Machine Learning and optimal Control — AR-320

Rota	Duration	Semester	SWS	Credit Points	Workload
annually WS	1 Semester or block course	3rd (Semester)	3 SWS	5	150 h

1 Modul Structure

Course (Abbreviation)	Type/ SWS	Presence	Self Study	Credit Points
a) Machine Learning and optimal Control	Lecture/ 2 SWS	25 h	65h	3
b) Machine Learning and optimal Control	Tutorial/ 1 SWS	15 h	15 h	2

2 Language

English

3 Content

Machine Learning (ML) is one of the key technologies of the 21st century; the applications of ML in technical and information technology systems are already ubiquitous. In this context, the lecture offers a system-theoretically and control-technically motivated introduction to different aspects of Machine Learning. Based on the fundamental distinction between unsupervised, supervised and self-reinforcing learning, the following topics are covered:

- Reinforcement learning and its connection to optimal control (especially approaches of the Hamilton-Jacobi-Bellman equation and dynamic programming) and to model-predictive control.
- Formulation on discrete and continuous state spaces
- The formulation of supervised deep learning as an optimal control problem
- Data-driven approaches to model-predictive control for linear systems.

The application of these ML approaches is formally analysed and practically tested with the help of standard software (e.g. Matlab or Python).

Literature

Bishop, C. M. Pattern recognition and machine learning. Springer, 2006.
In der Vorlesung zur Verfügung gestellte Forschungsarbeiten

4 Competencies

After successful participation in the module, the students have basic knowledge of machine learning methods and their use in control engineering application contexts. In particular, they are able to recognise the different types of learning problems, formulate them and solve them with the help of suitable software tools.

They are able to explain the fundamental relationships between optimal control and self-reinforcing learning. They are also able to formulate problems of supervised deep learning as optimal control.

With regard to the numerical solution, the students are familiar with basic algorithmic structures and procedures so that they can interpret and evaluate solutions from software tools. Using control engineering examples, the students have also gained an insight into the diverse application possibilities of machine learning.

5 Examination Requirements

Modulprüfungen:

The final exam is a written (90 minutes) or an oral exam (30 minutes).*

* The exact examination modalities will be announced by the 2nd course at the latest.

6	**Formality of Examination** ☒ Module Finals ☐ Accumulated Grade
7	**Module Requirements (Prerequisites)** Recommended prerequisites: Prior knowledge of Fundamentals of Optimal Control (LQR) or numerical optimisation; state space representation and difference equations. The number of participants is limited to 50. Admission to participation is in accordance with § 9 of the examination regulations.
8	**Allocation to Curriculum:** Program: Automation & Robotics, Field of study: Robotics, Process Automation Program: Electrical Engineering and Information Technology
9	**Responsibility/ Lecturer** *Prof. Dr.-Ing. Timm Faulwasser* / Prof. Dr.-Ing. Timm Faulwasser