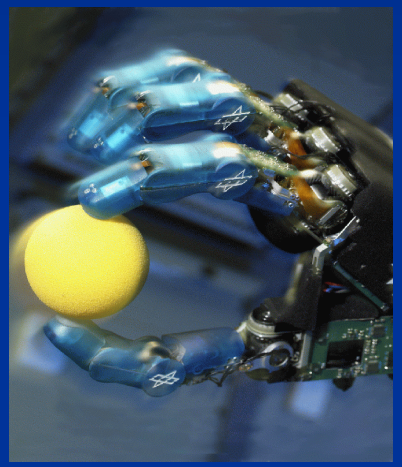
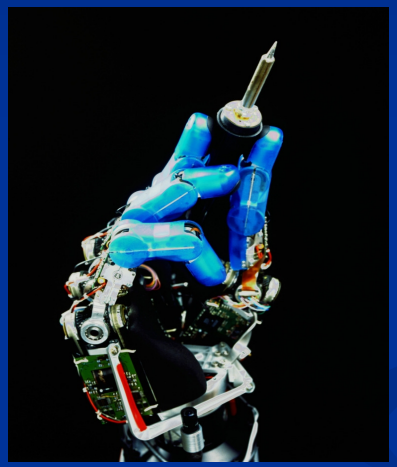
Towards a bio inspired grasping system


Grasping via gating of micro movements

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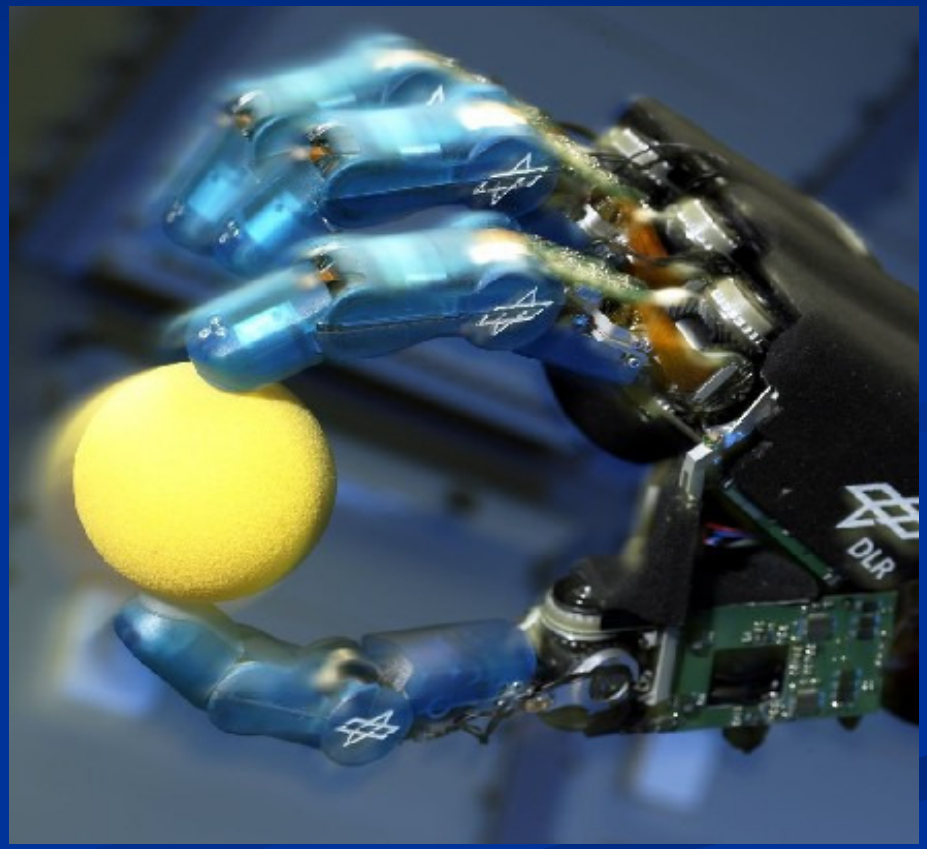
State of the art

- Strictly model based
- Hand/arm exactly known
- Object to be grasped has to be known *exactly*
- A search through the whole grip-space is performed
- No learning/self adapting
- No unforeseen events



How does biology do it?

- Motor cortex
- Cerebellum
- Spinal cord
- Arm/Hand
- Feedback to slow (thumb-cns ca. 50ms)
- Forward-Models of body and object based on experience
- Gating
- Continuously adapting

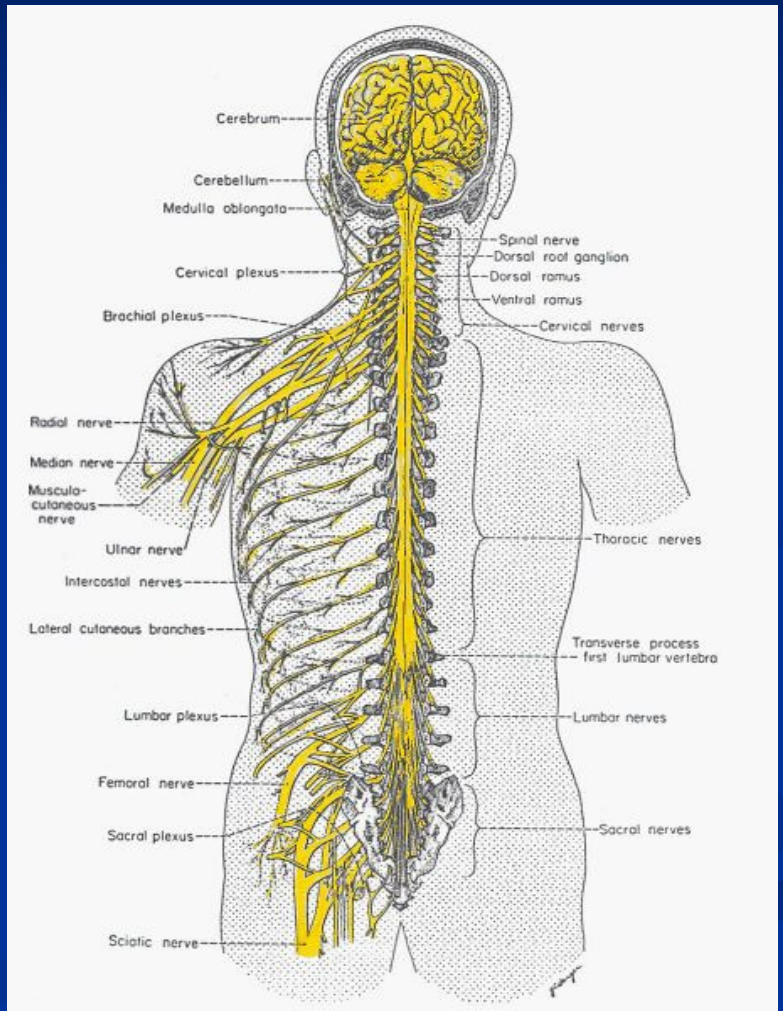


Fig. 2. The human central nervous system, exposed by dissection from the dorsal aspect. Shows the brain, spinal cord and the proximal parts of the spinal nerves. Compare this with the generalized vertebrate plan shown in Figure 1.

Cerebellum and Gating

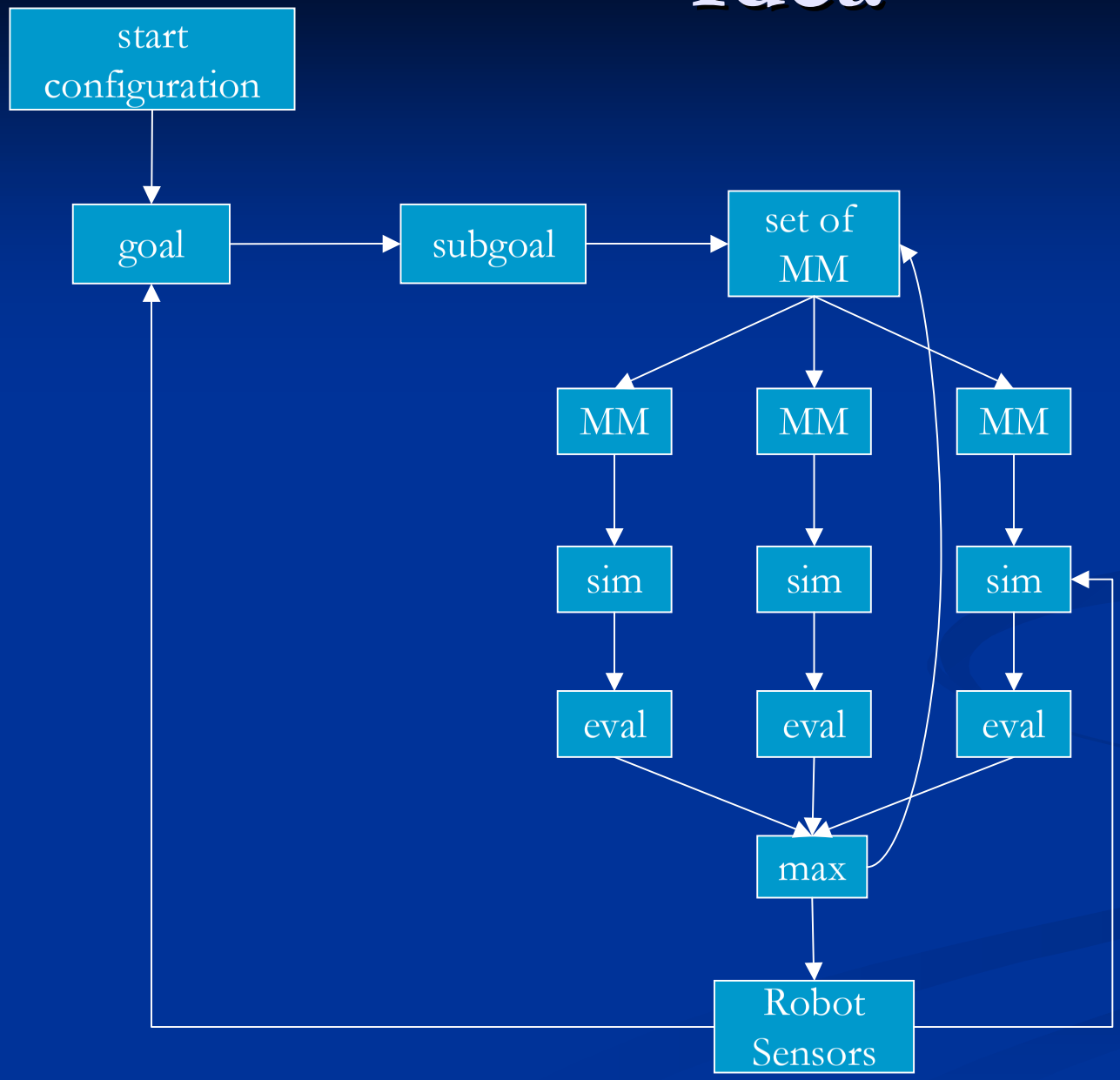
- About 50% of all neurons in a human body are in the cerebellum
- Afferent signals are routed through the cerebellum
- Cerebellum calculates forward-models
- Many different movements are evaluated in parallel
- The most promising one is gated
- Sensor-feedback helps to refine/switch the forward models

Micro movement

- Synchronized burst signal to different muscles
- Duration of about 100-200ms
- Created in the motor cortex
- Significant reduction of dimensionality

- Evolutionarily generating a set of MM, replacing the least used ones
- MM may be a good possibility to cope with the time lag

Idea



adaptation

micro movements

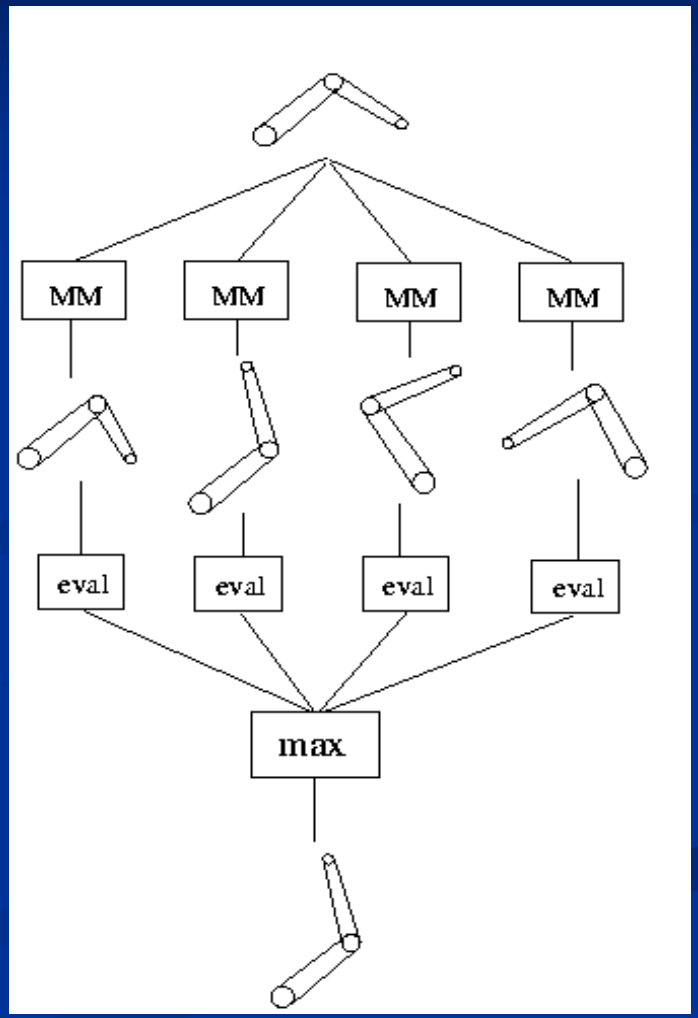
forward models

gating

sensor feedback

Simulation and Gating

- Simulate the outcome of a complete set of MM
- If computing power allows it, simulate more “layers”
- Guess the start condition on a purely visual input
- Optimize the model according to sensor feedback
- Evaluate and select the best MM in a greedy way



Learning/Adaptation

- For micro movements:
  - Evolutionary (GA, SA, PSO …)
- For simulation:
  - Model guesser?
  - Sensor data fusion?
- For subgoal creation:
  - Reinforcement learner?
  - Nearest Neighbour?

Problems

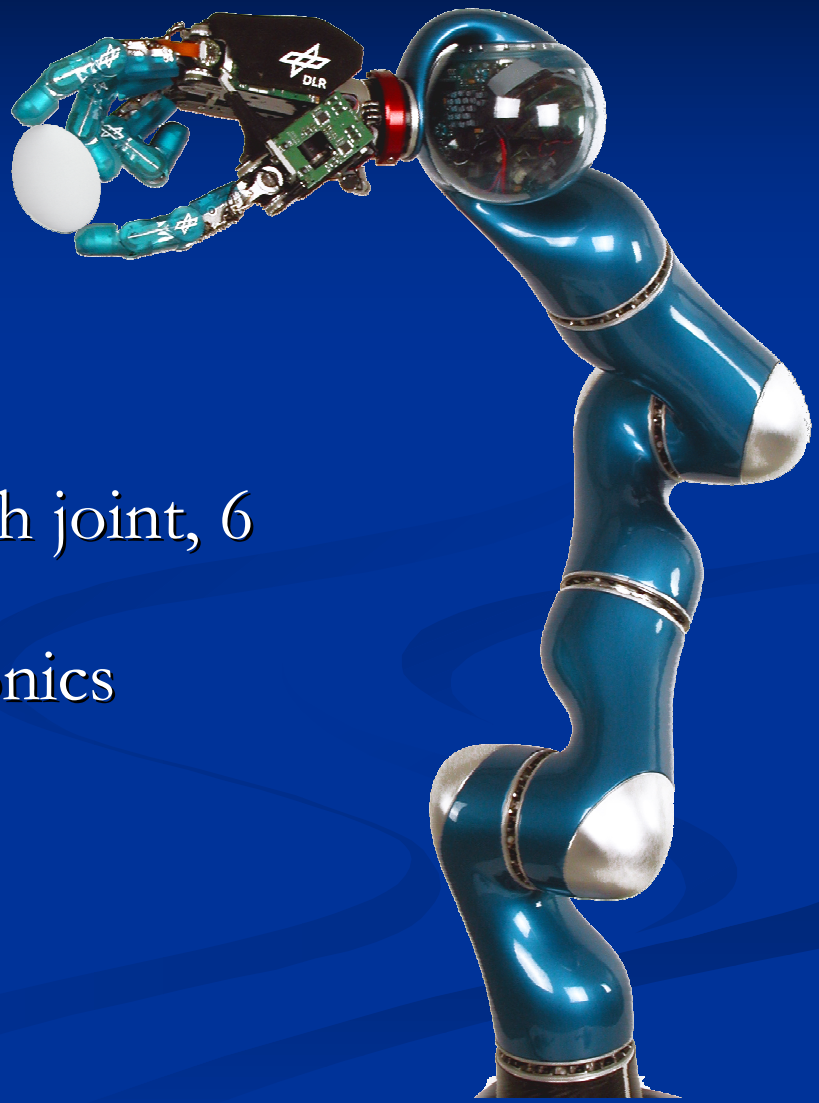
- Sensor data fusion
- Fast (massive parallel) simulation
- Learning Algorithms (curse of dimensionality)
- Which micro movements (generating the set of MMs)
- Evaluation function for the outcome of the simulation
- Some sort of knowledge-base, which should be able to generalize
- Generation of goals (and perhaps subgoals)
- Quality of hardware

Benefits

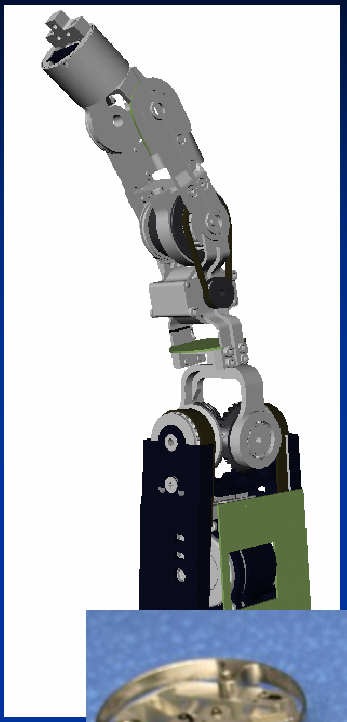
- Generality
- Able to cope with unknown objects
- Task specific grasps
- Reduction of dimensionality for the learning problems
- Incorporates (tactile) sensor data
- Interaction with environment (including dynamics)
- No extra calculation of grip-points and grip-forces (implicit in simulator)

Arm-3 facts

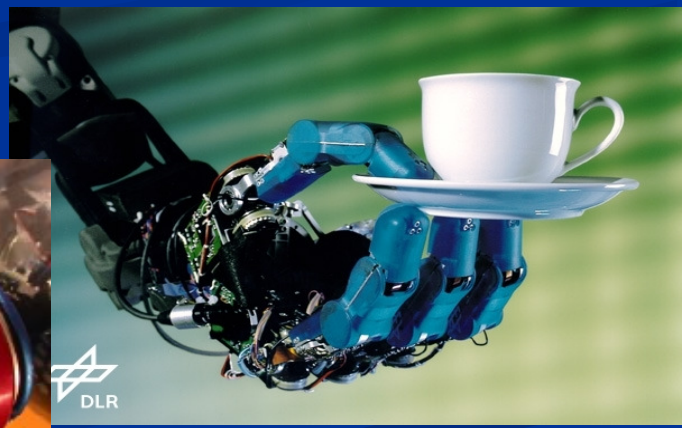
- 7 degrees of freedom
- Weight: 14kg
- Max. payload: 14kg
- Low power: ca. 150W
- Position and torque sensors in each joint, 6 DOF force torque sensor at wrist
- All electronics, even power electronics included
- Fast: 120°/s
- Active vibration damping



Hand-2 Facts



- Weight: 1.8 kg
- max fingertip force: 30N
- 1.5 size of human hand
- 4 joints, 3 DOF each finger, thumb reconfigurable for precision/power grasp
  => 13 DOF total
- 6 DOF fingertip sensor, torque and position sensors in each joint
- All motors and electronics included
  => Hotplugable



Movies Arm-Hand