Semantically-Guided Goal-Sensitive Theorem Proving

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Abstract

SGGS, for Semantically-Guided Goal-Sensitive theorem proving, is a new inference system for first-order logic. It was inspired by the idea of generalizing to first-order logic the *model-based* style of the Davis-Putnam-Logemann-Loveland (DPLL) procedure for propositional logic. Model-based reasoning is a key feature of SAT solvers, SMT solvers, and model-constructing decision procedures for specific theories, and a crucial ingredient to their practical success (e.g., [4]). However, model-based reasoning in first-order logic is challenging, because the logic is only semi-decidable, the search space is infinite, and model representation is harder than in the propositional case. SGGS meets the challenge by realizing a seemingly rare combination of properties: it is *model-based à la* DPLL; *semantically guided* by an initial interpretation, to avoid blind guessing in an infinite search space; *proof confluent*, to avoid backtracking, which may be cumbersome for first-order problems; *goal-sensitive*, which is important when there are many axioms or a large knowledge base; and it uses unification to avoid enumeration of ground terms, which is inefficient, especially for rich signatures. In terms of operations, SGGS combines *instance generation*, *resolution*, and *constraints*, in a model-centric approach: it uses *sequences of constrained clauses* to represent models, instance generation to extend the model, resolution and other inferences to repair it. This talk advertises SGGS to the rewriting community, presenting the main ideas in the method: a main direction for future work is extension to first-order logic with equality, which requires *rewrite-based* reasoning. A manuscript including all aspects of SGGS, the technical details, the proofs of *refutational completeness* and goal-sensitivity, a comparison with other work (e.g., resolution with *set of support* [6], the *disconnection calculus* [2], the *model evolution calculus* [1], the *Inst-Gen* method [5]) and more references, is available as [3].

References

[1] Peter Baumgartner and Cesare Tinelli. The model evolution calculus as a first-order DPLL method. *Artificial Intelligence*, 172(4–5):591–632, 2008.

[2] Jean-Paul Billon. The disconnection method. In Pierangelo Miglioli, Ugo Moscato, Daniele Mundici, and Mario Ornaghi, editors, *Proc. TABLEAUX 1996*, volume 1071 of *LNAI*, pages 110–126. Springer, 1996.

[3] Maria Paola Bonacina and David A. Plaisted. Semantically-guided goal-sensitive theorem proving. Technical Report 92/2014, Dipartimento di Informatica, Università degli Studi di Verona, January 2014. Revised April 2014, available at http://profs.sci.univr.it/~bonacina/pub_tr.html.

[4] Leonardo de Moura and Nikolaj Bjørner. Satisfiability modulo theories: introduction and applications. *Comm. ACM*, 54(9):69–77, 2011.

[5] Konstantin Korovin. Inst-Gen: a modular approach to instantiation-based automated reasoning. In Andrei Voronkov and Christoph Weidenbach, editors, *Programming Logics: Essays in Memory of Harald Ganzinger*, volume 7797 of *LNAI*, pages 239–270. Springer, 2013.

[6] Larry Wos, D. Carson, and G. Robinson. Efficiency and completeness of the set of support strategy in theorem proving. *J. ACM*, 12:536–541, 1965.