Sensorimotor Coordination - the Metaphor and Beyond

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Two fundamental problems:

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2. How to apply symbolic AI to real-life problems

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Behavior-based AI: Physical Grounding AI, Intelligence is seen as a feature unique to biological systems and the focus is on their capacity to interact with the world

"We begin not with a sensory stimulus, but with a sensorimotor co-ordination . . . In a certain sense it is the movement which is primary, and the sensation which is secondary, the movement of the body, head, and eye muscles determining the quality of what is experienced." (Dewey, 1898)

What is SMC?

Sensory-Motor Coordination (SMC) underlies the physical behavior of an animal in response to its environment. More than a response, SMC is a feedback loop that changes both the animal and the environment.

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- Allows for the integration of several sensory modalities
- Learning to master sensorimotor coordination itself.

Why is SMC so ubiquitous?

It is time to replace the information processing metaphor in the study of intelligent systems by the one of sensory-motor coordination!(Pfeifer,1994)

The Problem:

Emergence basic adaptive behaviors by sensorimotor coordination

Motivation:

1. Current humanoid robot project, more and more sensors and motors, changing kinematic structure
2. Current network based robots, no innate knowledge distributed sensors and effectors.
3. New AI approach

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- For our humanoid robot, this work will create a foundation for its interaction with the world.
- For network robots, this work will create a foundation for its using no innate knowledge devices.
- For embodied robotic system in general, this work will yield a mechanism which allows a system to automatically discover how sensory input and motor output are linked together.

Bovet's Works:

In [?][?][?], Bovet shows how approaching, following an object or different homing strategies observed in insects can emerge from homogeneous, non-hierarchical sensorimotor coupling.

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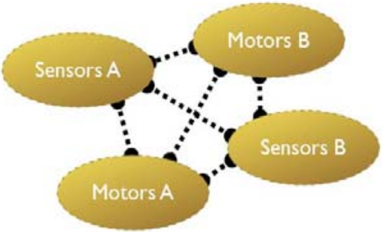

Figure: Homogeneous, non-hierarchical sensorimotor coupling

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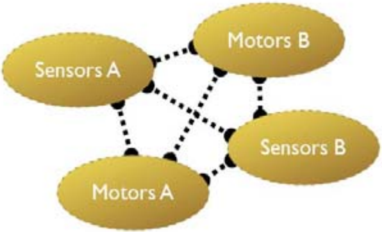

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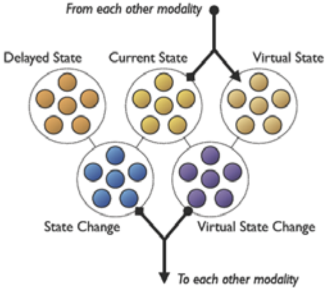

Figure: (a) The agent learns the correlation between a expanding visual flow (growing image of the cup) and activity in the arm muscle (contraction). (b) The agent learns the correlation between a decrease of thirst and the image of the close cup.

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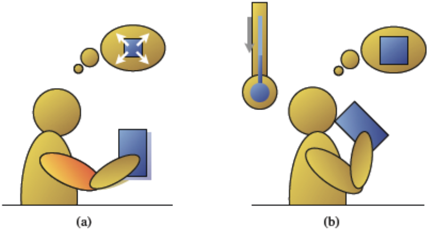

Figure: (a) An activity corresponding to a virtual decrease of thirst will propagate to the visual modality, thus projecting the image of a close cup in the corresponding population. (b) If the agent holds a cup in its hand, activity corresponding to a visual flow induced by the overlapping of a small cup image (current state) and a large image (virtual state) will propagate further and induce a muscle contraction.

Biological plausibility:

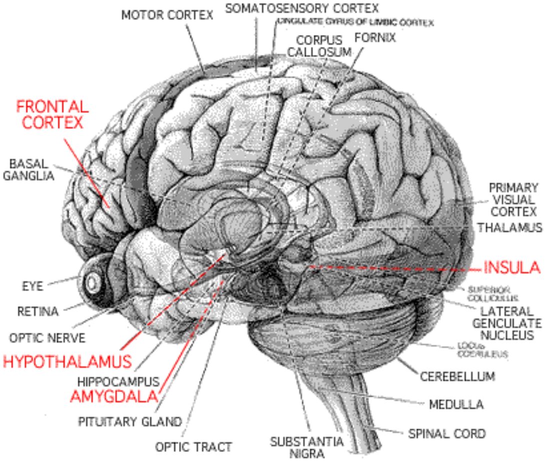

Figure: Motor cortex and somatosensory cortex in human brain

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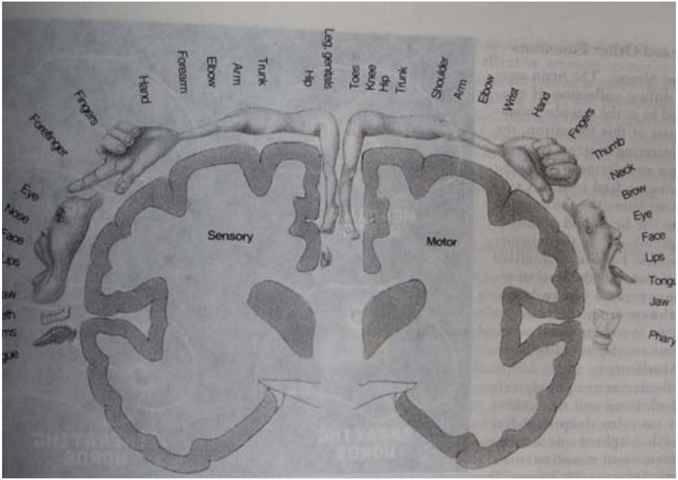

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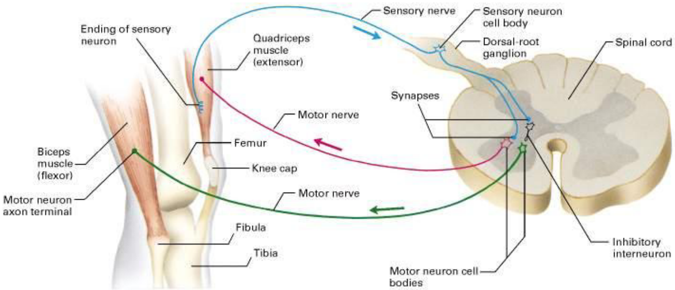


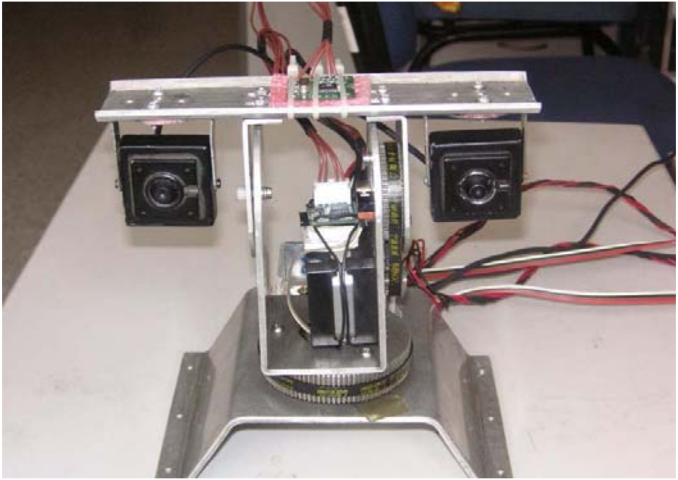
Figure: Knee-jerk Reflex

Approach

Primitive reflexes related to eye and head

- Vestibular-Ocular Reflexes
- Track Reflex
- Visual-neck Reflex
- Blinking Reflex
- Acoustic Blink Reflex

Active Head:



Thank you!