Lecture 30

CS 6380 Artificial Intelligence

Introduction to Knowledge Representation

Department of Computer Science and Engineering

Indian Institute of Technology Madras (IITM), India



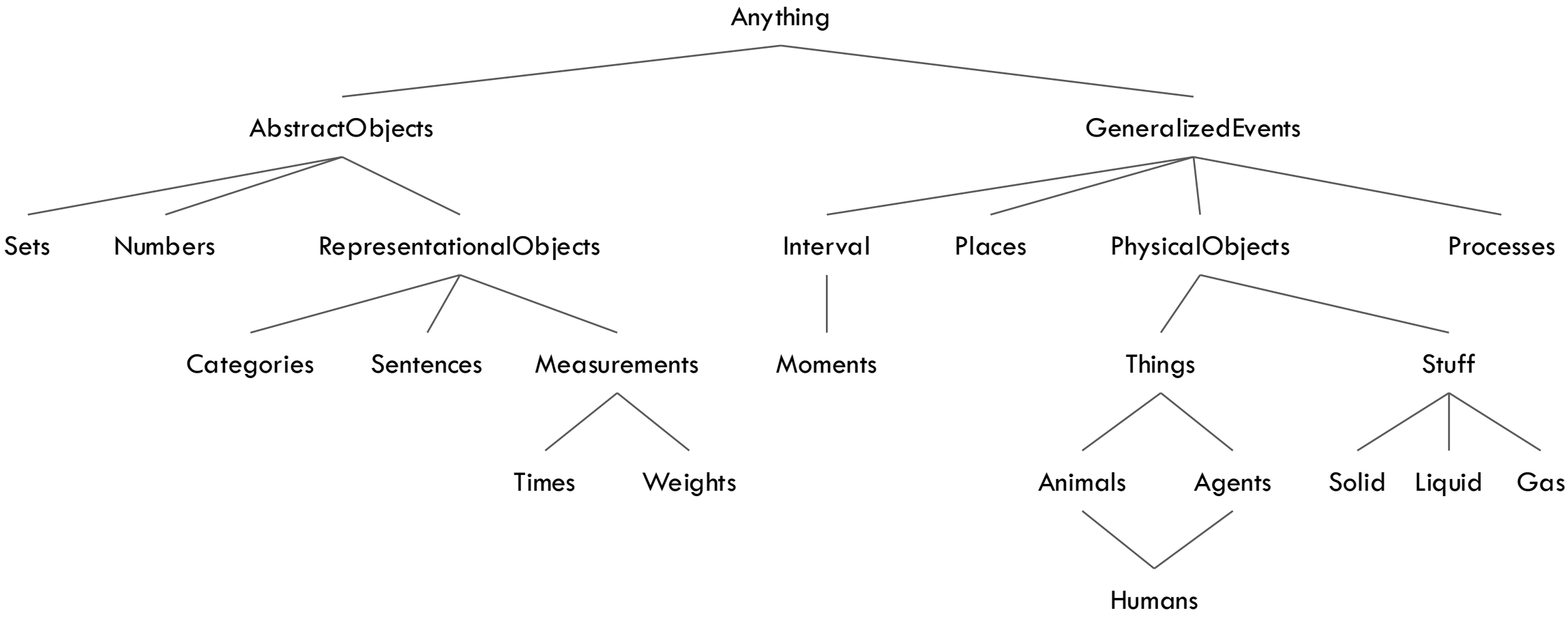
From Inference to Content

- Last lecture: how to reason (unification, chaining, resolution)
- Today: what to put in the knowledge base
- In toy domains, almost any representation works
- Real domains (shopping, driving) need general, reusable concepts
  - Categories, parts, measures, substances, events, time, beliefs
- Designing these is ontological engineering

Ontological Engineering

- We can't describe everything, but we can leave placeholders for any domain
- Like an object-oriented framework:
  - The framework defines `Window`; an application adds `SpreadsheetWindow`
- The most general concepts form an upper ontology
- Caveat: most generalizations have exceptions
  - "Tomatoes are red", but some are green, yellow or orange
  - Exceptions: Section 12.6. Uncertainty: Chapter 13

The Upper Ontology



Each line joins a concept to a more general one. Branches can overlap: a human is both an animal and an agent

General-Purpose Ontologies

- Must work in *any* domain, once domain-specific axioms are added
- Must unify areas: a circuit-repair robot reasons about wiring, layout and time together
- Four ways they have been built:
  - **Experts writing axioms**: CYC
  - **Importing databases**: DBpedia, from Wikipedia infoboxes
  - **Reading text**: TextRunner, from web pages
  - **Crowdsourcing**: Open Mind, from volunteers

"*Every ontology is a treaty*" (Tom Gruber, 2004)

Categories as Objects

- Most reasoning is about categories: you want *a basketball*, not BB_9
- Either a predicate $\mathrm{Basketball}(\mathrm{b})$, or reify the category as an object $\mathrm{Basketballs}$

  $\mathrm{b} \in \mathrm{Basketballs}$ $\mathrm{Basketballs} \subset \mathrm{Balls}$
- Inheritance: Food is edible, Fruit ⊂ Food, Apples ⊂ Fruit, so every apple is edible
- Subclass links form a taxonomy: Linnaeus for species, Dewey Decimal for books
- Our vocabulary:

  $\mathrm{Alfred} \in \mathrm{IITMStudents}$, $\mathrm{IITMStudents} \subset \mathrm{Students}$, $\mathrm{Students} \subset \mathrm{Persons}$

What We Can Say About Categories

Kind of fact	Example
Membership	$BB_9 \in \text{Basketballs}$
Subclass	$\text{Basketballs} \subset \text{Balls}$
Property of every member	$(x \in \text{Basketballs}) \Rightarrow \text{Spherical}(x)$
Recognizing members	$\text{Orange}(x) \wedge \text{Round}(x) \wedge \text{Diameter}(x) = 9.5 \wedge x \in \text{Balls} \Rightarrow x \in \text{Basketballs}$
Property of the category	$\text{Dogs} \in \text{DomesticatedSpecies}$

- DomesticatedSpecies is a category of categories
- Real rules have exceptions: a punctured basketball isn't spherical