

Data Integration: Description Logics

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Description logics knowledgebases

Description logics

- a family of **variable-free logics** developed in AI
- used to define **ontologies** for the Semantic Web (OWL DL)

Terminological box (TBox)

- corresponds to database **conceptual schema**
- vocabulary: atomic concepts and roles
- containment and transitivity assertions, definitions

Assertional box (ABox)

- corresponds to database **instance**
- named individuals
- assertions stating membership of individuals in concepts and roles

Atomic concepts

- correspond to **entity types**

Singleton concepts

- the concept consists of a single individual: $\{a\}$

Boolean concepts

- **intersection** of concepts: $C \sqcap D$
- **union** of concepts: $C \sqcup D$
- **negation** of a concept: $\neg C$
- **top** concept: $\top = A \sqcup \neg A$
- **bottom** concept: $\perp = A \sqcap \neg A$

Further concepts

Quantification and number restriction

- C is a concept, R a role
- individuals associated with **some** individual in C through R : $\exists R.C$
- individuals associated **only** with individuals in C through R : $\forall R.C$
- individuals associated with **at most** k individuals through R : $\leq k R$
- individuals associated with **at least** k individuals through R : $\geq k R$

Datatypes

In $\exists R.C$ and $\forall R.C$, C can be a datatype (Integer, String,...).

Atomic roles

- correspond to **relationship types**

Inverse roles

- *an individual a is associated with an individual b through R^- if and only if b is associated with a through R .*

Assertions

Definition

- atomic concept A is defined as concept C : $A \equiv C$

Containment

- *concept C is contained in concept D : $C \sqsubseteq D$*
- *role R is contained in role S : $R \sqsubseteq S$*

Transitivity

- role R is transitive: $R^+ \sqsubseteq R$

Membership

- *individual a is a member of concept C : $a \in C$*
- *pair (a, b) belongs to role R : $(a, b) \in R$*

E-R constructs in description logics

Integer attribute A for entity type E

- E is a concept, A is a role
- assertion:

$$E \sqsubseteq \forall A. \text{Integer}$$

- single-valuedness not enforced (no $\leq k. \text{Integer}$ or $\geq k. \text{Integer}$)

Relationship R is between entity types E_1 and E_2

- E_1 and E_2 are concepts, R is a role
- assertions:

$$E_1 \sqsubseteq \forall R. E_2$$

$$E_2 \sqsubseteq \forall R^-. E_1$$

Further E-R constructs

Relationship R is $n : 1$

- assertion:

$$E_1 \sqsubseteq \leq 1 R$$

E_1 isa E_2

- assertion:

$$E_1 \sqsubseteq E_2$$

Problematic constructs

- single-valued attributes
- keys
- n -ary relationships for $N > 2$ (but can be simulated)

Concepts C_1 and C_2 are disjoint

- assertion:

$$C_1 \sqcap C_2 \sqsubseteq \perp$$

Single parents

- assertion:

$$\text{SingleParent} \equiv \text{Person} \sqcap (\forall \text{Parent}. \leq 1 \text{Parent}^-)$$

Typical ontology reasoning tasks

- **correctness** of knowledge: *does the knowledgebase imply a given containment assertion?*
- **querying ontologies**: *does the knowledgebase imply a given membership assertion?*