e-Robot – Online Learning with Humanoid Robots
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)
All People Love Humanoids...
e-Robot – Online Learning with Humanoid Robots

...and so do Celebrities...

Manfred Hild
September, 13th, 2007

Computer Science Department
Artificial Intelligence Lab
...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
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

Interface

Actuators

Sensors
e-Robot – Online Learning with Humanoid Robots

Data Flow

- Benutzer
- Kontrollprogramm
- Analysedaten
- Benutzer-Schnittstelle
- Software
- Sensomotorische Kopplung
- Sensordaten
- Motoradaten
- 10ms
- Roboterhardware
Real-time Kernel

Linuxprozess → Linuxkernel als normaler Prozess → Hardware Abstraction Layer → Echtzeitprozess

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Echtzeitkernel

Hardware
System Architecture

Experiment IV

Experiment III

Experiment II

Experiment I

Streamingserver

Windows 2003 Server

Piccolo Diligent Streaming Driver MPEG4

VideoSpeicher

Benutzerverwaltung

Website

Internet über Uninetz

Zugangsverwaltungsserver

Hostserver

Firewall

Network:

LAN

USB

WAN

Experimentschnittstellen

Experimentadministration

Experimentserver

Linux (exkl. RTOS)

Simloid-Umgebung

RS485 Controller @ 1Mbit

Device:

Video

RS485
Process Interaction

- Zugangswaltungsserver
- Experimentalserver
- Videostreamingserver

**SimulationExperiment**
- startSimulation()
- CreateNewSimulation
- Simulation finished
- DestroyFinishedSimulation

**HardwareExperiment**
- startExperiment()
- pull Videostream
- send Videostream
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)
Didactic Path to the Real Robot

4. Switching to Parts of the Body
5. Using the Complete Robot
Simulation Example
Sensorimotor Loop on Robot
Sensorimotor Loop on Robot
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.“
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Meet at RoboCup 2009 in Graz...
All Questions are Welcome!