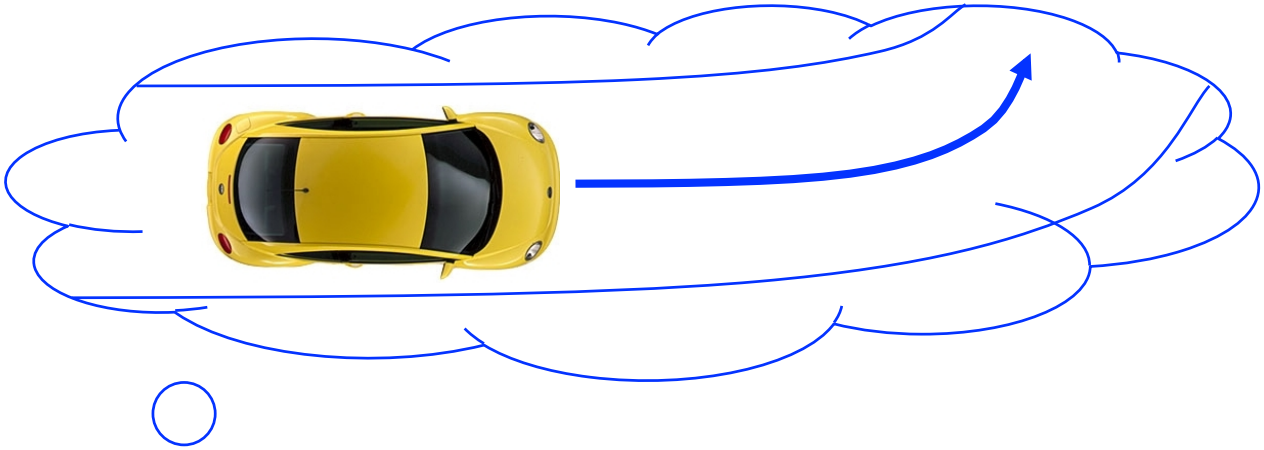
Team Specialty: Embedded Optimization

(optimization algorithm acting on a stream of incoming data)



Model Predictive Control (MPC)

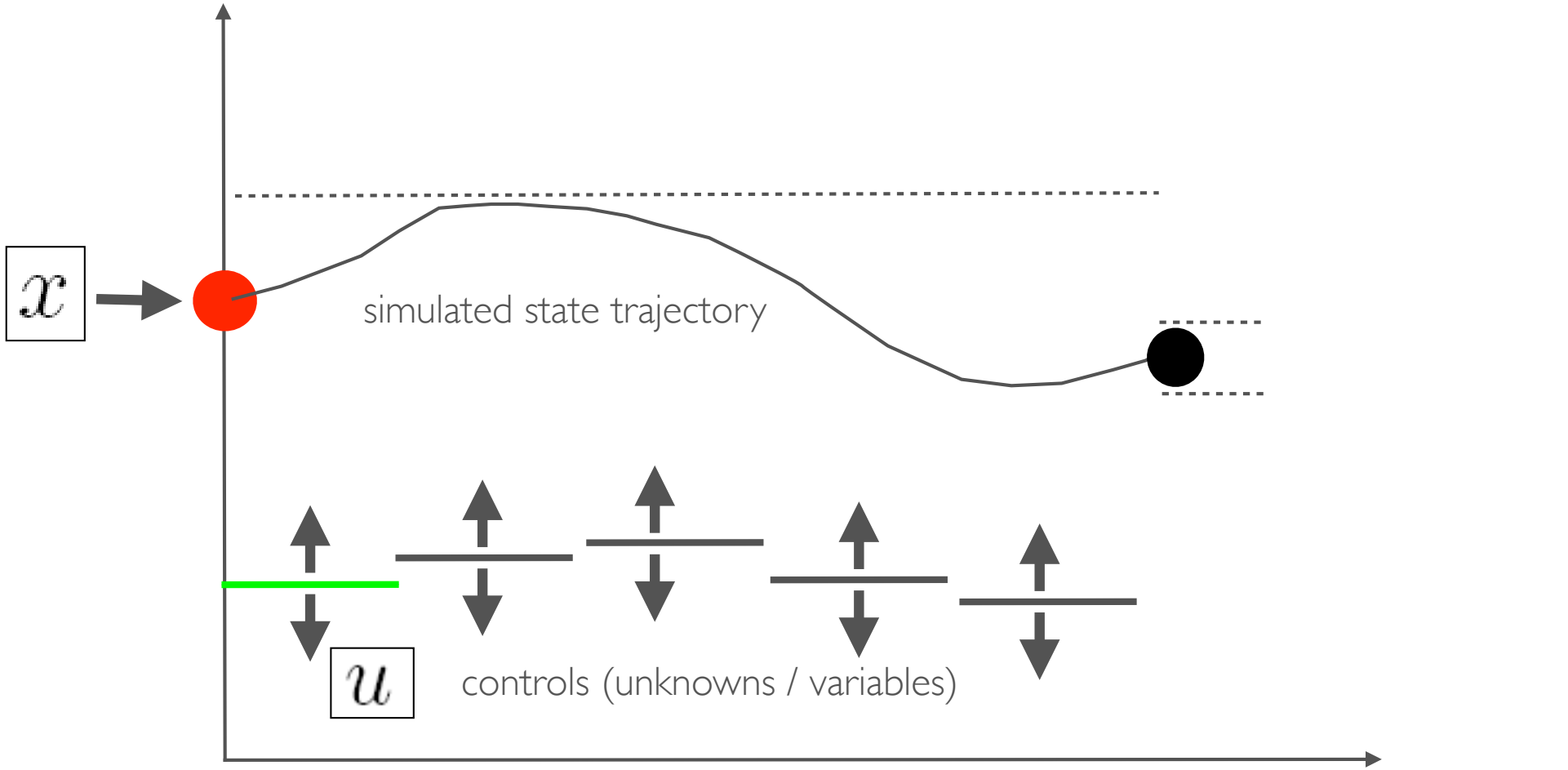
Always look a bit into the future



Example: driver predicts and optimizes, and therefore slows down before a curve

Optimal Control Problem in MPC

For given system state $\boldsymbol{x}$, which controls $\boldsymbol{u}$ lead to the best objective value without violation of constraints ?



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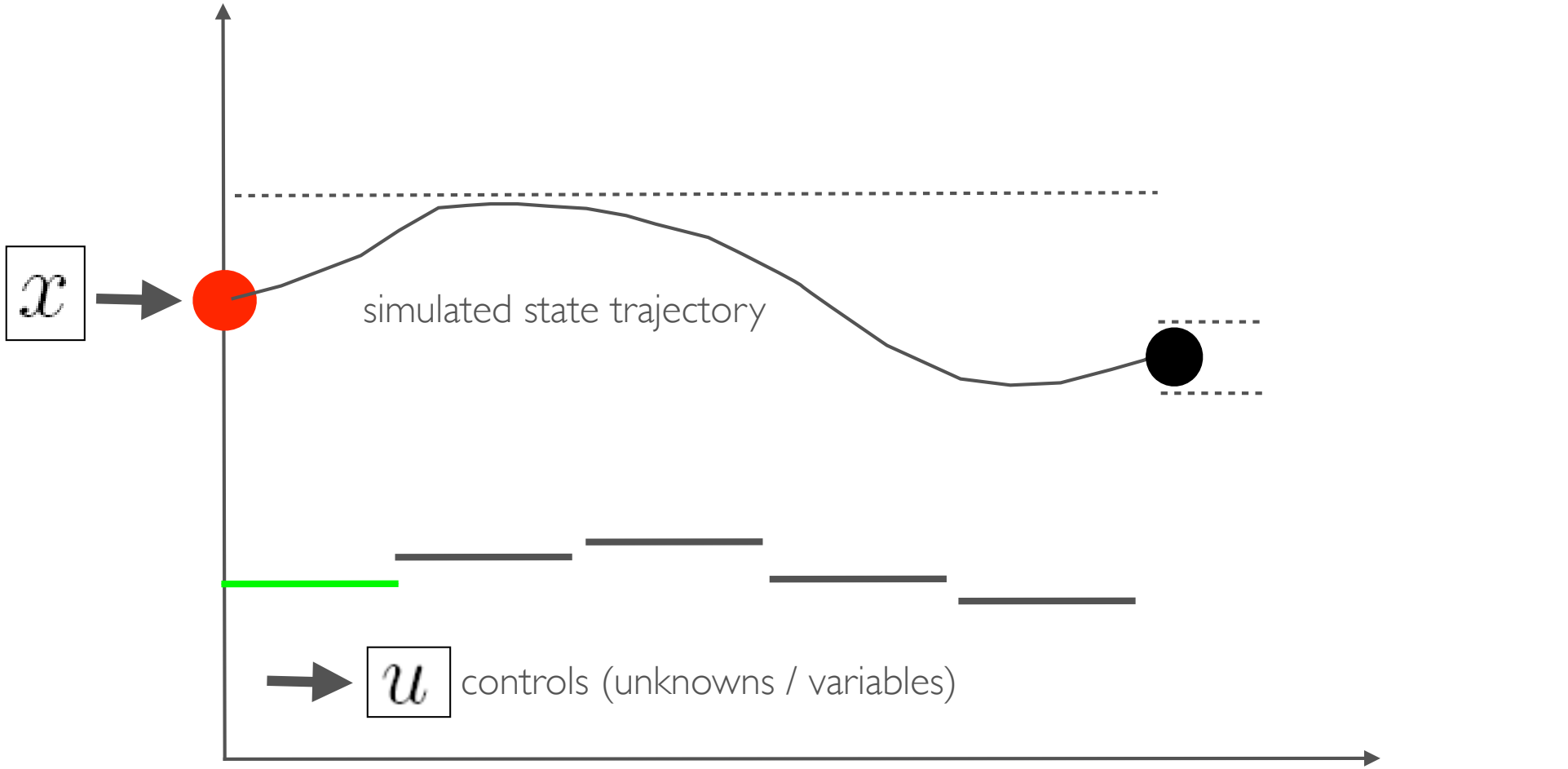

Time Optimal Motion of a Crane

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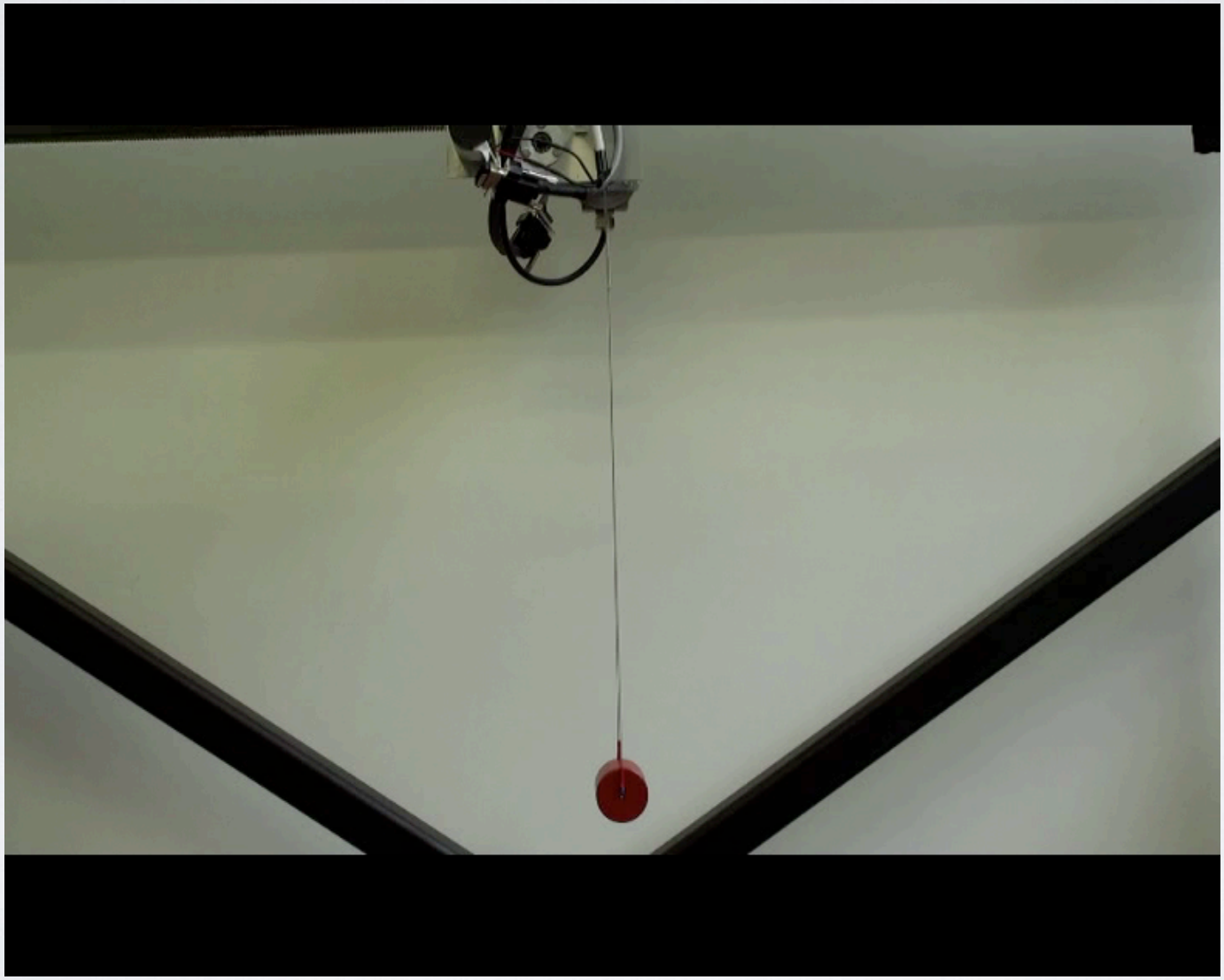
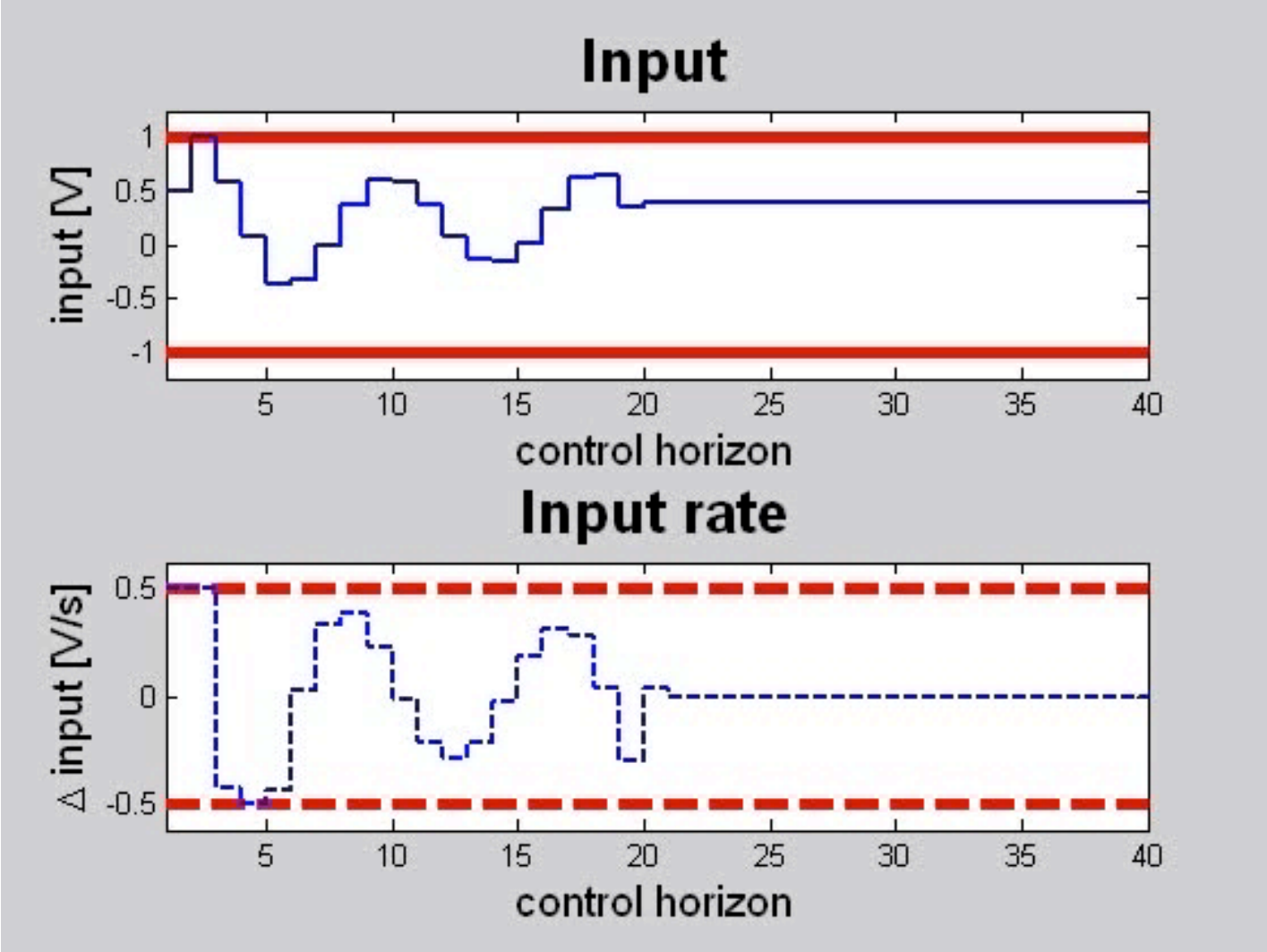


Optimal solutions varying in time (inequalities matter)



Solver qpOASES [PhD H.J. Ferreau, 2011], [Ferreau, Kirches, Potschka, Bock, D. , A parametric active-set algorithm for quadratic programming, Mathematical Programming Computation, 2014]

Crane Writing Time Optimally

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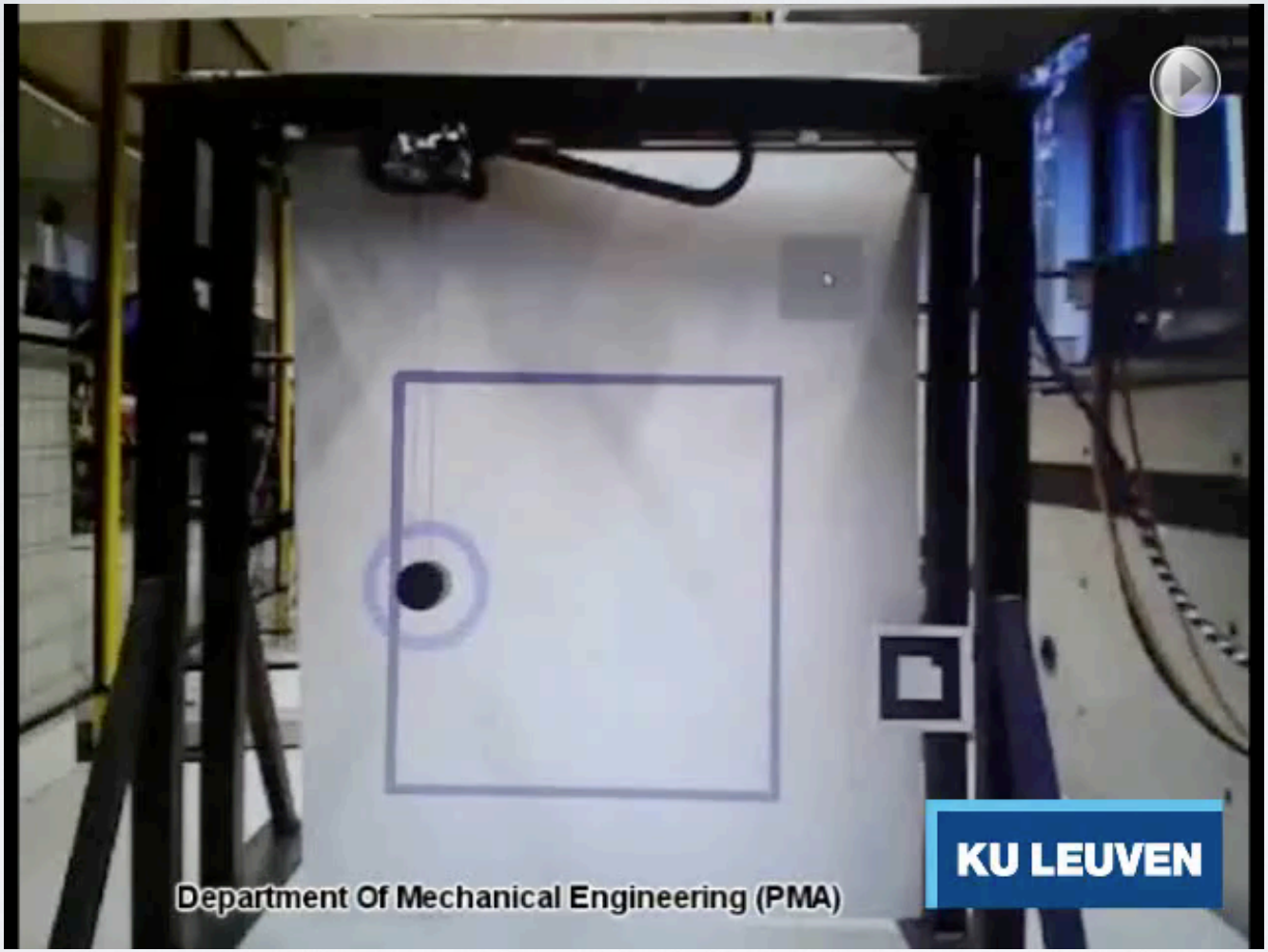
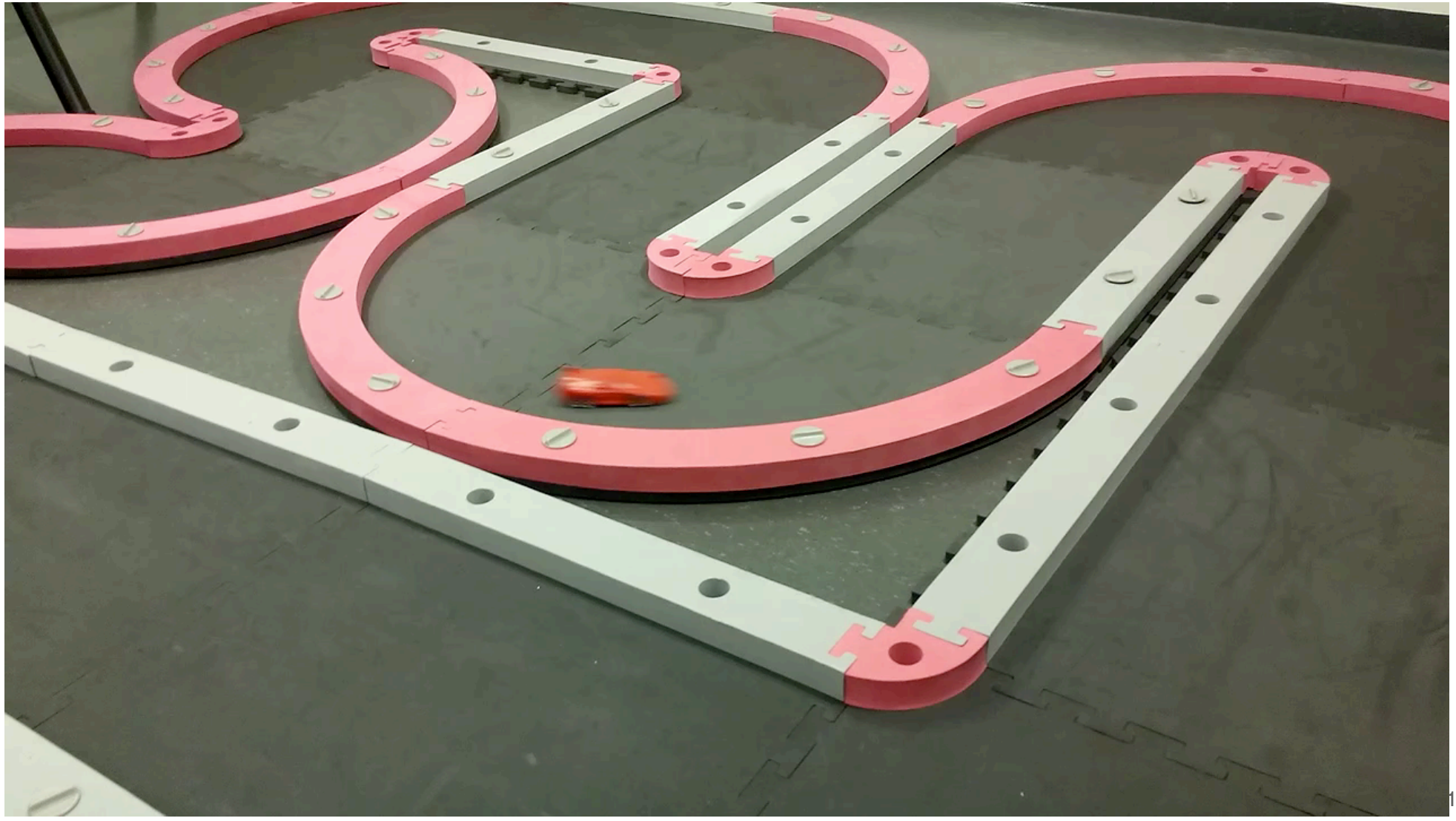


Predictive control example: time-optimal “racing” of model cars

Robin Verschueren

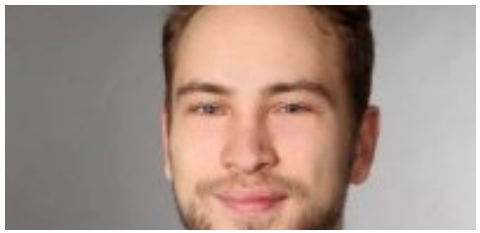
Freiburg/Leuven/ETH/Siemens-PLM. 100 Hz sampling time using MPC [Verschueren, De Bruyne, Zanon, Frasch, D. CDC 2014]

(Nonlinear MPC video from 22.6.2016 in Freiburg)



Metamorphosis of a wind turbine

Predictive Control of Kite Carousel in Freiburg



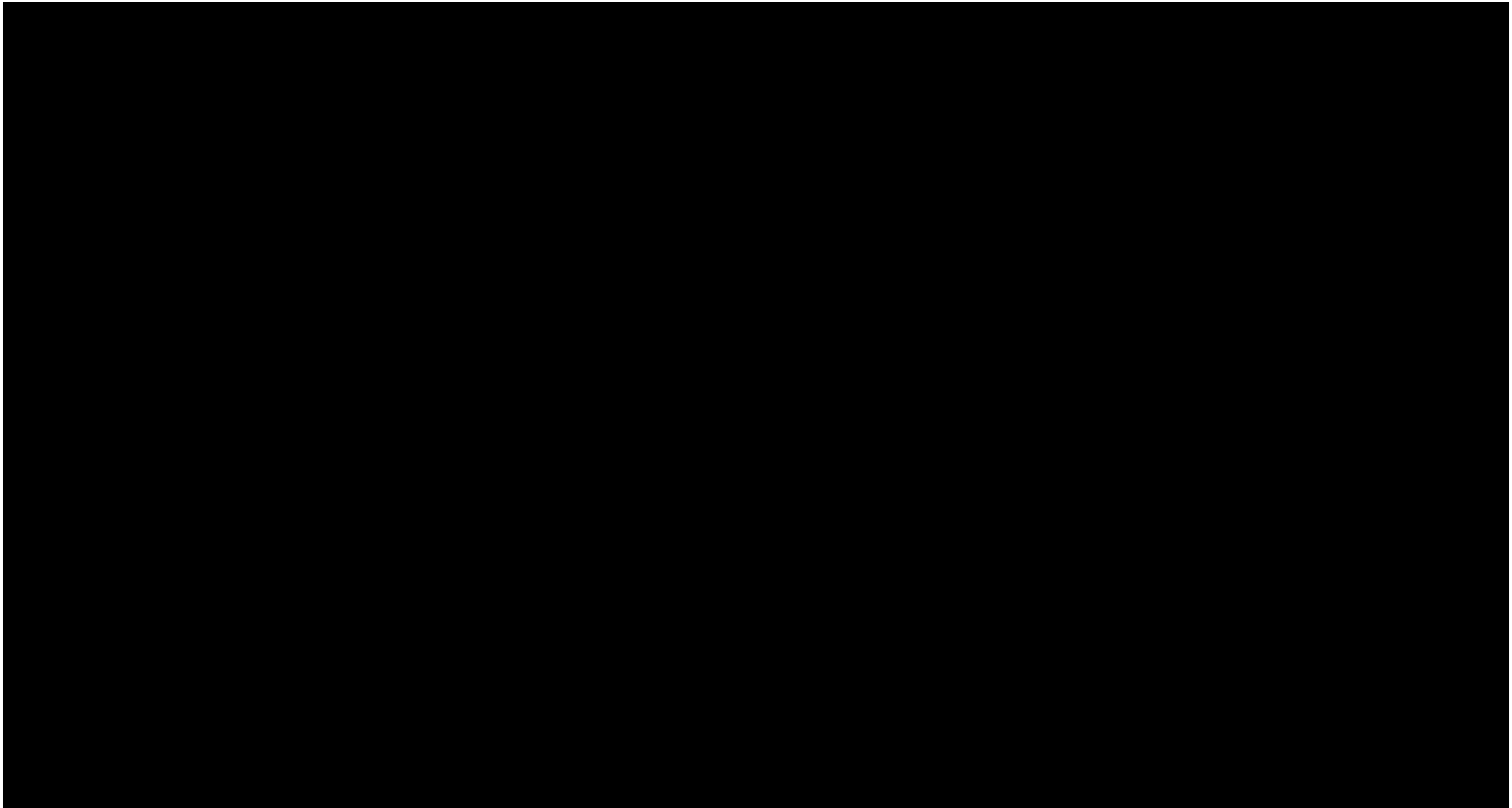
Jonas Schlangenhauf

Thorbjörn Jörger

20Hz/50ms sampling time using ACADO

(Nonlinear MPC video from 13.12.2016 in Freiburg)

(video by Ben Schleusener)



Schedule (this week)

Thu, June 1, 2017, Lecture Slot 1

- Introduction
- Linear time invariant (LTI) systems in state space
- Controllability

Fri, June 2, 2017, Lecture Slot 2

- Linear Quadratic Regulator (LQR)
- Explanation of Exercise 1 (homework)

Seven weeks to rehearse background material and to work on Exercise 1

Schedule (cont.)

Thu, July 20, 2017, Lecture Slot 3
- o Discussion and Solution of Exercise 1
- o Observers, Kalman Filter and Output Feedback

Fri, July 21, 2017, Lecture Slot 4
- o Discrete Time Systems
- o Explanation of Exercise 2 (homework)

Thu, July 27, 2017, Lecture Slot 5
- o Model Predictive Control (MPC)

Fri, July 28, 2017, Lecture Slot 6
- o Discussion and Solution of Exercise 2
- o Lecture Summary

Course Webpage

All info can be found on

https://www.syscop.de/ —>

Teaching —>

Power Electronics Devices and Circuits - Control Part

In particular, download and read the PDF of the Course Manuscript