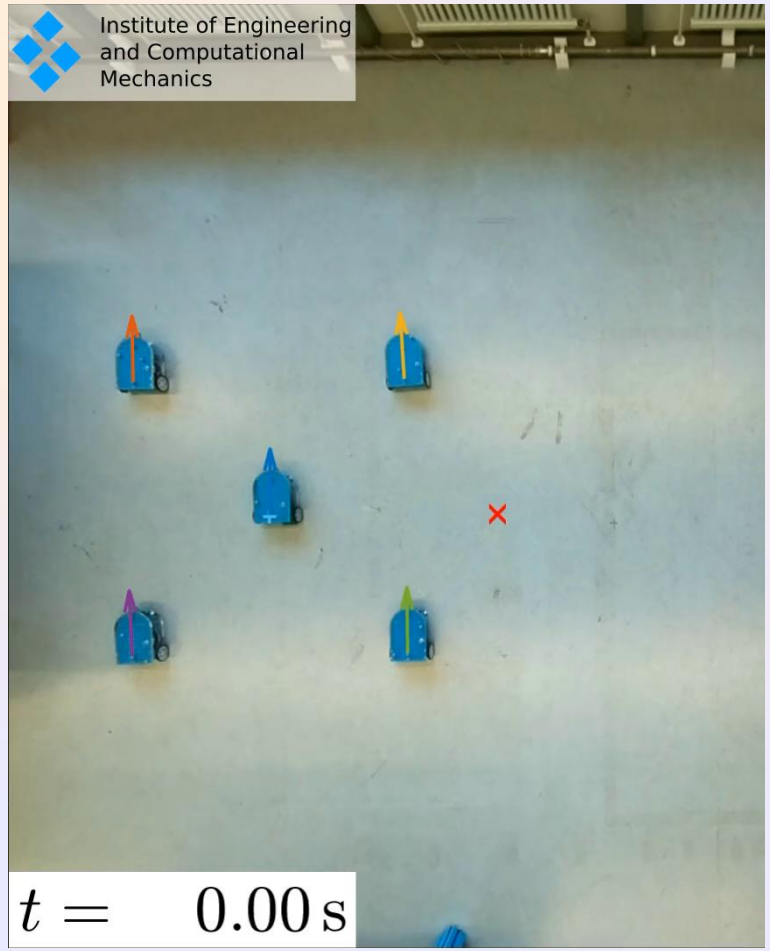
Specialization Subject in the M.Sc. Engineering Cybernetics
Winter Semester 2026 / 2027

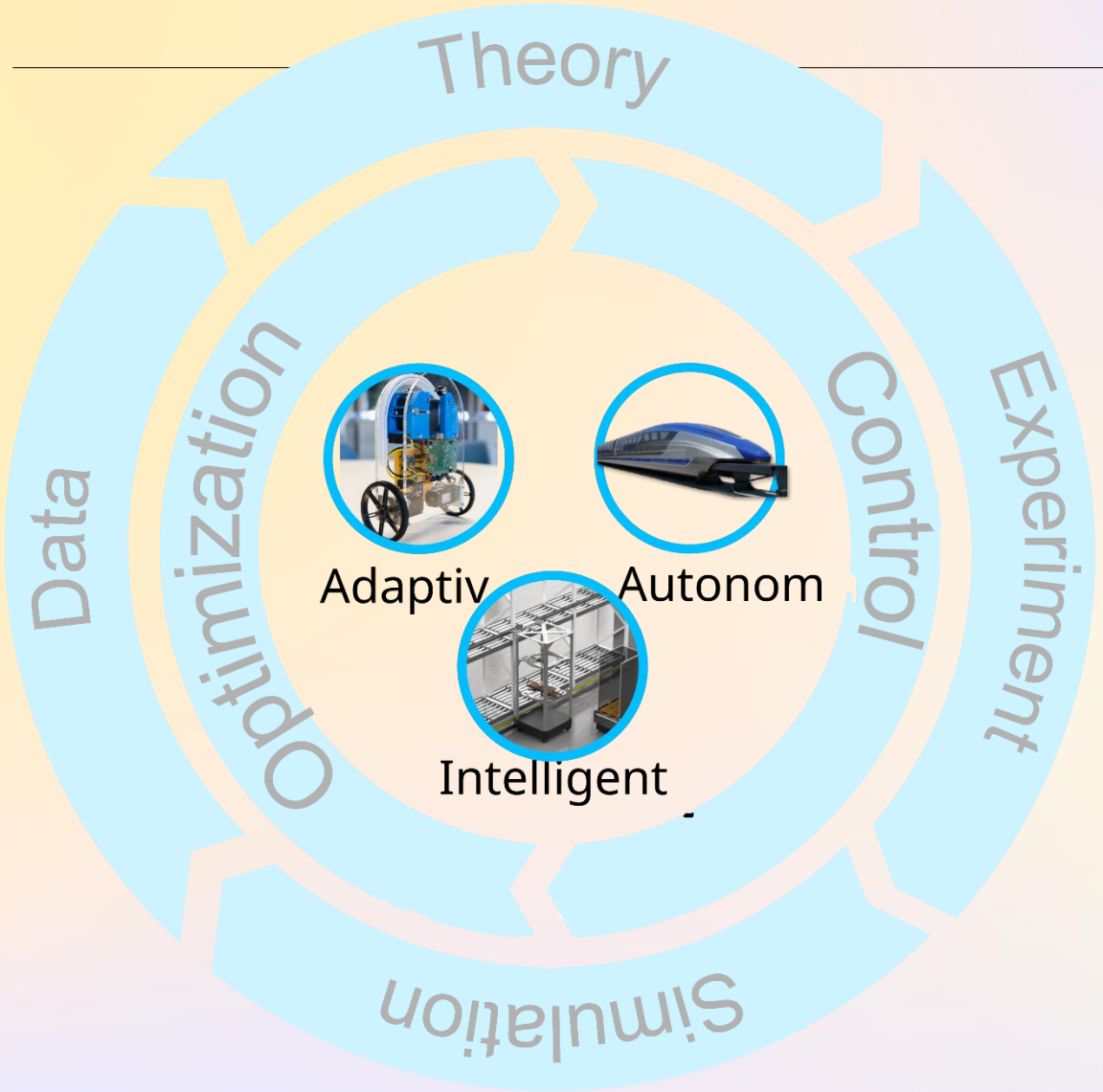
Technical Dynamics / Technische Dynamik

Profs. Eberhard, Fehr, Hanss



Institute of Engineering and
Computational Mechanics
University of Stuttgart, Germany
Profs. Eberhard/Fehr/Hanss

The 4th Paradigm



- From understanding to operation of complex technical systems
  - **Vehicle and machine dynamics**
  - **Robotics**
  - **Vehicle safety / biomechanics**
  - **Automation engineering**
  - **Production**

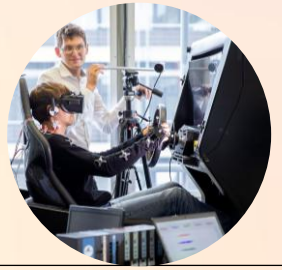
Your Benefits

- particularly bright, creative staff in a diverse team
- **Our team teaches you skills in**
  - Theory → Modeling → Numerics → Optimization → Visualization
- 40 years of experience in software development and digital twins
  - Dynamics, multibody systems
  - **Mo**del **O**rder **R**eduction and **M**achine **L**earning
  - mesh-free methods such as SPH and particle simulation for analyzing and optimizing complex technical processes
- State-of-the-art methods in digital literacy and software development
  - GitLab, CTest, code reviews

- Daring More Intelligence – Design Assistants in Mechanics and Dynamics
  - better
  - faster
  - Human-Machine Teaming

DFG
SPP 2353

- **Extensive, centrally located laboratory for validation and experiments**
  - large fleet of laser Doppler vibrometers (scanning, 3D, 1D)
  - Robotics lab (13 mobile robots, 4 quadcopters, 4 further robots, MoCap)
  - Vibration lab with many shakers, sensors, loggers, climate chamber
  - Driver-in-the-Loop Simulator



What you Will Learn

Prof. P. Eberhard

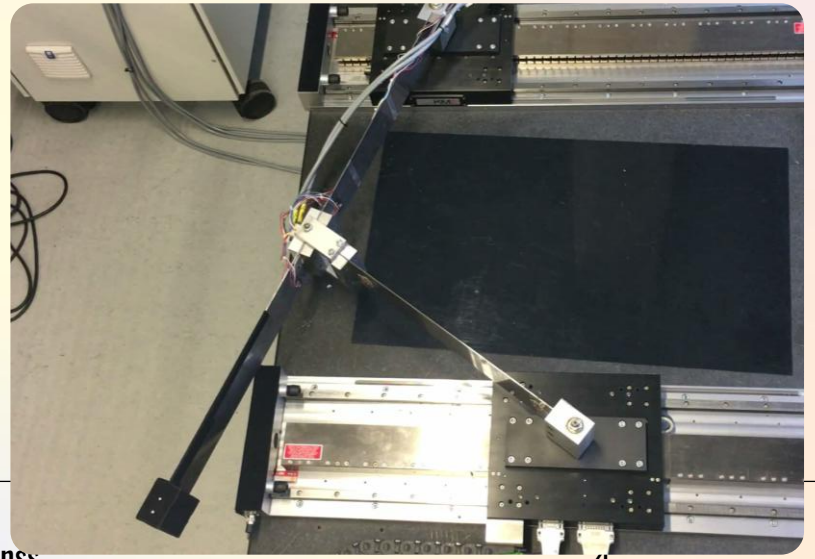
Prof. M. Hanss

Prof. J. Fehr

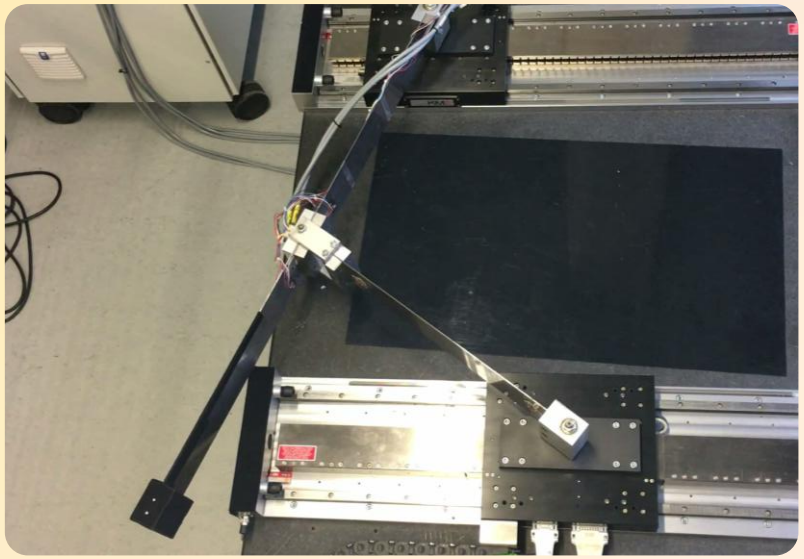
Dr.-Ing. P. Ziegler

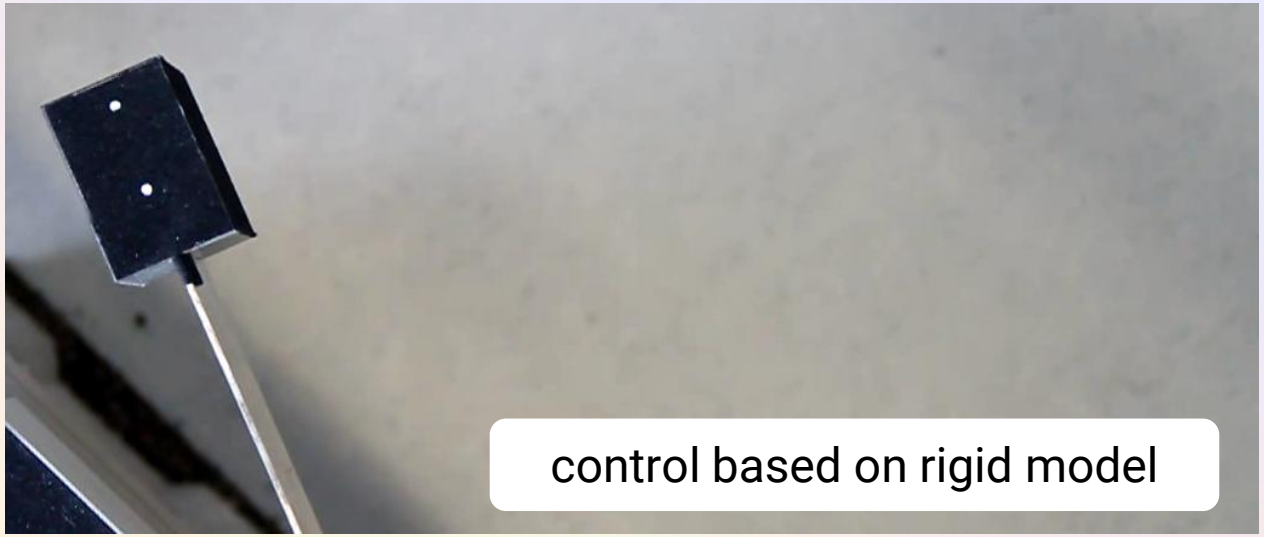
complex mecha(tro)nic systems

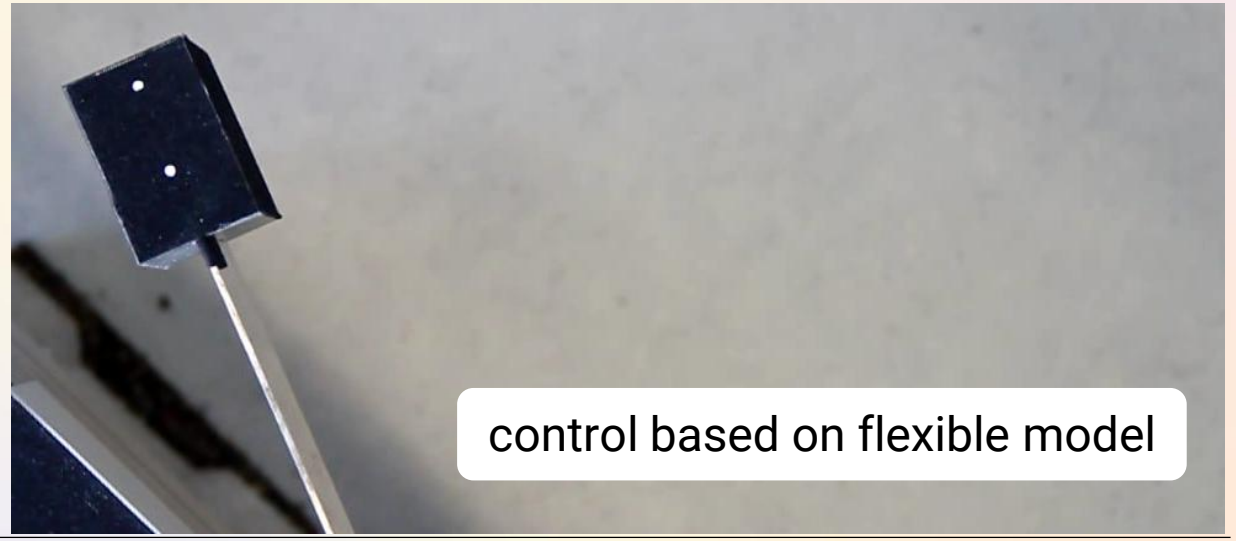
- Analysis
- Modeling
- Simulation
- Optimization
- Control



Before / After



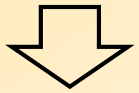




Example: Model Predictive Control

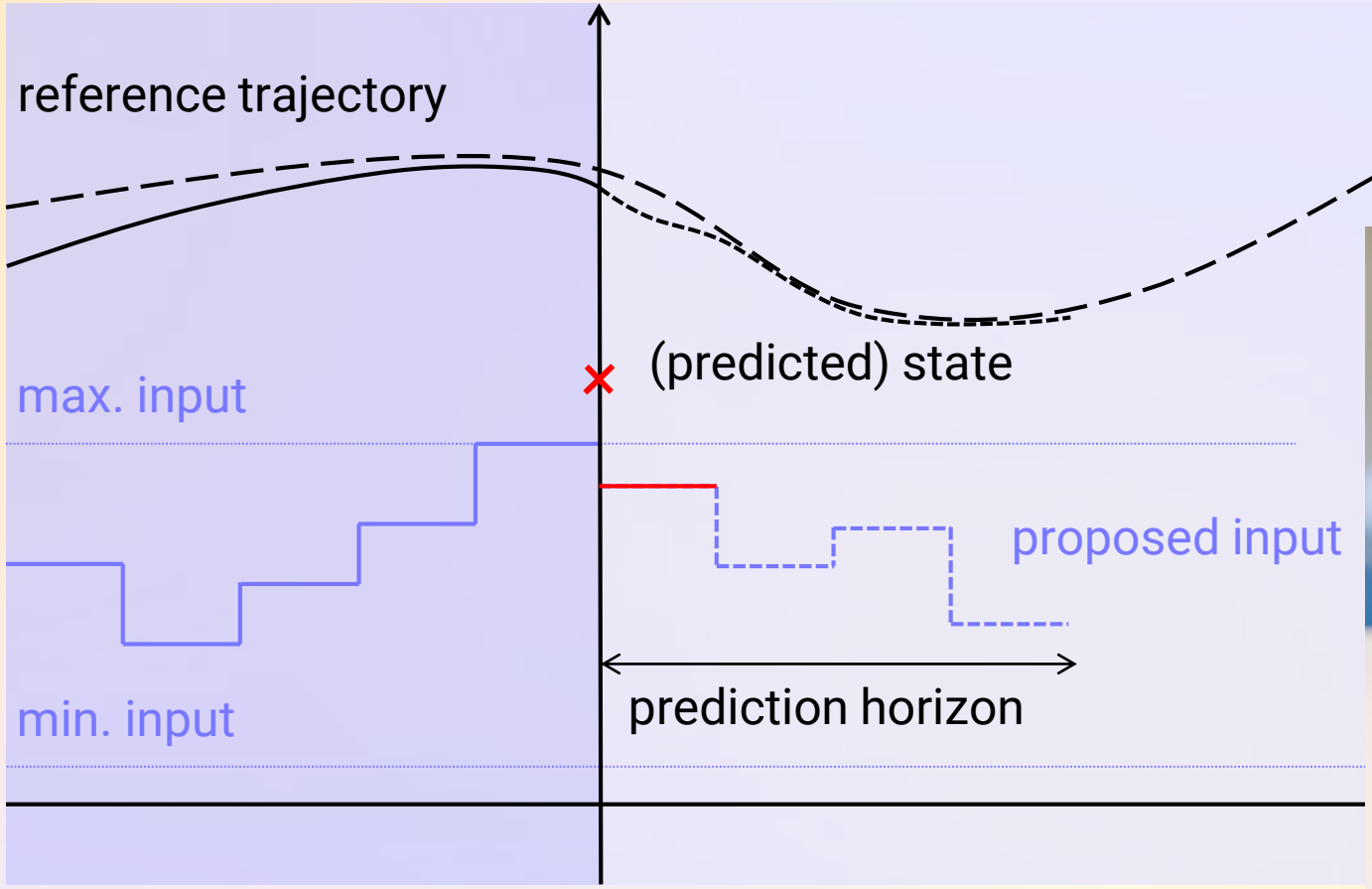
- Balancing Robot

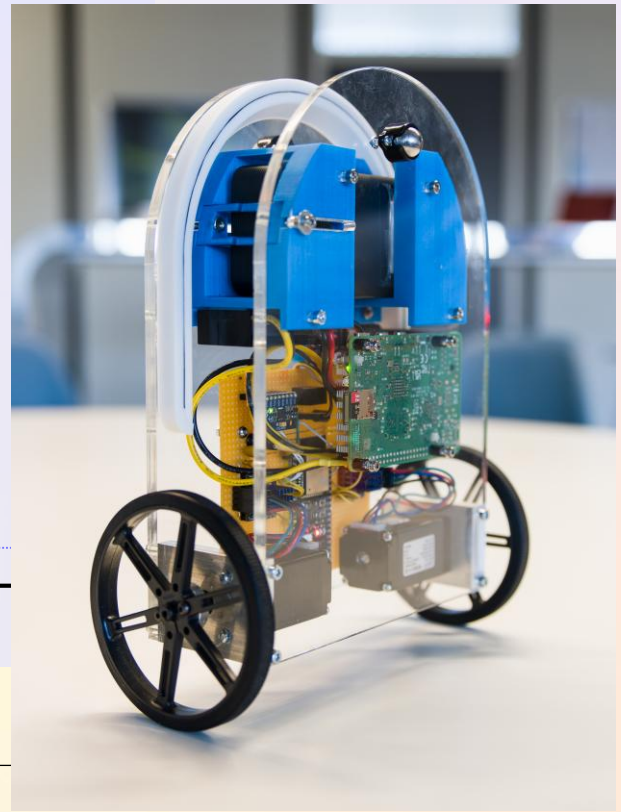
measure / estimate current state



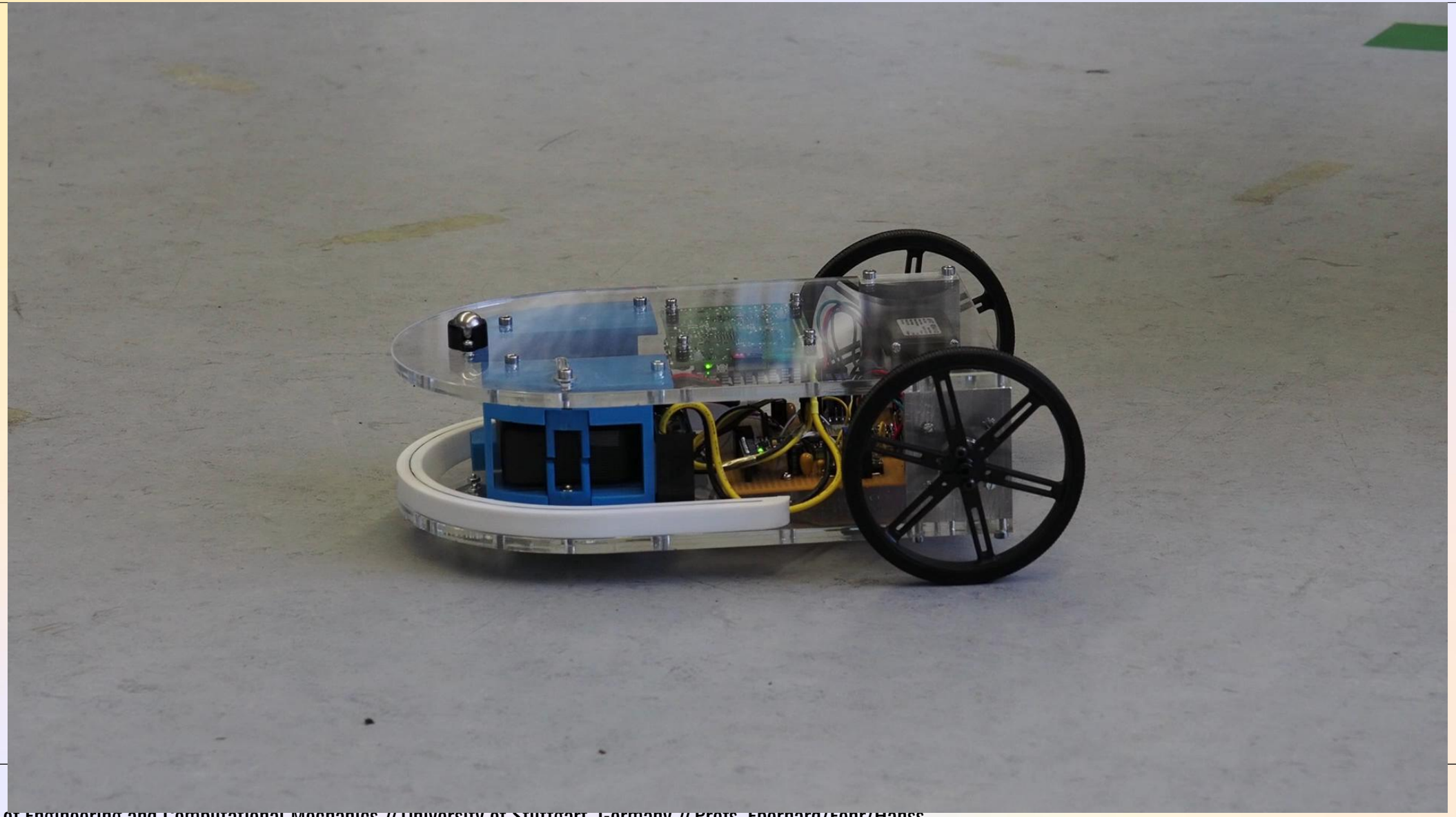
solve optimal control problem

implement first control input





DIANA Balancing Robot



Master's Specialization Subject

Modeling & Simulation

- **Flexible Mehrkörpersysteme– Core Subject**
  SS, 6 ECTS (Fehr/Eberhard)
- Modelling and Simulation in der Mechatronik
  WS, 6 ECTS (Fehr/Eberhard)
- Simulation of Particles and Mesh-free Computation Methods
  WS, 3 ECTS (Eberhard/Baumann)
- Model Reduction of Mechanical Systems
  WS, 3 ECTS (Fehr)
- Numerische Methoden der Dynamik*
  SS, 6 ECTS (Eberhard/Ziegler)

Dynamics, Optimization & Control

- Fahrzeugdynamik
  WS, 3 ECTS (Ziegler/Eberhard)
- Optimization of Mechanical Systems
  WS, 3 ECTS (Eberhard)
- Nonlinear Oscillations
  WS, 3 ECTS (Hanss)

Uncertainty & Experiments

- Uncertainty Quantification
  SS, 6 ECTS (Hanss)
- Modal Testing
  SS, 3 ECTS (Ziegler)
- Practical Training Technical Dynamics
  WS/SS, 3 ECTS (Eberhard/Hanss)

Technical Dynamics

- 18 ECTS (major) or 12 ECTS (minor)

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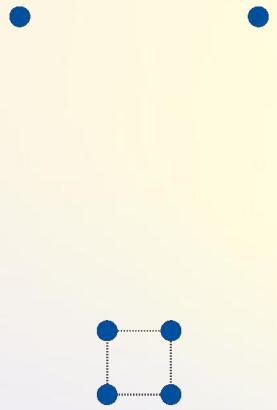
* only if not already taken in the B.Sc.

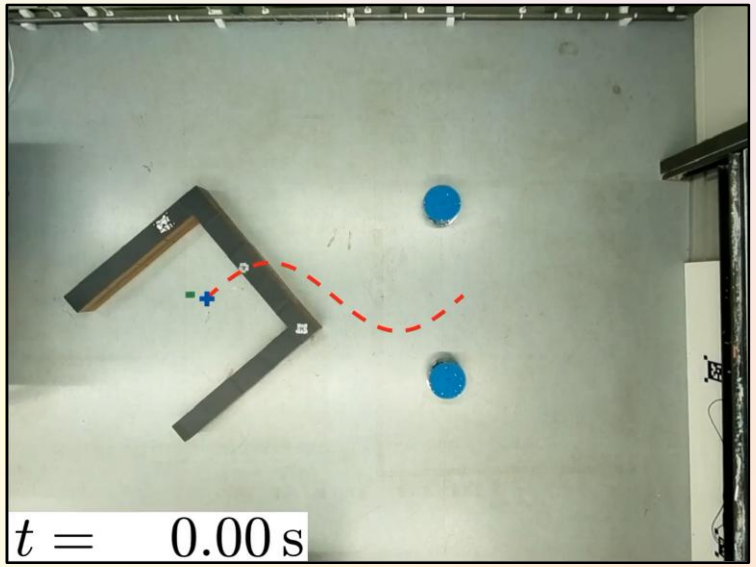
Robotics

- e.g. swarm of **mobile robots**, **drones**, etc.

- diverse applications
  - Formation control
  - Cooperative object manipulation
  - Target search in complex environments
  - …

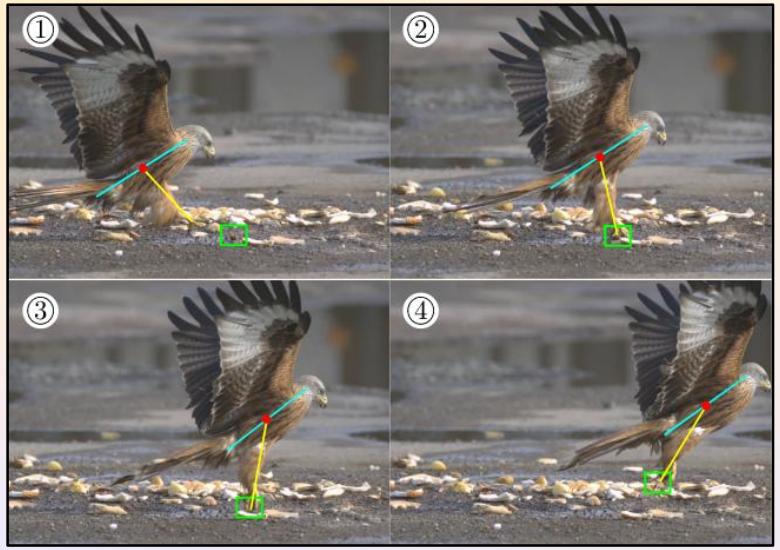
- special properties
  - Flexibility / scalability
  - Robustness
  - Organization / task allocation
  - Multi-sensor

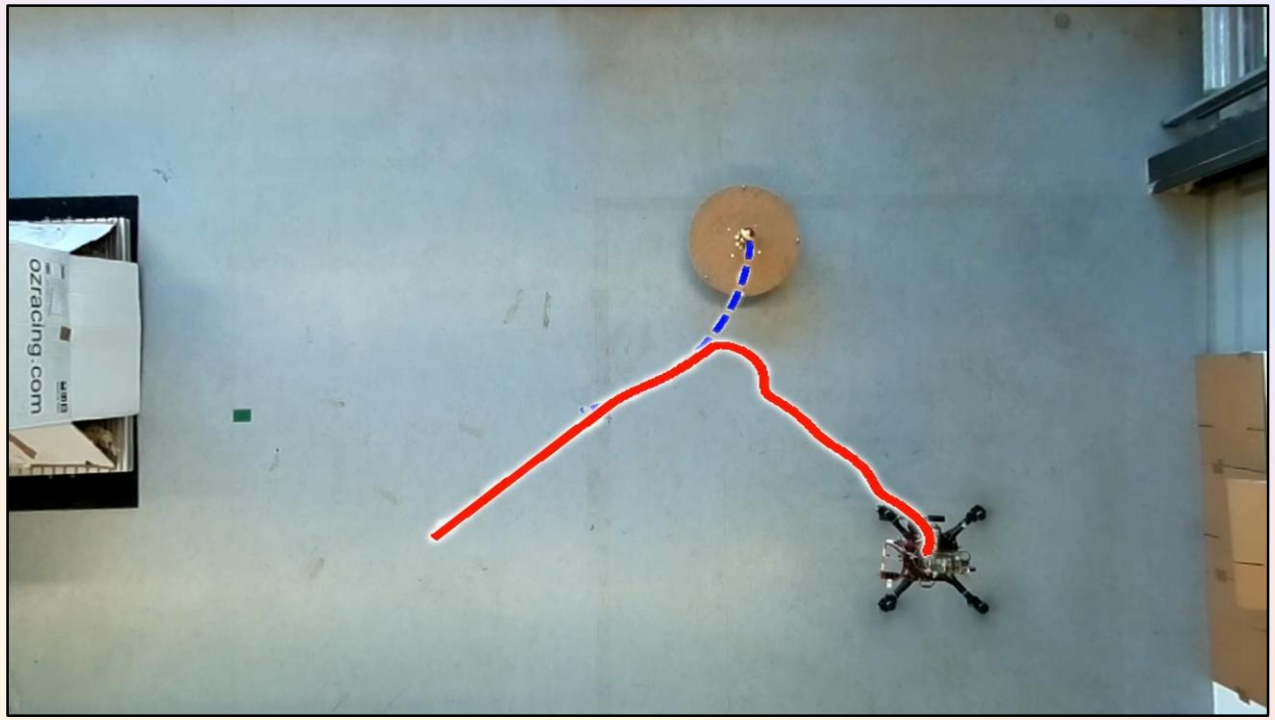




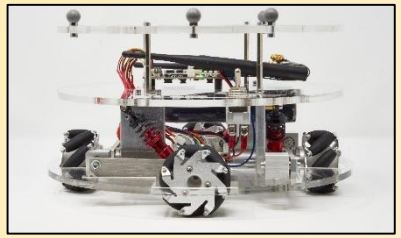
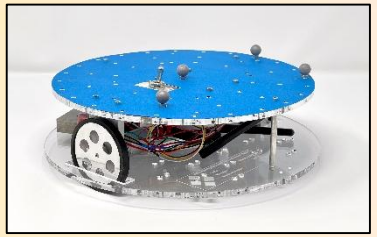
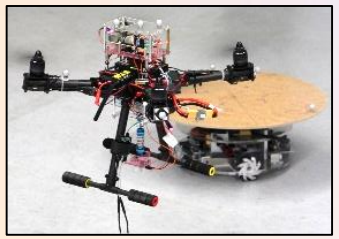
Heterogeneous Robot Swarms

- Handover of objects between quadcopter and mobile robot
- Tasks: trajectory planning, dynamic control
- here: both optimization- and model-based, model predictive control

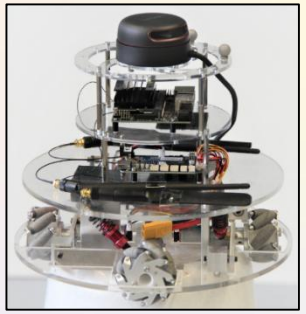




Student project / Theses

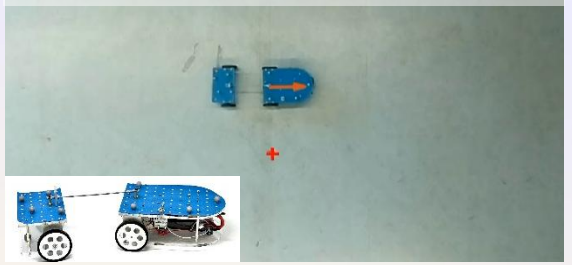




- in-house robots are very useful not only for research on distributed control, but also for other topics and for student projects – localization, mobile manipulators, …
- existing hardware-in-the-loop framework eases the transition from simulations to hardware experiments
- valuable data source for machine learning and artificial intelligence methods

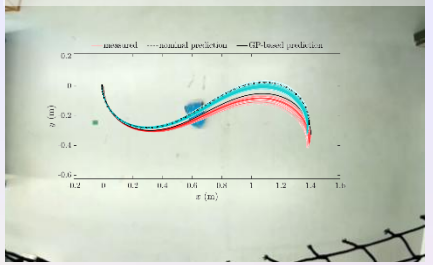


Selection of student theses

J. Krauspenhaar, BSC-145, ITM, 2022

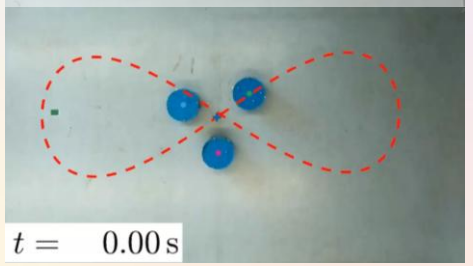


I. Khemakhem, BSC-138, ITM, 2021

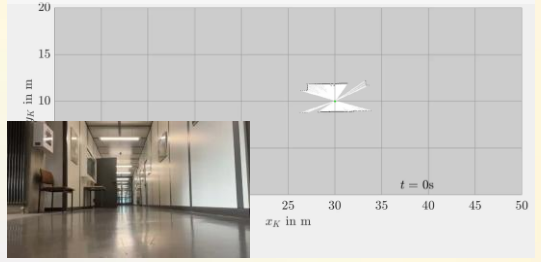


J. Rühle, BSC-107, ITM, 2019

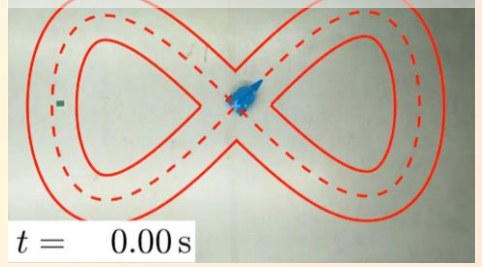
M. Hermle, MSC-328, ITM, 2022



P. Ziegler, BSC-146, ITM, 2022

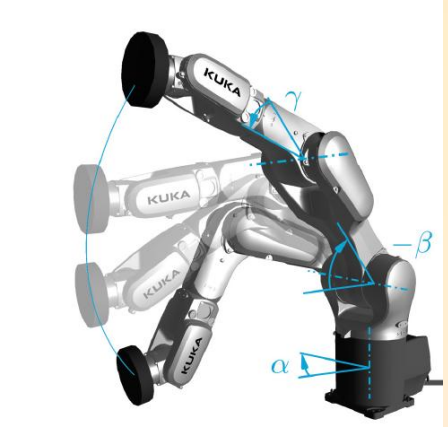


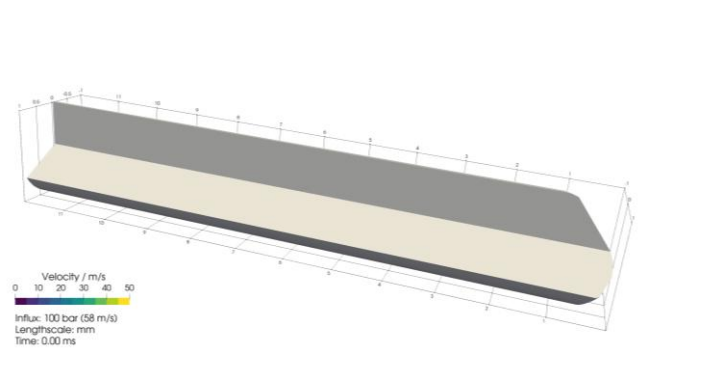
M. Hermle, MSC-328, ITM, 2022



Modeling, Simulation & Digital Twins

Representing, predicting and understanding complex technical systems in the virtual world





Key Topics

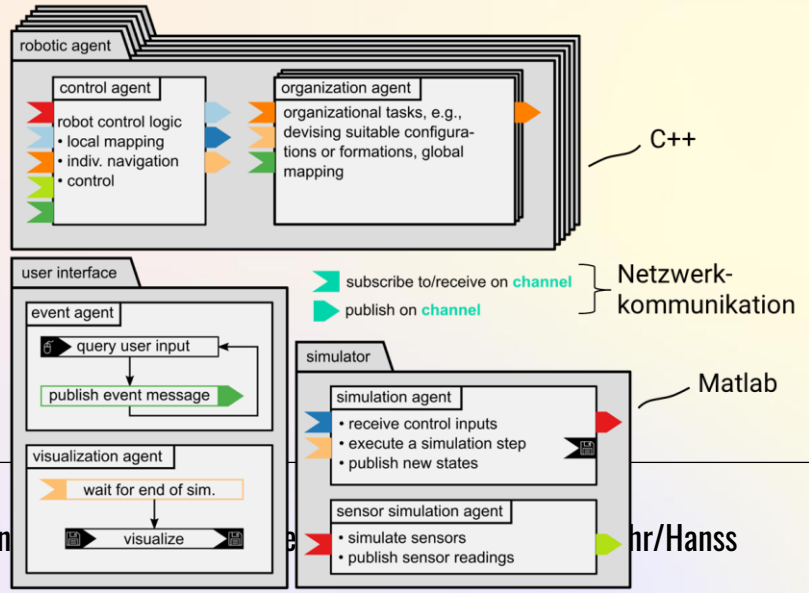
- Mathematical Modeling
- Numerical Simulation
- Model Reduction
- Uncertainty Qunantification & Data Integration

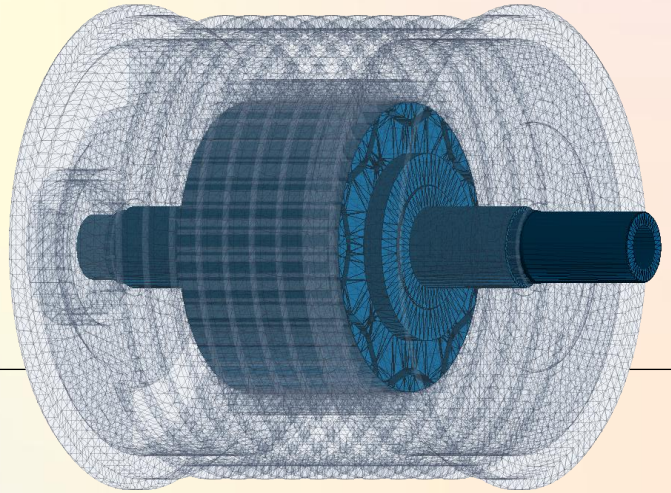
Applications

- Virtual Prototyping
- Real-time Simulation
- Virtual Sensing
- Model-based Design

Software Architecture Robotics

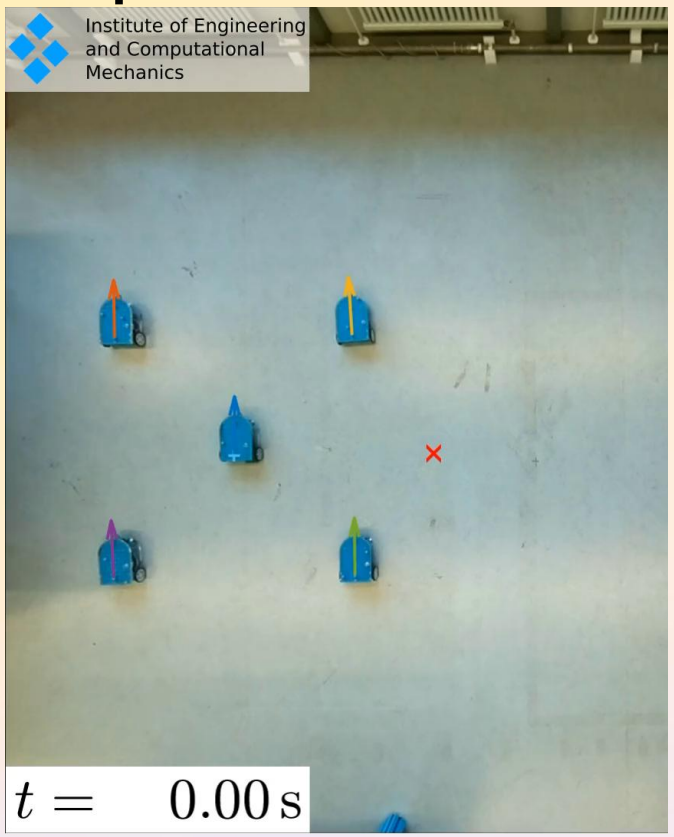
Mixed Virtual Hybrid Development





Robotics & Autonomous Systems

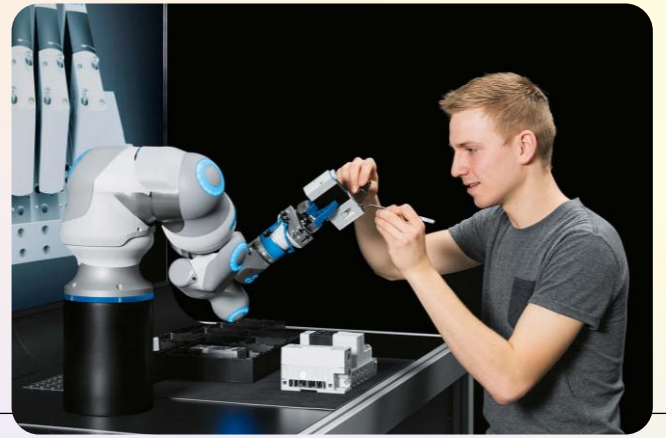
Designing intelligent machines that perceive, decide and act autonomously in complex environments.



Applications

- Mobile & Swarm Robotics
- Legged Robots
- Soft Robotic Systems
- Autonomous Manipulation

- **Key Topics**
- Robot Dynamics & Locomotion
- Planning & Autonomous Control
- Soft & Adaptive Robotics
- Human–Robot Interaction



We hope to see you!