

Sensorimotor Coordination - the Metaphor and Beyond

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What is AI?

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According to Russell and Norvik

1. Systems that think like humans



What is AI?

According to Russell and Norvik

1. Systems that think like humans
2. Systems that act like humans

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According to Russell and Norvik

1. Systems that think like humans
2. Systems that act like humans
3. Systems that think rationally



What is AI?

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According to Russell and Norvik

1. Systems that think like humans
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3. Systems that think rationally
4. Systems that act rationally



Different Approaches to AI

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Classical AI Symbol Grounding AI, uses symbols to represent knowledge so that a machine can work with them to derive some additional knowledge

Two fundamental problems:

1. Symbolic systems lacked the ability to detect and use context information



Different Approaches to AI

Classical AI Symbol Grounding AI, uses symbols to represent knowledge so that a machine can work with them to derive some additional knowledge

Two fundamental problems:

1. Symbolic systems lacked the ability to detect and use context information
2. How to apply symbolic AI to real-life problems

Different Approaches to AI



In [1] "Elephants don't play chess", Brooks proposed an alternative route of AI.

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Different Approaches to AI



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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

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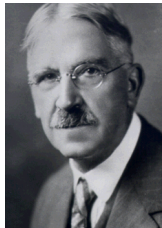
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"We begin not with a sensory stimulus, but with a sensorimotor co-ordination . . . In a certain sense it is the movement which is primary, and the sensation which is secondary, the movement of the body, head, and eye muscles determining the quality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

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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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Why is SMC so ubiquitous?

- ▶ It provides the basis for physical control over objects.

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- ▶ A perceptual nature: it implies that both sensory and motor processes play an integral part in perception.
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- ▶ Allows for the integration of several sensory modalities

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- ▶ It provides the basis for physical control over objects.
- ▶ A perceptual nature: it implies that both sensory and motor processes play an integral part in perception.
- ▶ Induces correlations, thus reducing the high dimensional sensory-motor space to a low-dimensional sub-space.
- ▶ 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)

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The Problem:

Emergence basic adaptive behaviors by sensorimotor coordination

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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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Impact:

- ▶ For AI research, this work will try to answer the question, whether basic behaviors, or even high-level intelligence, can emerge from the interaction with the real world.

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- ▶ For AI research, this work will try to answer the question, whether basic behaviors, or even high-level intelligence, can emerge from the interaction with the real world.
- ▶ For our humanoid robot, this work will create a foundation for its interaction with the world.

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- ▶ For AI research, this work will try to answer the question, whether basic behaviors, or even high-level intelligence, can emerge from the interaction with the real world.
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- ▶ For AI research, this work will try to answer the question, whether basic behaviors, or even high-level intelligence, can emerge from the interaction with the real world.
- ▶ 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.

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Bovet's Works:

In [2][3][4], 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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Bovet's Works:

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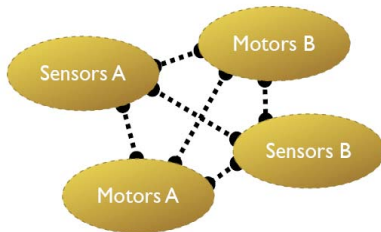


Figure: Homogeneous, non-hierarchical sensorimotor coupling

Bovet's Works:

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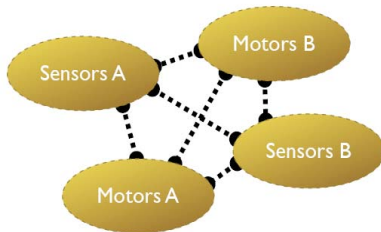


Figure: Homogeneous, non-hierarchical sensorimotor coupling

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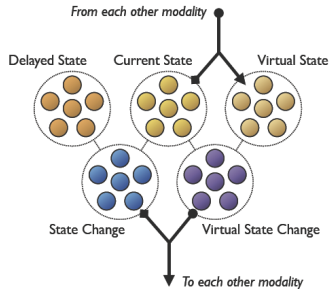


Figure: (a) The agent learns the correlation between a expanding visual flow (growing image of the cup) and activity in the arm muscle (contraction). (b) The agent learns the correlation between a decrease of thirst and the image of the close cup.

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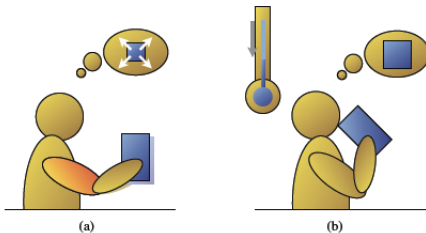


Figure: (a) An activity corresponding to a virtual decrease of thirst will propagate to the visual modality, thus projecting the image of a close cup in the corresponding population. (b) If the agent holds a cup in its hand, activity corresponding to a visual flow induced by the overlapping of a small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

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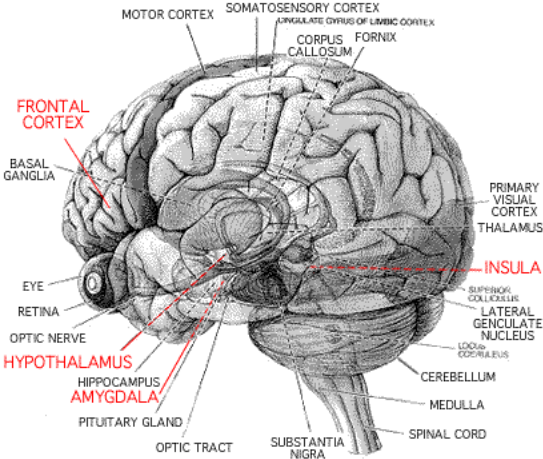


Figure: Motor cortex and somatosensory cortex in human brain

Biological plausibility:

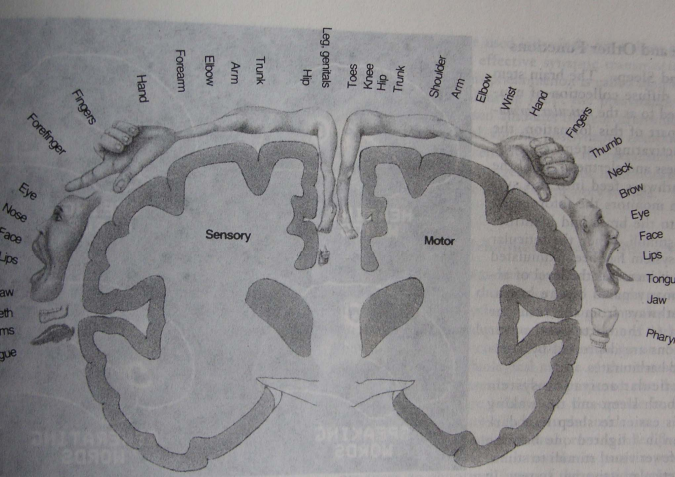


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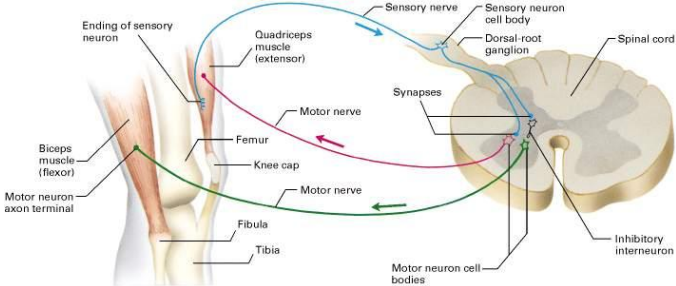


Figure: Knee-jerk Reflex

Approach

Primitive reflexes related to eye and head



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

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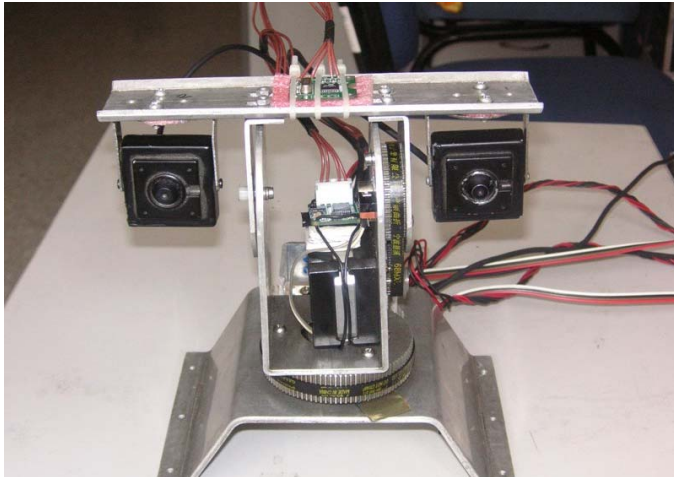
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Active Head:



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Thank you!

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