Introduction to Robotics

Lecture 13

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Technical Aspects of Multimodal Systems

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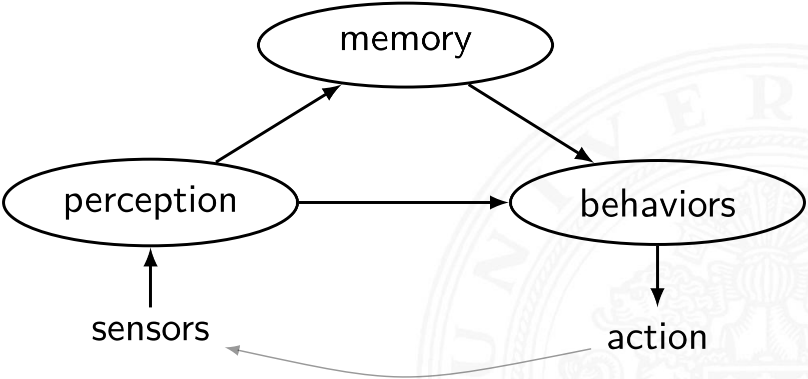
Outline

Outline (cont.)

Overview

- Basic behavior
- Behavior fusion
- Subsumption
- Hierarchical architectures
- Interactive architectures

The Perception-Action-Model with Memory



CMAC-Model

CMAC: `Cerebellar Model Articulation Controller`

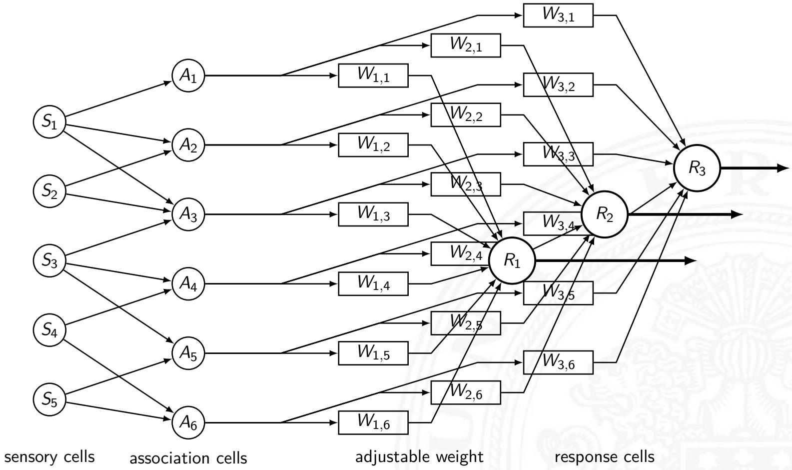
- **S** sensory input vectors (firing cell patterns)
- **A** association vector (cell pattern combination)
- **P** response output vector $(\mathbf{A} \cdot W)$
- W weight matrix

The CMAC model can be viewed as two mappings:

$$f : \mathbf{S} \longrightarrow \mathbf{A}$$

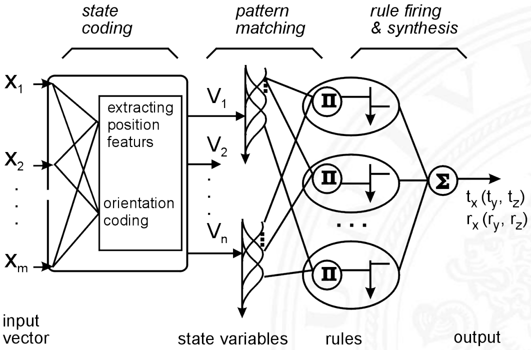
$$g : \mathbf{A} \xrightarrow{W} \mathbf{P}$$

CMAC-Model (cont.)

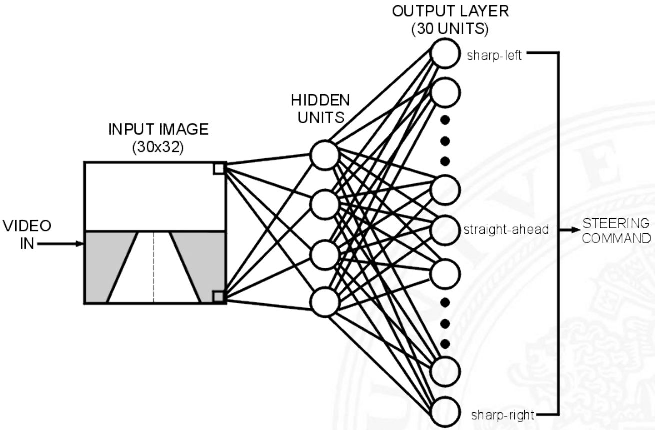


B-Spline-Model

The B-Spline model is an ideal implementation of the CMAC-Model. The CMAC model provides an neurophysiological interpretation of the B-Spline model.

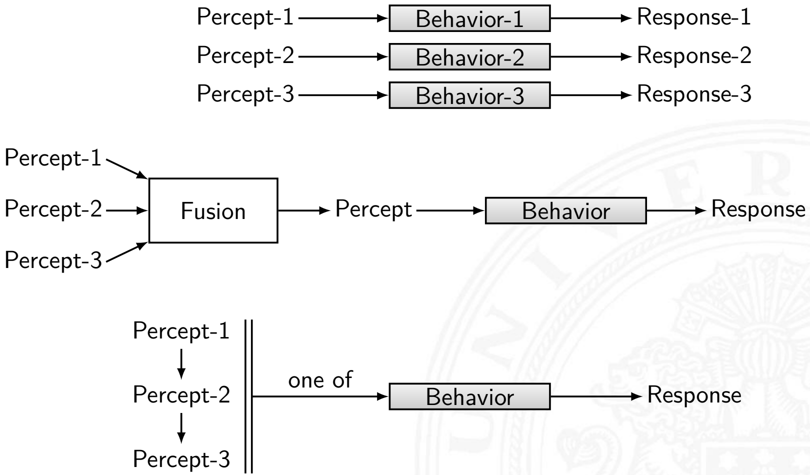


Alvinn – Visual Navigation



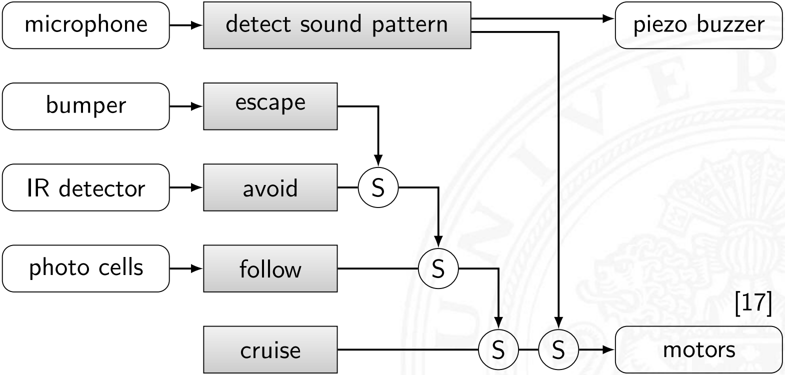
CMU – Carnegie Mellon University

Action-oriented Perception



The Subsumption Architecture

- hierarchical structure of behavior
- higher level behaviors subsumpe lower level behaviors



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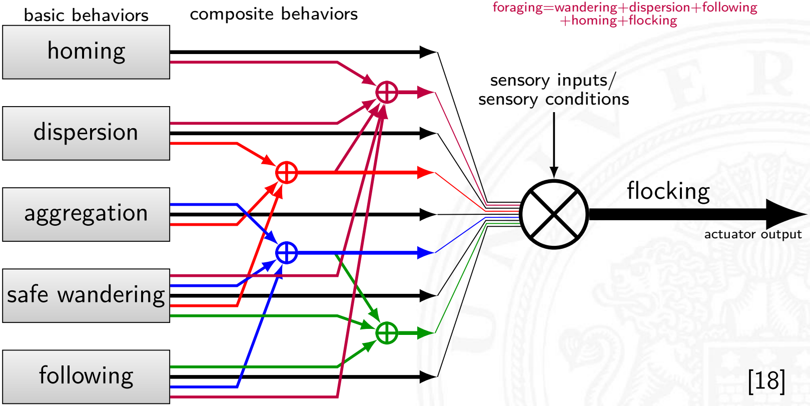
Foraging and Flocking

- multi-robot architecture
- basic behaviors are sequentially executed

flocking=wandering+aggregation+dispersion
surrounding=wandering+following+aggregation
herding=wandering+surrounding+flocking
foraging=wandering+dispersion+following +homing+flocking



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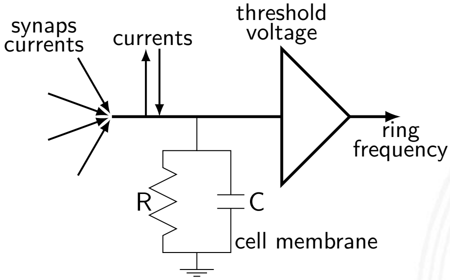
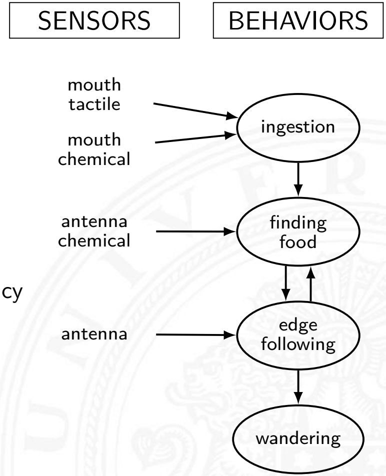
Cockroach Neuron / Behaviors





Control Architecture of a Fish

Control and information flow in artificial fish

Perception sensors, focuser, filter

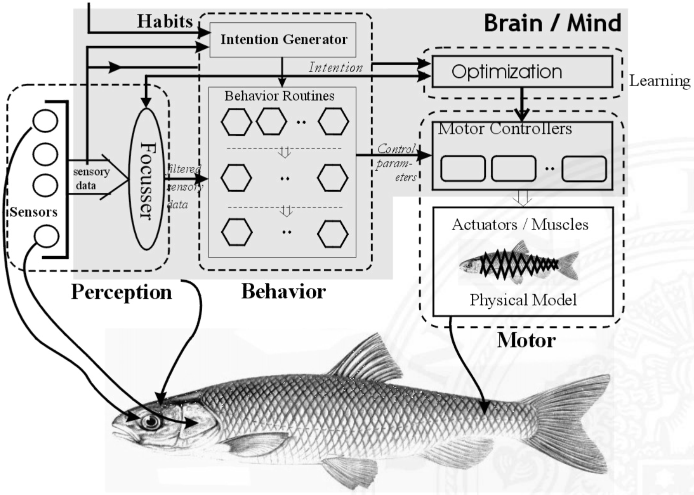
Behaviors behavior routines

Brain/mind habits, intention generator

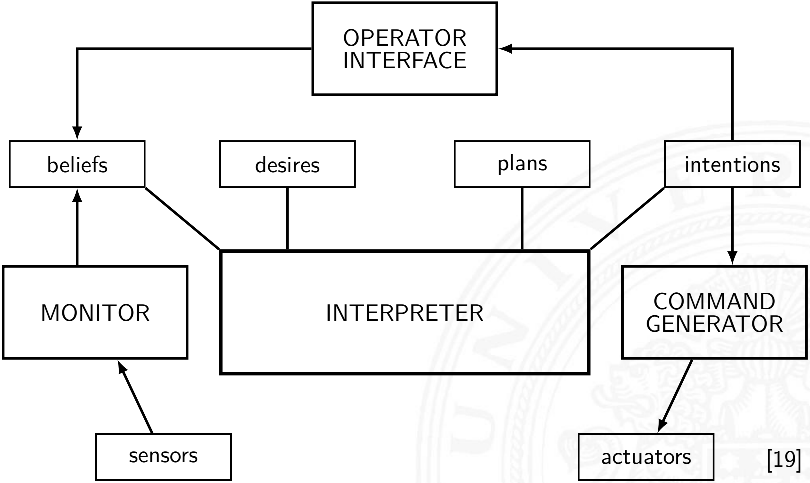
Learning optimization

Motor motor controllers, actuators/muscles

Control Architecture of a Fish (cont.)



Procedural Reasoning System



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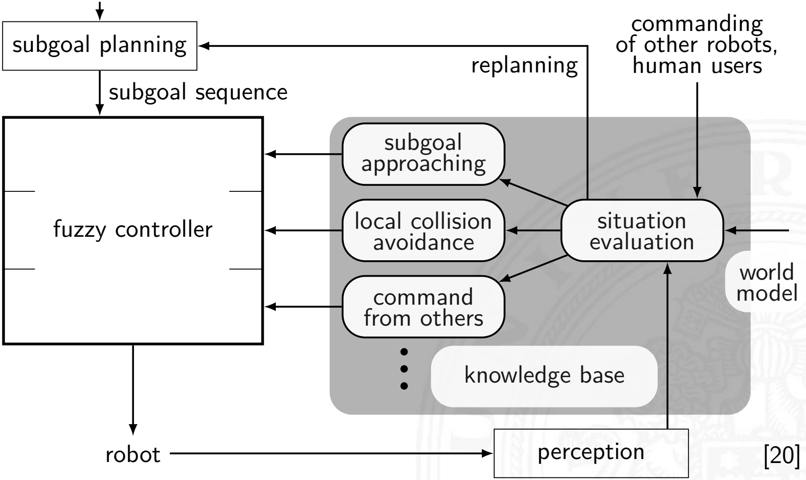
Hierarchical Fuzzy-Control of a Robot



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Fuzzy rules evaluate current situation.

Situation evaluation determines 3 fuzzy-parameters

- the priority K of the LCA rule base
- the replanning selector
- `NextSubgoal` (whether a subgoal has been reached)

Typical rule IF ($SL85$ IS HIGH) AND ($SL45$ IS VL) AND ($SLR0$ IS VL) AND ($SR45$ IS VL) AND ($SR85$ IS VL) THEN (*Speed* IS LOW) AND (*Steer* IS PM) K IS HIGH AND *Replan* IS LOW

Translation If the leftmost proximity sensor detects an obstacle which is near and the other sensors detect no obstacle at all, then steer halfway to the right at low speed. Mainly perform obstacle avoidance. No re-planning required.

Coordination of multiple rule bases

$$Speed = Speed_{LCA} \cdot K + Speed_{SA} \cdot (1 - K)$$
$$Steer = Steer_{LCA} \cdot K + Steer_{SA} \cdot (1 - K)$$

LCA: Local Collision Avoidance SA: Subgoal Approach

Hierarchy

Real-Time Control System (RCS)

- RCS reference model is an architecture for intelligent systems.
- Processing modes are organized such that the BG (Behavior Generation) modules form a command tree.
- Information in the knowledge database is shared between WM (World Model) modules in nodes within the same subtree.

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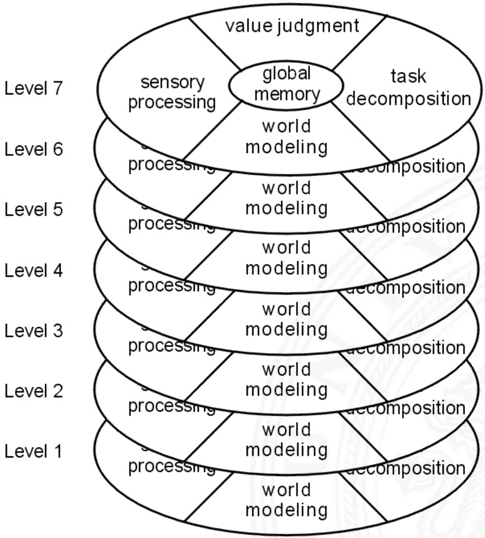
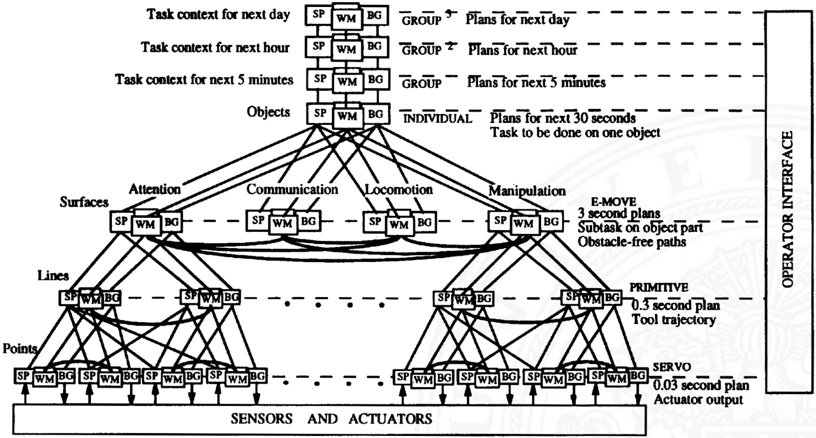
Examples of functional characteristics of the BG and WM modules:

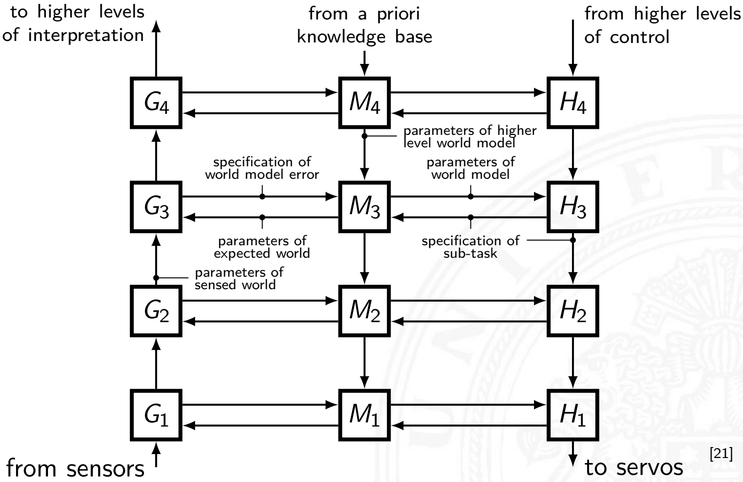
Hierarchy (cont.)



Hierarchy (cont.)



Hierarchy (cont.)



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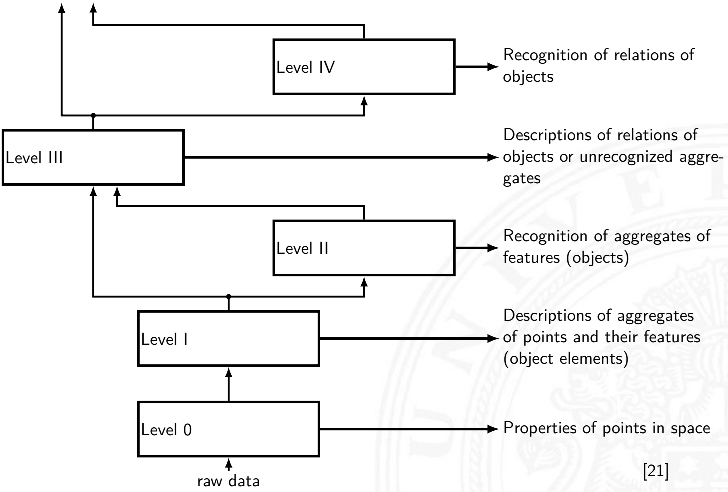
Sensor-Hierarchy



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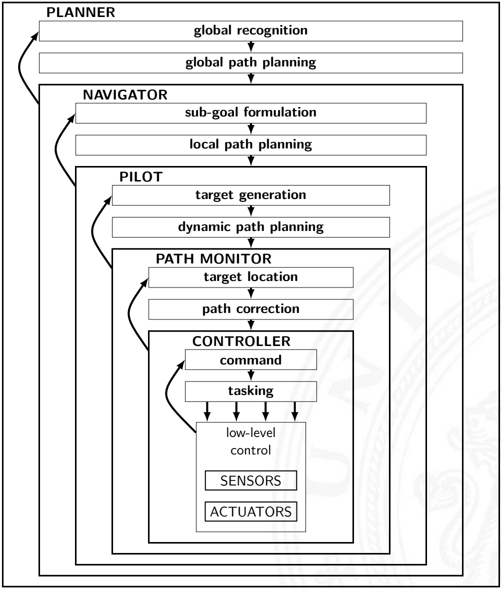
Other examples



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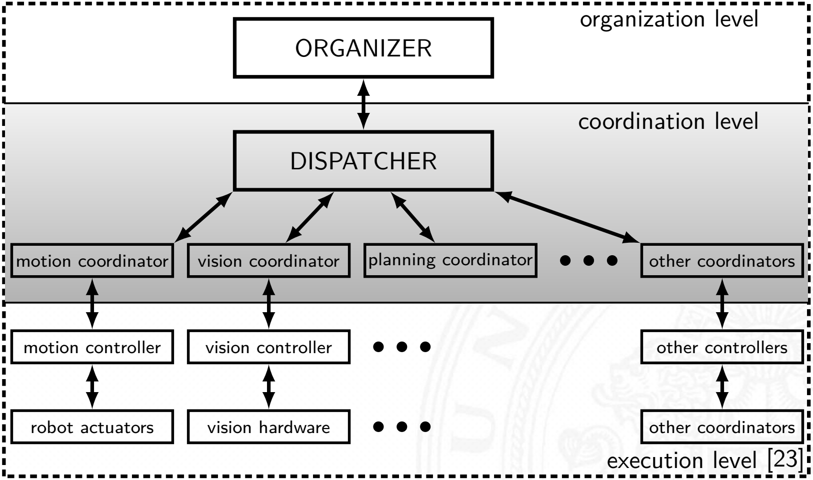
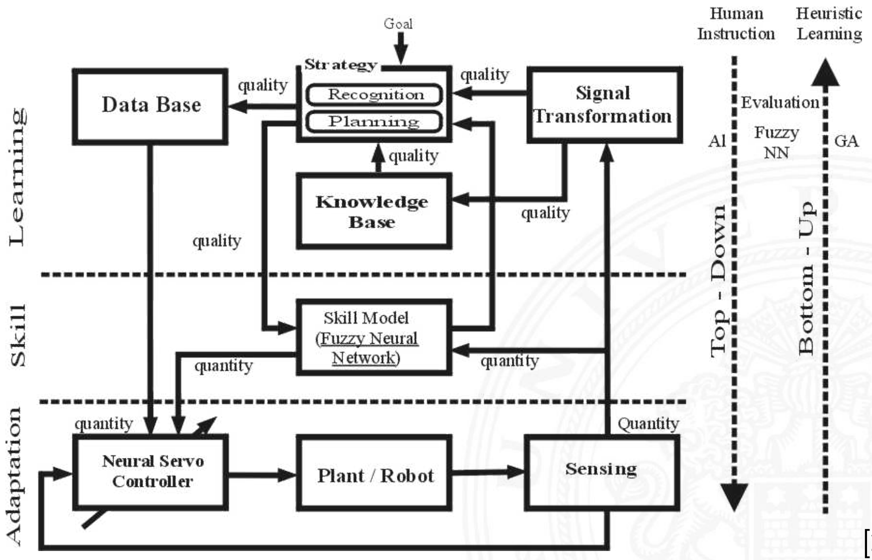
Other examples



An Architecture for Learning Robots



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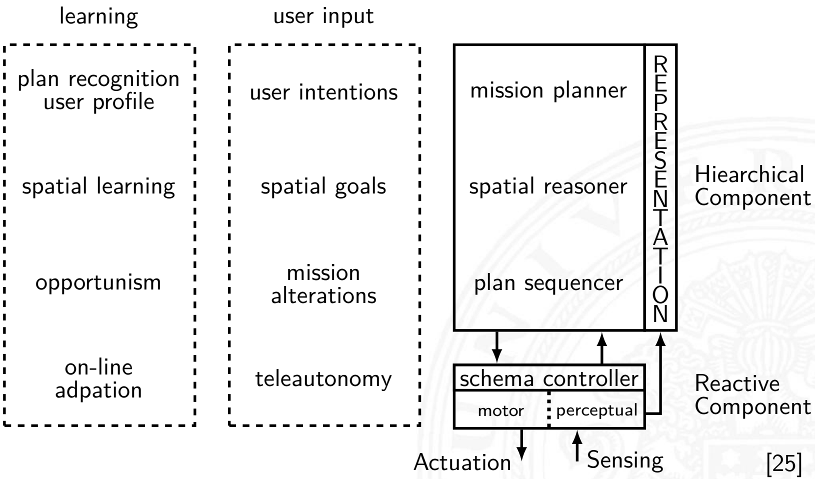
AuRA Architecture



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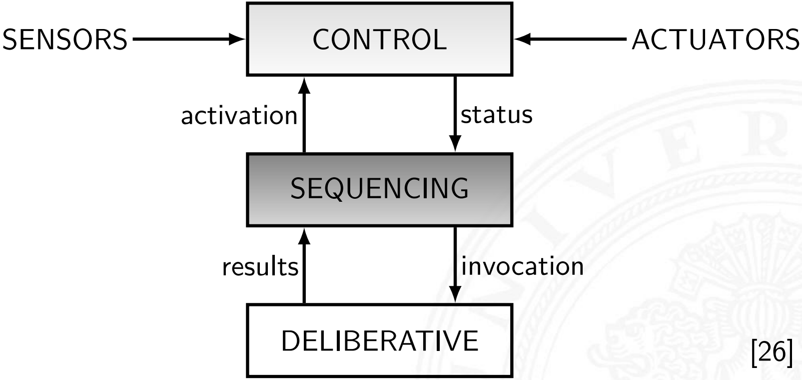
Atlantis Architecture



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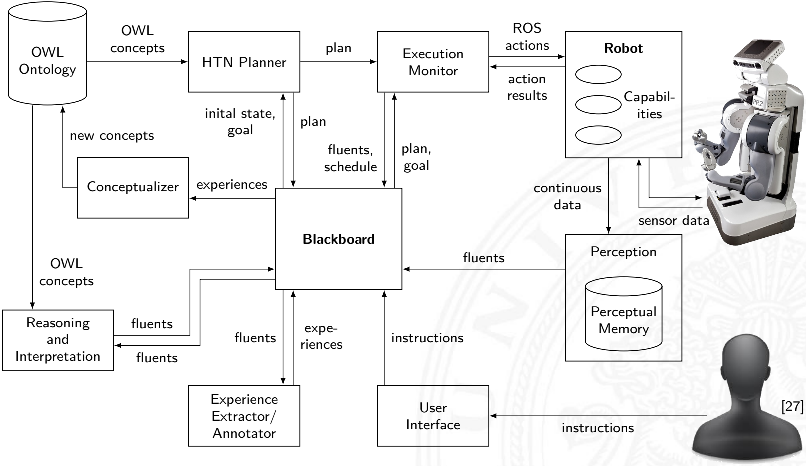
RACE
Robustness by Autonomous Competence Enhancement



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