Optimization of an abductive reasoner for description logics

Master thesis

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Aims

- Descripton logic
- ELK reasoner
- Abduction
- Minimal Hitting Set (Reiter)
- Implementation of Reiter's algorithm with optimizations
- Semantic minimality
- Evaluation of results (ELK/Conclude)

Description logic

- family of knowledge representation languages
- every description logic has different expression
- each type of expression supports different constructors
- we will use DL $\mathcal{EL}$ and DL $\mathcal{EL}++$

Description logic (DL)
Syntax

- important terms: individual, concept (atomic or complex), role
- DL is shaped by 3 mutually disjoint sets:

$$N_I = \{a, b, c...\}$$

$$N_C = \{A, B, C...\}$$

$$N_R = \{R_1, R_2, R_3\}$$

- DL consists of following constructors:

$$\neg, \sqcup, \sqcap, \forall, \exists$$

DL conceptualization: Everybody who is sick, is not happy.

$$Sick \sqsubseteq \neg Happy \text{ (axiom)}$$

Description logic
Ontology

- ontology describes relationships between entities in a specific area
- contains knowledge base $\mathcal{KB} = (\mathcal{T}, \mathcal{A})$
- $\mathcal{T}$ stands for TBox, $\mathcal{A}$ stands for ABox
- TBox contains all axioms that model ontology
- ABox creates database, it contains individuals

$$\mathcal{KB} = \left\{ \begin{array}{l} Sick \sqsubseteq \neg Happy \\ mary : Sick \end{array} \right\}$$

Reasoning

- Reasoning problems: consistency, satisfiability, inference
- Algorithm: Tableau algorithm
- Aims: finding model, classification
- Current reasoners: Elk, Conclude, Fact++, Hermit, Pellet ...

ELK reasoner

- ELK is a reasoner in DL $\mathcal{EL}++$, earlier DL $\mathcal{EL}$
- ELK reasoning in polynomial time
- Communication through OWL API in Java
- ELK works with ontologies (model retrieving, classification)

Abduction

- Knowledge base and observation is known
- Search for explanations

$$\mathcal{KB} = \left\{ \ Sick \sqsubseteq \neg Happy \ \right\}$$

$$\mathcal{O} = \{mary : \neg Happy\}$$

- We use minimal HS algorithm to find minimal explanations
- Algorithm finds this explanation:

$$\mathcal{E}_1 = \{mary : Sick\}$$

- Reiter's algorithm computes minimal hitting sets
- Definitions: Hitting set, HS-tree
- Algorithm: Generate pruned HS-tree

Progress

- Theoretical part:
  - Descripton logic
  - ELK reasoner
  - Abduction
  - Minimal Hitting Set

- Practical part:
  - Project base with libraries
  - running OWL API

What is next?

- Implementation of Reiter's algorithm with optimizations
- Semantic minimality
- Evaluation of results (ELK/Conclude)

References
Articles

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Thank you for your attention