hybr2d Theory of Hybrid Systems Informatik 2

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Solving Pseudo-Boolean Constraints

Student assistant or Master thesis

Background Satisfiability checking aims at fully automated solutions for determining the satisfiability of logical formulas. While *SAT solving* focuses on propositional logic, *satisfiability modulo theories* (*SMT*) *solving* broadens the scope to quantifier-free Boolean combinations of constraints from different theories like for example real and integer arithmetic, bitvector arithmetic or the theory of uninterpreted functions. SMT solvers use SAT solvers as engines to analyse the Boolean structure of a given problem, and integrate different decision procedures to check the consistency of theory constraint sets. Though there are well-known decision procedures for many theories, integrating them into the SMT solving framework is often challenging.

Topic In this project we address *pseudo-Boolean constraints*. Such constraints are like arithmetic constraints, but the domains of all variables are restricted to Boolean values from $\{0, 1\}$. For example, in the linear case they are of the form $\sum_i \alpha_i x_i \sim \alpha$ where $\alpha, \alpha_i \in \mathbb{Z}$ are constants and x_i are variables with domain $\{0, 1\}$. In the nonlinear case, instead of the linear expressions we can use polynomials in the constraints.

There are many applications that encode certain problems as Boolean combinations of pseudo-Boolean constraints, such that answering the question whether those formulas are satisfiable solves the original problems. In this project we work in cooperation with *Siemens Industry Software NV.* who will support us with industrially relevant applications as benchmarks. Our goal is to evaluate and to improve the efficiency of SMT solving technologies for the above logic. Whereas most state-of-the-art approaches transform pseudo-Boolean constraints to proposition logic formulas and use SAT solvers for their satisfiability check, the alternative of applying adapted decision procedures for arithmetic theories is yet largely unexploited.

Your task You will

- develop and implement algorithms to *transform* Boolean combinations of pseudo-Boolean contraints to satisfiability-equivalent *propositional logic* formulas, and employ *SAT solvers* (as black boxes) to check their satisfiability;
- develop and implement algorithms to *transform* Boolean combinations of pseudo-Boolean contraints to satisfiability-equivalent *real or integer arithmetic* formulas, and employ SMT-RAT, an *SMT solver* developed in our group, to check their satisfiability;
- analyse how the decision procedures in SMT-RAT could be *adapted* to solve this special problem class more efficiently and, if relevant, *implement* your ideas;
- *evaluate* and *compare* the different approaches regarding their efficiency.

Requirements You should be familiar with first-order logic and interested in algorithms. Knowledge of SAT and SMT solving, for example from the lecture "Satisfiability Checking", would be an advantage but is not mandatory. As the implementation will be in C++, some experience with modern C++ programming is required.

Contact If you are interested in working on this topic, either in the context of a Master thesis or as a student assistant, please contact *Gereon Kremer* (`gereon.kremer@cs.rwth-aachen.de`, Room 4228 in E1, Informatik, Ahornstr. 55).