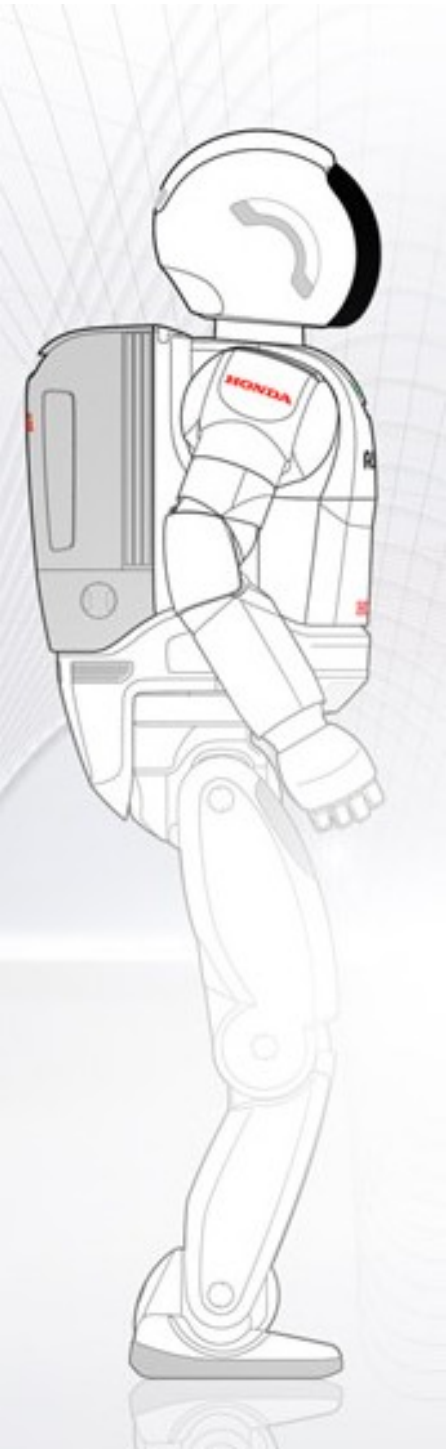

Cognitive Robotics

Anwendungsfach BSc Technische Kybernetik

Marc Toussaint
U Stuttgart

Cognitive Robotics

AI in the real world

AI: Machine Learning, probabilistic reasoning, optimization
Real World: Manipulation, perception, navigation, control, etc

Why AI needs to go real world

Why AI needs to go real world

They digest their brain once they settled!

- **Motion** was *the* driving force to develop intelligence
- **Manipulation** requires to acknowledge the structure (geometry, physics, objects) of the real world. Classical AI does not

Machine Learning & Robotics group

- Push ML to become applicable to real-world robotics & manipulation
- Extend methods to represent structural aspects of real worlds
  (e.g., relational Reinforcement Learning; relational Exploration)
- Consider **curious** systems (actively maximizing information gain)

work by Pieter Abbeel

Anwendungsfach “Kognitive Robotik”

- Core:
  - Robotics, WS, Toussaint, 6LP
  - Grundlagen der Künstlichen Intelligenz, WS, Bruhns, 6LP
  - Robotics Competition (Practical Course), SS, 3LP
  - Reinforcement Learning, SS, Vien Ngo, 3LP
- Extended:
  - Machine Learning, SS, Toussaint, 6LP
  - Optimization, SS, Toussaint, 6LP
  - Einfhrung in die verteilte KI, WS, Dr. Schanz, 3LP
  - Steuerungstechnik der Werkzeugmaschinen und Industrieroboter, SS, Prof. Verl, 6LP
  - Robotersysteme: Auslegung und Einsatz, WS, Dr. Wurd, 3LP
  - Dynamische Filterverfahren, SS, Prof. Kistner, 6LP

Robotics Lecture

- **Kinematics & Dynamics**

  goal: orchestrate joint movements for desired movement in task spaces

  Kinematic map, Jacobian, optimality principle of inverse kinematics, singularities, configuration/operational/null space, multiple simultaneous tasks, special task variables, trajectory interpolation, motion profiles; 1D point mass, damping & oscillation, PID, general dynamic systems, Newton-Euler, joint space control, reference trajectory following, optimal operational space control

- **Planning & optimization**

  goal: planning around obstacles, optimizing trajectories

  Path finding vs. trajectory optimization, local vs. global, Dijkstra, Probabilistic Roadmaps, Rapidly Exploring Random Trees, differential constraints, metrics; trajectory optimization, general cost function, task variables, transition costs, gradient methods, 2nd order methods, Dynamic Programming

- **Control Basics**

  goal: designing optimal controlers

  Topics in control theory, optimal control, HJB equation, infinite horizon case, Linear-Quadratic optimal control, Riccati equations (differential, algebraic, discrete-time), controllability, stability, eigenvalue analysis, Lyapunov function

- **Mobile robots**

  goal: localize and map yourself

  State estimation, Bayes filter, odometry, particle filter, Kalman filter, Bayes smoothing, SLAM, joint Bayes filter, EKF SLAM, particle SLAM, graph-based SLAM