Visually and haptically controlled skills for the dextrous manipulation of humanoid robots

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Visually and haptically controlled skills for the dextrous manipulation of humanoid robots

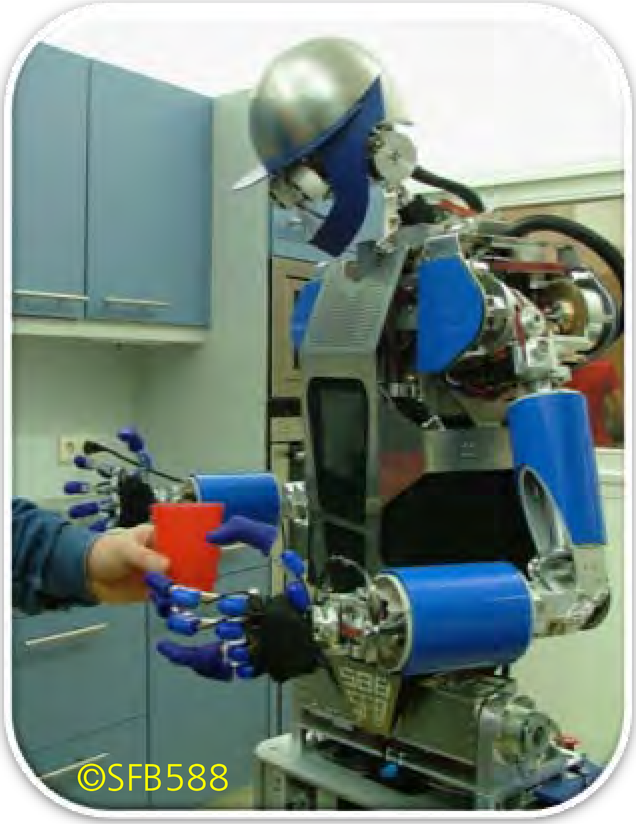
1. Motivation
2. Visual controlled approach
3. Slip and force controlled grasping
4. Conclusions

Motivation

- In order to act autonomously in a time-varying environment humanoid robots require human-like capabilities such as:
  - Dedicated *sensors* covering the range of human perception,
  - *Intelligence* to evaluate the collected information and
  - appropriate *control strategies* to execute the required actions

- The investigation and development of such outstanding features are the main objectives of the ongoing Collaborative Research Center SFB 588 - "Humanoid Robots" in Karlsruhe (Germany)

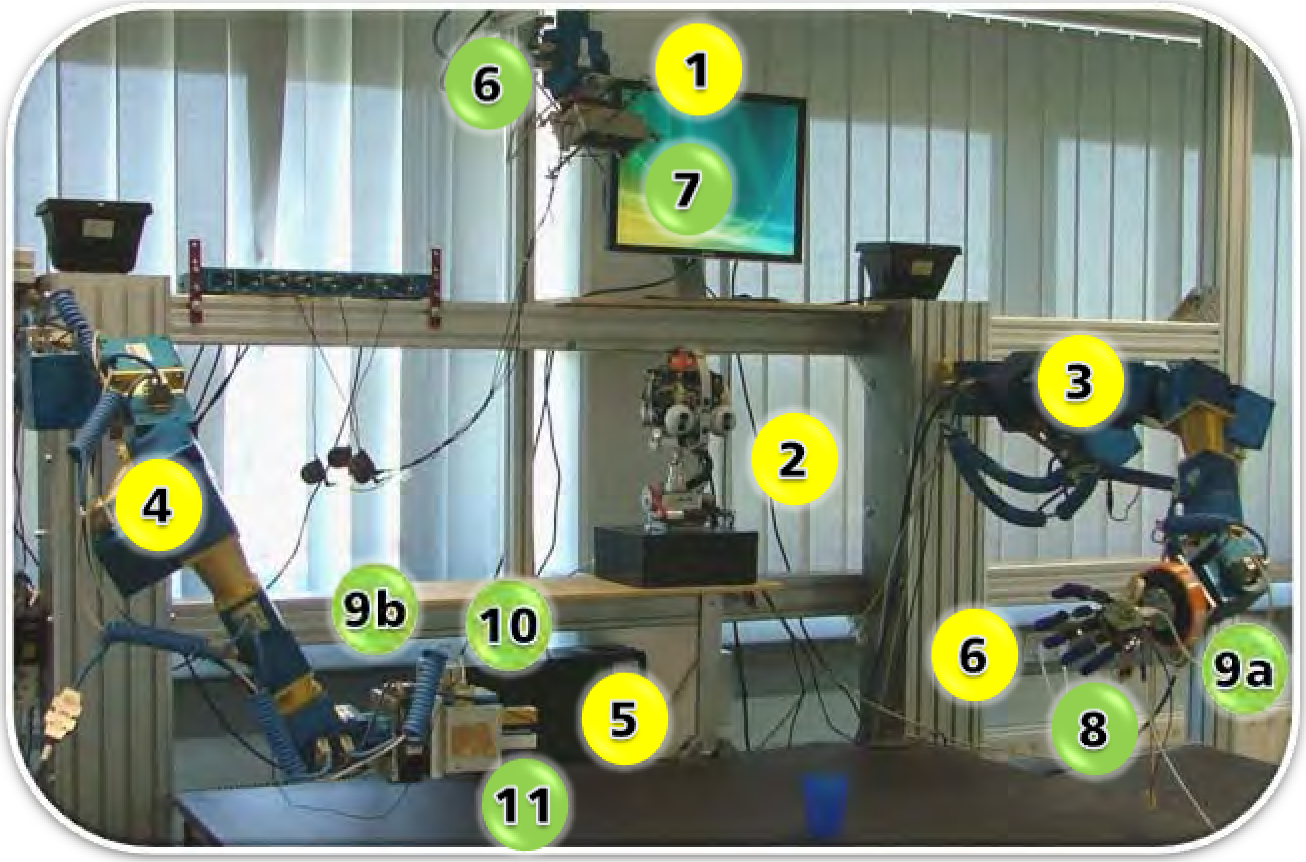
Motivation



By the execution of a grasping task the robot has to cope with *internal* (kinematic) and *external* (surrounding, object) *uncertainties*

Continuous sensory feedback is required!

Test and development platform



Actors

1. 2DoF-Sensorhead
2. 7DoF-Kopf
3. Left 7DoF-Arm
4. Right 7DoF-Arm
5. 2-Finger-Gripper
6. 5-Finger-Hand

Sensors

6. Mikrophone-Array
7. Stereo camera
8. Hand camera
9. Force-Torque-Sensors
10. Tactile sensors
11. Slip sensor

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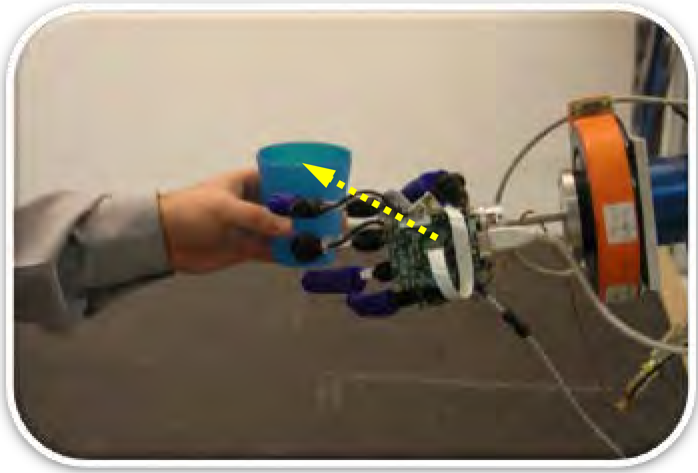
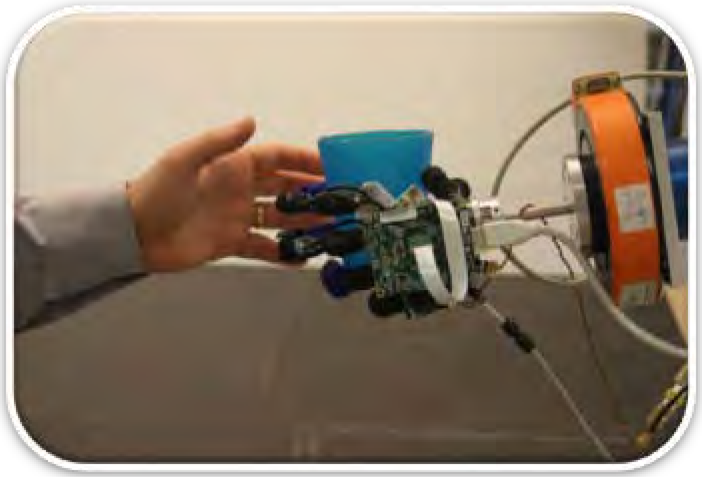
Multisensory grasping process





- Approach phase:
  - Control of the distance to the target object by means of visual sensors

- Grasping phase:
  - Control of the grasp stability by means of tactile and slip sensors

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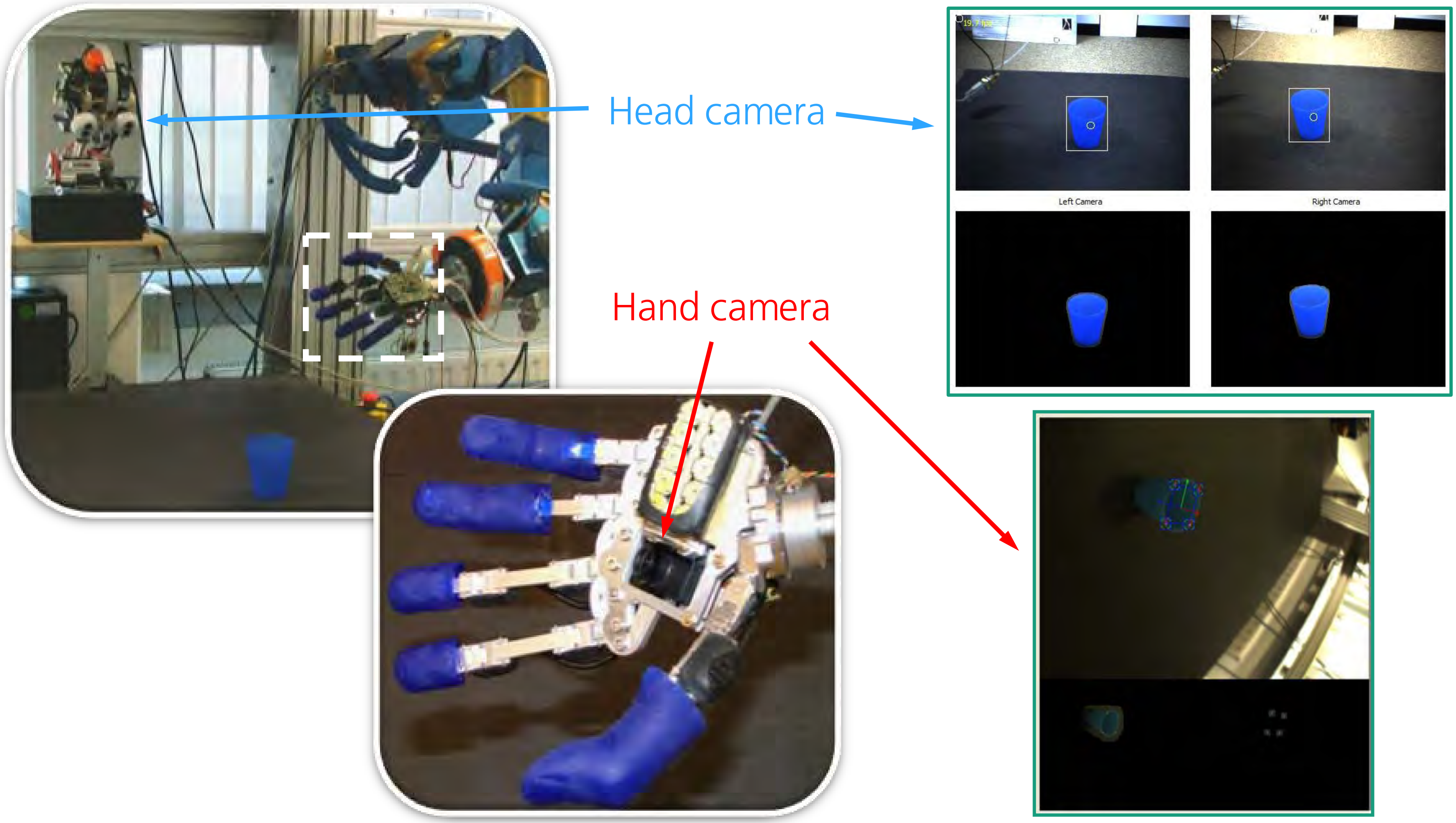
Visual controlled approach

- Observation only by one stereo camera in the head has constraints (e.g. occlusions)

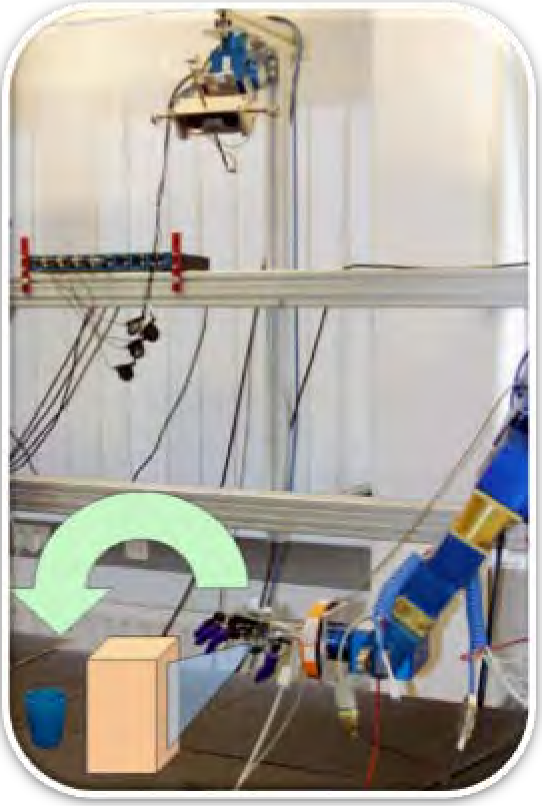
- Combination with a miniature camera embedded in the hand more flexible:
  - Advantages in case of occlusions
  - Robustness of position estimation by means of intelligent fusion of the two measurements
  - Allocation of the optical sensors for parallel tasks

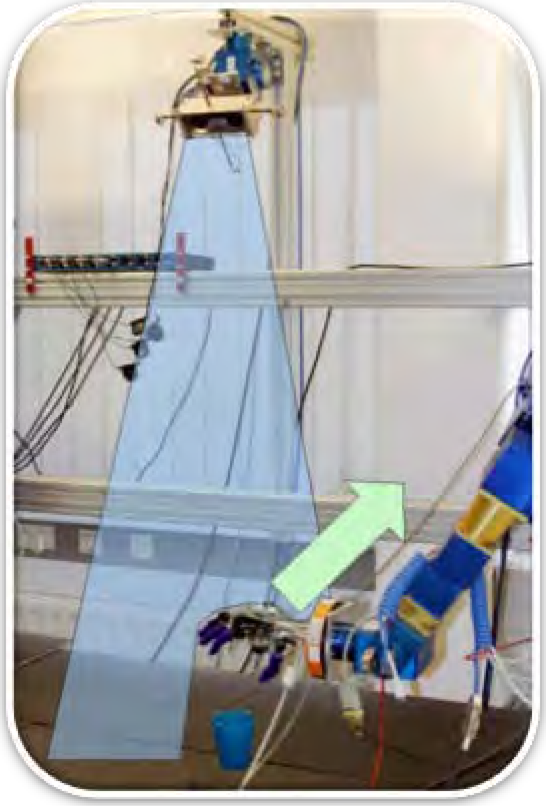
Visual controlled approach



Visual controlled approach

- Combination of the two visual sensors in order to cope with unexpected occlusions





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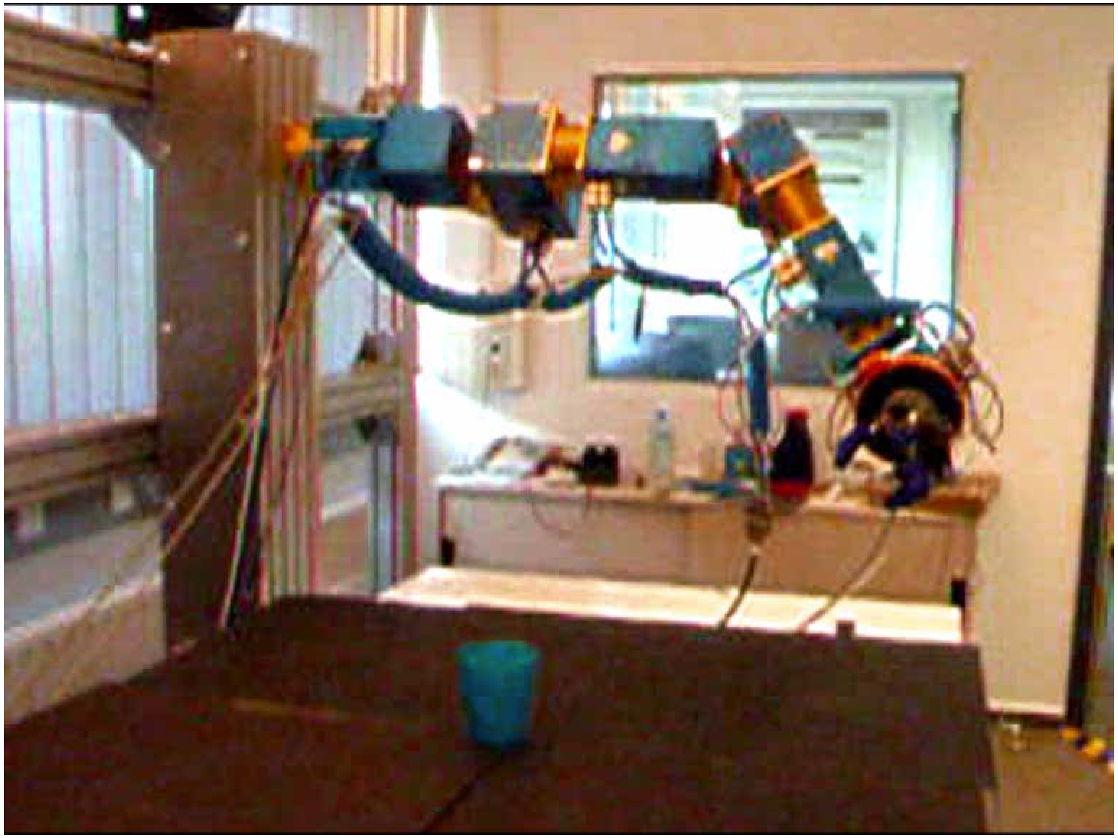
Visual controlled approach



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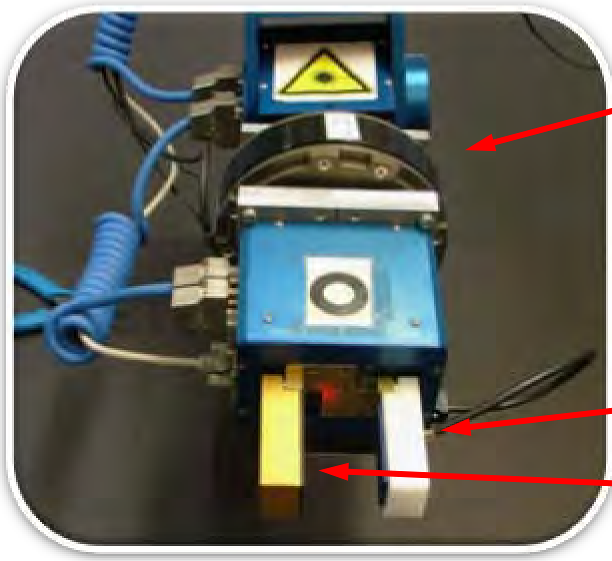
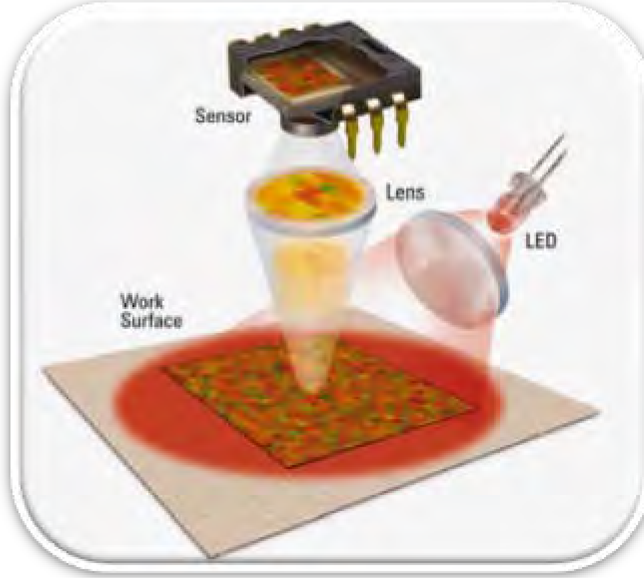
Slip and force controlled grasping



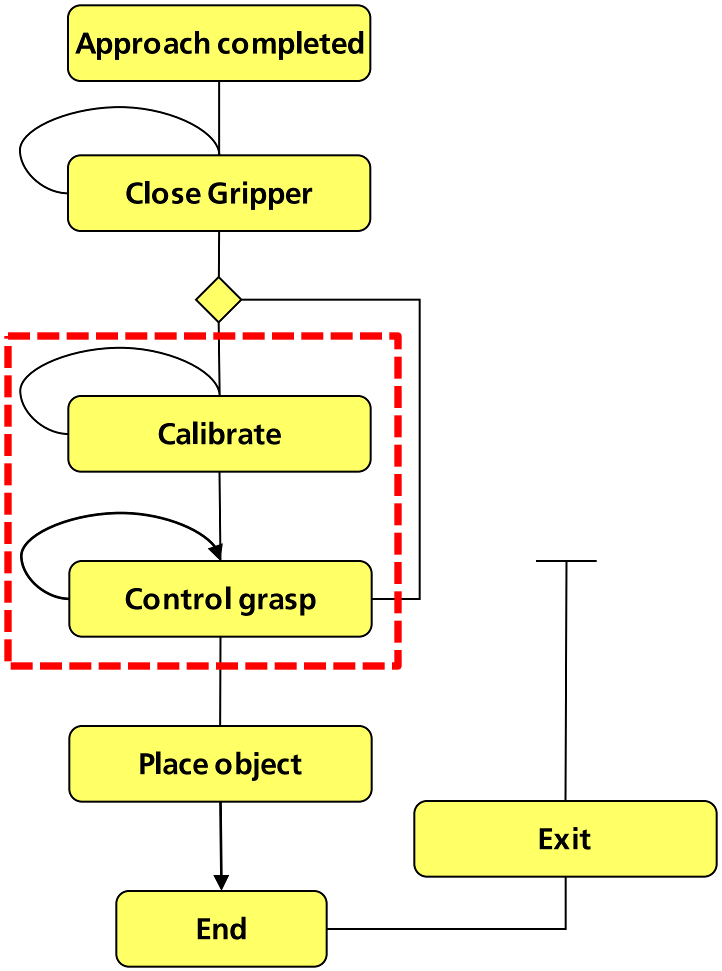
FT-sensor

Tactile array

Slip sensor

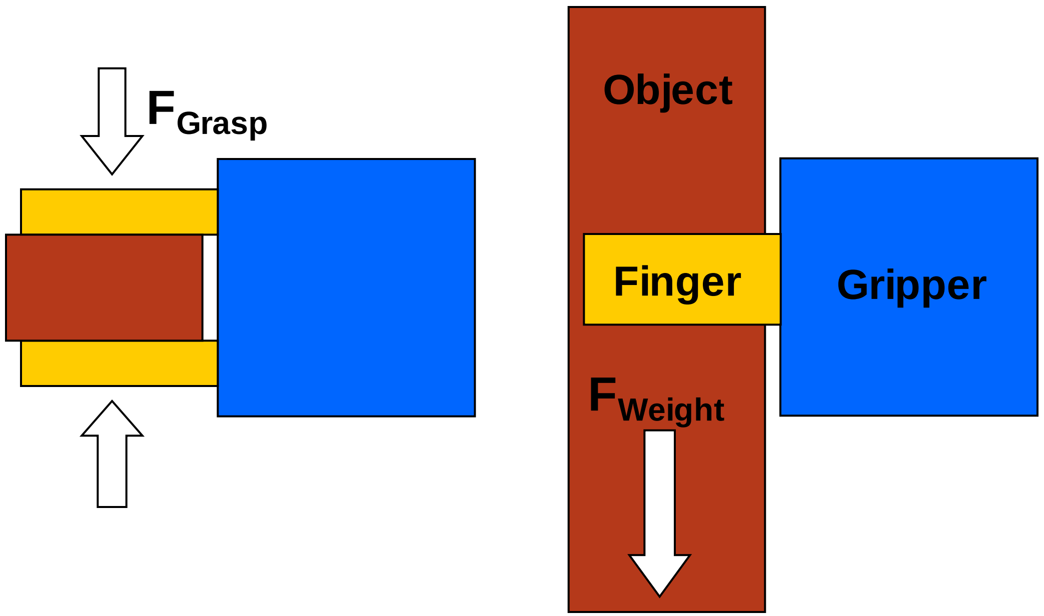


Slip and force controlled grasping



Slip and force controlled grasping

- Automatic calibration for optimizing the control parameters depending on the friction coefficient of the grasped object



Object starts to slip:

$$F_{Weight} = \mu_H F_{Grasp}$$

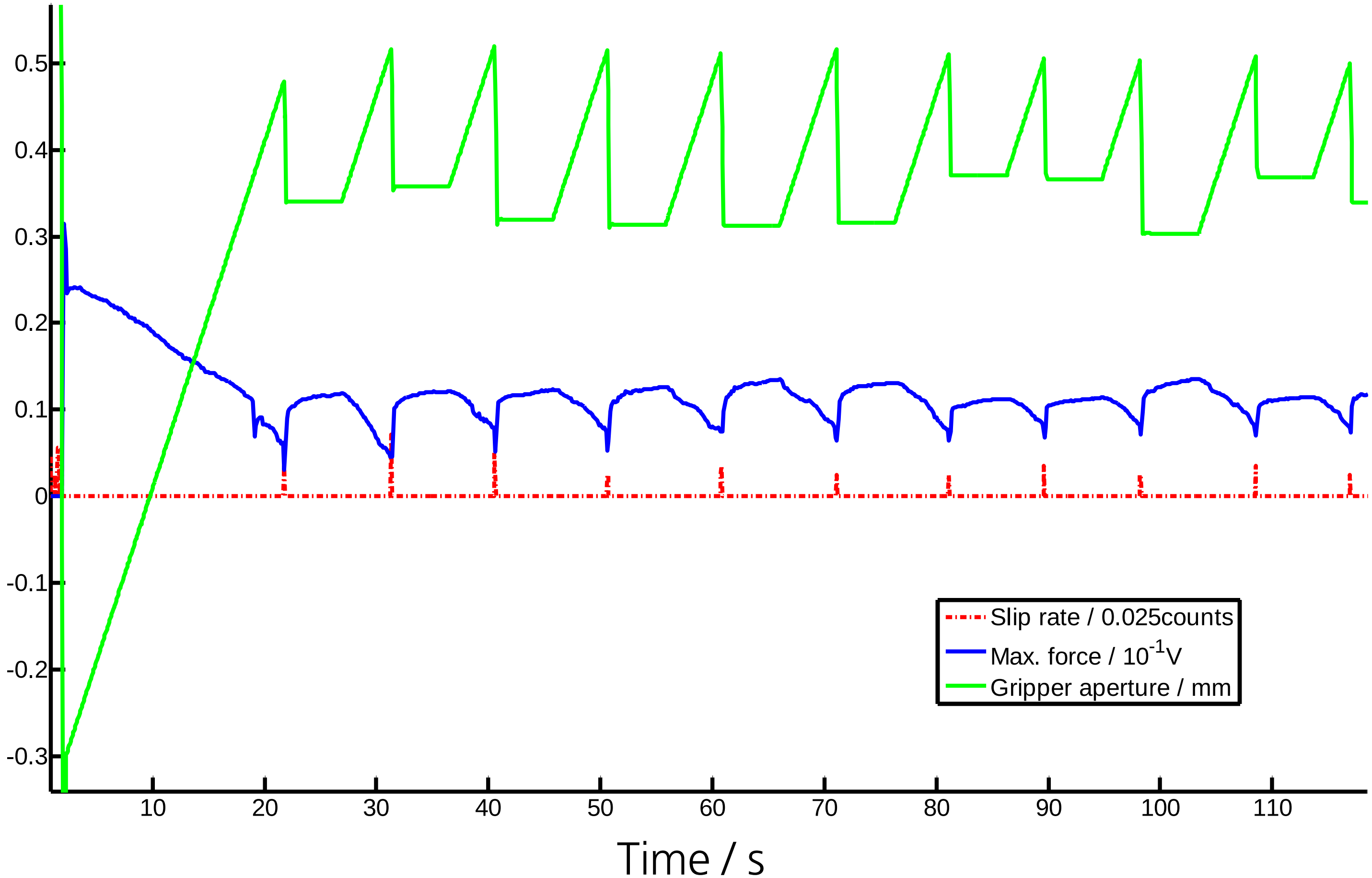
FTS

$$\mu_H = \frac{F_{Weight}}{F_{Grasp}}$$

Tactile Array

Slip and force controlled grasping

Human-like control in stationary phase



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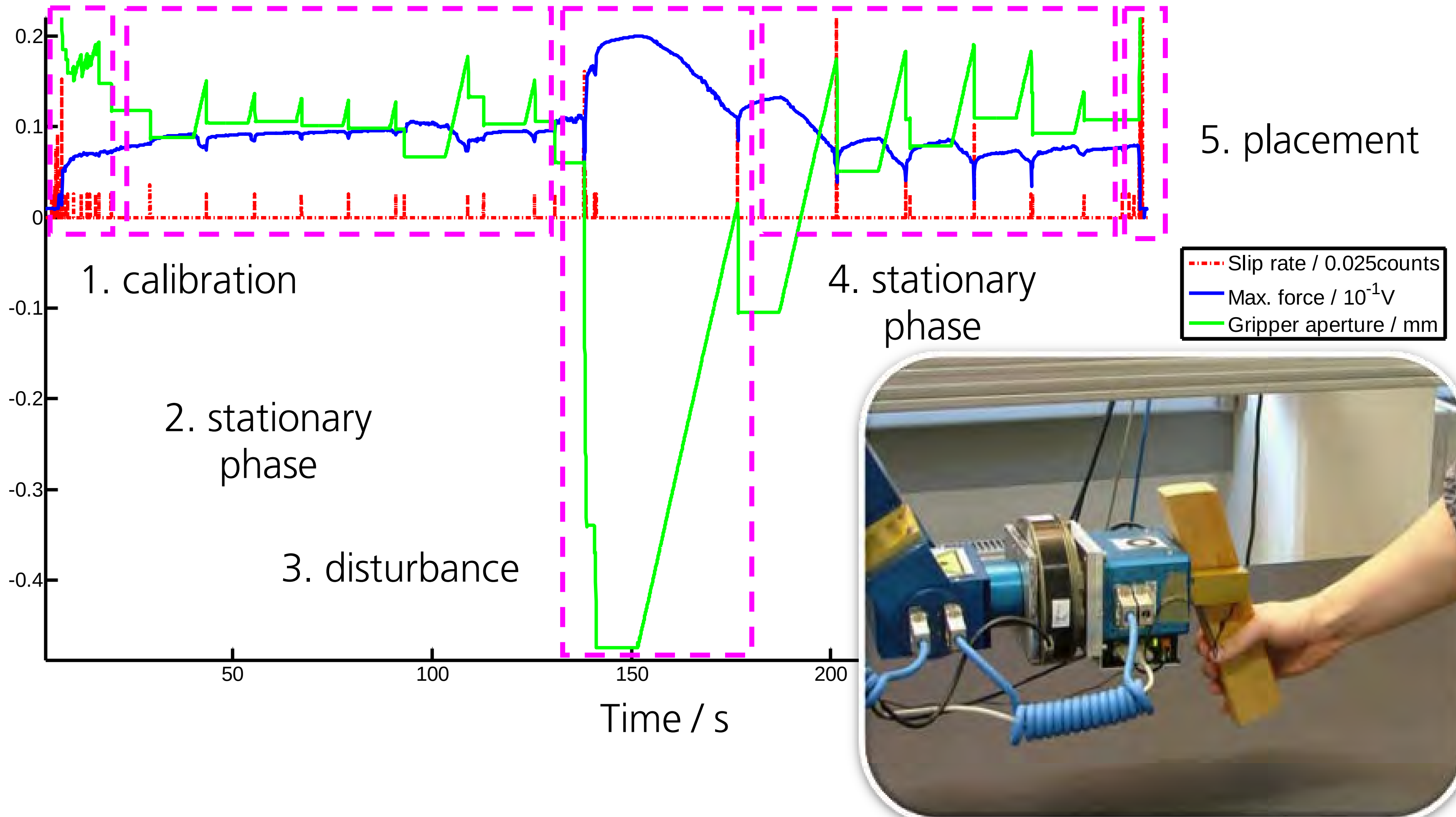
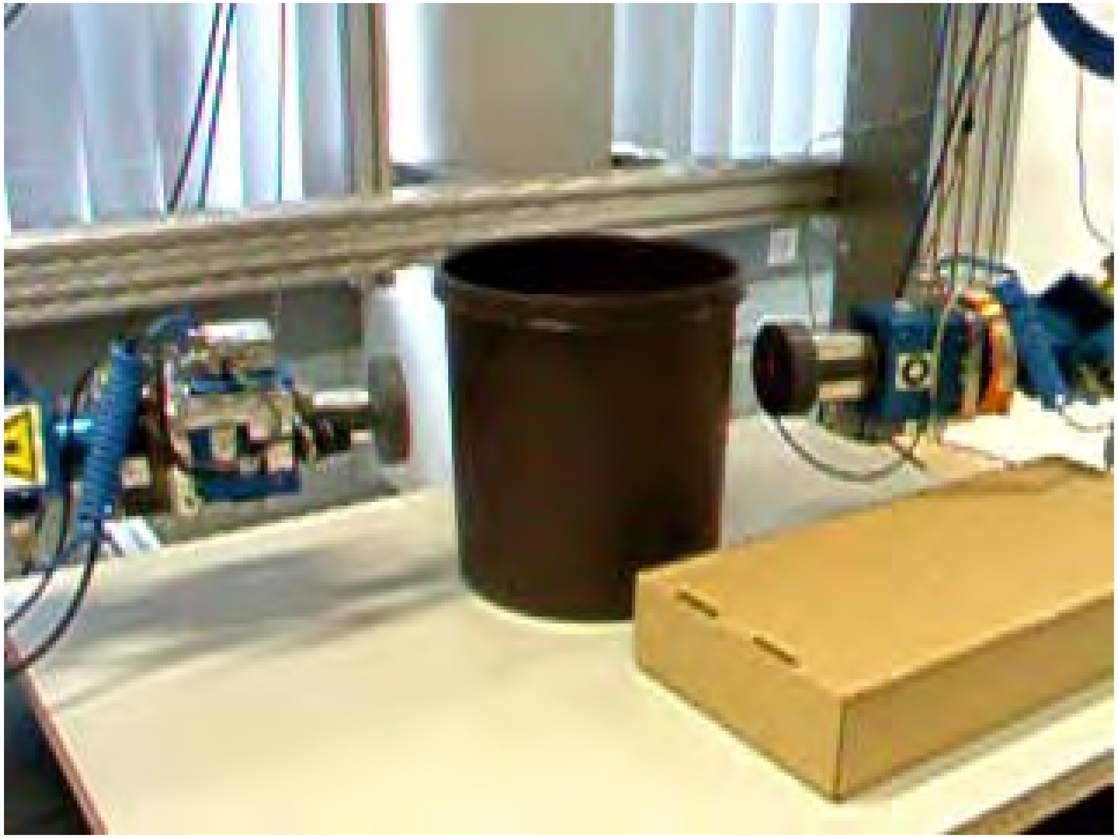
Slip and force controlled grasping



Slip and force controlled grasping



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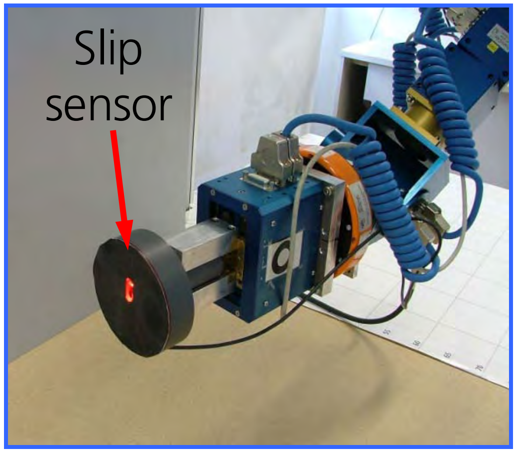
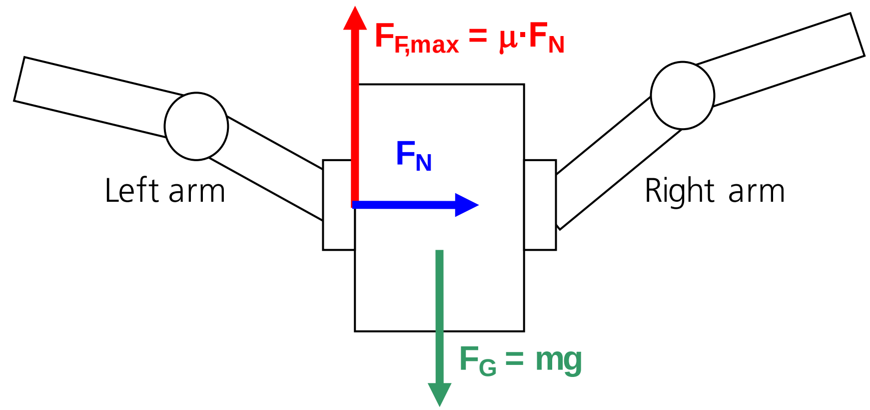
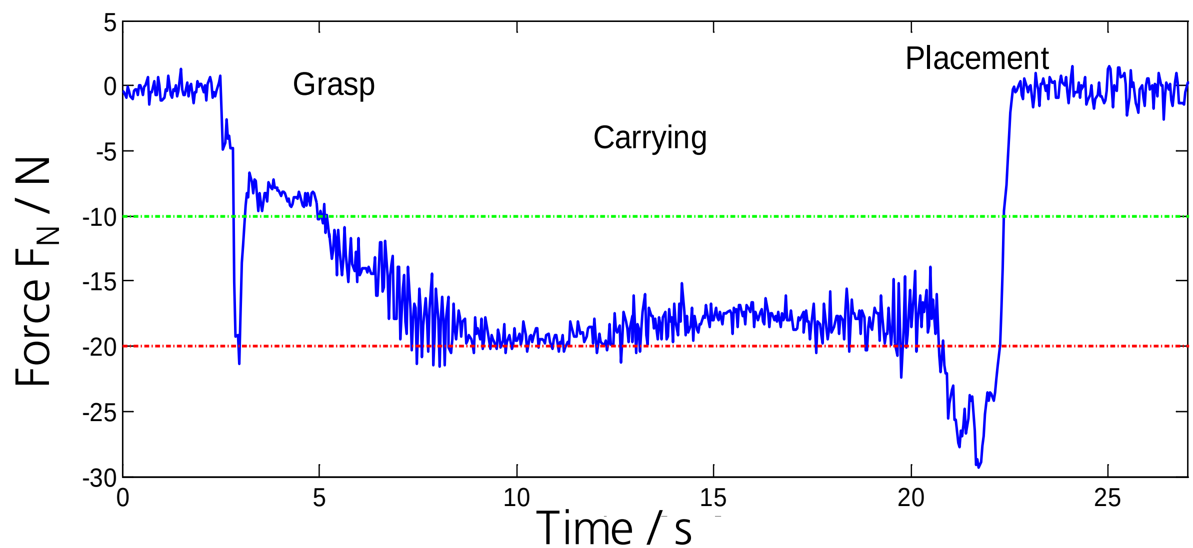
Slip and force controlled grasping

Lifting and carrying of unknown objects (mass, shape, surface) by adherence







Starting desired value

Adapted desired value

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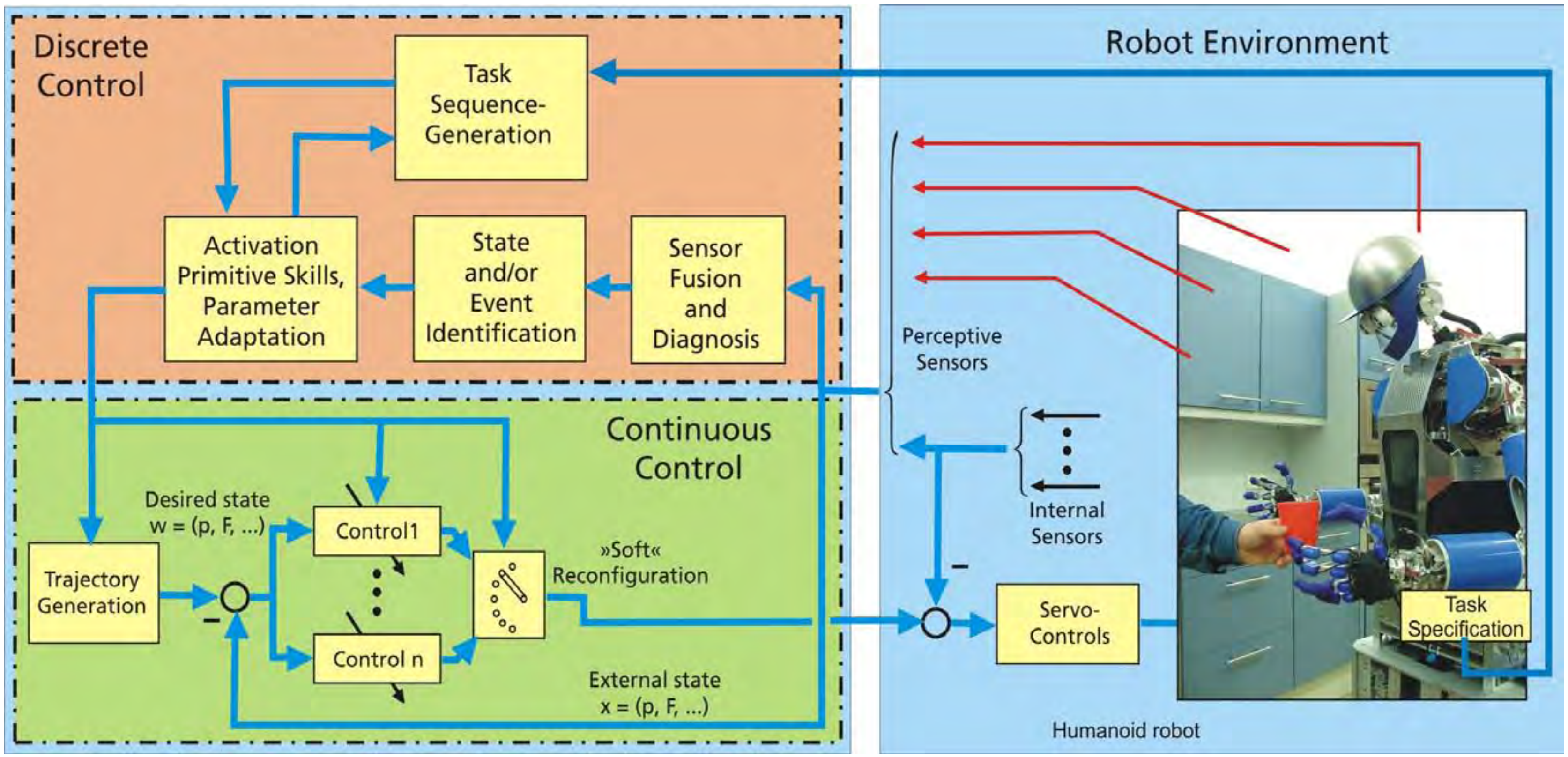
General control concept

Combination of the different control phases thanks to a flexible discrete-continuous control architecture based on primitive skills



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Conclusions

- A two-phase grasping process has been presented which combines both vision and haptic control
- Accurate vision controlled approach phase → fusion of a head camera (eyes) with a hand camera (vision aid) for an accurate approach
- Safe haptic controlled grasping phase → fusion of force, slip and tactile sensors for a stable and reactive grasping
- Flexible control structure based on primitive skills for combining the different motion phases