Nonlinear Model Predictive Control – Theory and Applications					AR-318
Rota annually WS	**Duration** 1 Semester	**Semester** 3rd (Semester)	**SWS** 5 SWS	**Credit Points** 10	**Workload** 300 h

1 Modul Structure

Course (Abbreviation)	Type/ SWS	Presence	Self Study	Credit Points
c) Nonlinear Model Predictive Control – Theory and Applications	Lecture/ 3 SWS	35 h	40 h	
d) Nonlinear Model Predictive Control – Theory and Applications	Tutorial/ 1 SWS	15 h	40 h	
e) Nonlinear Model Predictive Control – Theory and Applications	Practical training / 1 SWS			

2 Language

English

3 Content

Elemente1

1. Basics of optimal control theory and numerical optimal control
   a. Optimality condtions for static problems
   b. Formulation of optimal control problems
   c. Gateaux derivative
   d. Pontryagin Maximum Principle
   e. Indirect and direct solution methodsffiiziente derivative computation
2. Advanced aspects of optimal control
   a. Existence of optimal solutions
   b. Dual variables
   c. Singular problems
   d. Dissipativity and turnpike properties
3. Modell predictive control of sampled-data systems
   a. Basics of MPC
   b. Sufficient stability conditions with and without terminal constraints
   c. Economic cost functions
   d. Differences of continuous time and discrete time formulations
   e. Design and implementation aspects
4. Outlook
   a. Stochastic and robust MPC
   b. Limits of MPC
5. Case studies
   a. Energy efficiency in technical systems, multi-energy systems, and others
6. Elemente 2 und 3
7. Black board and programming sessions (ca 20h at home and ca 10h in course)

Literature:

- Chachuat, Benoit. Nonlinear and dynamic optimization: From theory to practice. Lecture Notes EPFL

4 Competencies

The students are able to formulate and to solve problems of operation and control of technical systems on their own. The students are able to understand and to analyze the interplay of problem formulation and efficiency aspects of numerical solutions and to deduce problem-specific formulations. They know how to apply and to implement optimization methods to practical problems. Furthermore, the students

	can tackle complex problems of predictive control by means of abstraction, they are able to document their results in written form. The students are able to design predictive controllers for nonlinear systems and to validate them by means of simulation.
5	**Examination Requirements** Project* oral exam (max. 30 minutes) ** * Elaboration of a project (Simulation and optimization, 50h) and documentation of the results in report form (ca. 20 pages DIN A4) ** The exact examination arrangements will be announced in the second week of the course.
6	**Formality of Examination** ☐ Module Finals ☒ Accumulated Grade
7	**Module Requirements (Prerequisites)** Necessary Requirements: • Basics of control engineering (state space description, LQR control, Lyapunov functions) • Basics of ordinary differential equations Recommended Requirements: • Basic of optimization, Multivariate Control and Optimal Control
8	**Allocation to Curriculum:** Program: Automation & Robotics, Field of study: Robotics, Process Automation, Cognitive Systems
9	**Responsibility/ Lecturer** *Prof. Dr.-Ing. Timm Faulwasser/* Prof. Dr.-Ing. Timm Faulwasser