Fundamentals of Artificial Intelligence and Knowledge Representation (Module 2)

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Contents

1 Propositional and first order logic

See Languages and Algorithms for AI (module 2).

2 Ontologies

Ontology Formal (non-ambiguous) and explicit (obtainable through a finite sound procedure) description of a domain.

Category Can be organized hierarchically on different levels of generality.

Object Belongs to one or more categories.

Upper/general ontology Ontology focused on the most general domain.

Properties:

- Should be applicable to almost any special domain.
- Combining general concepts should not incur in inconsistences.

Approaches to create ontologies:

- Created by philosophers/logicians/researchers.
- Automatic knowledge extraction from well-structured databases.
- Created from text documents (e.g. web).
- Crowd-sharing information.

2.1 Categories

Category Used in human reasoning when the goal is category-driven (in contrast to specific-instance-driven).

In first order logic, categories can be represented through:

Predicate A predicate to tell if an object belongs to a category (e.g. `Car(c1)` indicates that `c1` is a car).

Reification Represent categories as objects as well (e.g. $c1 \in Car$).

2.1.1 Reification properties and operations

Membership Indicates if an object belongs to a category. (e.g. $c1 \in Car$).

Subclass Indicates if a category is a subcategory of another one. (e.g. $Car \subset Vehicle$).

Necessity Members of a category enjoy some properties (e.g. $(x \in Car) \to hasWheels(x)$).

Sufficiency Sufficient conditions to be part of a category
(e.g. $hasPlate(x) \wedge hasWheels(x) \to x \in Car$).

Category-level properties Category themselves can enjoy properties
(e.g. $Car \in VehicleType$)

Disjointness Given a set of categories S, the categories in S are disjoint iff they all have different objects:

$$\texttt{disjoint}(S) \iff (\forall c_1, c_2 \in S, c_1 \neq c_2 \rightarrow c_1 \cap c_2 = \emptyset)$$

Exhaustive decomposition Given a category c and a set of categories S, S is an exhaustive decomposition of c iff any element in c belongs to at least a category in S:

$$\texttt{exhaustiveDecomposition}(S, \ c) \iff (\forall o \in c \iff \exists c_2 \in S : o \in c_2)$$

Partition Given a category c and a set of categories S, S is a partition of c when:

$$\texttt{partition}(S, \ c) \iff \texttt{disjoint}(S) \wedge \texttt{exhaustiveDecomposition}(S, \ c)$$

2.1.2 Physical composition

Objects (meronyms) are part of a whole (holonym).

Part-of If the objects have a structural relation (e.g. $\texttt{partOf(cylinder1, engine1)}$).

    Properties:

        Transitivity $\texttt{partOf(x, y)} \wedge \texttt{partOf(y, z)} \rightarrow \texttt{partOf(x, z)}$

        Reflexivity $\texttt{partOf(x, x)}$

Bunch-of If the objects do not have a structural relation. Useful to define a composition of countable objects (e.g. $\texttt{bunchOf(nail1, nail3, nail4)}$).

2.1.3 Measures

A property of objects.

Quantitative measure Something that can be measured using some unit (e.g. $\texttt{length(table1)} = \texttt{cm(80)}$).

    Qualitative measures propagate when using $\texttt{partOf}$ or $\texttt{bunchOf}$ (e.g. the weight of a car is the sum of its parts).

Qualitative measure Something that can be measured using terms with a partial or total order relation (e.g. $\{\texttt{good}, \texttt{neutral}, \texttt{bad}\}$).

    Qualitative measures do not propagate when using $\texttt{partOf}$ or $\texttt{bunchOf}$.

Fuzzy logic Provides a semantics to qualitative measures (i.e. convert qualitative to quantitative).

2.1.4 Things vs stuff

Intrinsic property Related to the substance of the object. It is retained when the object is divided (e.g. water boils at 100°C).

Extrinsic property Related to the structure of the object. It is not retained when the object is divided (e.g. the weight of an object changes when split).

Substance Category of objects with only intrinsic properties.

    Stuff The most general substance category.

Count noun Category of objects with only extrinsic properties.

    Things The most general object category.

2.2 Semantic networks

2.3 Frames