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OPTIMIZED ABSORPTION METHOD TO REDUCE THE TIME OF TABLEAUX ALGORITHM.

Introduction

Ontologies are an effective tool for describing the knowledge bases [1]. Unlike other tools the advantage of using ontologies is the logical formalism of description logic [2, 3, 4], which doesn't only allow one to describe the knowledge, but also to carry out basic tasks of logical analysis, such as consistency checking and concepts classification of the knowledge base. To perform these tasks the tableaux algorithm is used [5]. Another very important advantage of using ontologies is the fact that ontologies are the standard recommended by the World Wide Web Consortium W3C [6], which was designed specially for the implementation of semantic information retrieval.

Problems

OWL 2 language [6] is based on the formalism of description logic SROIQ (D) [7] (also description logic SROIQ [8] is applied, but it does not apply specific datatypes), which is an executable fragment of first-order logic. To carry out the tasks of logical analysis the tableaux method is used, which performs a single task

– knowledge base consistency checking, to which all other tasks can be consolidated. Consistency checking involves determining whether the knowledge base has inconsistencies in explicit or latent form. For example, an axiom can be given in explicit form:

$$\mathrm{Bird} \sqsubseteq \exists \mathrm{Can.Fly} \sqcap \exists \mathrm{Have.Feathers},$$

which states that any bird can fly and has feathers. Another axiom:

$$\mathrm{Ostrich} \sqsubseteq \mathrm{Bird} \sqcap \forall \mathrm{Can}. \neg\, \mathrm{Fly},$$

which states that the ostrich is a bird that can do something but does not fly. Such inconsistency is called explicit. The example of the latent inconsistency may be presented by axioms:

$$\text{ЛетучаяМышь} \sqsubseteq \exists \mathrm{Can.Fly} \sqcap \mathrm{Animal};$$

$$\text{ЛетучаяМышь} \sqsubseteq \forall \mathrm{Have}.\neg\text{Шерсть};$$

$$\mathrm{Animal} \sqsubseteq \text{Пресмыкающееся} \sqcup \mathrm{Mammal};$$

$$\exists\ \mathrm{Can.Fly} \sqsubseteq \neg\text{Пресмыкающееся};$$

$$\exists\ \mathrm{Can.Fly} \sqcap \mathrm{Mammal} \sqsubseteq \exists \mathrm{Have}.\text{Шерсть}.$$

The idea of the tableaux method consists in iterating a finite set of models in set of axioms. By checking this set of models it is possible to answer the question whether the set of axioms describing the relationship between the concepts in the knowledge base is consistent.

The tableaux method has exponential operating time that does not allow using it for large knowledge bases (more than 5000 axioms) as consistency checking of such bases can last than 4 hours, which does not meet the requirements of application tasks efficiency. To reduce the operating time in practice a large number of heuristics are developed. One of the classical heuristics is the heuristic proposed by Haarslev, also called the absorption technique.

This paper deals with the improvement of the absorption technology. This will allow reducing the algorithm operating time.

Absorption method and its improvement

The main cases of nondeterministic choice arise when rewriting the inclusion and equivalence axioms into the form of description logic formula.

All disjunction operations result in nondeterministic choice when processing the concept. The absorption method consists in rewriting the inclusion axioms as it is shown in Table 1.

Table 1 - Rules of the absorption method

1.	$A \sqcap B \sqsubseteq C$	$A \sqsubseteq \neg B \sqcup \neg C$
2.	$A \sqcup B \sqsubseteq \neg C \sqcup \neg D$	$C \sqsubseteq \neg A \sqcap \neg B \sqcup \neg D$
3.	$A \sqsubseteq B$ $A \sqsubseteq C$	$A \sqsubseteq B \sqcap C$
4.	$A \equiv B$ $A \equiv C$	$A \equiv B \sqcap C$

However, in this table the rules that transform axioms of concepts inclusion are presented mostly. The equivalence axiom without conversion $C \equiv D$ will be converted into the form$(\neg C \sqcup D) \sqcap (\neg D \sqcup C)$, where two additional alternatives of nondeterministic choice appear.

To reduce the number of nondeterministic choice alternatives rewriting of axioms in the form $A \sqcap B \equiv E \sqcap H$ into two different kinds of axioms $A \sqsubseteq \neg B \sqcup (E \sqcap H)$ and $E \sqsubseteq \neg H \sqcup (A \sqcap B)$ is offered. These two axioms also contain two nondeterministic choice alternatives, however the addition of each of these axioms is performed only when the corresponding concept (A or E, respectively) appears. Later these axioms may be absorbed by other axioms so as it's presented by rule 3 in Table 1.

Such rewriting will allow significant reducing the number of equivalence axioms in the knowledge base.

Conclusion

The presented absorption method allows in some cases reducing the algorithm operating time. However there are still a lot of cases where non-deterministic choice is performed. So reducing the number of alternatives of such choices will be the subject of further research.

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