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

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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 their interventions, yet computational methods stop short of providing human-like explanations. Presented here is an automatic method based on analogical reasoning for generating causal schema to support biological explanation. The approach used offers the potential for systematic, scalable, and hierarchical mechanism schema construction which could be used for mechanism retrieval, identification, evaluation, and inference tasks.

The transmission and transference of ideas among the many domains of biomedical research can be difficult. It is diverse, with many areas of specialty, each with there own names, jargon, questions, and intests. However, many of these specialty areas have in common the pursuit of mechanistic explanations. Often these are communicated using general analogies ("the

heart is a pump", "the lock and key enzyme-substrate hypothesis", "unzipping DNA by heilcase") which can be effective both for communicating causal processes and inspiring new insights.

Analogies are efficient for communicating ideas about mechanisms. This is because they relate domain specific causal processes with widely understood causal processes. The analogies either implicitly or explicitly compare and align components of their subjects, allowing the domain specific knowledge to be abstracted away. These alignments can be formally represented as mechanism schema.

Mechanism schematization has a number of potential applications from retrieval and identification, to comparison and transformation, and even for causal inference.

4 Acknowledgments

References