

Ontology Evaluation Workflow in COLORE

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Track D: Software Environments for Evaluating Ontologies

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Common Logic Ontology Repository

- The objective of the COLORE project is to construct an open repository of first-order ontologies that will serve as a testbed for ontology evaluation and integration techniques, and that can support the design, evaluation, and application of ontologies in first-order logic.
- COLORE is a participant in the Open Ontology Repository Initiative `colore.oor.net`
- Today we will explore ontology evaluation within COLORE – what happens when an ontology is uploaded into the repository?

Ontology Evaluation

- Consistency and entailment
- Relationships and comparisons to other ontologies
- Verification
- Modularity
- Reusing ontologies

Consistency

- Each ontology is translated into Prover9 syntax, and we attempt to construct a nontrivial model.
- All models are stored in the consistency subdirectories of the repository.
- Example:
`http://code.google.com/p/colore/source/browse/trunk/verification/complex/combined_time/consistency/`

Entailments

- What are the logical consequences of the ontology?
- Example:
`http://code.google.com/p/colore/source/browse/trunk/verification/complex/combined_time/entailment/endpoints_lemmas`
- Competency questions
 - Given a motivating scenario, a set of queries will arise which place demands on an underlying ontology. We can consider these queries to be requirements that are in the form of questions that an ontology must be able to answer.
 - The competency questions are defined formally as an entailment or consistency problem with respect to the axioms in the ontology.

Relationships to Other Ontologies

Comparing ontologies

- Do two ontologies make the same commitments?
- What are the differences between two ontologies?

Sharability

- Which subtheories are common between two ontologies?

Metalogical Relationships in COLORE

Do the theories have the same signature?

- Nonconservative extension

Do the theories have different signatures?

- Conservative extension
- Relative interpretation

Theories and Extensions

Definition

Let T_1, T_2 be two first-order theories such that $\Sigma(T_1) \subseteq \Sigma(T_2)$.

We say that T_2 is an extension of T_1 iff for any sentence $\sigma \in \mathcal{L}(T_1)$,

$$\text{if } T_1 \models \sigma \text{ then } T_2 \models \sigma.$$

T_2 is a conservative extension of T_1 iff for any sentence $\sigma \in \mathcal{L}(T_1)$,

$$T_2 \models \sigma \text{ iff } T_1 \models \sigma.$$

T_2 is a non-conservative extension of T_1 iff T_2 is an extension of T_1 and there exists a sentence $\sigma \in \Sigma(T_1)$ so that

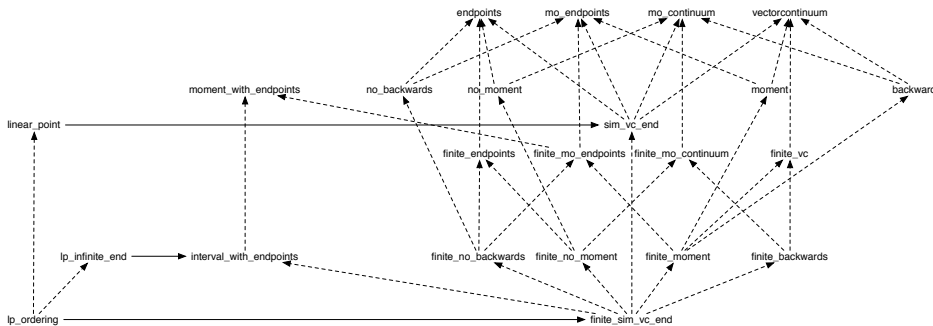
$$T_1 \not\models \sigma \text{ and } T_2 \models \sigma.$$

Definition

A hierarchy $\mathbb{H} = \langle \mathcal{H}, \leq \rangle$ is a partially ordered, finite set of theories $\mathcal{H} = T_1, \dots, T_n$ such that

- 1 $\Sigma(T_i) = \Sigma(T_j)$, for all i, j ;
- 2 $T_1 \leq T_2$ iff T_2 is an extension of T_1 ;
- 3 $T_1 < T_2$ iff T_2 is a non-conservative extension of T_1 .

Combined Time Ontologies



Specify mappings between models by specifying the relationships between modules in the repository.

- Interpretable – mapping between theories that preserves theorems
- Faithfully interpretable – mapping between theories that preserves models
- Definable equivalence – theories that are interpretable into each other.

Reducibility

Definition

A theory T is reducible to a set of theories T_1, \dots, T_n iff

- 1 T faithfully interprets each theory T_i ,

$$T \cup \Delta_i \models T_i$$

- 2 $T_1 \cup \dots \cup T_n$ faithfully interprets T .

$$T_1 \cup \dots \cup T_n \cup \Pi \models T$$

Example:

http://code.google.com/p/colore/source/browse/trunk/verification/complex/combined_time/interpret/endpoints2strict_graphical

Amalgamating Models

Theorem

Let \mathfrak{N} be the set of amalgamations of models in

$$\langle \mathcal{N}_1, \dots, \mathcal{N}_n \rangle \in \text{Mod}(T_1) \times \dots \times \text{Mod}(T_n)$$

for the theories T_1, \dots, T_n .

A theory T is reducible to T_1, \dots, T_n iff there is a bijection $\varphi : \text{Mod}(T) \rightarrow \mathfrak{N}$, such that \mathcal{M} is definably equivalent to $\varphi(\mathcal{M})$.

Ontology Verification

- With verification, we want to characterize the models of an ontology up to isomorphism (or elementary equivalence) and determine whether or not these models are equivalent to the intended models of the ontology.

Can we decompose an ontology into smaller modules?

- Theories in the reduction of an ontology T are definably equivalent to modules of T .
- The reduction gives us a modular decomposition of the ontology, and also provides guidance on how to combine smaller ontologies into larger ones.

Procedures

- The *FindTheory* Procedure finds a set of theories which are interpretable by the theory T .
- The *Decomp* Procedure finds the modules of T that are definably equivalent to the theories in the reduction of T .
- The *UpdateHierarchy* Procedure inserts a new theory into a hierarchy and guarantees that similarities and differences are also theories in the hierarchy.

Which ontology in the repository do I need?

- We can adapt the Procedures to search for the weakest theories in a hierarchy that can entail a given set of competency questions.
- We can also search for the weakest theories that are satisfied by a set of models that formalize examples of concepts and relations with the user's intended semantics.

References

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Summary

- Ontology repositories can support ontology evaluation by exploiting the relationships between different ontologies.
- Techniques include – consistency-checking, entailment, relative interpretation, verification, and modularization.
- Automated theorem provers play a critical role in these techniques.

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