Abstract for SMLC 2013

Open Question

7. How can one build an agent aware of its environment?

Title

Emergent representations from stochastic diffusion dynamics

Authors

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Extended Abstract

According to a representationalist view, symbols are tools that enable cognitive agents to create internal ontological models of the outside world. These internal models allow anticipation of and adaption to the variety and novelty within their external environments, as well as communication, learning, and reasoning. However, despite the explanatory power of symbol systems, assigning them to represent experience must require previous experience of the symbols, and so the nature of their grounding remains elusive [Harnad1990, Ziemke2000]. Therefore, either one must conclude that symbols cannot exist, or at some level, there must be an *a priori* elemental understanding about the environment from which experience derives. Since natural language and formal logic are both symbol systems evolved by humans and used to reason and communicate about our world, it seems apparent that representational symbols do exist, and we must therefore understand what form of elementary experience could ground these symbols in a physical sense [Svensson2005, Muller2009].

Howard Pattee offers a possible approach to understanding symbols in a physical way [Pattee1995, Pattee2001, Raczaszek-Leonardi2012]. He suggests that symbol systems, whether they are cognitive symbols, genetic phenotypes, or computer software, can be viewed from two perspectives: on the one hand, they are symbols, full of meaning, whose manipulation may support reference, communication, and reasoning; but on the other hand, these symbols must have a physical or material nature which explains their existence, replication, and persistence. For instance, while DNA provides the “blueprint” for a life form, it is also a molecule, following the physical laws of molecular interaction. When DNA interacts with specific other proteins, it can serve to describe the structure of proteins such that they can be generated from amino acids; however, this interaction between the DNA and the other proteins is supported by the physics of molecular bonding. It seems possible

that an analogous dual-perspective model might provide insight to symbol dynamics of the brain [Cariani2001].

In this dual-perspective view, elementary symbols actually have physical forms, and it is through their physical interactions that their semantic potential is realised and complex structures can be represented. Then, a multi-level ontology can emerge wherein high-level symbols are clusters of lower-level symbols. As clusters or swarms generally are, these clusters are fluid and dynamic [Hofstadter2008], gradually gaining and losing lower-level symbols over time, potentially completely transforming their meaning or physical basis. They might also merge together or break apart, as generalizations or details become important.

However, there must be some force to drive the physical dynamics of the elementary symbols and, for symbols to have meaning, they must have something to represent. Interactive or enactive models of cognition emphasize the importance of environmental interaction in the emergence of an organism's consciousness [Ziemke2003, DiPaolo2006, Froese2009]. In the Interactivist model, put forth by Mark Bickhard, representation emerges through an organism maintaining its own far-from-equilibrium state via interaction with its environment [Bickhard2009]. In particular, an organism which has multiple potential modes of interacting with the environment must anticipate and select beneficial interactions for each situation. The formation and reinforcement of these anticipations can be driven by a simple dynamical process, resulting in a dual-perspective view akin to Pattee's.

This paper aims to explore the role of embodied interaction on the formation of symbols, by modelling the cognitive aspect of an organism as a swarm of elementary agents (where each agent serves as a loose functional representation of a neuron or a small group of neurons) governed by dynamics akin to Stochastic Diffusion Search [Bishop1989, Nasuto1998, Nasuto1999]. Stochastic Diffusion Search is a stochastic swarm model that, through a combination of exposure to an environment and basic communication amongst the population's members, produces dynamic clusters around "interesting" features in the environment. The exact definition of "interesting" may vary depending on the application, but the population's ability to cluster around these features using little more than local information is perhaps analogous to how neuronal populations synchronize into transient clusters when engaged in cognitive tasks. We suggest that this model may provide a metaphor presenting features that are intuitively recognizable as representations, without making any claims to the specific place that meaning occurs in the brain. Thus, this models demonstrates how representations could emerge from an organism's interaction with the environment in such a way that it may serve to reconcile the divergent opinions on the subject of representation.

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