Neuro-Symbolic Modeling: Overview

Learning & Reasoning

This lecture

- The Two Systems of Thinking
- Learning & Reasoning
- History: Statistical relation learning
- Some examples of neural-symbolic integration
- Technical challenges for neural-symbolic integration
- A taxonomy of approaches

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Learning & Reasoning

Two fundamental aspects of intelligent behavior

Valiant, Leslie G. 2003. “Three Problems in Computer Science.” Journal of the ACM (JACM) 50 (1): 96–99.

Learning & Reasoning

Two fundamental aspects of intelligent behavior

- Learning from experience
- Reasoning with knowledge (including perhaps learned knowledge)

> We need a semantics of knowledge that can computationally support the basic phenomena of intelligent behavior

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Let’s see some examples: Learning

A self-driving vehicle learning to navigate a fixed path through repeated trials

Training a neural network on a large dataset of images to recognize cats

A robot learning to walk by repeatedly attempting to walk and adjusting its movements

Let’s see some examples: Reasoning

Finding a path through a maze

Making a chess move, considering current board position, potential consequences of each move, and opponent’s strategies

Diagnosing a patient by deciding which tests to conduct, and observing and interpreting results

An analogy to two systems

	The “two systems” view	The AI view
Fast heuristics based on experience		
Slow deliberative thinking		

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In both cases, intelligent behavior requires both fast heuristics and deliberative thinking

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We need a way of looking at and manipulating knowledge that is consistent with and can support both learning and reasoning

- Neural networks represent the most effective learning systems today
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We would like the best of both worlds

A fundamental mismatch?

Both learning and reasoning have been extensively studied in computer science, *but the tools to formalize them seem irreconcilable*

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- e.g., PAC learning
- Performance is measured by goodness of fit with real world experience

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- e.g., the standard semantics of propositional logic
- A presumption that a precise formalization of knowledge is possible

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There are alternative approaches for deduction based on probability theory

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