03-IBAP-MRCA	Modern Robot Control Architectures
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Lehrform *(teaching format)* / **SWS** *(hours per week)*: 2VL + 2UE

Kreditpunkte *(credit points)*: 6

Turnus *(frequency)*: usually, each summer term

Inhaltliche Voraussetzungen *(content-related prior knowledge/skills)*: NONE

Sprache *(language)*: English

Lehrende *(teaching staff)*: AG Robotik (Prof. Dr. Frank Kirchner)

Studiengang *(degree program)*	Module	Semester
Informatik (Bachelor VF)	IBAP	ab 4. Sem.
Informatik (Bachelor KF)	KINF-A1/A2	ab 4. Sem.
Systems Engineering (Bachelor)	Spezialisierung (AuR)	ab 4. Sem.
Informatik (Master)	*General Studies*	ab 1. Sem.
Systems Engineering II (Master)	M07-AM-INF	1. Sem.
(Industr.)Mathematics (Master)	Anwendungsfach Informatik	
Zertifikatsstudium DiMePäd	DM in Lernumgebungen	ab 1.Sem.

Lernergebnisse / *Learning Outcome*:

This course provides the basics of modern robotic control approaches in order to create an architecture for an agent to operate autonomously in an environment. It will provide the basic understanding of the origins of autonomous robots, along with the advantages and disadvantages of the four control architectures: reactive, deliberative, hybrid and behavior based. Advanced control architectures along with machine learning control will also be introduced. This class will contribute to understanding the challenges of deploying autonomous robots with respect to model dynamics, sensor data, robot actuation and localization. These challenges will be put into practice using a simulated environment in the Python programming language. The student will also learn to basic representations of linear and rotational transformations as well as some applications of probability theory in robotics.

- Introduction: Definition of autonomous robots, milestones, range of robot control approaches, definition of behavior, decentralized robot control and bio-inspired robotics
  Representations of transformations: transformations relevant to robotics, display possibilities of rotations e.g., through quaternions, advantages through the knowledge of algebraic properties of the transformations in 2D and 3D
- Sensors and actuators (to be considered as modules for gaining information and the possibility of interaction from the point of view of the control architecture): sensor types, preprocessing, handling of large amounts of data, multimodal sensor solutions, long-term autonomy, actuator types, control (PID, cascade controller, decentralized control), various control objectives e.g., gravity compensation.
- Localization: Possible sources of information (e.g., landmarks, odometry, cameras, laser scanners), dealing with uncertainty, probabilistic localization with the particle filter, map generation with SLAM
- Planning: Various Representations, Restrictive Assumptions of Classic Planning Systems, Plan Space Planning, Graph Planning, Temporal Planning, Path and Motion Planning, Algorithms (e.g., STRIPS and A *)

- Control architectures: principles and examples of reactive, deliberative, hybrid and behavioral approaches. Design of architectures with behavioral levels, engine schema, emergent behavior. Optimal control and machine learning based control will be introduced as well.
- State of the Art: How do the concepts and methods used in current systems come to be used? Modern behavior-based robotic architectures based on the example of locomotion and manipulation, challenges, and solutions in the control of kinematically complex robots in the real world.

Inhalte / *Contents*:

Introduction to control architectures, mechanics, robotics and AI, representation of transformations, actuation modalities, sensing modalities, localization, motion and path planning, task planning, behaviour-based control architectures, optimal control architectures, machine learning-based robot control, state of the art in control.

Hinweise *(remarks)*: The table lists only the primary / most specific modules to which this course is assigned.