Institute for Data Science Foundations

Computational aspects of the active self

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MOTIVATION

TOOL-USE PRIMATES

The self is a fundamental concept in human cognition and behavior, but its precise nature and origins remain poorly understood. The **minimal self** is constructed through sensorimotor experiences of embodied agents and consists of the **sense of agency** and **ownership** [1].

Figure 1: Maravita and Iriki [2] show how using a tool changes self-perception, hence the body schema and peripersonal space.

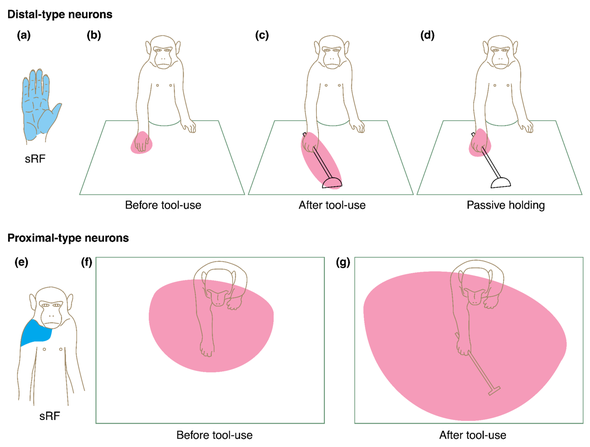

Figure 1: Peripersonal space and body schema during tool-use [2]

BACKGROUND

SENSORIMOTOR LOOP

The **sensorimotor loop** models the process of an embodied agent interacting with the world.

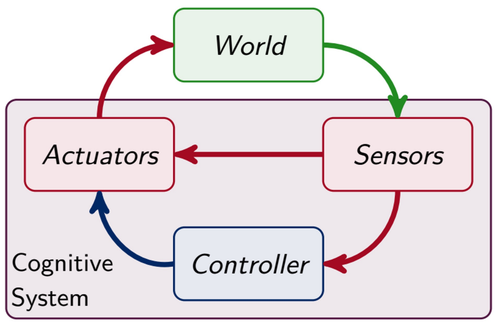

Figure 2: Sketch of the sensorimotor loop.

The dynamics of the system can be described by a stochastic process, where the world, actuators, sensors and the controller are given by random variables.

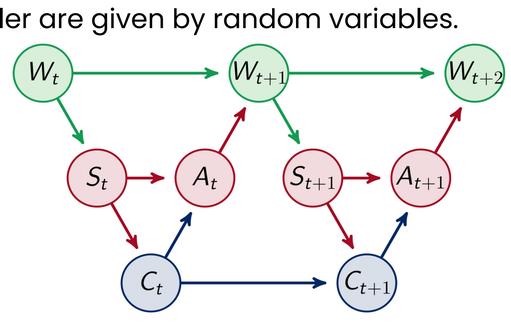

Figure 3: Graph of the process of the sensorimotor loop in time.

METHODS

INTERPLAY BETWEEN THE BRAIN AND THE ENVIRONMENT

We analyze the relationship between the **complexity of the brain** [7] of an agent and its **interaction with the environment** [8] from an information-theoretic perspective.

Experiments with simplistic simulated agents show that the complexity of the brain is inversely correlated to the interaction of the agent with its environment.

The better an agent exploits its surroundings, the less controller complexity is needed.

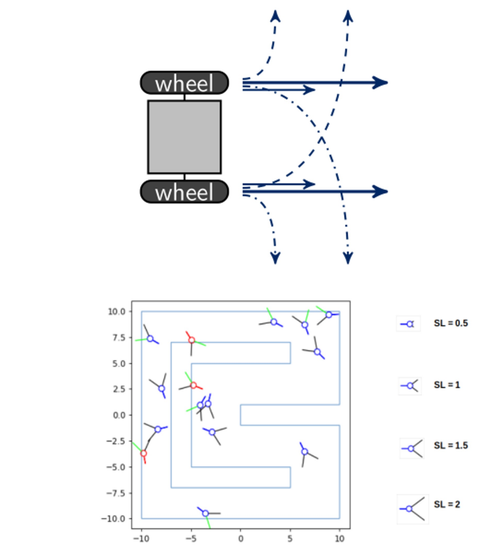

Figure 4: Sketch of the simulated agents on the top and the agents in their environment on the bottom.

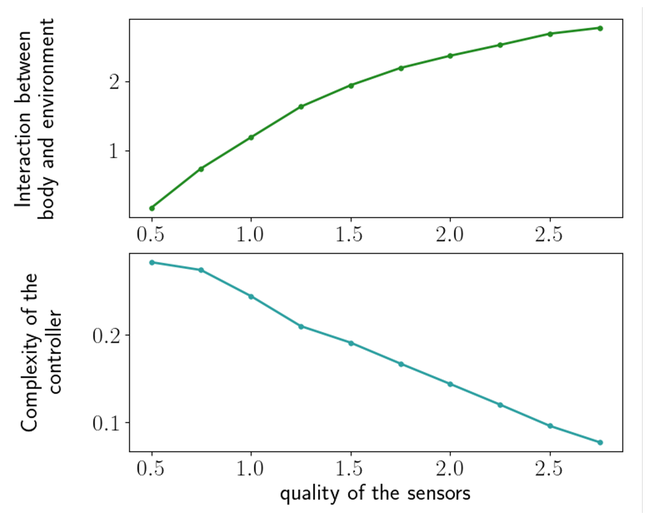

Figure 5: The results of the measures, published in [3].

RECONSTRUCTING THE BODY SCHEMA

In the previous work of Pathak et al. 2017 [4], the authors proposed the Intrinsic Curiosity Module (ICM) for intrinsic motivation in **reinforcement learning** [5]. A byproduct of their approach is a **body representation** shaped by a **forward** and **inverse model**, which reflect properties of the body schema and peripersonal space. We showcase our adaptation in Figure 6.

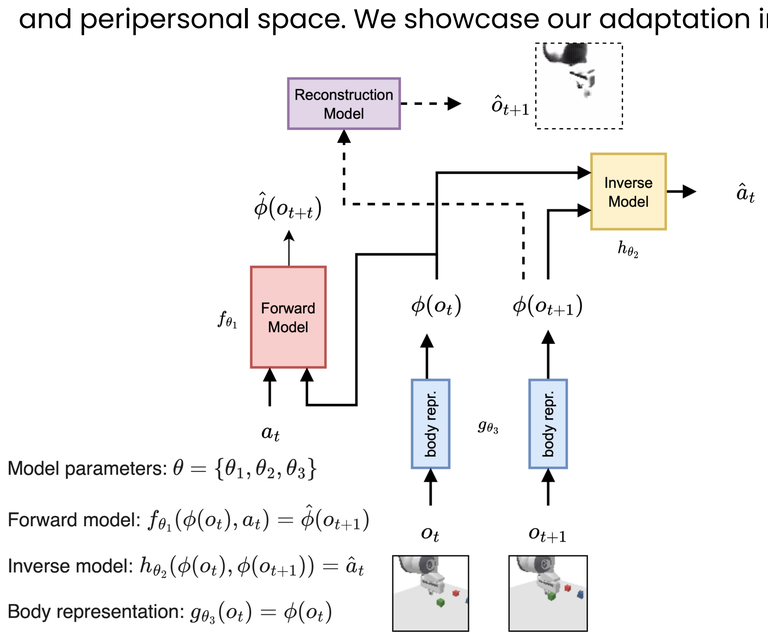

Figure 6: ICMR (ICM + Reconstruction)

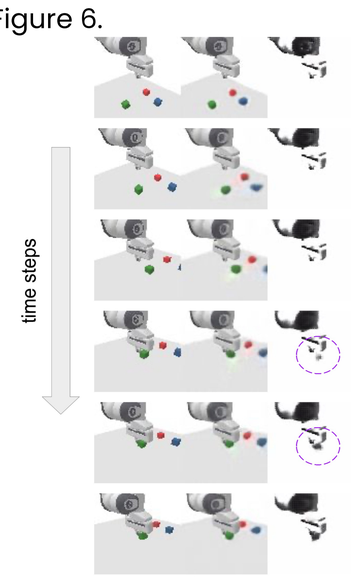

Figure 7: Experiment comparing the observation (left), an autoencoder reconstruction (center), and ICMR (right)

Video Link

Our initial experiment in Figure 7 illustrates the relevance of nearby objects that are in reach or about to be touched, are part of the **body representation**. This validates the findings of Maravita and Iriki [2] that objects being manipulated temporarily become part of the body schema. Our initial results suggest that ICMR resembles some properties of the **minimal self** [6].

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