Lecture 22

-Ontological Knowledge representation (FOL)

Upper-level ontology for knowledge representation

-general concepts at the top and specific concepts at the bottom of the tree (arrangement of objects & categories as per hierarchy)

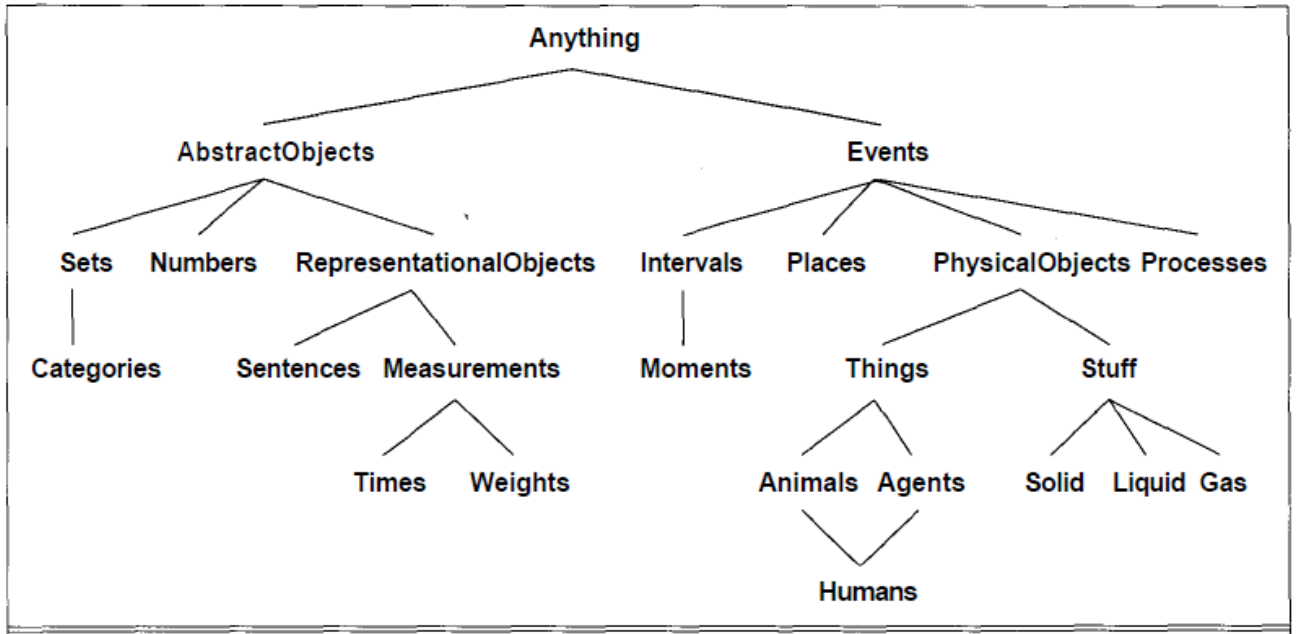

Figure 8.2 The top-level ontology of the world, showing the topics to be covered later in the chapter. Arcs indicate subset relations.

FOL for ontological knowledge representation

- Objects at the bottom of the ontology
- Categories in the higher levels
- Reification: when predicate/function in FOL is considered as an object
- Inheritance: lower categories inherit properties of higher categories
- Objects are members of categories
- Smaller categories are subsets or subclasses of higher categories
- Task: Write equivalent First Order Logic (FOL) sentences for ontologies

Examples of FOL for ontological KB

- FOL versus corresponding ontological facts

- An object is a member of a category. For example:
  $Tomato_{12}$ G *Tomatoes*
- A category is a subclass of another category. For example:
  Tomatoes C *Fruit*
- All members of a category have some properties. For example:
  $\forall x \; x$ G *Tomatoes* $\Rightarrow$ *Red*(x) A *Round*(x)
- Members of a category can be recognized by some properties. For example:
  $\forall x$ *Red*(*Interior*(x))A *Green*(*Exterior*(x))A $x \in$ *Melons* $\Rightarrow$ $x \in$ *Watermelons*
- A category as a whole has some properties. For example:
  Tomatoes G *DomesticatedSpecies*

$A \xrightarrow{Subset} B$ $A \xrightarrow{Member} B$	$A C B$ $A \in B$	*Cats C Mammals* *Bill* G *Cats*

- $Tomato_{12}$ object is a member of the category Tomatoes
- The smaller category Tomatoes is a subset or subclass of the bigger category Fruit
- All (members of) Tomatoes are red and round
- Those melons that have a red interior and a green exterior are Watermelons
- Tomatoes (as a unit or object) are domesticated species [Hint: we are not visualizing the individual tomato members here]

Some more relations found in ontological knowledge representation

- PartOf (eg. Eastern Europe is a part of Europe)

$$PartOf(EasternEurope, \quad Europe)$$

- BunchOf (eg. Using individual objects to form a new composite object)

$$BunchOf(\{Apple_1, Apple_2, Apple_3\})$$

- Example of a FOL script describing a biped/bicycle with two wheels/legs

$$\forall a \;\; Biped(a) \Rightarrow$$
$$\exists l_1, l_2, b \;\; Leg(l_1) \wedge Leg(l_2) \wedge Body(b) \wedge$$
$$PartOf(l_1, a) \wedge PartOf(l_2, a) \wedge PartOf(b, a) \wedge$$
$$Attached(l_1, b) \wedge Attached(l_2, b) \wedge$$
$$l_1 \neq l_2 \wedge \forall l_3 \;\; Leg(l_3) \wedge PartOf(l_3, a) \Rightarrow (l_3 = l_1 \vee l_3 = l_2)$$

FOL for Measures

- Properties of objects having definite values eg. 0.16 kg, 0.32$, 24hrs

$$Mass(Tomato_{12}) = Kilograms(0.16)$$
$$Price(Tomato_{12}) = \$(0.32)$$
$$\forall d \quad d \in Days \Rightarrow Duration(d) = Hours(24)$$

- Ones that cannot be measured only compared eg. Difficulty level

Although measures are not numbers, we can still compare them using an ordering symbol such as >. For example, we might well believe that Norvig's exercises are tougher than Russell's, and that one scores less on tougher exercises:

$$\forall e_1, e_2 \quad e_1 \in Exercises \wedge e_2 \in Exercises \wedge Wrote(Norvig, e_1) \wedge Wrote(Russell, e_2) \Rightarrow Difficulty(e_1) > Difficulty(e_2)$$
$$\forall e_1, e_2 \quad e_1 \in Exercises \wedge e_2 \in Exercises \wedge Difficulty(e_1) > Difficulty(e_2) \Rightarrow ExpectedScore(e_1) < ExpectedScore(e_2)$$