Knowledge Representation and Reasoning

CSE 595 – Semantic Web
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http://www3.cs.stonybrook.edu/~pfodor/courses/cse595.html
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/](http://www.wolframalpha.com/examples/)
  - Try: the nutrition example
- 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}].
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