

Chapter 26. Reasoning and Representation

The Quest for Artificial Intelligence, Nilsson, N. J., 2009.

Lecture Notes on Artificial Intelligence, Spring 2012

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Contents

26.1 Nonmonotonic or Defeasible Reasoning

Nonmonotonic or Defeasible Reasoning

26.2 Qualitative Reasoning

Qualitative Reasoning

26.3 Semantic Networks

Semantic Networks

26.3.1 Description Logics

26.3.2 WordNet

26.3.3 Cyc

Appendix

Overview of Chapter 26

- In 1980s, new methods emerged for representing knowledge and reasoning to overcome some problems
 - Nonmonotonic or defeasible reasoning
 - Taxonomy hierarchies
 - Qualitative reasoning
 - For not logical formulas
 - NEWTON, The Naïve Physics Manifesto
 - New types of semantic networks in 1980s
 - Description logic
 - WordNet
 - Cyc

Chapter 26. Reasoning and Representation

26.1 Nonmonotonic or Defeasible Reasoning

Nonmonotonic or Defeasible Reasoning

- **Monotonic: A problem in logical reasoning**
 - The set of logical conclusions that can be drawn from a set of logical statements does not decrease as more statements are added to the set
 - But human reasoning does not seem to work that
- **Nonmonotonic and defeasible reasoning**
 - Retract that conclusion when we learn some new fact that contradicts the assumptions.
 - Methods with defeasible reasoning in early works
 - PLANNER(C. Hewitt), PROLOG, STRIPS
 - Database applications
 - “exception principle” in SIR
 - “cancelation inheritance” in taxonomy hierarchies
- **Taxonomy hierarchies**
 - Ex. Office machines

Nonmonotonic or Defeasible Reasoning

- 1980s' works for defeasible reasoning
 - New methods based on theoretical analysis
 - Default rules (R. Reiter)
 - Circumscription (J. McCarthy)
 - Circumscribing: Tall(John), Tall(Frank), ..., Tall is circumscribed $\rightarrow \neg$ Tall(Susy) if Tall(Susy) is not implied
 - Frame problem
 - to make the assumption that if a predicate describing some state of the world is not mentioned by a description of an action then that predicate is not changed by the action. \rightarrow nonmonotonic
 - Shanahan's and Thielscher's approaches

Chapter 26. Reasoning and Representation

26.2 Qualitative Reasoning

Qualitative Reasoning

■ Do our brains use anything like the equation?

■ Mathematical formulas

■ Ex. $F=ma$ (force), $v = \sqrt{\frac{g\lambda}{2\pi} \tanh\left(2\pi\frac{h}{\lambda}\right)}$ (wave equation)

■ Probably not.

■ Procedural knowledge and declarative statements

■ Qualitative knowledge

■ Neither procedural “muscle memory” nor mathematical formulas

■ Ex. How do we know that if we drive to our destination a little bit faster, we'll get there a little bit sooner?

Qualitative Reasoning

- System for qualitative reasoning
 - BUILD (S. Fahlman): the first AI system for QR
 - NEWTON (J. de Kleer)
 - Use of its qualitative knowledge about physics to produce approximate problem solutions
 - Envisioning
 - The Naïve Physics Manifesto (P. Hayes, 1979)
 - the construction of a formalization of a sizable portion of common-sense knowledge about the everyday physical world
 - how to represent “clusters” of common-sense knowledge about the physical world.
- Lead to a rapidly growing subfield of AI such as diagnosing faults

Chapter 26. Reasoning and Representation

26.3 Semantic Networks

Semantic Networks

■ Taxonomy networks

- Semantic network representing taxonomy hierarchies for defeasible reasoning
- Ontologies
- Frames: a collection of special data structures for taxonomy networks

```
Printers
subset_of: Office_machines
superset_of: {Laser_printers,
              Ink_jet_printers}
energy_source: Wall_outlet
creator: John_Jones
date: 16_Aug_91
```

Figure 26.2: A frame. (Adapted from Nils J. Nilsson, *Artificial Intelligence: A New Synthesis*, p. 313, San Francisco: Morgan Kaufmann Publishers, 1998.)

26.3.1 Description Logics

- **Controversy on knowledge representation**
 - Data structures (semantic networks) vs. sets of logical statements
 - R. J. Brachman and H. J. Levesque
 - Semantic networks is thought as a special way of representing some kinds of logical statements
- **KL-ONE (R. Brachman)**
 - The basis of description logics
- **KRYPTON (H. Levesque)**
 - The forerunner of description logics
 - Hybrid of logical formulas and semantic networks
 - Examples



Figure 26.3: Ronald Brachman (top) and Hector Levesque (bottom).

26.3.2 WordNet

■ WordNet

- A large “conceptual” dictionary of English words, organized somewhat like a semantic network
- Inspired by psycholinguistic and computational theories of human lexical memory
- Synsets
 - Collections grouping words of WordNet
 - Relations of synsets
 - Hypernym: is kind of
 - Hyponym: is a general case of
 - Meronym: has as parts (opp. Holonym)
- 155,287 words and 117,659 synsets
- Available: <http://wordnetweb.princeton.edu/perl/webwn>

26.3.3 Cyc

■ Cyc (D. Lenat, 1984)

- A program with common sense
- From encyclo~~p~~edia
- Need for a large amount of common-sense knowledge
- Three steps for Cyc
 - The first: the millions of everyday terms, concepts, facts, and rules of thumb
 - The second: read all kinds of material and acquire additional knowledge on its own knowledge
 - The third: perform experiments to gain more knowledge, which is beyond what humans already known



Figure 26.5 (a) : Douglas Lenat

26.3.3 Cyc

■ CycL

- a language for represent knowledge in Cyc
- An extended first-order predicate calculus
- Structure of Cyc knowledge

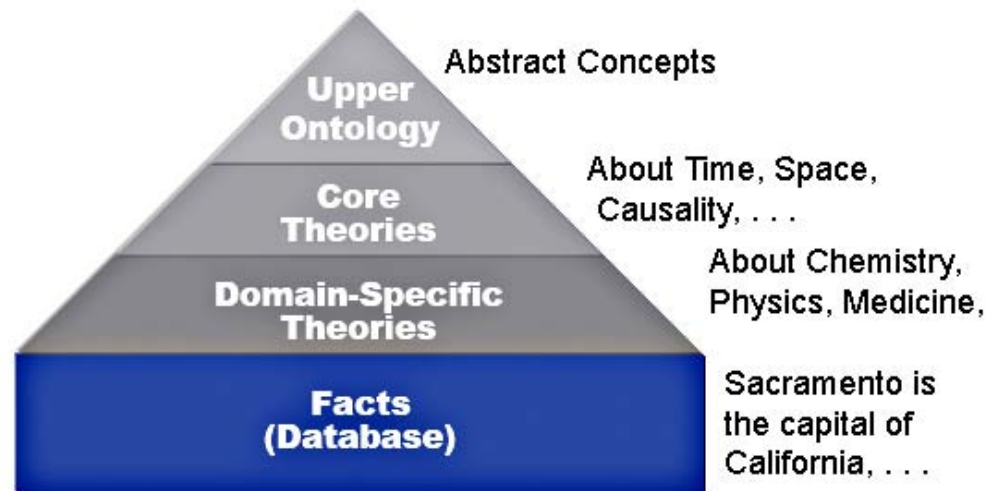


Figure 26.5 (b) : Structure of the Cyc knowledge base

26.3.3 Cyc

- **Cyc's knowledge base (KB)**
 - Thousands of “micro-theories” - collections of concepts and facts about some circumscribed area
 - Ex. One micro-theory: knowledge about European geography
 - over five-million general assertions
 - grammatical and lexical knowledge needed for natural language processing
- **Cyc inference engine**
 - conclude new facts from other existing facts and rules in its KB
 - Two methods
 - Resolution
 - Property inheritance
 - Over 1,000 special-purpose inferencing modules for handling specific classes of inference
- **Cycrop: intelligent search and information retrieval**

26.3.3 Cyc

■ Criticism of Cyc

- Some reasoning problem
- Not generally available for peer evaluation due to private setting
- Cannot automatically translate English to CycL yet

■ How to get Cyc

- ResearchCyc: license is needed
- OpenCyc: open source

■ Similar works

- Commonsense Computing Initiative:
<http://xnet.media.mit.edu/>
- FACTory: <http://game.cyc.com/game.html>

Chapter 26. Reasoning and Representation

Appendix

Nonmonotonic or Defeasible Reasoning



■ Taxonomy hierarchies

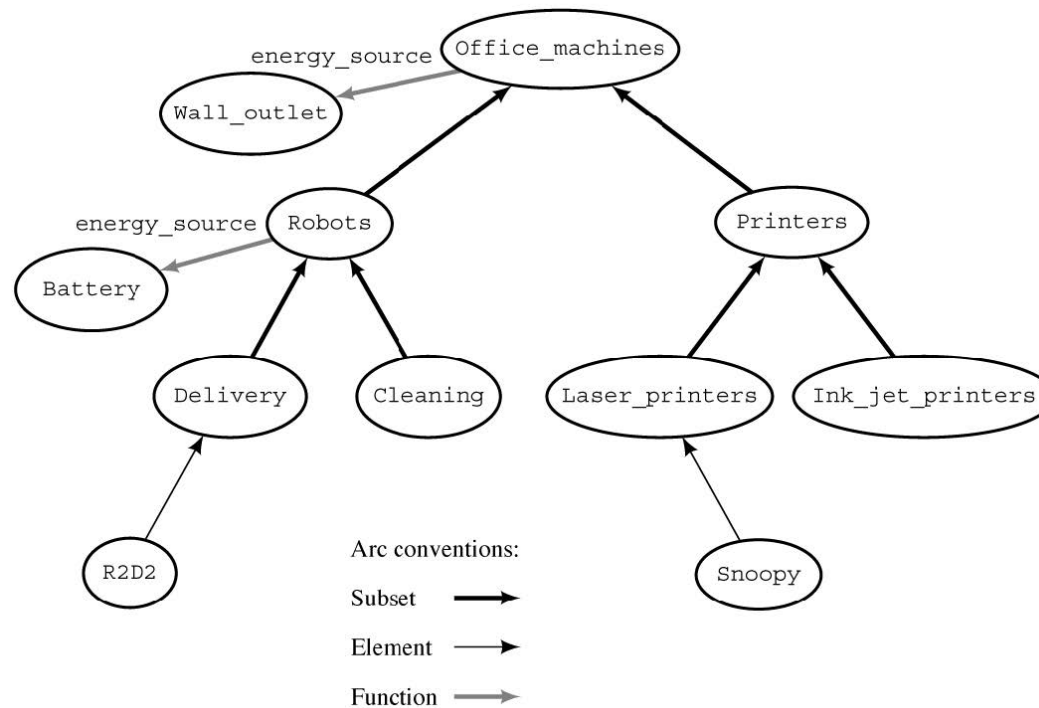


Figure 26.1: A hierarchy of office machines. (From Nils J. Nilsson, *Artificial Intelligence: A New Synthesis*, p. 311, San Francisco: Morgan Kaufmann Publishers, 1998.)

26.3.1 Description Logics



- The Diagram from KRYPTON

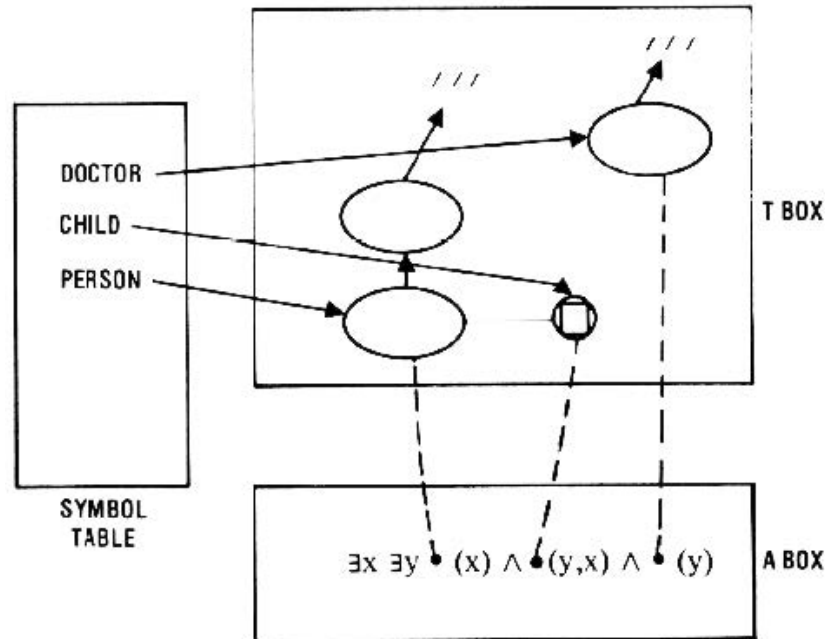


Figure 26.4: Parts of a KRYPTON T Box and A Box. (Adapted from Ronald J. Brachman, Richard E. Fikes, and Hector J. Levesque, "KRYPTON: A Functional Approach to Knowledge Representation, IEEE Computer, Vol. 16, No. 10, p.71, October 1983.)

- Description logics are used in ontology language such as DAML-ONT and OWL