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
Concepts

Atomic concepts

- correspond to entity types

Singleton concepts

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

Boolean concepts

- intersection of concepts: \(C \cap D\)
- union of concepts: \(C \cup D\)
- negation of a concept: \(\neg C\)
- top concept: \(\top = A \cup \neg A\)
- bottom concept: \(\bot = A \cap \neg A\)

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,...).
Roles

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 $D$: $C \subseteq D$
- role $R$ is contained in role $S$: $R \subseteq S$

Transitivity
- role $R$ is transitive: $R^{+} \subseteq R$

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:

$$C_1 \cap C_2 \subseteq \bot$$

**Single parents**

- assertion:

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

**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?*