(Abstract) Conceptual Abstraction and Analogy in Natural and Artificial Intelligence

Harrison Pielke-Lombardo

August 5, 2020

Contents

1 Questions and Topics

- What are potential AI applications in which humanlike concept formation, abstraction, and analogy could improve performance and make systems more robust?

- What is known in psychology and neuroscience about the mechanisms by which humans (and non-human animals) develop and use concepts, form abstractions, and make analogies? How can such mechanisms inspire AI research?

- Can gradient-descent-based systems learn to produce analogical reasoning on novel problems? What can the state-of-the-art in inductive program synthesis teach us about abstraction and reasoning?

  – How can abstraction and analogy-making abilities in AI systems be assessed? What can we do to ensure that performance on a test will guarantee generalization?

- Can we discover general computational mechanisms for abstraction and analogy by focusing on idealized microdomains, or could the real

challenges lie in interfacing analogical mechanisms with a vast array of commonsense knowledge?

- If we want machines to creatively invent wholly new theories from data, like scientists do, what roles would abstraction, analogy, and strong generalization play?

2 Track

☐ AI for Social Good

☐ Artificial Intelligence in Government and Public Sector

☐ Cognitive Systems for Anticipatory Thinking

☒ Conceptual Abstraction and Analogy in Natural and Artificial Intelligence

☐ Physics-guided AI to Accelerate Scientific Discovery

☐ Trust & Explainability in Artificial Intelligence for Human-Robot Interaction (AI-HRI)

3 Abstract

One of the main goals of biomedical research is to explain the biological phenomena involved in human diseases and interventions, yet computational methods stop short of providing human-like explanations. Understanding of these phenomena is often in terms of biological mechanisms which in turn are often understood in terms of analogies. Therefore the automatic generation of human-like explanations of biological phenomena will likely involve analogical reasoning. One kind of analogical reasoning, generalization, is related to an important task of reasoning about mechanisms called schematization. Mechanism schema can be used for the retrieval, mapping, adjustment, and evaluation of newly discovered and previously known mechanisms. Here, I present a method for the automatic schematization of biological mechanisms which uses both causal and non-causal knowledge about a set of structurally represented target mechanisms.

References