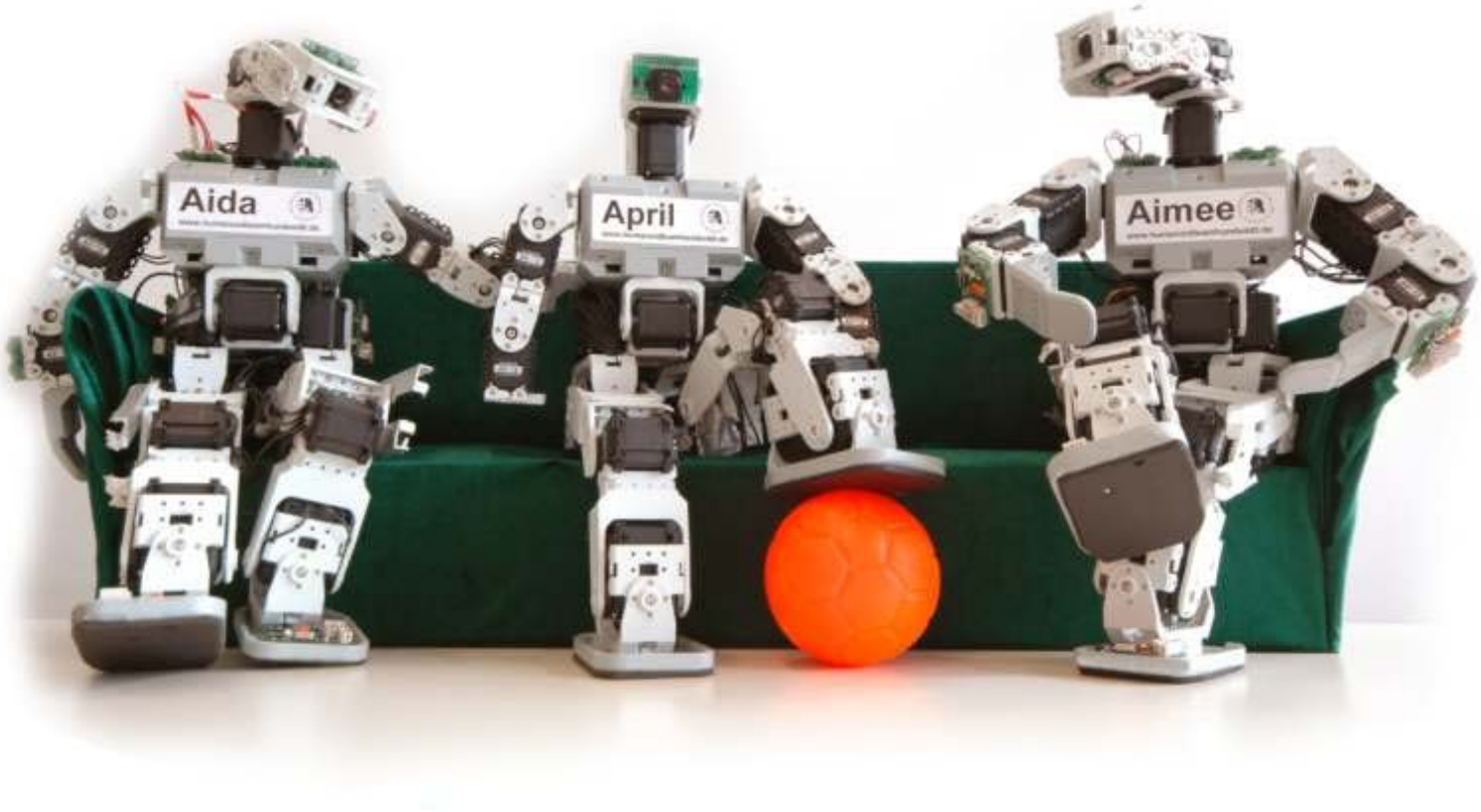
e-Robot – Online Learning with Humanoid Robots



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Research at the AI Lab

- Case Based Reasoning and Knowledge Management
- Agent-Oriented Techniques and Distributed AI
- Socionics and AI-Applications in Health Care
- Intelligent Robotics (Autonomous Mobile Systems)

AIBO Team

Simulation Team

Humanoid Team

All People Love Humanoids...

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...and so do Celebrities...

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...and even Students!

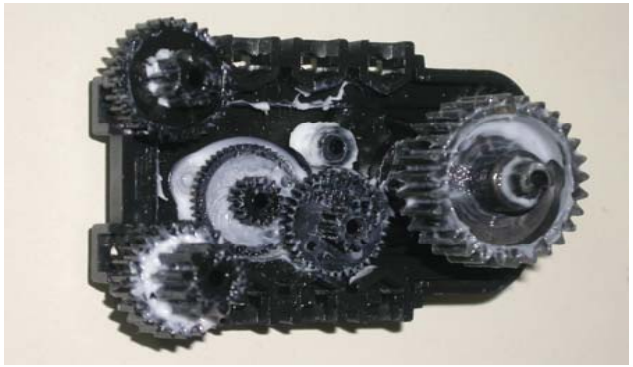
Advantages are:

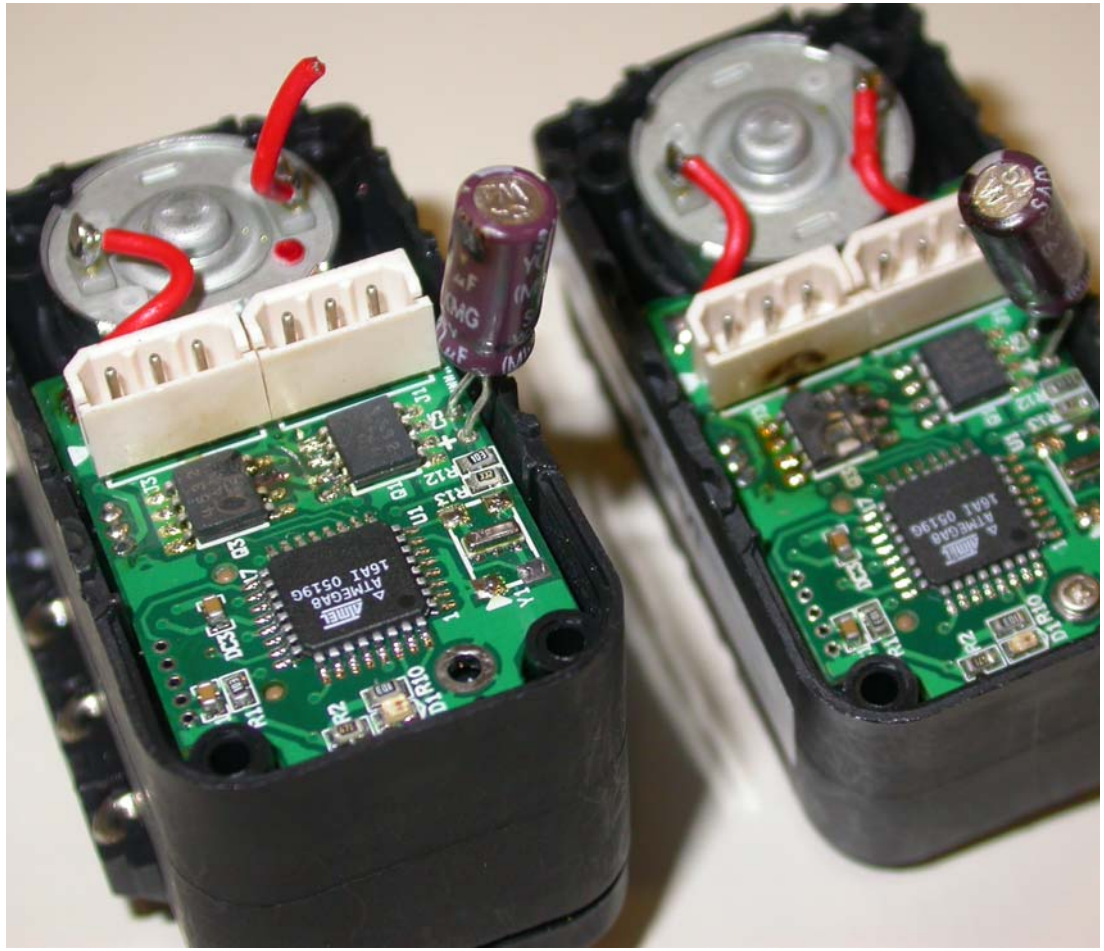
- Students are highly motivated
- Robotics is interdisciplinary:
  - Computer Science
  - Electronics
  - Mechanics
  - Physics
  - Biology
  - Psychology
- They have to work in groups
- Their results may be seen in the mass media

But there are also Problems:

- Only few students can be given access to the expensive hardware
- They need access for longer timespans in order to make something useful
- Simulation environments are by no means an adequate alternative
- The hardware is fragile

Examples of Broken Hardware





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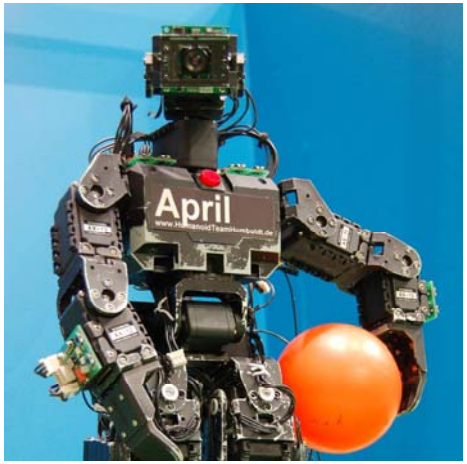
The Solution: e-Robot



- Robotics experiments with increasing complexity are set-up in the lab
- Cameras point to each experiment
- Students at home establish an online connection to an experiment server

- They execute their code
- They watch their experiment in real-time
- They get a video and sensori-motor data for offline analysis

Specific Hardware Components

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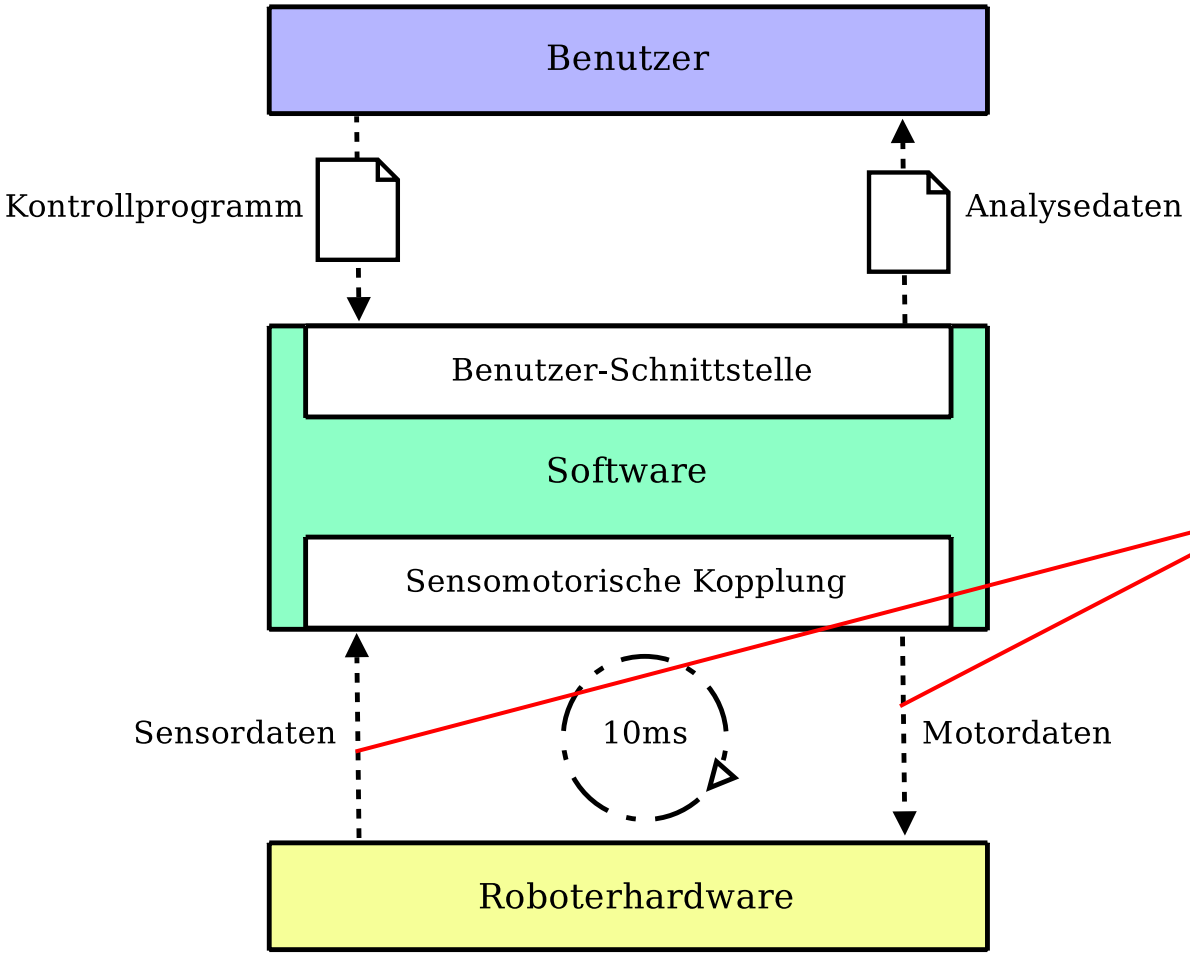
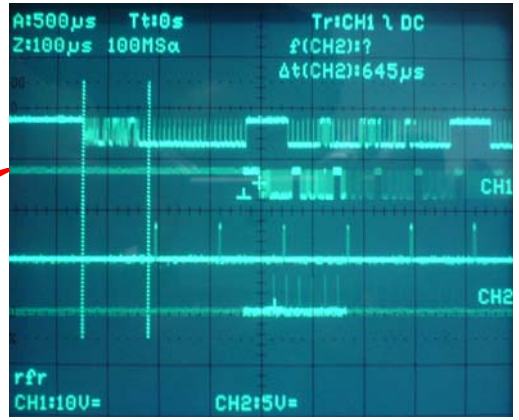
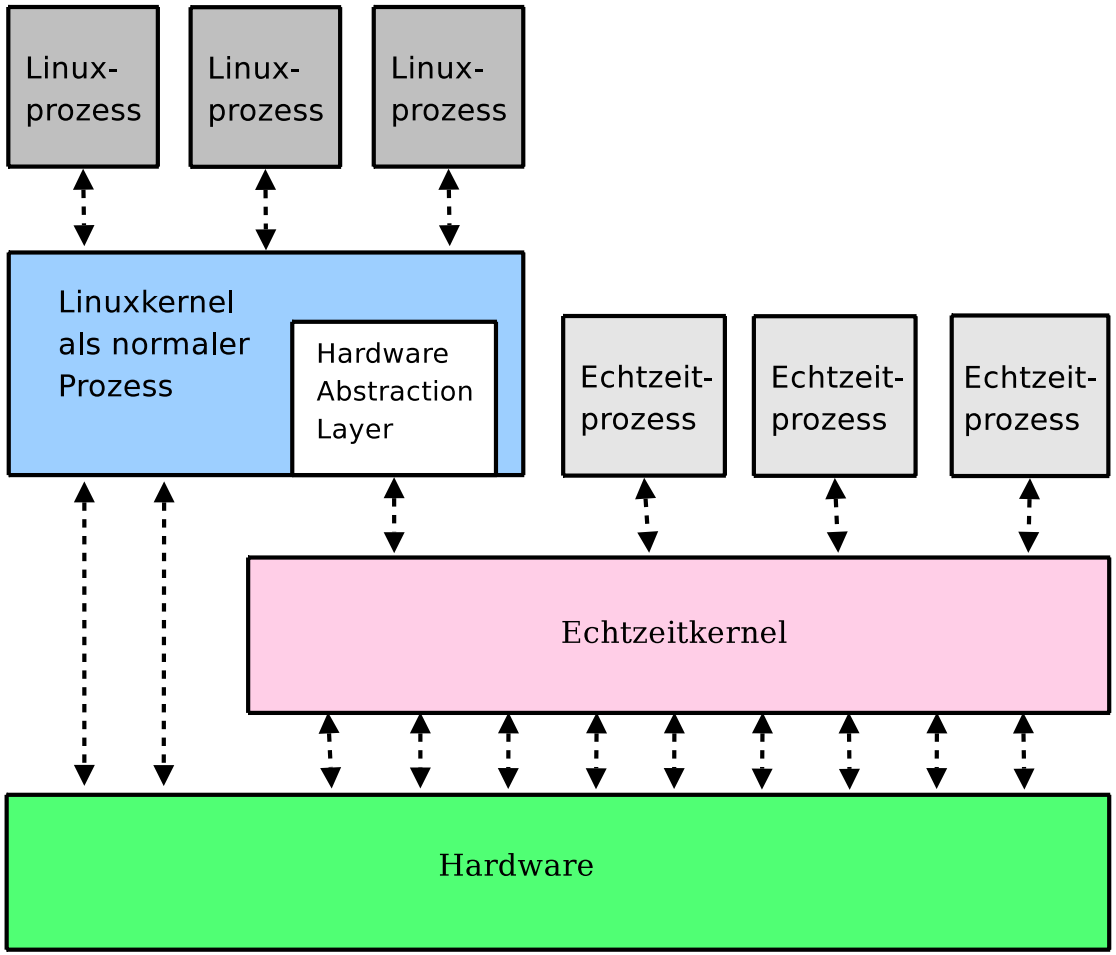
Data Flow

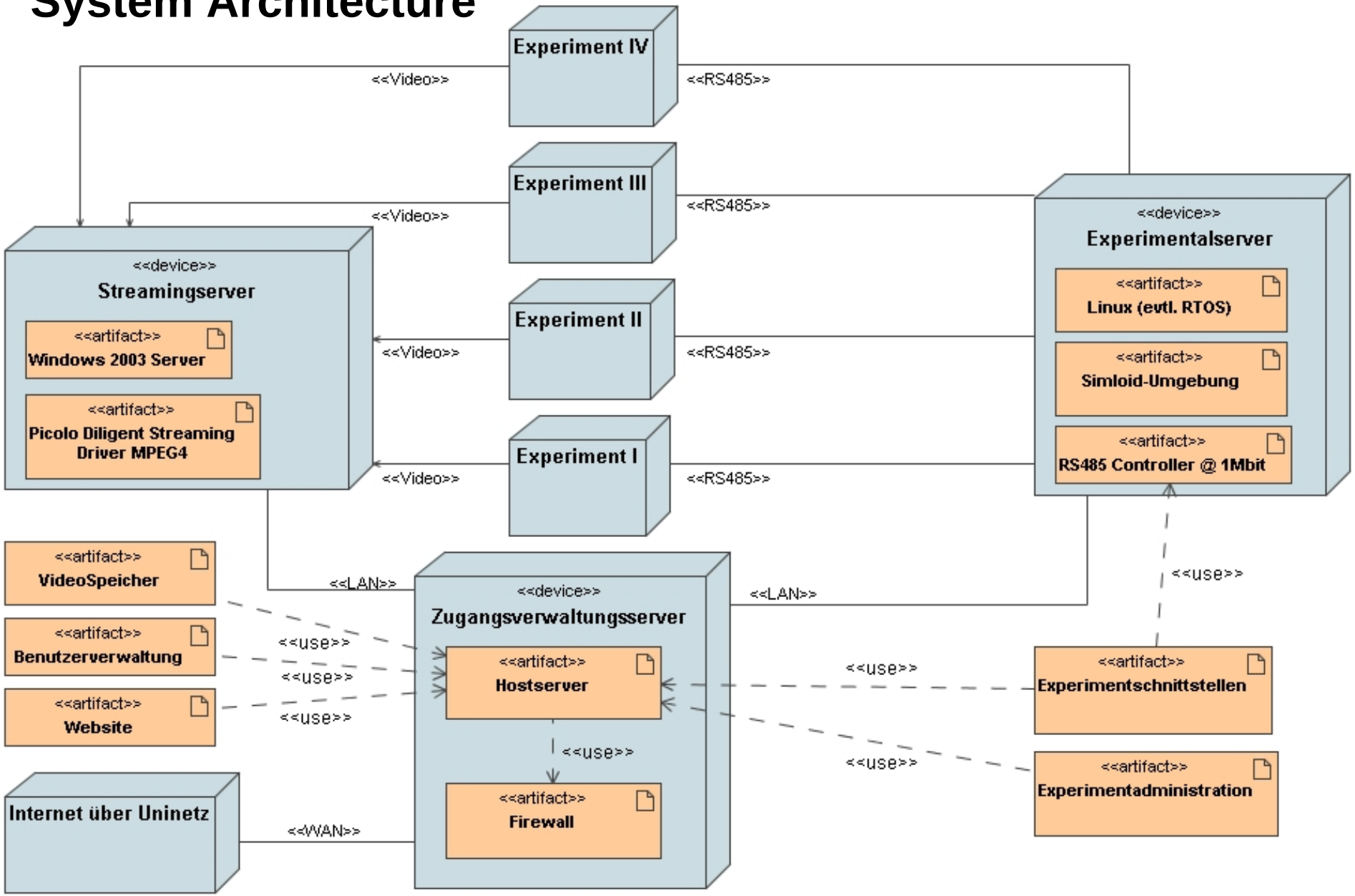

Benutzer
Kontrollprogramm
Analysedaten
Benutzer-Schnittstelle
Software
Sensomotorische Kopplung
Sensordaten
10ms
Motordaten
Roboterhardware


A:500µs T:0s
Z:100µs 100MSα
Tr:CH1 ↘ DC
f(CH2):?
Δt(CH2):645µs
CH1
CH2
rfr
CH1:10V=
CH2:5V=

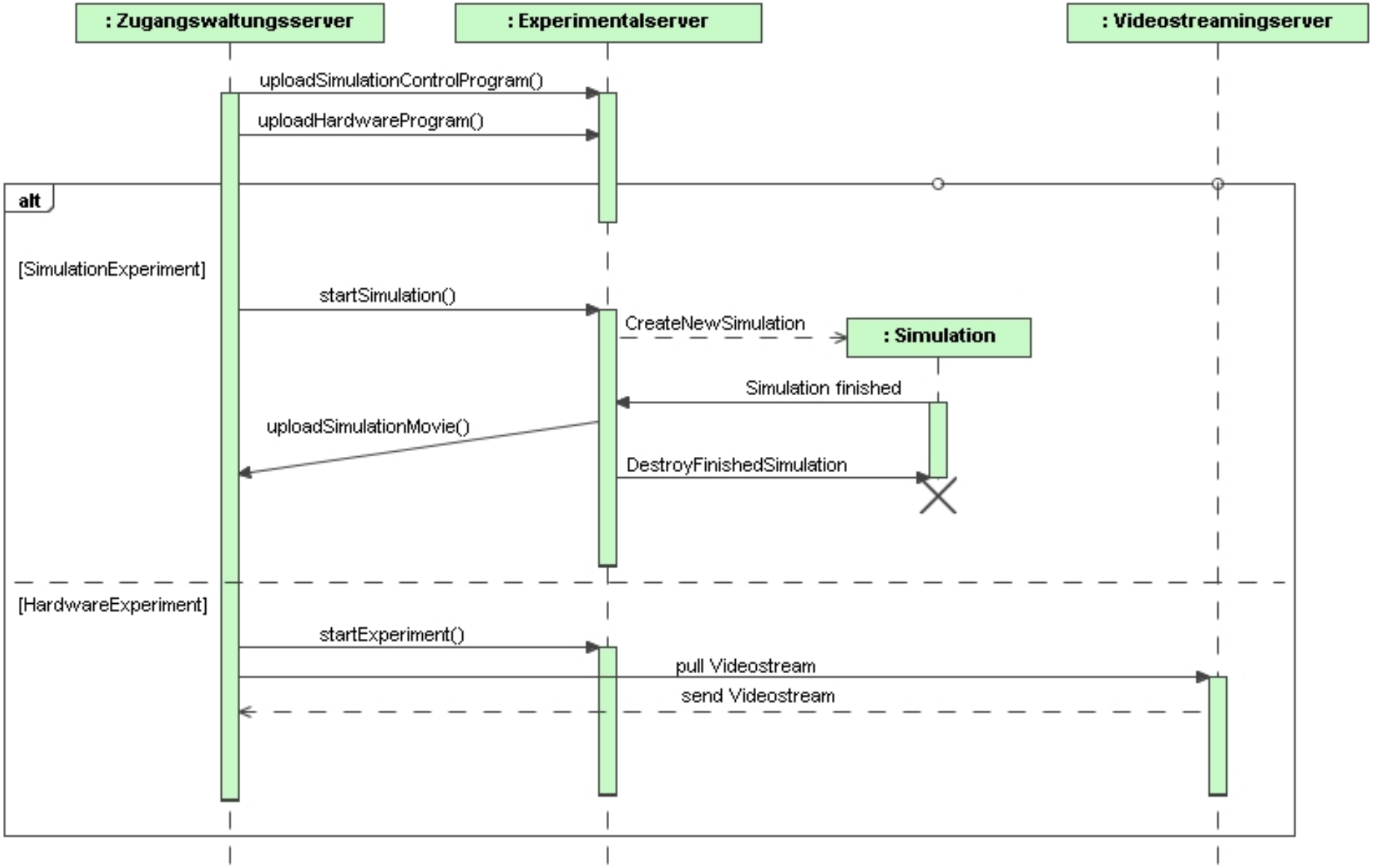
Real-time Kernel



System Architecture



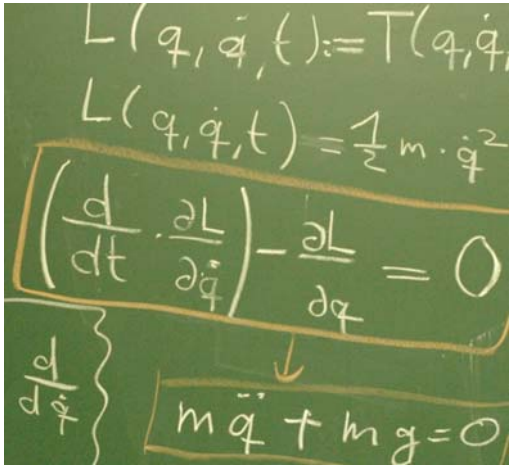
Process Interaction



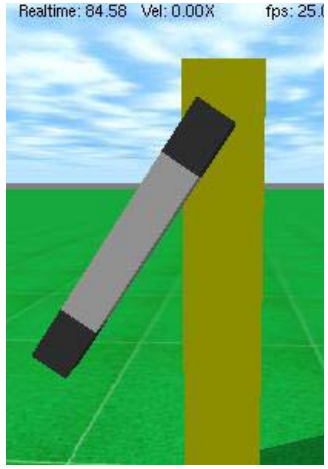
Time, Budget, and Staff

- Hardware costs overall:
  € 15.000
- Kick Off:
  June 2006
- Staff:
  Ferry Bachmann (HW, FW, Kernelmod.)
  Robin Meißner (Webservices, Video)
  Daniel Hein (Simulation Environment)

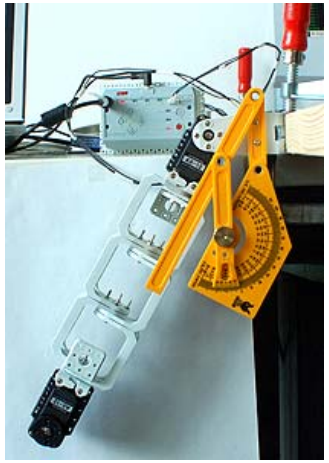
Didactic Path to the Real Robot



1. Theoretical Foundations



2. Simulation Experiment

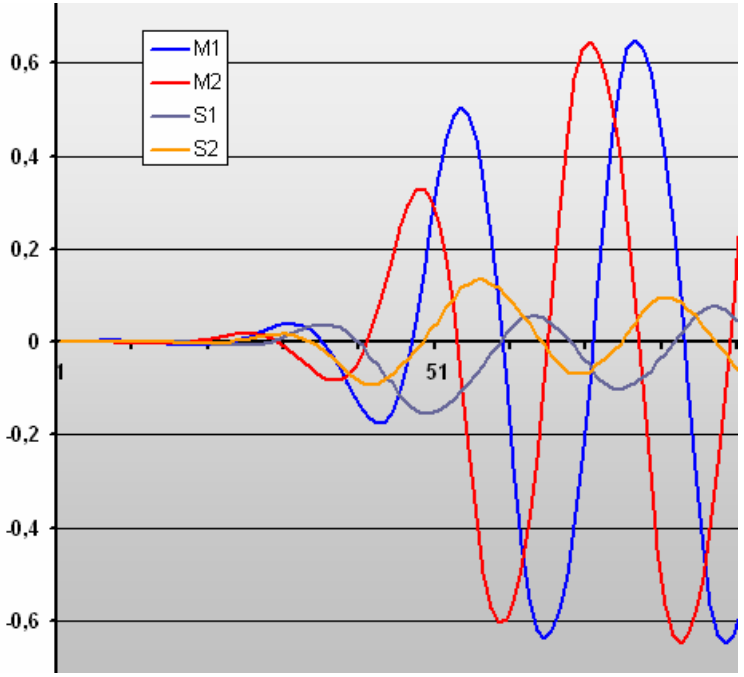


3. Using Real Hardware

Didactic Path to the Real Robot

```
INIT:       ; initialization

 0.000 >V1 ; set neurons' start values
 0.001 >V2

 ; use two dynamixels with fixed torque
 0.8 dup >D1.pt >D2.pt


LOOP:       ; sensorimotor loop

 ; sine and cosine waves
 V1>  1.1 * V2>  0.3 * + tanh ! dup >V1
 >D1.gp
 V1> -0.3 * V2>  1.1 * + tanh ! dup >V2
 >D2.gp

 D1.pp> ! drop     ; measure phase delay of
 D2.pp> ! drop     ; physical apparatus
```

Input Code and Output Data (and videos)



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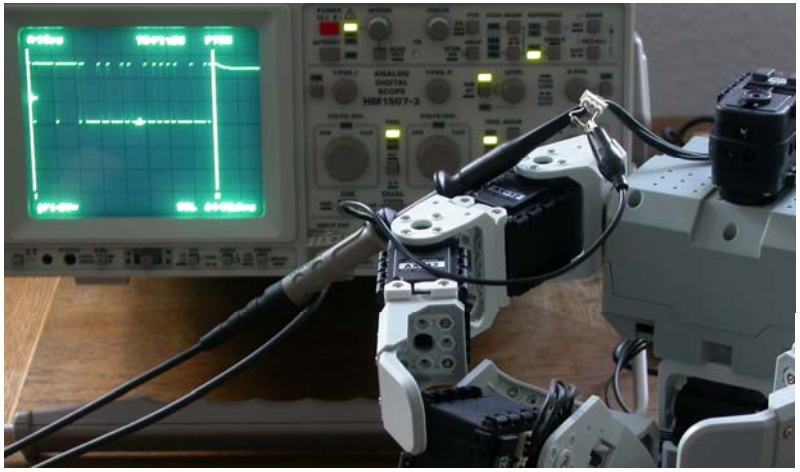
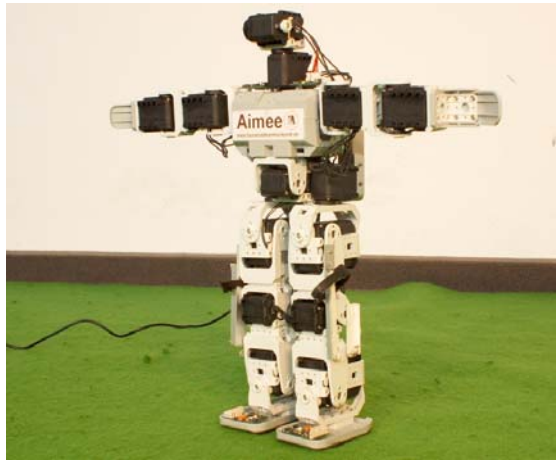
Didactic Path to the Real Robot

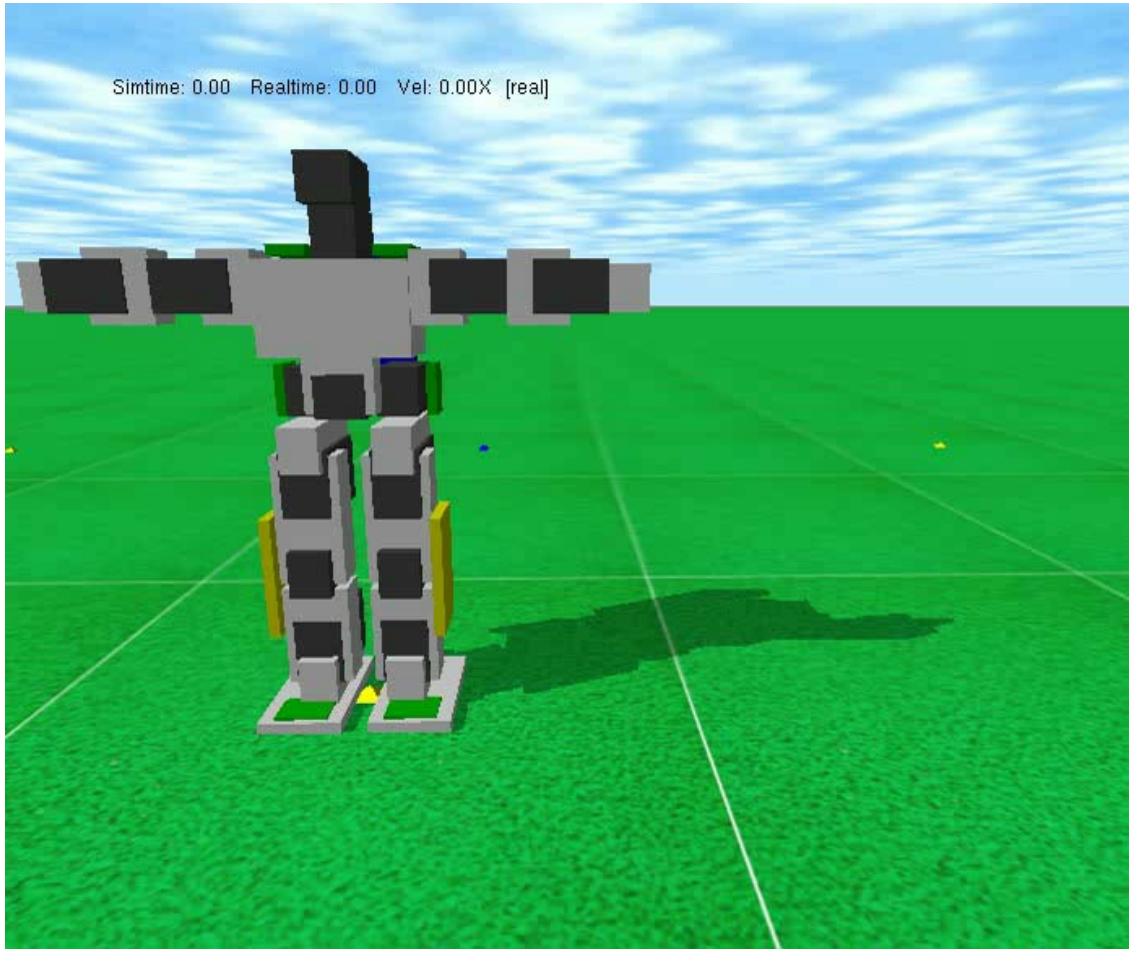


4. Switching to Parts of the Body

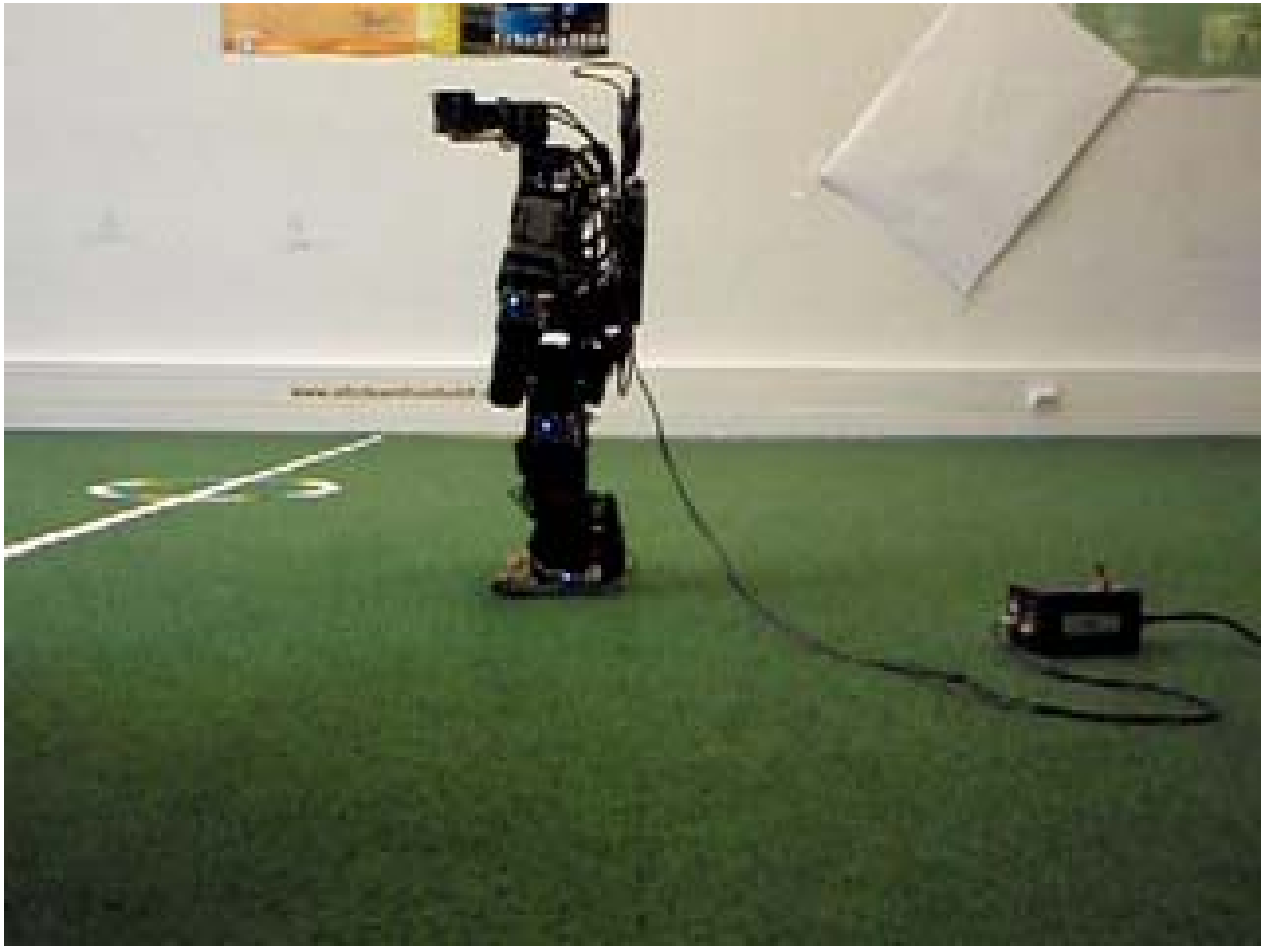


5. Using the Complete Robot

Simulation Example



Sensorimotor Loop on Robot



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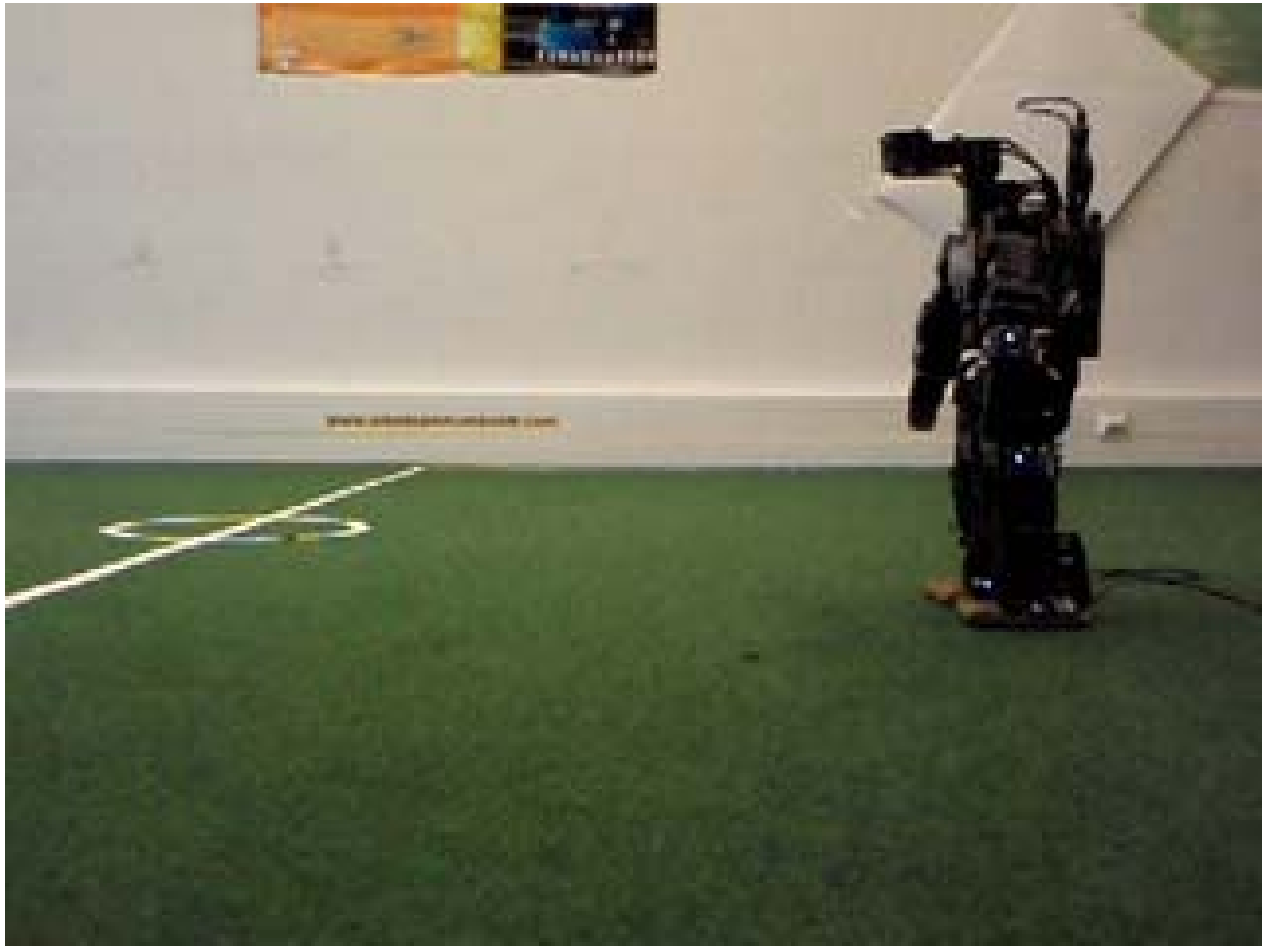
Sensorimotor Loop on Robot



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Advantages of e-Robot

- Many students are able to conduct experiments on real robots (Everybody)
- No restricted lab access (Anytime)
- Experiments can be terminated automatically in case of danger or potential harm to hardware (Safe)
- Results can be easily compared,
  therefore automatic tests/exams are possible (Objective)
- Access can be scheduled for people from the institute, the university, or the world (night shifts could go to Japan)
- Interdisciplinary and international communication
- Attractive for several institutes, and even schools

Testbed: RoboCup

- Championship of soccer-playing robots
- Takes place every year since 1997

- Many different leagues
- Vision:
  „In 2050 a team of humanoid robots should play (and win) against the human champion team according to the official FIFA rules.“

Meet at RoboCup 2009 in Graz...

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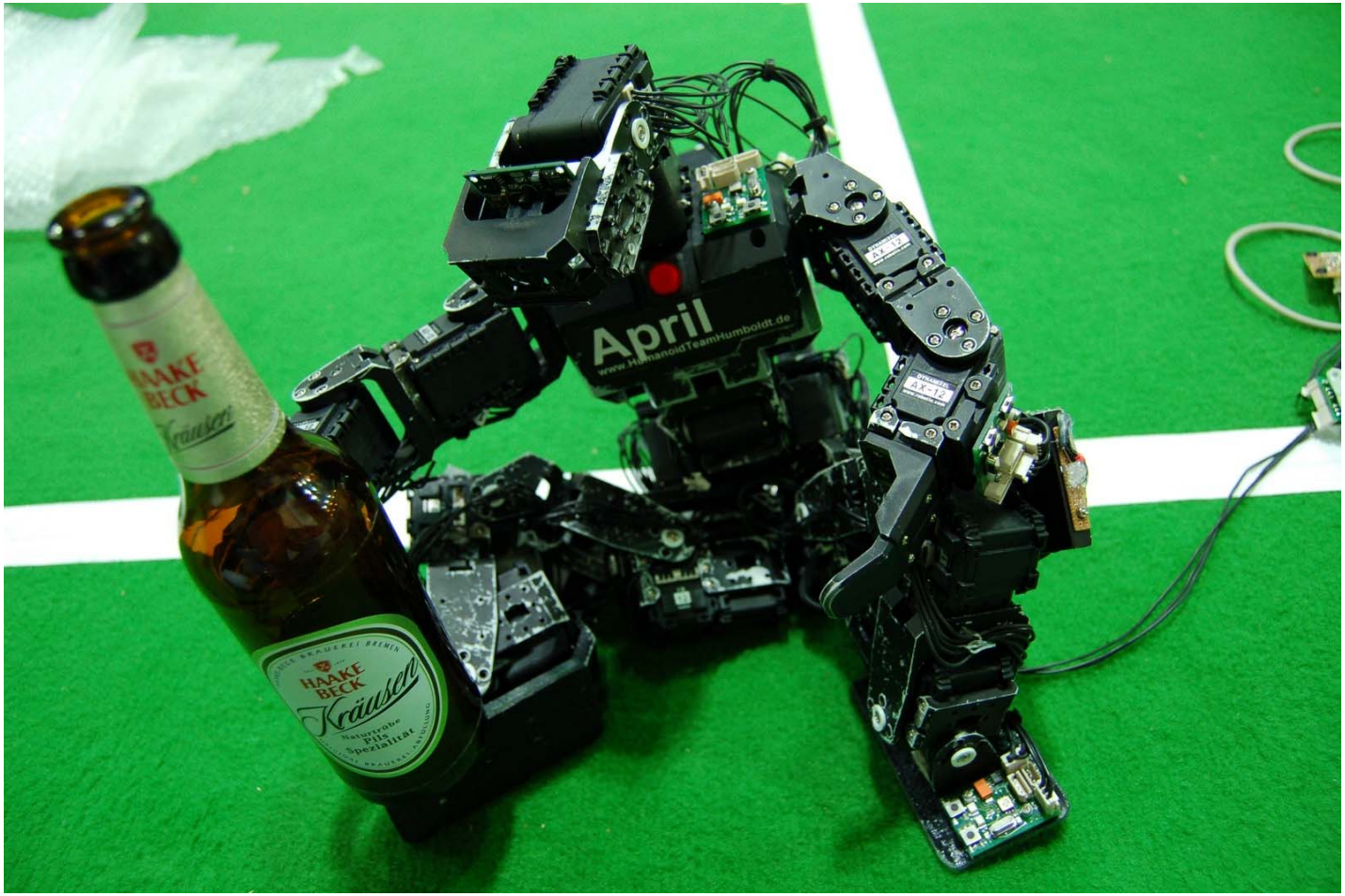
All Questions are Welcome!



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