

Ontologies - A Very General Overview

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February 2003

Preamble

- the meaning of the term “ontology” in computing is different its meaning in philosophy
 - there is a connection, though
- initially, understand the term “ontology” in computing as a **“standard vocabulary”**

Overview

- context and motivation for ontologies
- definitions
- ontologies for humans, ontologies for machines
- examples: WordNet and CYC; investigation
- stating/expressing an ontology
- reasoning within an ontology
- levels of abstraction; types of ontologies
- ontologies and domain descriptions
- conjecture: ontologies are necessarily required

Dialogues between humans and machines

Type of dialogue	Role of Software System (Machine)	Example
human-human (via a software)	acts as a notice board, with some “nice” editing features; it does not need to understand anything of the phrases exchanged by the human agents through it	editor
human-software	may act as a structured repository of data, providing query facilities more or less independent of the meaning of the stored data; the human must know the structure of data and map that structure to meaning	database
human-software	may act as an agent who has some knowledge of a part of “the world” and who is able to communicate a part of that knowledge in response to the human’s questions; the human and the software must share the same understanding of the domain (part of “the world”)	semantic web
software-software	acts as an agent who has some knowledge of a part of “the world” and who is able to communicate a part of that knowledge in response to another software agent’s questions; the two software agents must share the same understanding of the domain (part of “the world”)	agents and the semantic grid

Ontologies - Motivation

- truism: many agents can understand each other only if they share a common language (syntax and semantics)

Ontology - Definitions

- a **shared** and **common/unitary** understanding of a domain that can be **communicated** between people and heterogeneous software systems (Fensel, 2001)
- a shared and common language (or a standard language) for a specific domain
 - vocabulary
 - syntax / grammar

Ontologies - Examples

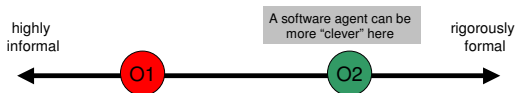
- in medicine ...
- in computing ...
- in the financial sector ...
- in the context of local governmental councils ...
- in museums ...
- *level of abstraction*

Ontologies – Who Uses Them?

- humans
 - informal
- software agents
 - machine readable (interpretable) - formal

From Informal to Formal

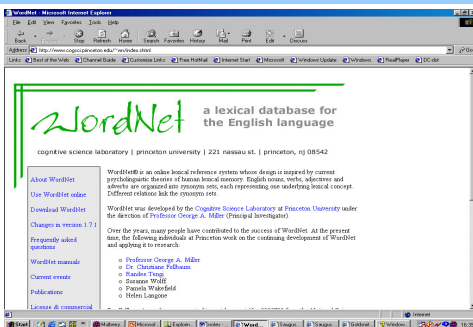
- there is a continuum between informal and formal
 - informally (sic!): the better the quality of the reasoning/processing that a software agent can perform within an ontology, the more formal the ontology is
 - the degree of formality of an ontology increases with its expressive power regarded from the point of view of software agents



Ontologies - Examples

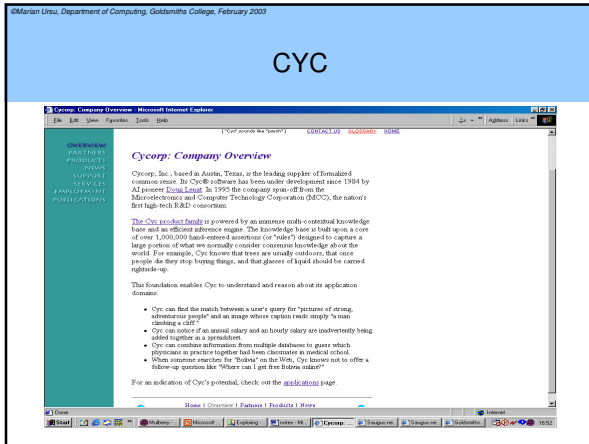
- WordNet
 - informal
 - thesaurus for natural language terms, explained in natural language
- CYC
 - formal
 - theories for common sense knowledge

WordNet



WordNet

- <http://www.cogsci.princeton.edu/~wn/>
- explore and discuss its features



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CYC - Applications

- applications currently available or in development
 - [Integration of Heterogeneous Databases](#)
 - [Knowledge-Enhanced Retrieval of Captioned Information](#)
 - [Guided Integration of Structured Terminology \(GIST\)](#)
 - [Distributed AI](#)
 - [WWW Information Retrieval](#)
- potential applications
 - Online brokering of goods and services
 - "Smart" interfaces
 - Intelligent character simulation for games
 - Enhanced virtual reality
 - Improved machine translation
 - Improved speech recognition
 - Sophisticated user modelling
 - Semantic data mining

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CYC

- explore and discuss:
 - [Knowledge-Enhanced Retrieval of Captioned Information](#)
 - [WWW Information Retrieval](#)
 - [Integration of Heterogeneous Databases](#)
 - [Guided Integration of Structured Terminology \(GIST\)](#)
 - [Distributed AI](#)

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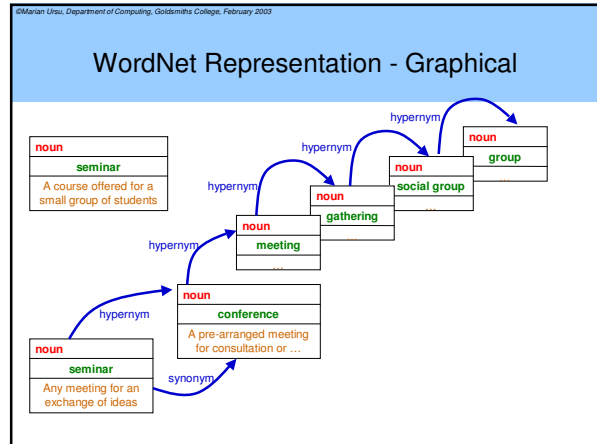
Stating/Expressing an Ontology; Reasoning

- informal ontology
 - a limited set of pre-defined categories and relationships and abundant natural language annotations
 - limited capabilities for automatic inferences/reasoning
- formal ontology
 - a formal language; for example, a subset of first order predicate logic
 - good capabilities for automatic inferences/reasoning

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Informal Ontology - Language

- example: WordNet (simplified)
 - some pre-defined categories:
 - Noun: name; explanation
 - Verb: name; explanation
 - Adjective: name; explanation
 - Adverb: name; explanation
 - some pre-defined relationships
 - Synonym
 - Hypernym (X is a kind of ...)
 - Hyponym (... is a kind of X)
 - pre-defined terms are "understood" by the system



WordNet Representation - Relational DB

nouns

Name	Meaning	Description
seminar	1	any meeting for an exchange of ideas
seminar	2	a course offered for a small group of students
conference	1	a pre-arranged meeting for consultation or ...
meeting	1	...
gathering	1	...
social group	1	...
group	1	...
...

hypernyms

Name	Meaning	Name	Meaning
seminar	1	conference	1
conference	1	meeting	1
meeting	1	gathering	1
gathering	1	social group	1
social group	1	group	1
...

synonyms

Name	Meaning	Name	Meaning
seminar	1	conference	1
...

WordNet - Reasoning Capabilities

- find all the explanations for a given noun (name)
- find all the level one synonyms for a certain noun
- find all the level one hypernyms for a certain noun
- find all the hypernyms for a certain noun
- ...
- *quite poor*

Formal Ontology - Formal Language

- declarative
- a subset of natural language, but much better structured, to the extent that machines can make inferences — can “reason” — with its expressions
 - to infer/reason means to deduce new expressions from existing ones
- domain categories and relationships can be introduced by means of the language

Formal Ontology - Example

FACTS

woman(Julie)
 woman(Margaret)
 man(Marian)
 friend-of(Julie, Margaret)
 friend-of(Marian, Julie)
 works-for(Const-How, Julie)
 works-for(Const-How, Margaret)
 works-for(Computing, Marian)

RULES

person(x) IF man(x)
 person(x) IF woman(x)
 friend-of(x, z) IF
 friend-of(x, y) AND
 friend-of(y, z)
 colleague-of(x, y) IF
 works-for(x, z) AND
 works-for(y, z)

INFERENCE RULES

FROM fact(a)
 AND rule(b IF a)
 INFER
 fact(b)

Formal Ontology - Reasoning Capabilities

- find all the women
- find all the persons
- find Marian's friends
- find all the pairs of friends
- find Marian's friends who work for “Constance Howard”
- are there any colleagues who do not work for the same department?
- ...
- *quite rich*

Ontology vs Domain Description

Ontology

man/1
 friend-of/2 : person x person
 works-for/2 : institution x person
 person(x) IF man(x)
 person(x) IF woman(x)
 friend-of(x, z) IF
 friend-of(x, y) AND
 friend-of(y, z)
 colleague-of(x, y) IF
 works-for(x, z) AND
 works-for(y, z)

Domain Description

//FACTS
 man(Danny)
 man(Tony)
 man(Marian)
 friend-of(Danny, Tony)
 friend-of(Marian, Danny)
 works-for(Lew-Council, Danny)
 works-for(Lew-Council, Tony)
 works-for(Gold-Uni, Marian)
 //PLUS THE ONTOLOGY

Ontologies vs Databases - Differences

- an ontology is usually “richer” (in terms of being reasoned with) than a database schema
 - this aspect relates to technology
- an ontology must be a **shared and consensual terminology**
 - this aspect is beyond technology - it relates to the dynamics and interactions between social systems

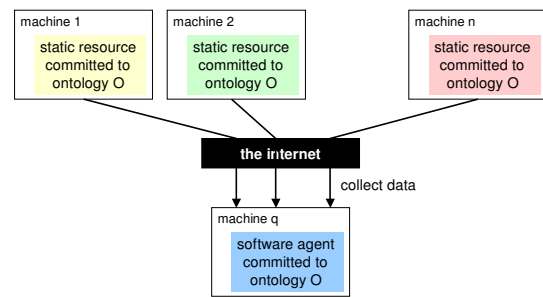
Ontologies – Levels of Abstraction

- domain ontologies
 - vocabularies for medicine, museums, government agencies
- ontologies for general and common sense knowledge
 - e.g. for mathematics (numbers, arithmetic operators), for physical descriptions (space, time) and for common sense knowledge (dangerous, avoid, ...)
- representational ontologies
 - domain (understood as above) independent; e.g. the frame ontology (Gruber 1993), for frame based (Object Oriented) representations

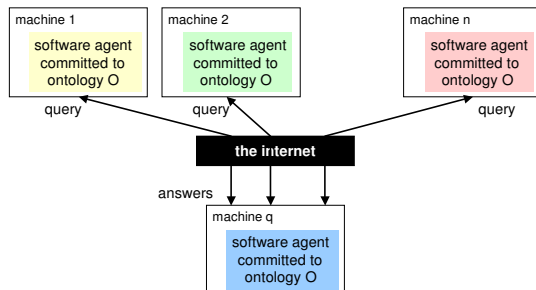
Ontologies - Conjectures

- ontologies are needed in the context of any knowledge based or knowledge management system, whenever the issue of knowledge sharing arises
- the more refined and formal (sic!) an ontology is, the better are the capabilities for developing “intelligent” software agents
- ontologies are necessarily required for the next stage in the development of the WWW — the semantic web
 - current meta-data standards (e.g., Dublin Core) represent only the beginning (*will become clearer later*)

Ontologies and the Semantic Web



Ontologies and the Semantic Web



Ontologies and Meta-Data

- an ontology can be used to express meta-data
- a meta-data standard/class is an (informal) ontology

Summary

- why ontologies
- what are ontologies
- from very informal to rigorously formal
- examples
- representations and reasoning
- types of ontologies
- ontologies and domain descriptions
- the semantic web and ontologies
- ontologies and meta-data standards

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