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Tutorials for Decision Procedures
Exercise Sheet 12

Exercise 1: DPLL(T) — 4 Points

Use the DPLL(T) algorithm to decide satisfiability of the following $\Sigma_{\mathbb{Q}}$-formulae. Please use the rule-based notation.

(a) $(z \leq 1 \to x \leq y) \wedge y + z \leq x \wedge 0 \leq z \wedge (z > 1 \to x + z \leq y)$

(b) $(x \leq 0 \ \to \ y \leq 0) \wedge (y \leq 0 \ \to \ z \leq 0) \wedge (x \leq 0 \vee y \leq 0) \wedge z > 1$

Exercise 2: DPLL(T) with Nelson–Oppen Theory Combination — 4 Points

Use the DPLL(T) algorithm together with the Nelson–Oppen theory combination method to decide satisfiability of the following $\Sigma_{\mathbb{Z}} \cup \Sigma_{\mathsf{E}}$-formula.

$$
\begin{aligned}
&(\ell \leq i \wedge i \leq j \wedge j \leq u \to f_a(i) \leq f_a(j)) \\
\wedge\ &(\ell \leq i \wedge i \leq u \wedge u \leq u \to f_a(i) \leq f_a(u)) \\
\wedge\ &f_a(u) \leq v \\
\wedge\ &\ell \leq i \wedge i \leq j \wedge j \leq u + 1 \\
\wedge\ &\neg(f'_a(i) \leq f'_a(j)) \\
\wedge\ &(i \neq u + 1 \to f_a(i) = f'_a(i)) \\
\wedge\ &(j \neq u + 1 \to f_a(j) = f'_a(j)) \\
\wedge\ &f'_a(u + 1) = v
\end{aligned}
$$

Exercise 3: Basic Paths and Verification Condition — 4 Points

Look at the example program `InsertionSort` from the πVC-website

`https://cs.stanford.edu/people/jasonaue/pivc/samples/`

Perform the following tasks:

(a) Give all basic paths of `InsertionSort`.

(b) Compute the verification condition for the last basic path (ending with the post-condition). Use `true` as loop invariant for both loops.