# 64-424
# Intelligent Robotics

https://tams.informatik.uni-hamburg.de/lectures/2018ws/vorlesung/ir

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University of Hamburg
Faculty of Mathematics, Informatics and Natural Sciences
Department of Informatics
**Technical Aspects of Multimodal Systems**

Winterterm 2018/2019

# Outline

# 64-424 Lecture

| | |
|---|---|
| **Lecture** | Monday 14:15 - 15:45 (s.t.) |
| **Room** | G-021/G-022 |
| **Web** | `https://tams.informatik.uni-hamburg.de/lectures/2018ws/vorlesung/ir` |
| **Organizers** | Marc Bestmann |
| **Room** | F-308 / F-315 |
| **Phone** | +49 40 42883-2431 / -2432 |
| **E-mail** | bestmann@informatik.uni-hamburg.de |
| **Lecturers** | Marc Bestmann<br>Michael Görner |

# 64-425 Seminar

| | |
|---|---|
| **Seminar** | Monday 16:15 - 17:45 (s.t.) |
| **Room** | G-021/G-022, G-203 |
| **Web** | `https://tams.informatik.uni-hamburg.de/lectures/2018ws/seminar/ir/` |
| **Organizers** | Lasse Einig, Marc Bestmann |
| **Room** | F-324 / F-313 |
| **Phone** | +49 40 42883-2504 / -2398 |
| **E-mail** | einig, bestmann@informatik.uni-hamburg.de |

**Today, the seminar takes place in G-021/22 only.**

# Expected background knowledge

- Basic knowledge of physics
  - concepts of gravity, acceleration, force...
- Linear algebra
  - vector and matrix operations, systems of linear equation, basic differential calculus...
- Probability calculus
  - conditional probability, conditional independence, ...
- General understanding of electrical engineering concepts
- **No background in robotics is required**

# Purpose of this course

A cross section of fields required for intelligent robotics:

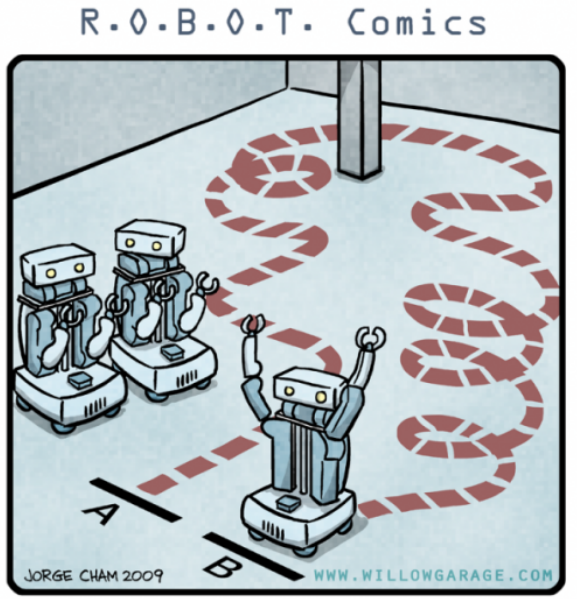
- Fundamental sensor/actuator technology
  - rotation, motion, force/torque, tactile, distance, vision ...
- Established data processing algorithms
  - sequence filters, camera calibration, ...
- Model estimation methods
  - Probabilistic State Estimation, ICP registration, ...
- Task-Level Robot Control
  - Reasoning Methods, Fuzzy Logic ...
- Machine Learning in Robotics

This course should provide you with a broad basis
for understanding current intelligent autonomous robots

# Outline

# Robotics is fun!

- Robots can act in mundane environments
- Autonomous robotics is an interdisciplinary field
  - Mechatronics
  - Architecture- and system design
  - Control theory
  - Data science / Machine Learning
  - Reasoning Methods
  - Psychology
  - Cognitive Science
  - ...
- Lots of problems wait for your solution!



# What is an "Intelligent Robot"?

- There is no general definition
- Intelligence is often associated with
  - Interpretation of percepts
  - Mental world models
  - Goal-directed actions
  - The Total Turing test
- These are hard to define or model when programming robots
- We *can* talk about
  - Scene / Object recognition
  - Tracking
  - Pick&Place
  - Path planning
  - Localization
  - ...

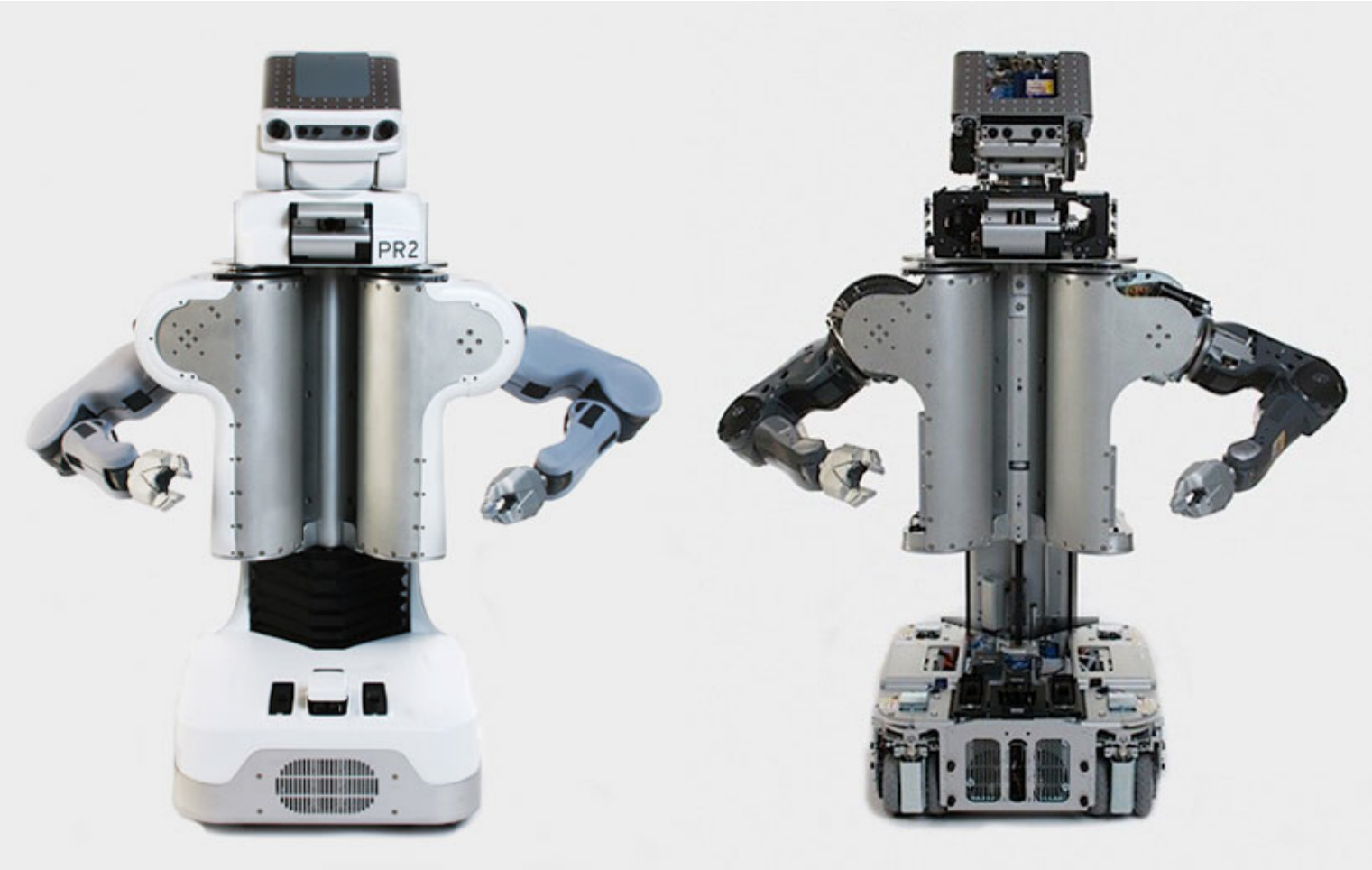
**The old problem with AI**

*"Robots can do it [already], so it's not Intelligence"*

# Definitions Intelligence

- "Intelligence is the computational part of the ability to achieve goals in the world" John McCarthy
- "Judgment, otherwise called good sense, practical sense, initiative, the faculty of adapting one's self to circumstances ... auto-critique." Alfred Binet
- "A very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings—"catching on," "making sense" of things, or "figuring out" what to do." Mainstream Science on Intelligence

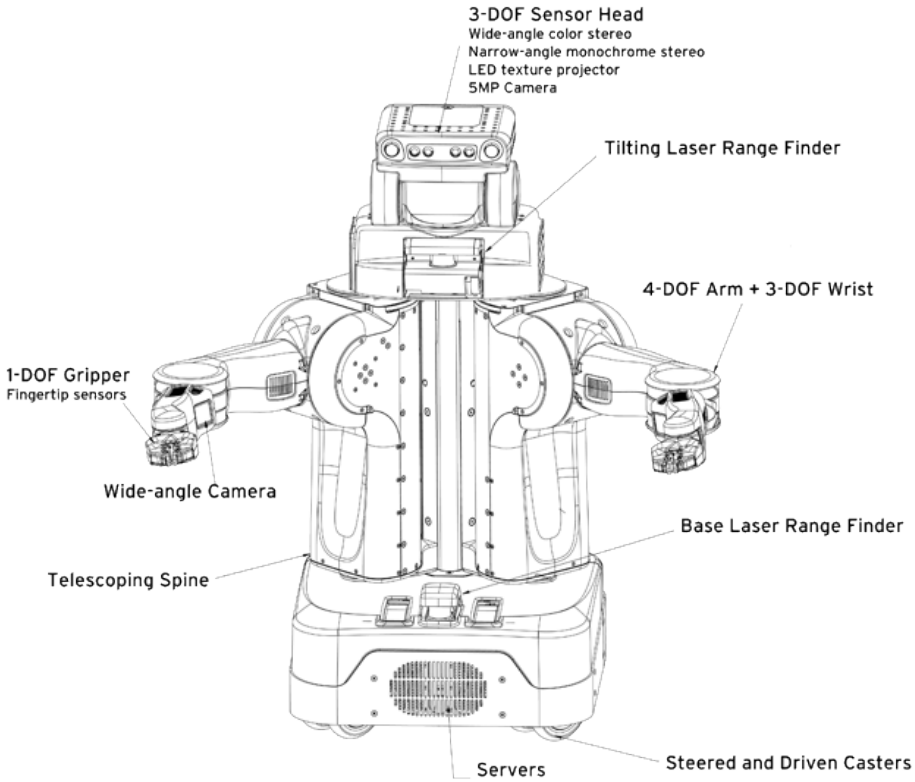
# Example: Personal Robot 2 (PR2)



# Personal Robot 2 (PR2)

# Personal Robot 2 (PR2): Platform

- Mobile base
  - 4-wheel omnidirectional drive
  - 1kHz motor control loop
  - Fixed laser range finder
- Two compliant arms
  - Passive counterbalance
  - 4 DOF [1] arms
  - 3 DOF wrists
  - Payload: $\approx$ 1.8kg




[1] Degree of freedom

# Personal Robot 2 (PR2): Sensor head

- 2 degrees of freedom (pan/tilt)
- 5MP RGB camera
- Kinect RGB-D camera (not shown)
- Environment (wide) stereo cameras
- Manipulation (narrow) stereo cameras
- LED texture projector
- Inertial measurement unit
- Tilting laser range finder

# Personal Robot 2 (PR2): Grippers

- 1 degree of freedom
- 90mm range of motion
- 3-axis accelerometers
- Fingertip pressure sensor arrays
- Grip force: 80N ($\approx$ 8kg)
- Gripper cameras in forearm

# Personal Robot 2 (PR2): Processing and control

- Dual Quad-Core i7 Xeon CPUs
- 24 GB main memory
- 1.5 TB storage
- Multi-gigabit interconnections
- Synchronized network cameras
- EtherCAT communication bus

# It's your turn!

- The field and community of robotics is growing fast
- Lots of innovative research work
- Many amazing interdisciplinary applications
- Lots of grant money and high demand for specialists

- Many problems are yet to be solved
- Existing literature provides a good foundation to build upon