KIT-Focus: Anthropomatics and Robotics

Tamim Asfour

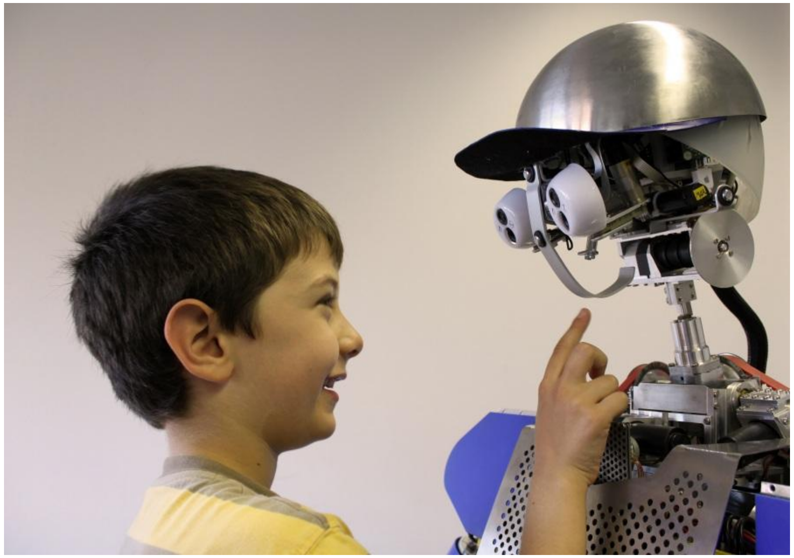
KIT-FOCUS ANTHROPOMATICS AND ROBOTICS

Robotics is …

… the science of automatic handling, services for humans and manufacturing

Anthropomatics is …

… the science of the symbioses between human and machine



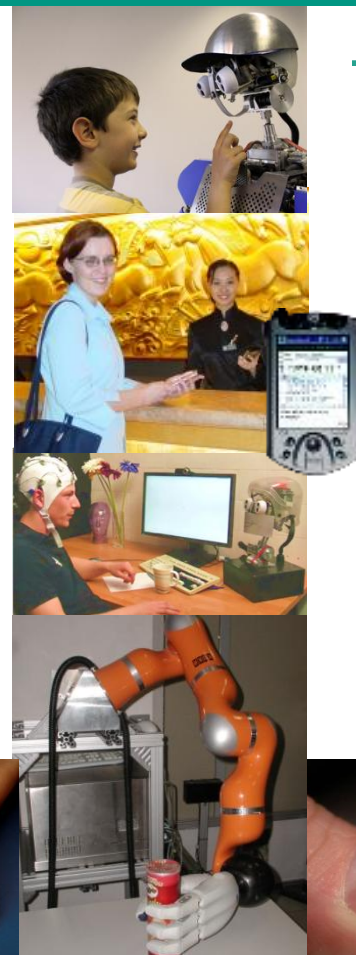
KIT-Focus: Anthropomatics and Robotics

Anthropomatics is…

… the science of the symbioses between human and machine

Research topics

- Multimodal Human-Machine Interaction
- Image and Speech Understanding
- Learning through Experience and Interaction
- Biosignal Processing
- Cognitive Information Processing
- Human-Machine Interfaces



Robotics is…

… the science of automatic handling, services for humans and manufacturing

Research topics

- Humanoid Robotics
- Service Robotics
- Industrial Robotics
- Medical Robotics
- Micro Robotics
- Swarm Robotics

Strategic Goal and Mission

Design, implement and evaluate anthropomatic systems to improve humans' quality of life

- Understanding of humans in terms of anatomy, motoric, perception, behavior and information processing
- Building systems and technologies that coexist with humans as assistants and companions at different ages, in different situations, different environments and with varying activities
- Technology transfer to different industries

Research Topics

MI – Machine Intelligence
- Representations
- Memory Structures
- Machine Learning
- Cognitive Architectures

HCR – Human-Centered Robotics
- Humanoid and Service Robotics
- Prosthetics and Orthotics
- Medical Robotics
- Sensor-Actuator Networks

MIC – Multimodal Interaction and Communication
- Speech Processing and Translation
- Robot and Computer Vision
- Biosignal Processing
- Multimodal Perception

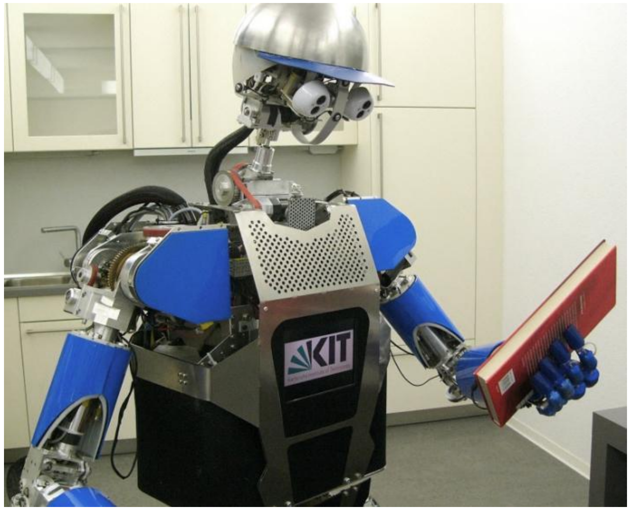
RT – Robot Technologies
- Mechatronics and Control
- Lightweight Design
- Sensors and Actuators
- Embedded Systems

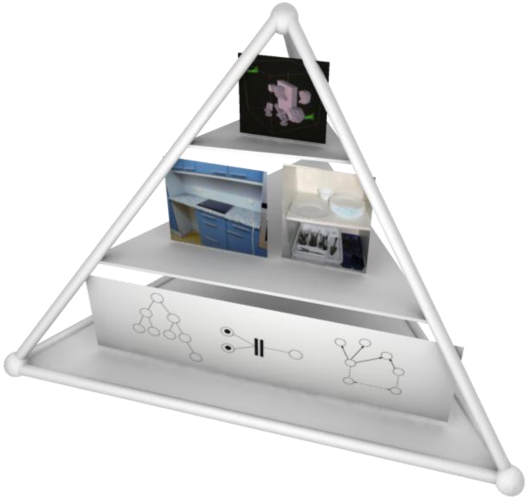
IR – Industrial Robotics
- Manufacturing
- Automation
- Industrial Vision Processing
- Supervision

TT – Technology Transfer

Machine Intelligence

- How to implement intelligence in technical systems?
- How can robots learn from humans?
- How can knowledge be represented at different levels of abstraction?
- How can memory structures and cognitive architectures be realized in technical systems?





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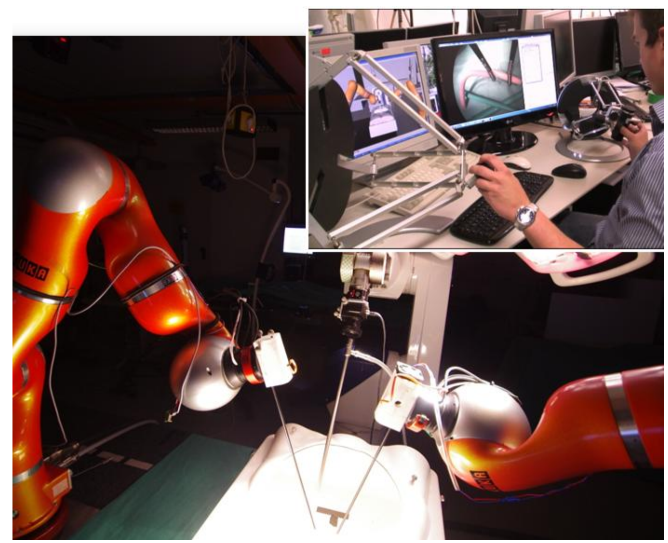
Human Centered Robotics

- Humanoid robots that act and interact in the real world to perform a wide variety of tasks
- Prosthetic and orthotic devices
- Intelligent systems for medical assistance in the diagnosis and treatment
- Robot-assisted and robot-guided surgery



Multimodal Interaction and Communication

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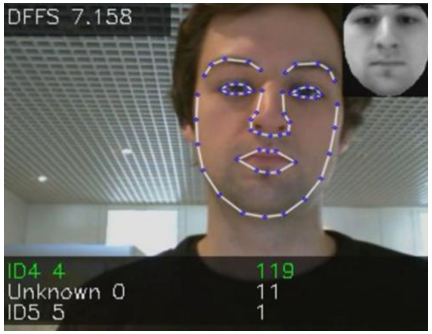
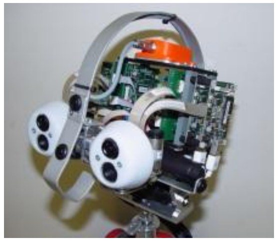
- Systems for automatic speech recognition, translation and syntheses
- Applications: Simultaneous translation of lectures and debates in Parliament
- Biosignal analysis for salient Speech
- Face recognition, facial expressions and gaze direction detection for the development of better Human-Machine Interfaces



Robot Technologies

- Mechatronics for anthropomatic Systems such as humanoid and service robots
- Light-weight and energy efficient robot components
- Microrobot for the handling of objects in micro-and nano-scale



Industrial Robotics

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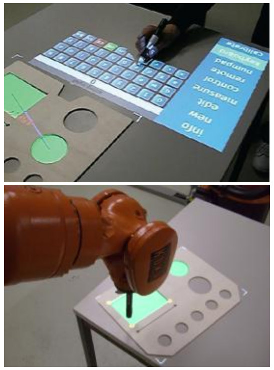
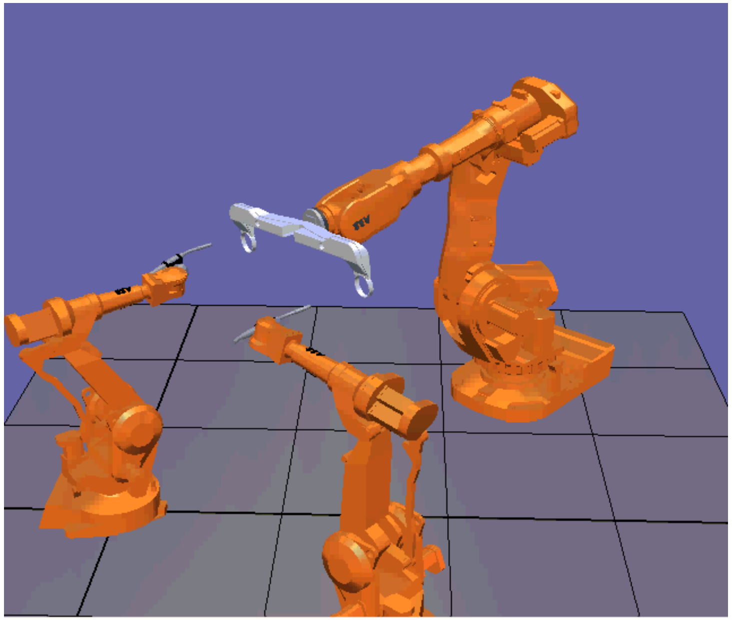
- Novel Man-Machine Interfaces for programming of and interaction with industrial robots
- New sensor technologies and user interfaces for enhanced safety
- Sensor-based control of robotic systems in tasks, such as assembly, handling, inspection and testing





Members of the KIT APR-Focus

- 4 Departments
  - Department of Informatics
  - Department of Electrical Engineering and Information Technology
  - Department of Mechanical Engineering
  - Department of Humanities and Social Sciences

- Partners
  - Fraunhofer Institute of Optronics, System Technologies and Image Exploitation (IOSB)
  - Research Center for Information Technology (FZI)
  - International Center for Advanced Communication Technologies (interACT)
  - Study Centre for the Visually Impaired Students (SZS)
  - Städtisches Klinikum Karlsruhe, Department of Neurosurgery

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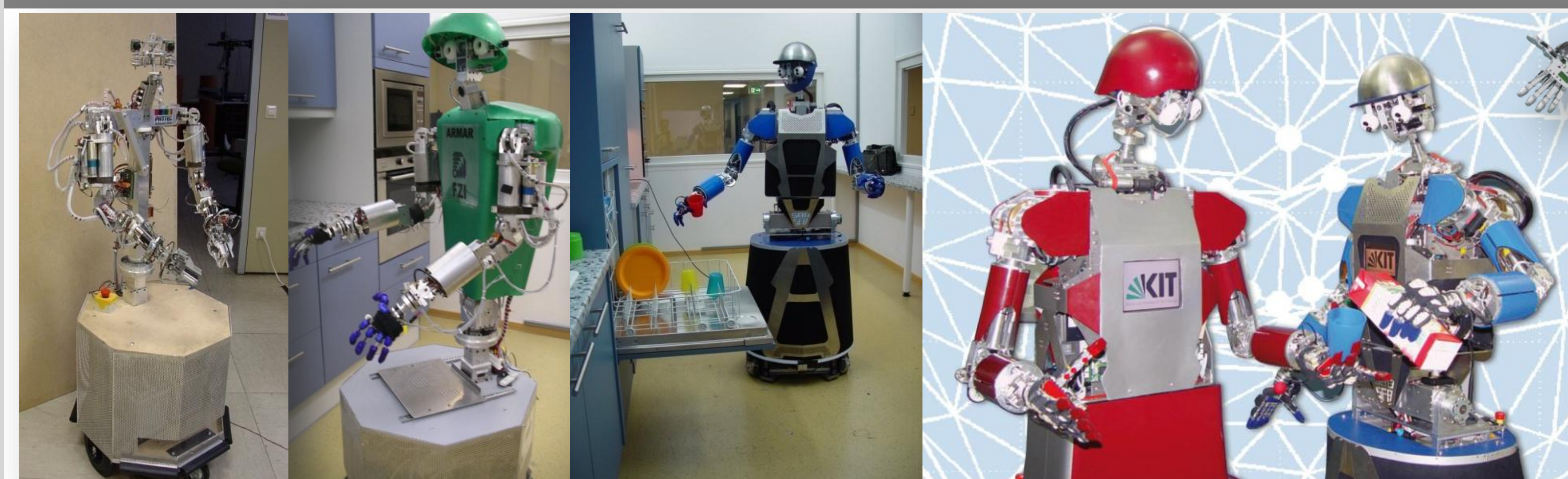
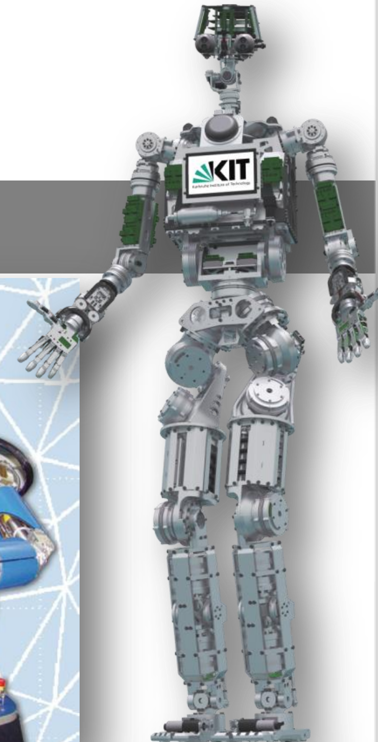
Humanoid Research @ KIT

Tamim Asfour

Institute for Anthropomatics (IFA)
High Performance Humanoid Technologies (H^2T)





http://his.anthropomatik.kit.edu/english/65.php

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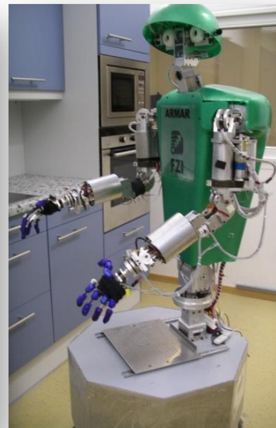
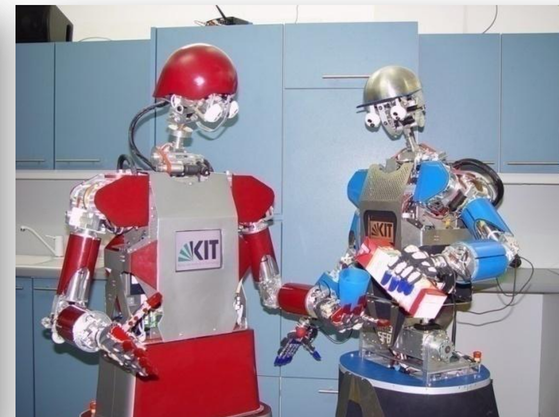
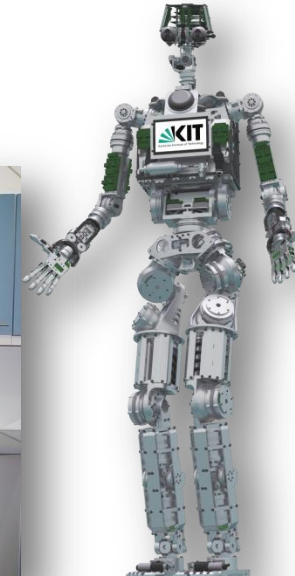
Humanoid Robots @ KIT


ARMAR, 2000


ARMAR-II, 2002


ARMAR-IIIa, 2006


ARMAR-IIIb, 2008

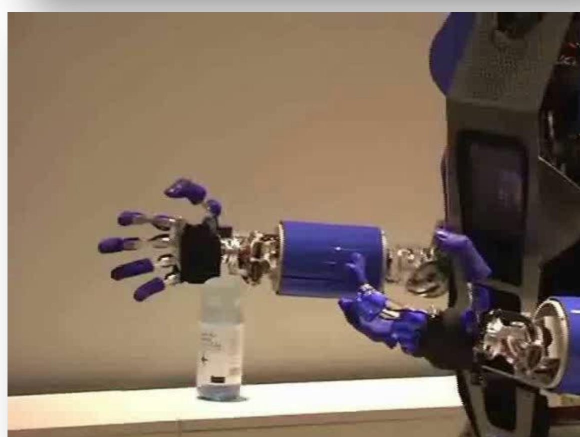

ARMAR-IV, 2011

- Collaborative Research Center 588: Humanoid Robots - Learning and Cooperating Multimodal Robots (SFB 588)
  - Funded by the German Research Foundation (DFG: Deutsche Forschungsgemeinschaft)
  - 2001 – 2012
  - http://www.sfb588.uni-karlsruhe.de/

Deutsche Forschungsgemeinschaft
DFG

ARMAR-IIIa and ARMAR-IIIb

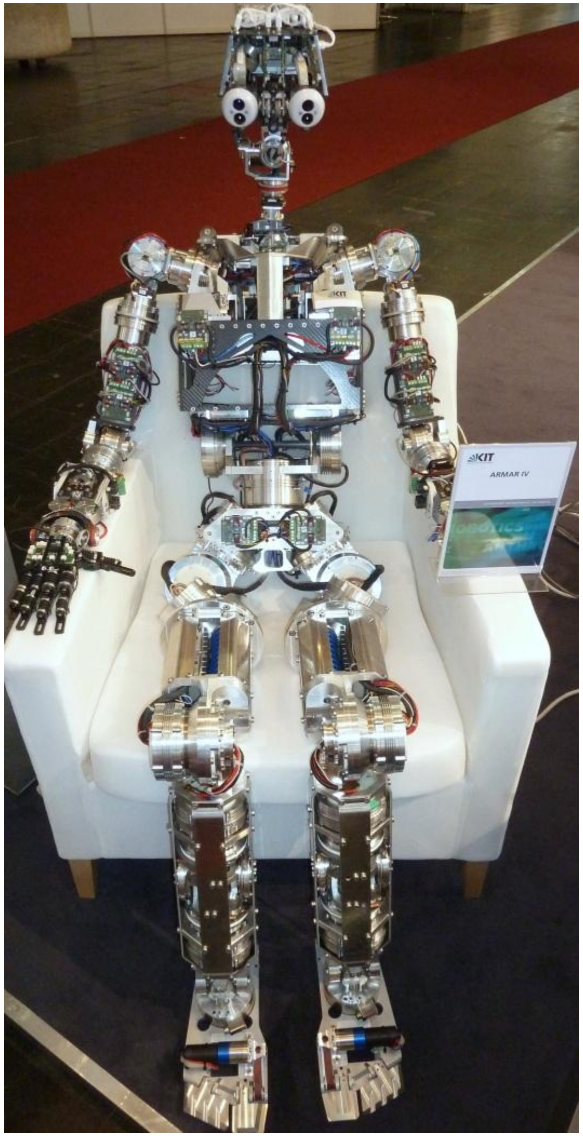
- 7 DOF head with foveated vision
  - 2 cameras in each eye
  - 6 microphones
- 7-DOF arms
  - Position, velocity and torque sensors
  - 6D FT-Sensors
  - Sensitive Skin
- 8-DOF Hands
  - Pneumatic actuators
  - Weight 250g
  - Holding force 2,5 kg
- 3 DOF torso
  - 2 Embedded PCs
  - 10 DSP/FPGA Units
- Holonomic mobile platform
  - 3 laser scanner
  - 3 Embedded PCs
  - 2 Batteries
- Weight: 150 kg

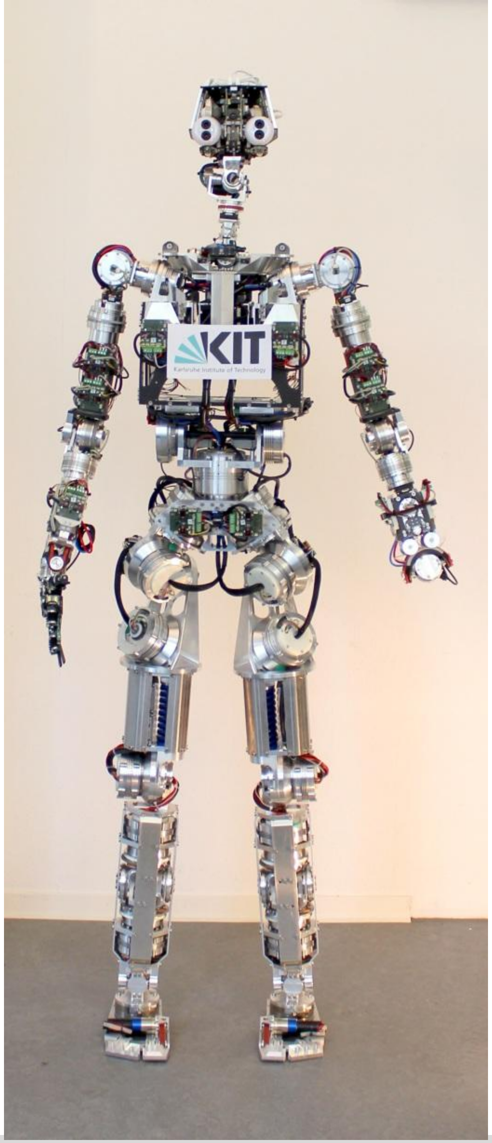


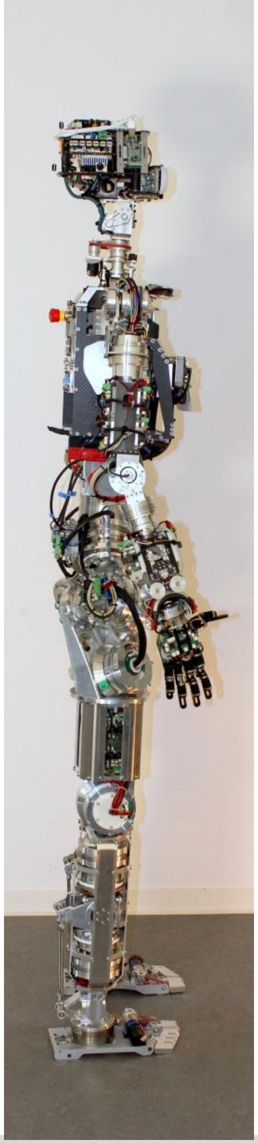
Fully integrated humanoid system

ARMAR-IV

- 63 DOF
- 170 cm
- 70 kg
- Torque-controlled!







ARMAR-IV: Mechano-Informatics

- Torque controlled
- 3 on-board embedded PCs
- 76 Microcontroller
- 6 CAN Buses

- 63 DOF
  - 41 electrically-driven
  - 22 pneumatically-driven (Hand)

- 238 Sensors
  - 4 Cameras
  - 6 Microphones
  - 4 6D-force-torque sensors
  - 2 IMUs
  - 128 position (incremental and absolute), torque and temperature sensors in arm, leg and hip joints
  - 18 position (incremental and absolute) sensors in head joints
  - 14 load cells in the feet
  - 22 encoders in hand joints
  - 20 pressure sensors in hand actuators
  - …

More than mechatronics

ARMAR-IV

made@KIT

70 kg

170 cm

Three key questions

- Grasping and manipulation in human-centered and open-ended environments
- Learning through observation of humans and imitation of human actions
- Interaction and natural communication

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ARMAR-III in the RoboKITchen

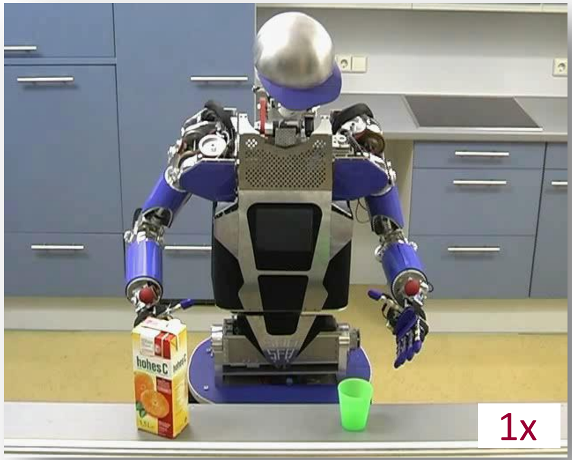
- Object recognition and localization
- Vision-based grasping
- Hybrid position/force control
- Combining force and vision for opening and closing door tasks
- Collision-free navigation
- Vision-based self-localisation
- Multimodal human-robot dialogs
- Continuous speech recognition
- Learning new objects, persons and words
- Audio-visual tracking and localization
- …

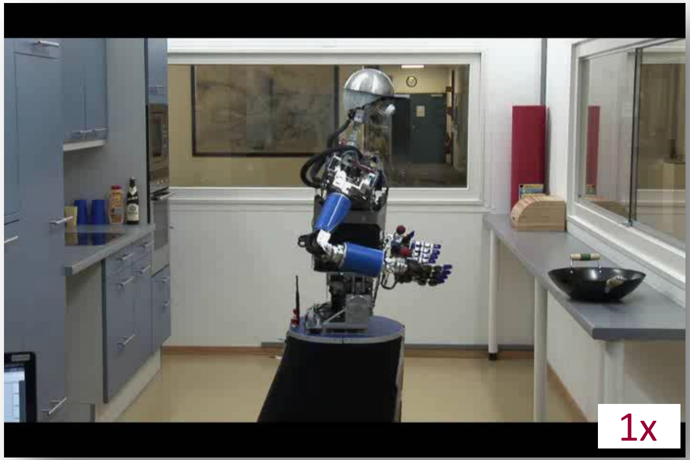
ARMAR-III in the RoboKITchen

- First step towards 24/7
  - 45 minutes demonstration
  - Shown more than 600 times, since 03. February 2008, to experts and public (75 times in 5 days for approx. 5000 visitors at CeBIT 2012)

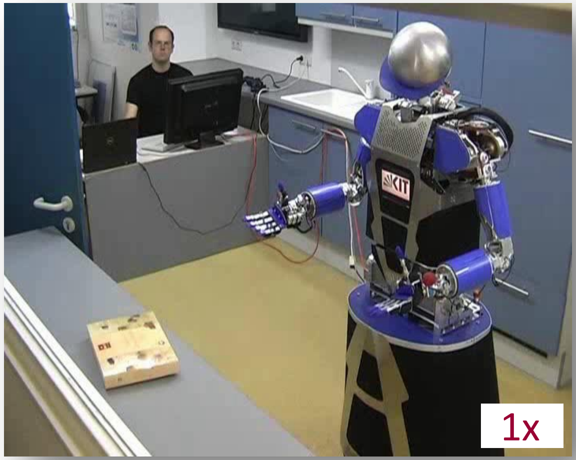
Advanced grasping capabilities

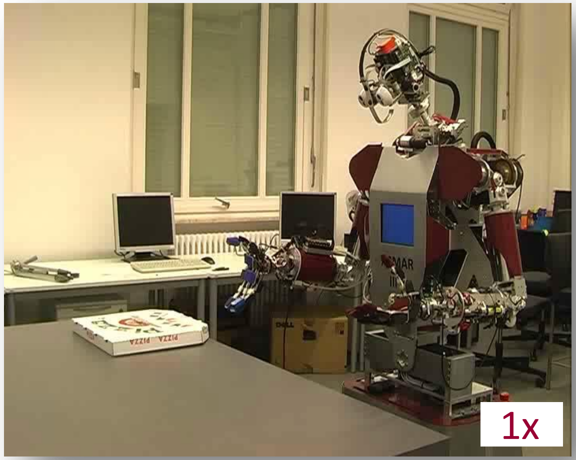
- Bimanual grasping and manipulation





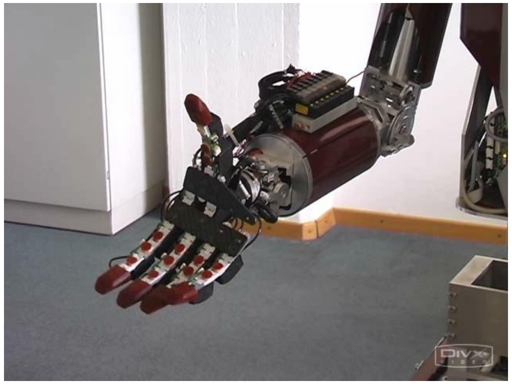
- Pre-grasp manipulation

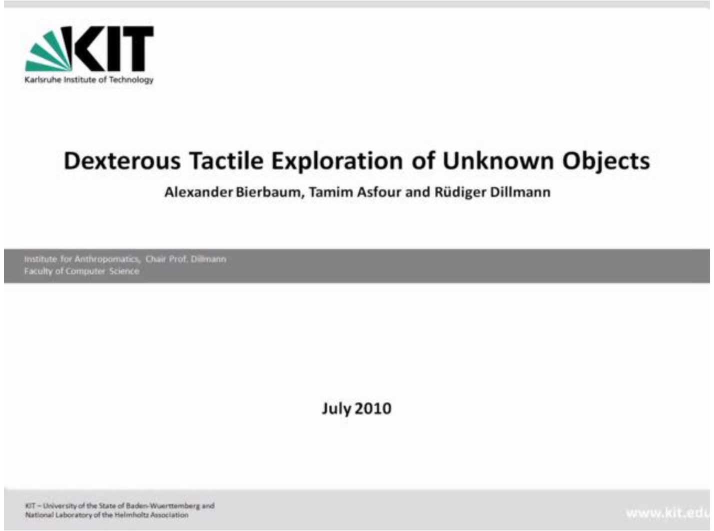


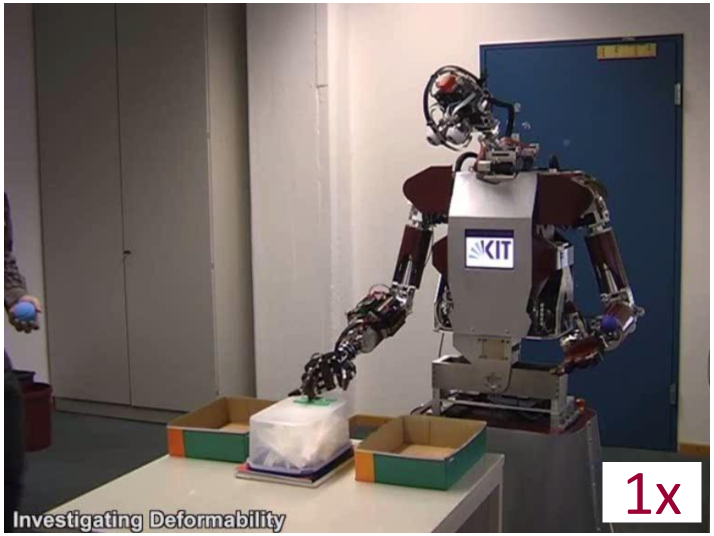


Haptic exploration of unknown objects

- Multisensory (contact, pressure, force, proprioception) approach for
  - Detection of contact and “objectness”
  - Assessment of object deformability

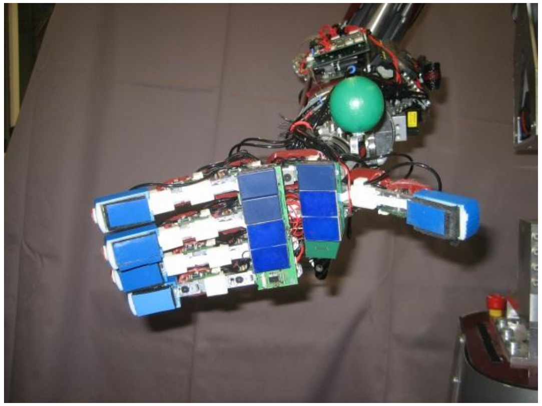


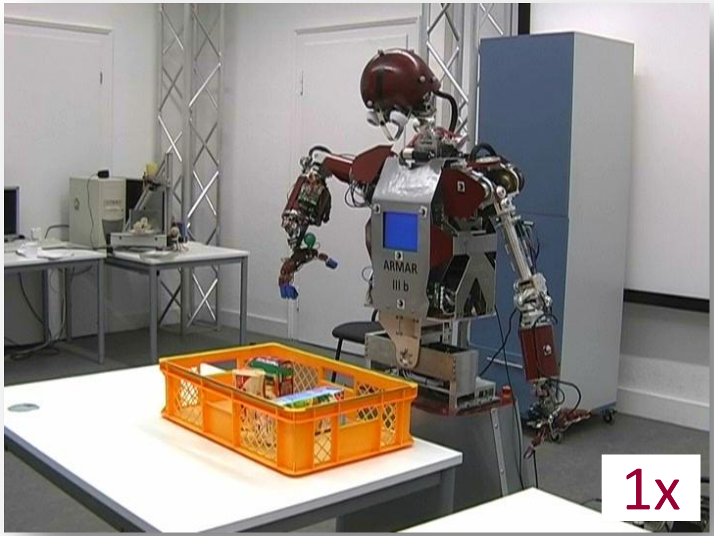


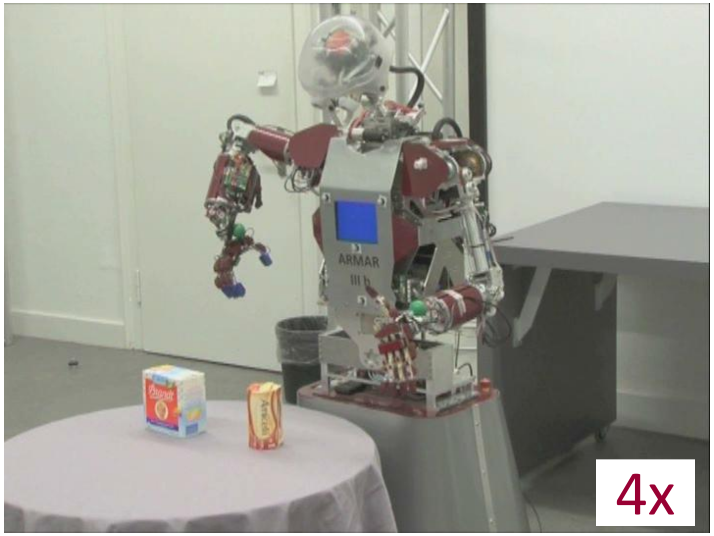


“Blind” grasping

- Corrective movements for grasping based on multisensory strategy
- SVM-based approach for grasp stability assessment based on haptic data and finger joint data

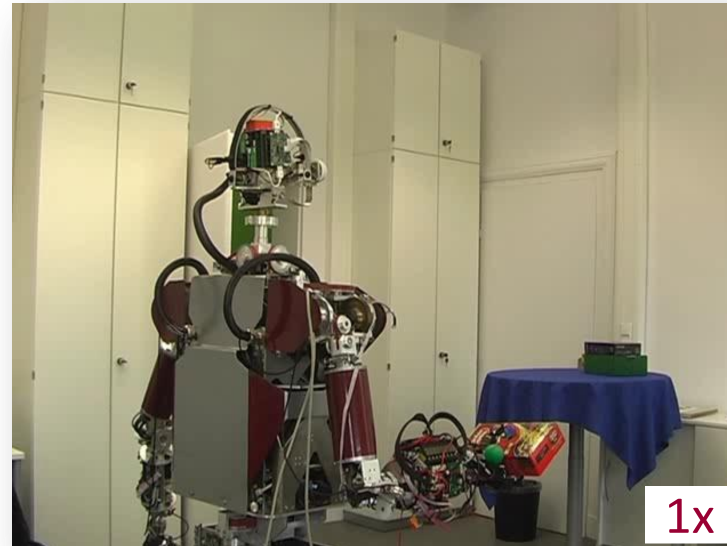


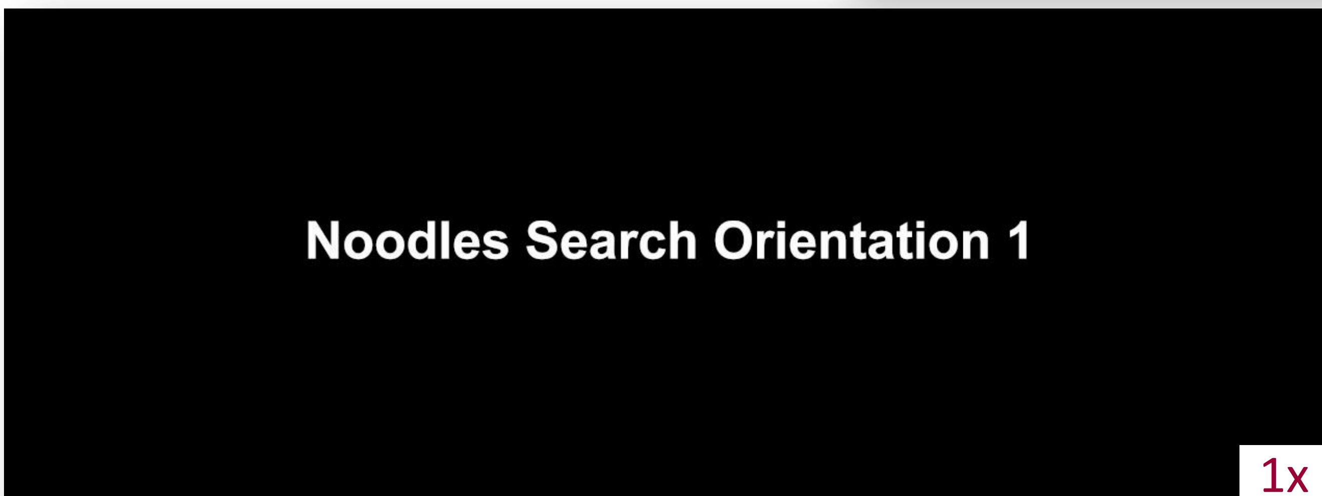




Learning visual object representations by manipulation

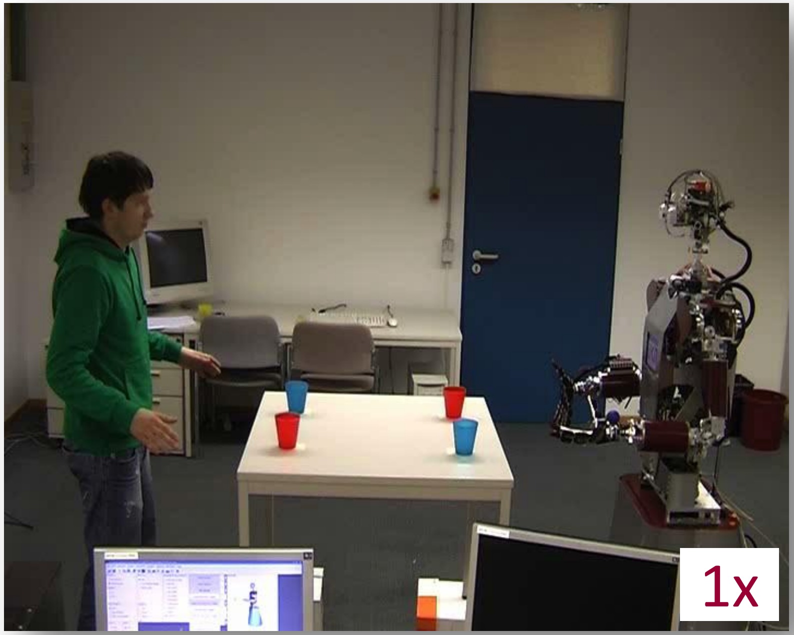
- Generation of different views through manipulation
- Active search using perspective and foveal camera
- Integration of object hypotheses in an ego-centric representation (scene memory)





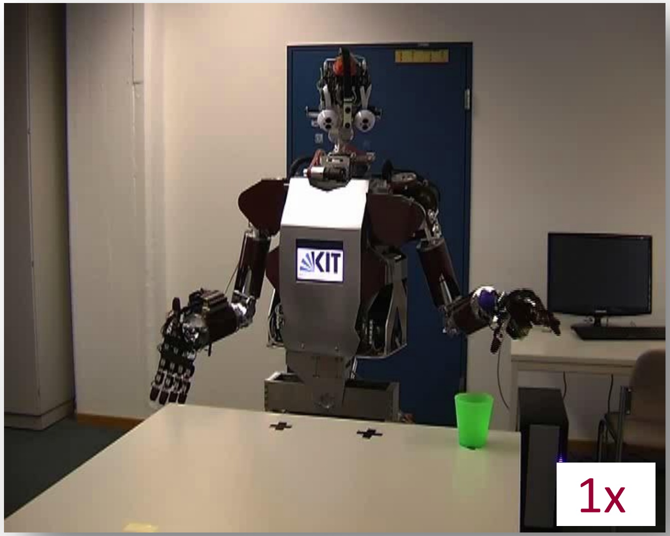
Learning from Observation

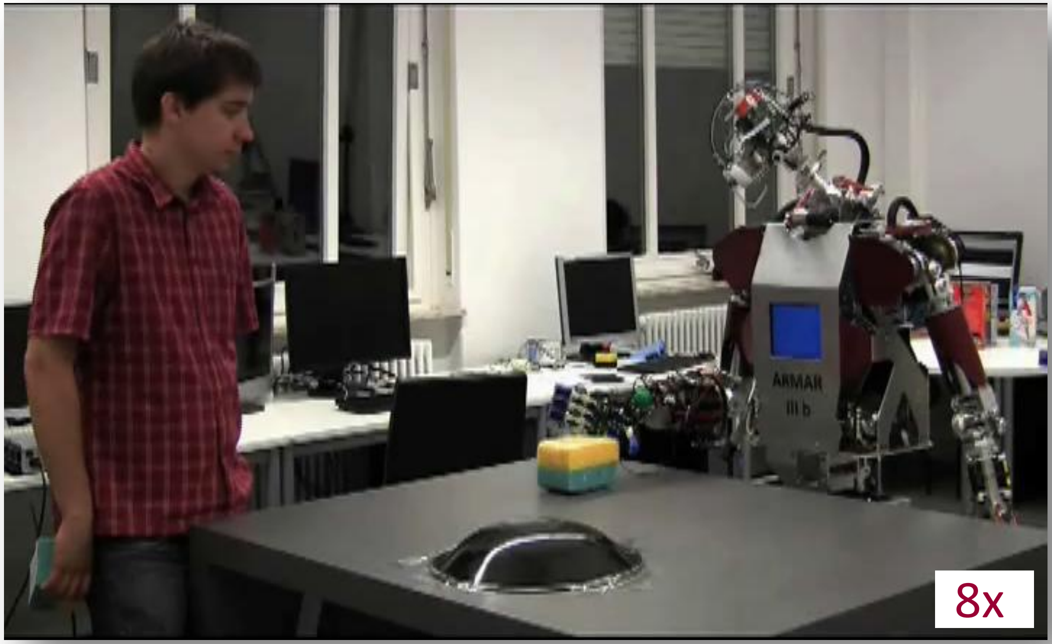
- Tracking of human and object motion
- Building a library of motion primitives

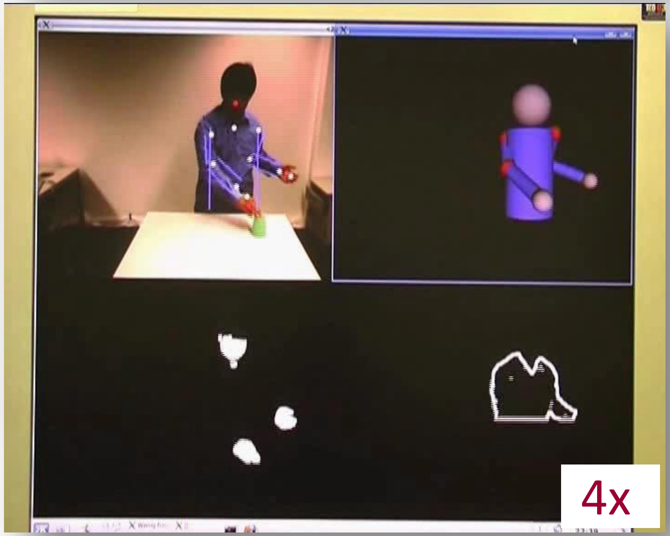


Learning from Observation

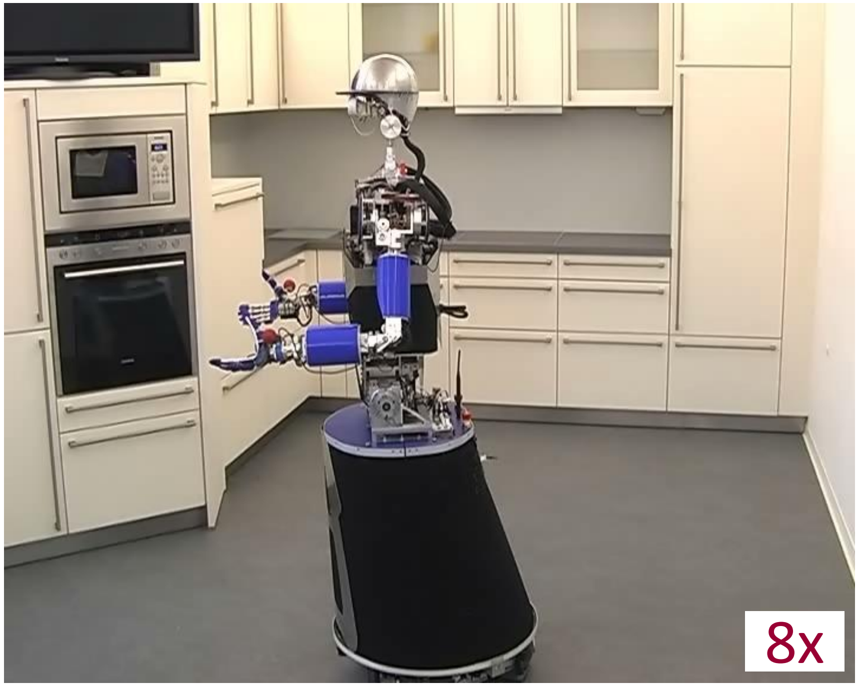
- Dynamic movement primitives for discrete and periodic movements







Physical human-robot interaction



Limitation and Challenges

- Actuation
  - Actuation concepts for high speed and force capabilities
  - Energy efficiency and compliance
- Sensing
  - Multimodal artificial skin for manipulation and safe interaction with humans
- Computation
  - Low power systems
  - Dependable software
- Interaction
  - 24/7 natural interaction
- Learning
  - 24/7 learning from observation and experience
  - Learning from failure
- Prediction
  - Prediction based on little experience

Thanks for your attention

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