Introduction to Mobile Robotics

Welcome

Wolfram Burgard, Cyrill Stachniss,

Maren Bennewitz, Kai Arras

Organization

- Wed 2pm – 4pm
  Fri 12pm – 1pm
  - lectures, discussions
- Fri 1pm – 2pm
  - homework, practical exercises

- Web page:
  - www.informatik.uni-freiburg.de/~ais/

People

Teaching:

- Maren Bennewitz
- Wolfram Burgard
- Cyrill Stachniss

Teaching assistants:

- Jonas Rist
- Benjamin Suger

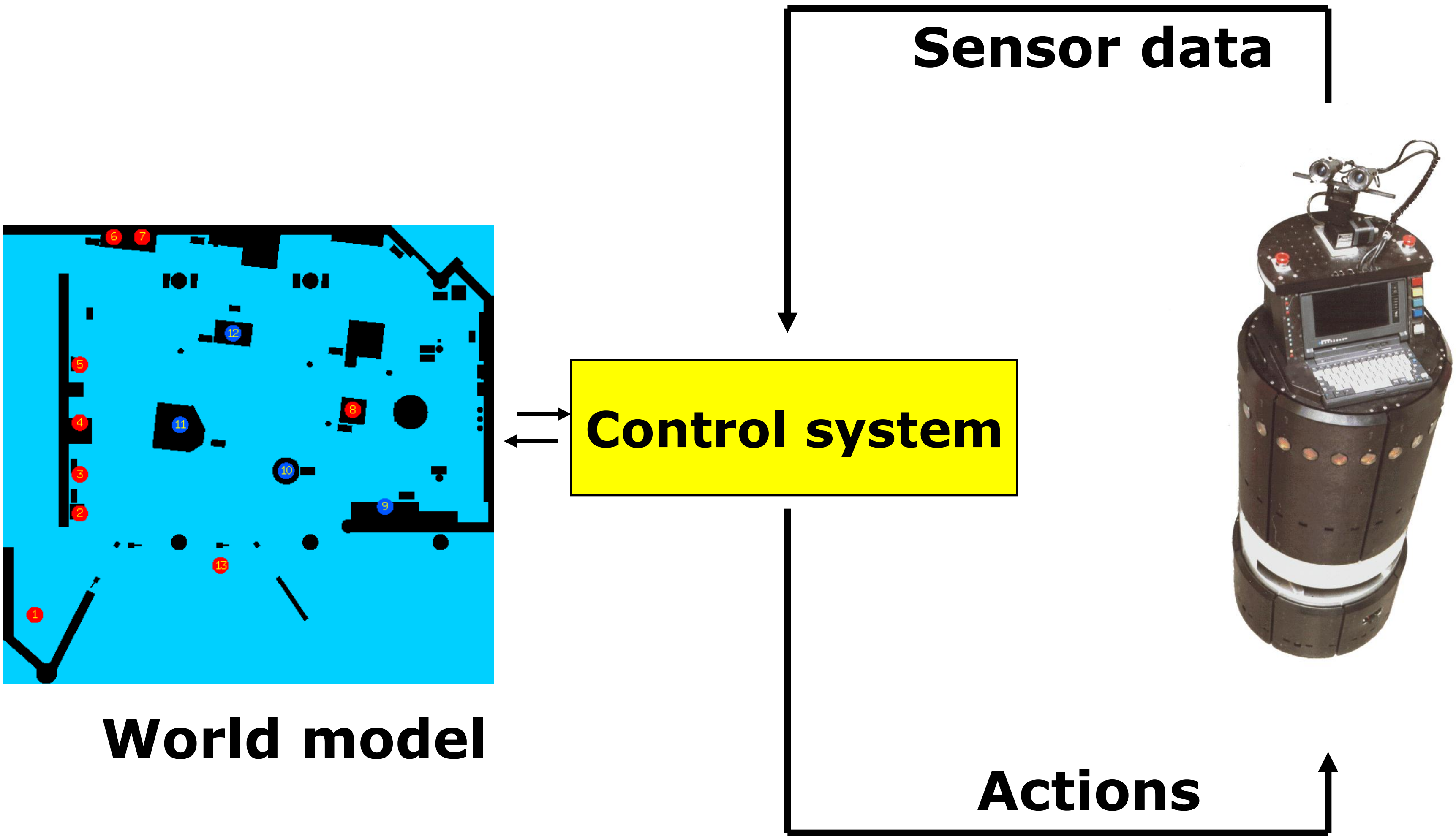
Students:

- Evis Plaku
- Eddy Ilg

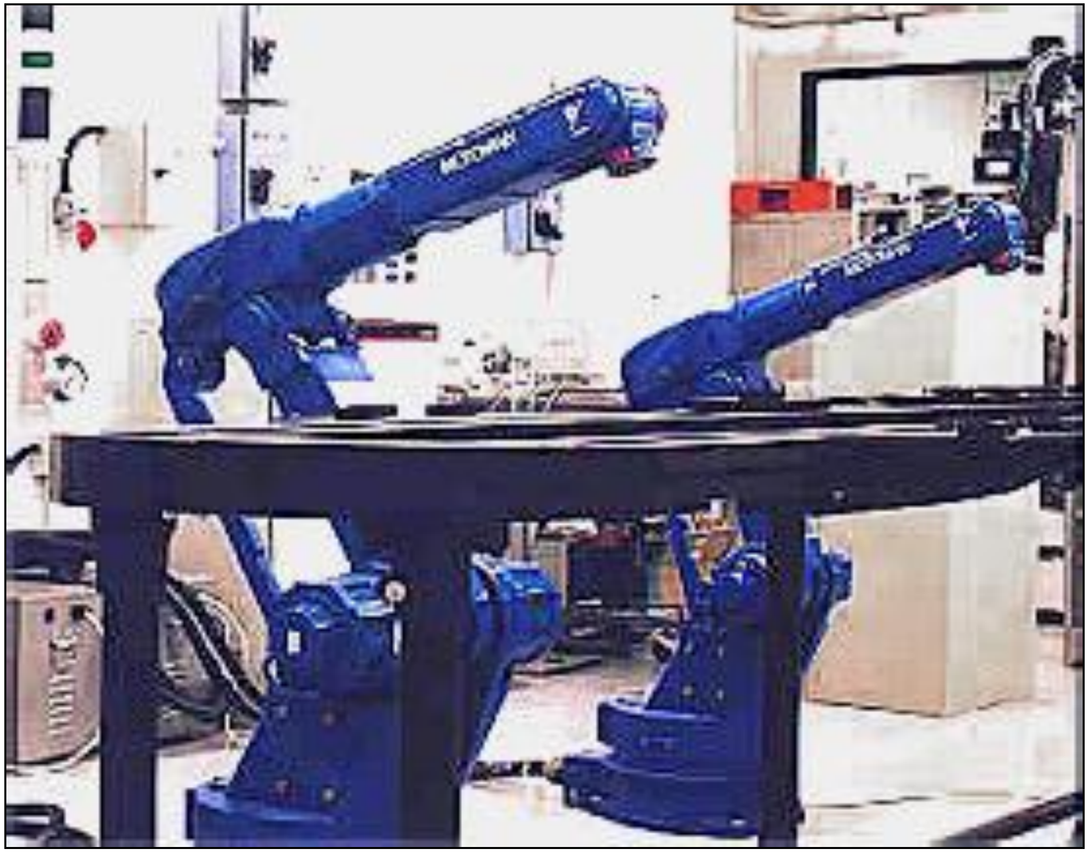
Goal of this course

- Provide an overview of problems / approaches in mobile robotics
- Probabilistic reasoning: Dealing with noisy data
- Hands-on experience

AI View on Mobile Robotics



Robotics Yesterday

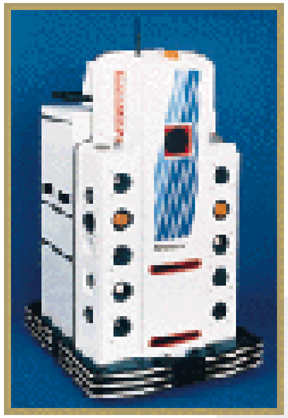


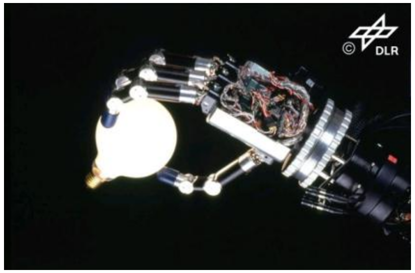
Current Trends in Robotics

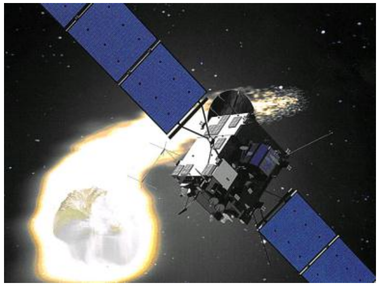
Robots are moving away from factory floors to

- Entertainment, toys
- Personal services
- Medical, surgery
- Industrial automation (mining, harvesting, …)
- Hazardous environments (space, underwater)

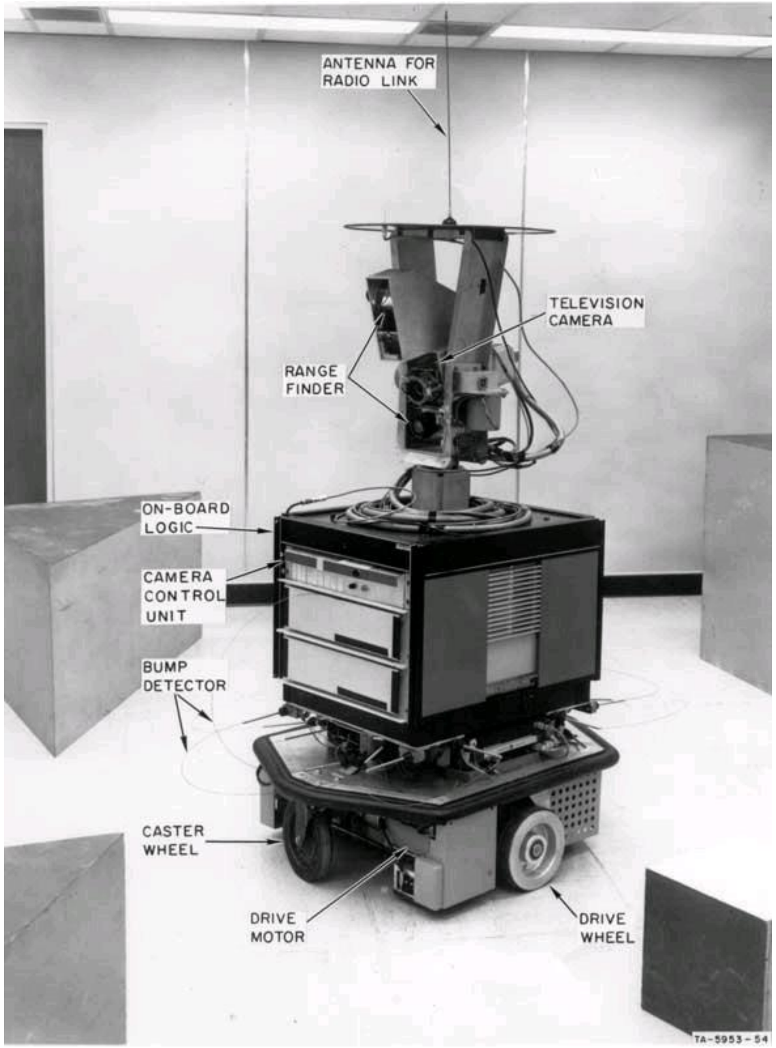
Robotics Today







Shakey the Robot

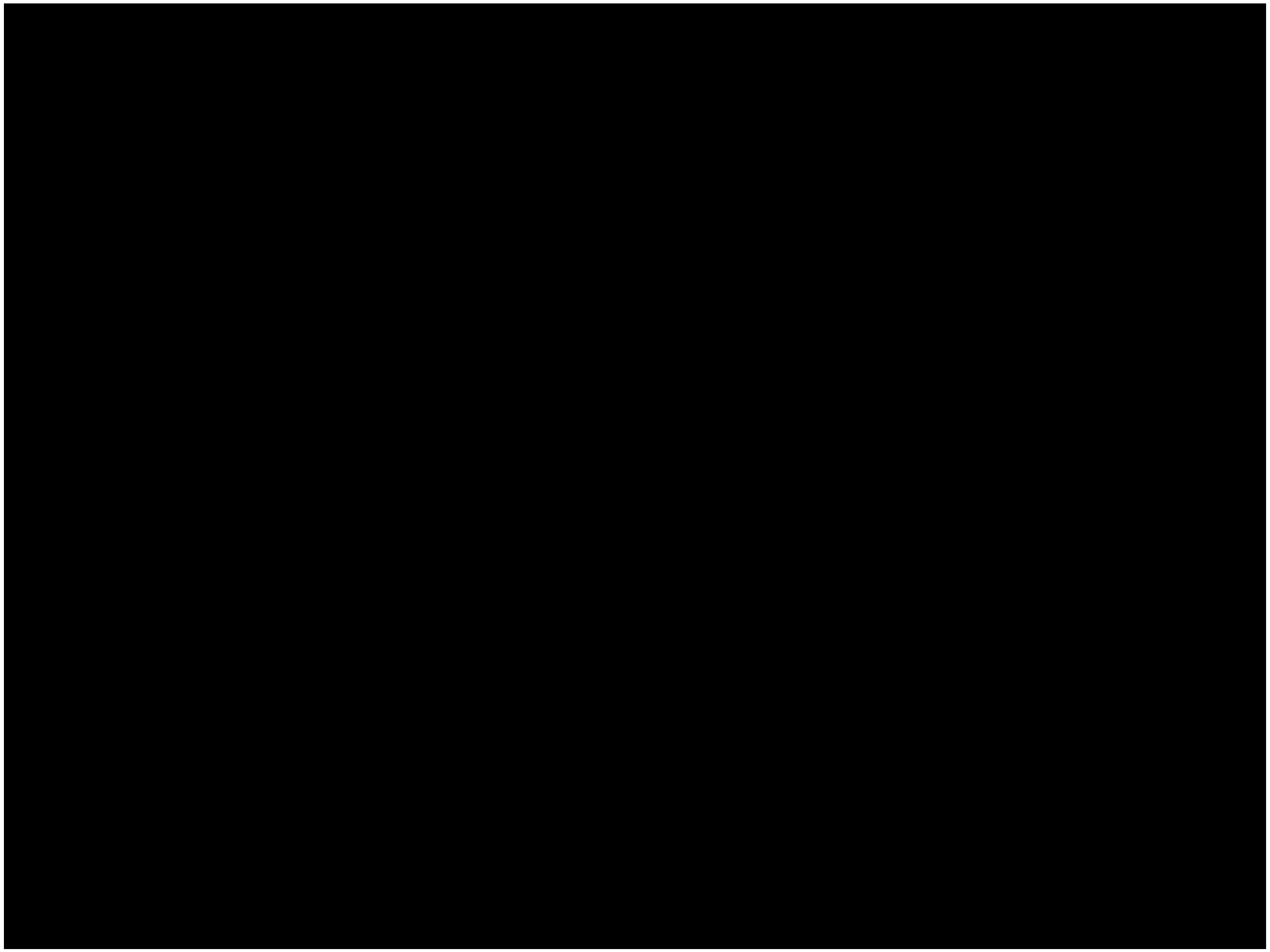


Shortcut to Shakey.ram.lnk

Shakey the Robot

The Helpmate System

Mobile Manipulation

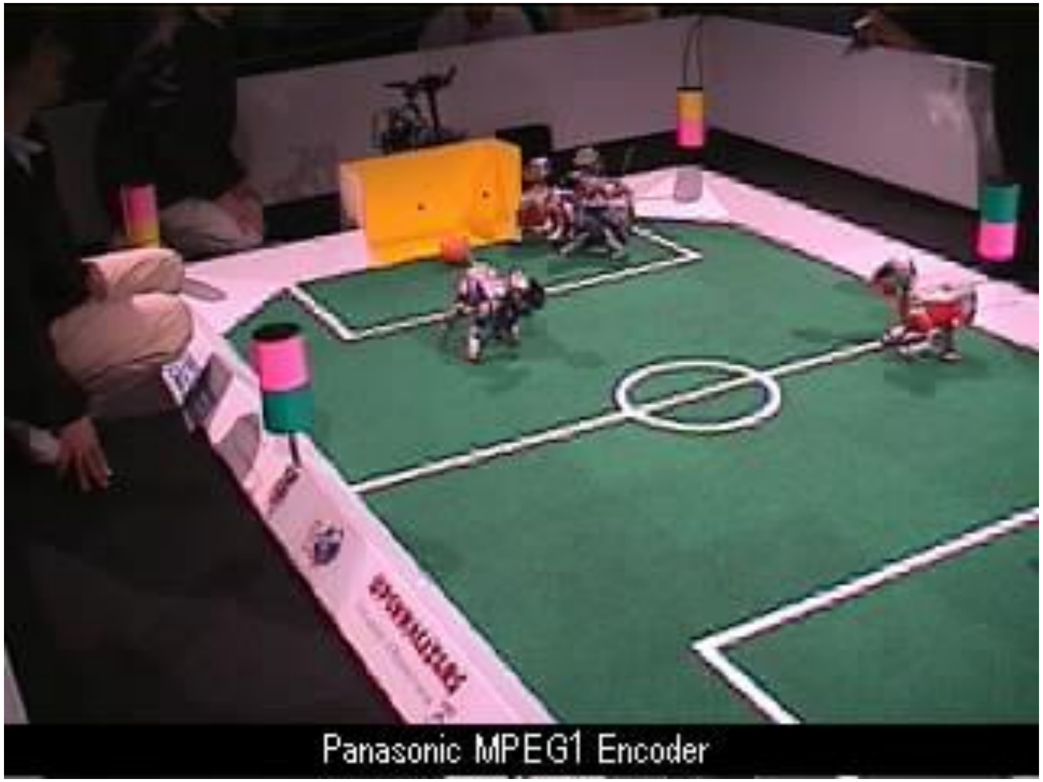


[Brock et al.]

DARPA Grand Challenge

[Courtesy by Sebastian Thrun]

RoboCup-99, Stockholm, Sweden



Emotional Robots: Cog & Kismet

[Brooks et al., MIT AI Lab, 1993]

PR2 Robot

PR2 Robot

pr2-drawing.m4v

General Background

- Autonomous, automaton
  - self-willed (Greek, auto+matos)

- Robot
  - Karel Capek in 1923 play R.U.R. (Rossum's Universal Robots)
    - labor (Czech or Polish, robota)
    - workman (Czech or Polish, robotnik)

Asimov's Three Laws of Robotics

1. A robot may not injure a human being, or, through inaction, allow a human being to come to harm.

2. A robot must obey the orders given it by human beings except when such orders would conflict with the first law.

3. A robot must protect its own existence as long as such protection does not conflict with the first or second law.

[Runaround, 1942]

Wiener, Cybernetics

- Studied regulatory systems and their application to control (antiaircraft gun)

- "it has long been clear to me that the modern ultra-rapid computing machine was in principle an ideal central nervous system to an apparatus for automatic control; and its input and output need not be in the form of numbers or diagrams, but might very well be, respectively, the readings of artificial sensors such as photoelectric cells or thermometers, and the performance of motors or solenoids".

[Electronics, 1949]

Trends in Robotics Research

Classical Robotics (mid-70's)

- exact models
- no sensing necessary

Reactive Paradigm (mid-80's)

- no models
- relies heavily on good sensing

Hybrids (since 90's)

- model-based at higher levels
- reactive at lower levels

Probabilistic Robotics (since mid-90's)

- seamless integration of models and sensing
- inaccurate models, inaccurate sensors

Brief Case Study: Museum Tour-Guide Robots

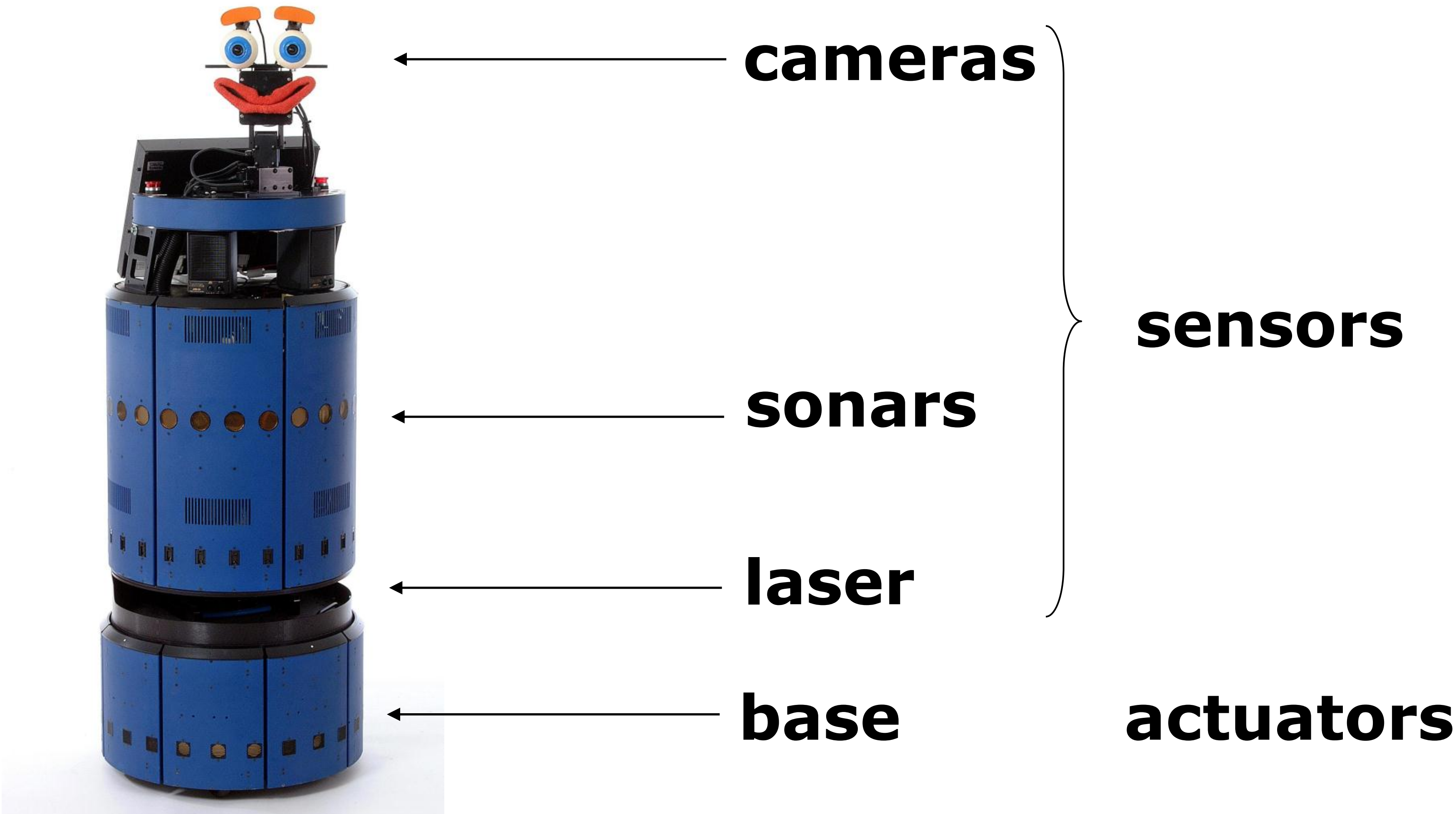
Rhino, 1997

Minerva, 1998

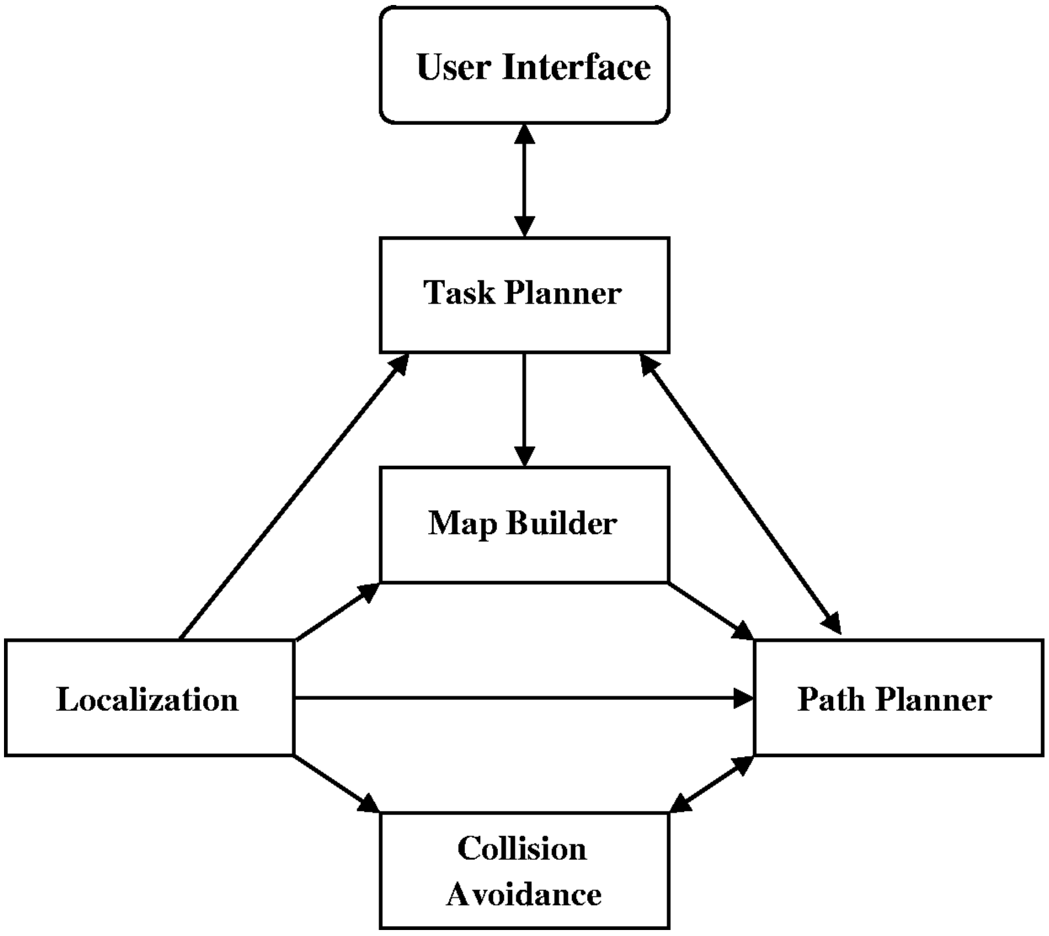
Rhino (Univ. Bonn + CMU, 1997)

Minerva (CMU + Univ. Bonn, 1998)

Components of Typical Robots



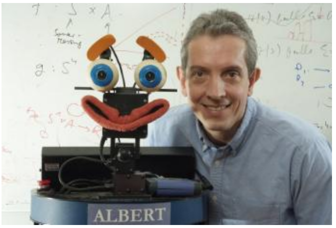
Architecture of a Typical Control System



Robotics in Freiburg

Foundations of Artificial Intelligence
Bernhard Nebel

Machine Learning
Martin Riedmiller



Autonomous Intelligent Systems
Wolfram Burgard

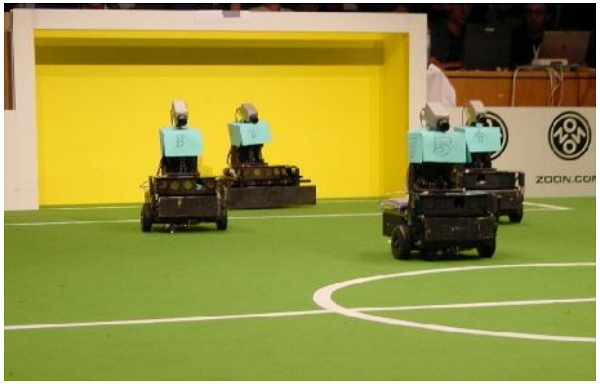
Autonomous Intelligent Systems
Cyrill Stachniss

Humanoid Robots
Maren Bennewitz

Social Robotics
Kai Arras

Foundations of Artificial Intelligence

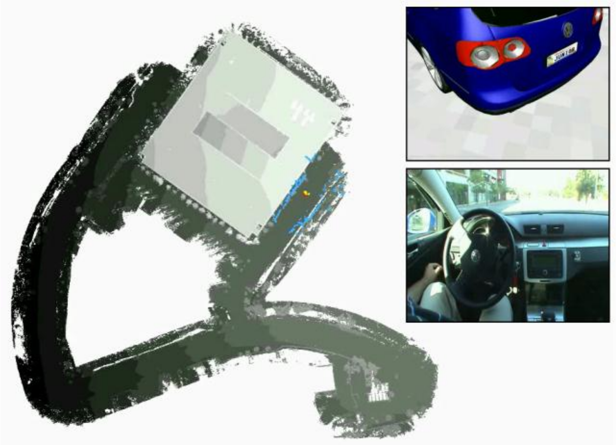
- Action Planning: Theory and Practice
  - Fast planning systems (intern. competitions!)
  - Applications at airports and for lift systems
  - Theoretical results (see new Russell/Norvig)
  - SFB AVACS
- Qualitative Temporal-Spatial Reasoning
  - Theory and reasoning algorithms
  - Application in qualitative layout description
  - SFB “Spatial Cognition”



- RoboCup
  - World champion three times
  - Autonomous table soccer
  - RoboCup Rescue
    (Multi-Agent-System for disaster relief)

Autonomous Intelligent Systems

- Mobile robots
- State estimation and models
- Adaptive techniques and learning
- Multi-robot systems
- Applications of mobile robots
- Robots and embedded systems
- Interaction and Web interfaces
- Probabilistic robotics






Machine Learning Lab

- Reinforcement Learning
- Supervised Learning
- Efficient Learning Algorithms
- Learning in Multi-Agent systems
- Self-learning robots
- Neural Forecasting Systems
- Neural Controllers
- Learning soccer robots in RoboCup
- Industrial Applications

Humanoid Robots

- Development of techniques for robots with
  - human-like body plan
  - human-like senses
- Navigation in complex indoor environments
  - 3D environment modeling
  - Path planning
  - Classification and learning
- Natural human-robot interaction
  - State estimation and modeling of people
  - Speech, gestures, facial expression, etc.

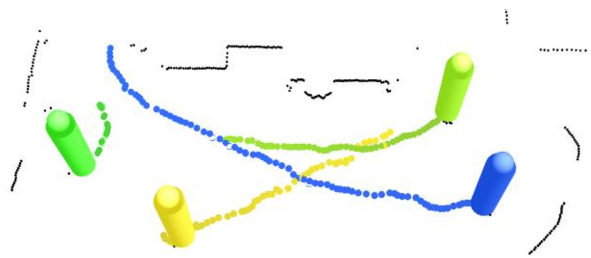


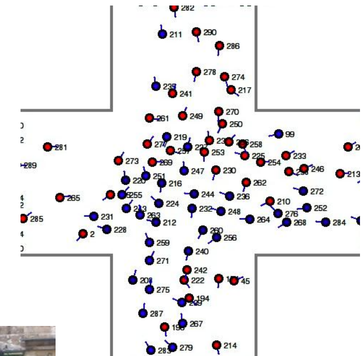


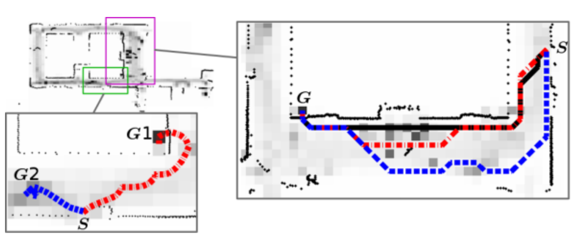
Social Robotics Lab

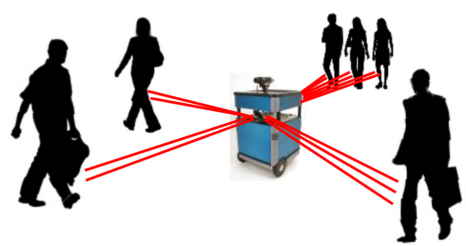
- Towards socially compatible robots
- Social learning, learning by observation
- People detection and tracking
- Motion planning
- Robot navigation
- Spatio-temporal models of human social behavior
- Human–robot interaction

"Free robots from their social isolation"









Robotics in Freiburg

- Foundations of Artificial Intelligence
- Machine Learning and Data Mining
- Knowledge Representation
- Autonomous Mobile Systems
- AI Planning
- Logic
- Game Theory
- Robotics II
- ...