

Knowledge Representation and Reasoning

CSE 505 – Computing with Logic

Stony Brook University

<http://www.cs.stonybrook.edu/~cse505>

Knowledge Representation and Reasoning Applications

- Knowledge representation and reasoning (KR) is the field of artificial intelligence (AI) dedicated to representing information about the world in a form that a computer system can utilize to solve complex tasks
- Think of the following systems:
 - Cognitive Assistant (SIRI) = having a dialog in a natural language
 - Computational Knowledge Engine (Wolfram Alpha) = scientific and medical thinking
- For each system:
 - What knowledge must it represent?
 - What reasoning must it do?
 - What would it take to extend it?
 - Where does it fail?
 - How is it different from (current) Google Search?



Cognitive Assistant SIRI

- What knowledge must it represent?
 - Restaurants, movies, events, reviews, ...
 - Location, tasks, web sources, ...
- What reasoning must it do?
 - Nearest location, date for tomorrow, AM vs PM, etc
- What would it take to extend it?
 - More sources, different sources
- Where does it fail?
 - Completely different environment, completely different task
- Differences from Google
 - Dialog driven, task-oriented, location aware

Wolfram Alpha

- <http://www.wolframalpha.com/examples/>
 - Try: the nutrition example
<http://www.wolframalpha.com/examples/FoodAndNutrition.html>
- What knowledge must it represent?
 - Different kinds of foods, their nutrition composition, caloric values
- What reasoning must it do?
 - Mathematical computations based on portions
- What would it take to extend it?
 - Add more data on foods and nutrition composition
- Where does it fail?
 - Does not know about recipes, how to combine foods
- Differences from Google:
 - Data driven as opposed to document driven, mathematical reasoning

Knowledge Representation

- What is representation?
- Symbols standing for things in the world:
 - first aid 
 - women 
 - John “John”
- Knowledge representation: symbolic encoding of propositions

Knowledge Representation

- What is reasoning?
- Manipulation of symbols encoding propositions to produce representations of new propositions
- Example: “Every man is mortal”
“Socrates is a man”
Therefore, “Socrates is mortal”

Knowledge Representation

- Knowledge base (in Flora-2):

Socrates : Man.

Socrates[age -> 56, home -> Athens].

Socrates[student -> {Plato, Xenophon}].

?X : Mortal :- ?X: Man.

?X:Athenian :- ?X[home->Athens].

KR and AI

- Much of AI involves building systems that are knowledge-based = ability derives in part from reasoning over explicitly represented knowledge
 - language understanding,
 - planning,
 - medical diagnosis,
 - “expert systems”, etc.
- Some, to a certain extent
 - game-playing, vision, etc.
- Some, to a much lesser extent
 - speech, motor control, etc.
- Current research question: how much of intelligent behaviour is knowledge-based?

Benefits of KR

- Knowledge-based system most suitable for open-ended tasks
 - We can add new tasks and easily make them depend on previous knowledge
- Good for
 - explanation and justification
 - “Because grass is a form of vegetation.”
 - debug faulty behavior by locating the erroneous beliefs
 - “No the sky is not yellow. It's blue.”
 - Explain and Justify the behavior of the system
 - “The program did X because Y“

Benefits of Reasoning

- Given
 - Patient X allergic to medication M
 - Anyone allergic to medication M is also allergic to medication M'
- Reasoning helps us derive
 - Patient X is allergic to medication M'

Entailment

- Sentences P_1 , P_2 , ..., P_n entail sentence P iff the truth of P is implicit in the truth of P_1 , P_2 , ..., P_n
 - If the world is such that it satisfies all the P_i then it must also satisfy P .
- Inference: the process of calculating entailments
 - sound: get only entailments
 - complete: get all entailments

KR&R and AI

- KR&R started as a field in the context of AI research
 - Need explicitly represented knowledge to achieve intelligent behavior
- Many of the AI problems today heavily rely on statistical representation and reasoning
 - Speech understanding, vision, machine learning, natural language processing
 - For example, the recent Watson system relies on statistical methods but also uses some symbolic representation and reasoning
- Some AI problems require symbolic representation and reasoning
 - Explanation
 - Diagnosis
 - KR&R today has many applications outside AI: Bio-medicine, Engineering, Business and commerce, Databases, Software engineering

KR&R and AI

- Some Long-Term Problems that need Knowledge Representation
 - Read a chapter in a textbook and answer questions at the end of the chapter
 - Learn how to repair a mobile robot and successfully demonstrate the capability by repairing one on Mars
 - Produce a 5000 word or less encyclopedia style article on a given subject by summarizing from the relevant information available on the web in less than 24 hours