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Graphs in space: A domain-general and level-spanning tool for representing structure.

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Structured representation has a critical role in cognition, thus modeling structured representation has a critical role in cognitive science. However, the lack of a unified representational framework stands in the way of connecting the insights generated by models of different domains. To address this challenge, we suggest graphs as a domain-general tool for representing high level models. A further challenge arises from the need to model cognition at multiple levels of analysis. Drawing on work in Vector Symbolic Architectures, we suggest an implementation of a graph with high dimenional vectors, employing representations and operations thought to be characteristic of neural processing. We discuss approaches and challenges for modeling generalization and compositionality within this framework. Finally, we implement a simple graphical language acquisition model using the VectorGraph to demonstrate how it can be used in cognitive modeling.

1 Introduction

The representation of structure is a fundamental prerequisite for sophisticated cognition. Whether an agent wants to navigate a physical environment, select a socially successful mate, or read an undergraduate's half-baked honors thesis, she will need an internal model of the relevant system. These internal models go beyond Skinnerian stimulus-response pairings discovered through reinfocement learning: They form a coherent and veridical view of the represented system, improving the agent's ability to interact with that system edelman08. These internal models play such an important role in cognition that the study of their form, acquisition, and use makes up the majority of work in cognitive science.

Given that the goal of science is to create models of the world, cognitive scientists are presented with a unique challenge: modeling internal models, or representing representations. As in other scientific fields, a model of internal models should be systematic and unified. It should explain how the details of specific internal models (e.g. of language) reflect general principles of mind/brain representations. Additionally, a theory of internal models must be described at multiple levels of abstraction marr82, edelman08. Human representations are ultimately implemented with synaptic weights and neural activations; however, a theory at the implementational is only partially explanatory. To fully understand a representational system, one must identify larger functional units that emerge from the representational substrate.

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