Universität Koblenz-Landau

FB 4 Informatik

Prof. Dr. Viorica Sofronie-Stokkermans **January 22, 2019**

Exercises for "Decision Procedures for Verification"
Exercise sheet 11

Exercise 11.1: *(4 P)*
Let $\mathcal{T}$ be the combination of $LI(\mathbb{Z})$ (linear arithmetic over $\mathbb{Z}$) and UIF_Σ, the theory of uninterpreted function symbols in the signature $\Sigma = \{\{f/1, g/2\}, \emptyset\}$.
Check the satisfiability of the following ground formula w.r.t. $\mathcal{T}$ using the "guessing" version of the Nelson-Oppen procedure:

$$\phi = (f(c) > 0 \wedge f(d) > 0 \wedge f(c) + f(d) \approx e \wedge g(c, e) \not\approx g(d, e))$$

Exercise 11.2: *(2 P)*
Let $\mathcal{T}$ be the combination of $LI(\mathbb{Q})$ (linear arithmetic over $\mathbb{Q}$) and UIF_Σ, the theory of uninterpreted function symbols in the signature $\Sigma = \{\{f/1, g/2\}, \emptyset\}$.
Check the satisfiability of the following ground formula w.r.t. $\mathcal{T}$ using the deterministic version of the Nelson-Oppen procedure (after purifying the formulae check for entailment of equalities between shared constants and propagate the entailed equalities):

$$\phi_2 = (g(c + d, e) \approx f(g(c, d)) \wedge c + e \approx d \wedge e \geq 0 \wedge c \geq d \wedge g(c, c) \approx e \wedge f(e) \not\approx g(c + c, 0))$$

Exercise 11.3: *(4 P)*
Use the Nelson-Oppen procedure for checking the satisfiability of the following formulae:

1. $1 \leq c \wedge c \leq 3 \wedge f(c) \not\approx f(1) \wedge f(c) \not\approx f(3) \wedge f(1) \not\approx f(2)$
   in the combination $LI(\mathbb{Z}) \cup UIF_{\{f\}}$.
2. $f(c) \approx f(c + d) \wedge 1 \leq c \wedge c \leq d + e \wedge c + e \leq d \wedge d = 1 \wedge f(c) \not\approx f(2)$
   in the combination $LI(\mathbb{Z}) \cup UIF_{\{f\}}$.

You will be able to solve the next exercise after the lecture on Monday, 28.01.19.

Exercise 11.4: *(2 P)*
Check the satisfiability w.r.t. $\mathcal{T} = LI(\mathbb{Q})$ of the following set of ground clauses using the "lazy" approach to SMT presented in the class.

$$(\neg(0 \leq x) \vee \neg(y \leq z)) \quad \wedge \quad (\neg(z \leq x + y) \vee (y \leq z)) \quad \wedge \quad (\neg(0 \leq y) \vee (0 \leq x)) \quad \wedge \quad (z \leq x + y)$$

For theory reasoning in $LI(\mathbb{Q})$ use the Fourier-Motzkin algorithm.

Please submit your solution until Wednesday, January 30, 2018 at 16:00. Joint solutions prepared by up to three persons are allowed. Please do not forget to write your name on your solution.

Submission possibilities:

- By e-mail to `sofronie@uni-koblenz.de` with the keyword “Homework DP” in the subject.
- Put it in the box in front of Room B 222.