

Decision procedures for verification

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1. Propositional logic

- Syntax; semantics; models, validity, satisfiability, entailment, equivalence;
- Translation to CNF/DNF (in particular structure-preserving translations!);
- Resolution: soundness; completeness (multiset orderings; ordering on clauses; the model construction; idea of completeness proof)
- The DPLL method (only the method, no soundness/completeness proofs required)

2. First-order logic

- Syntax, semantics: models and assignments; validity, satisfiability; Entailment and equivalence;
- Validity vs. unsatisfiability.
- The theory of a structure; Logical theories (syntactic/semantics view).
- Normal forms and Skolemization
- Herbrand interpretations (definition)
- General resolution:
resolution for ground clauses, Robinson's idea;
unification (definition of a most general unifier; algorithm for computing a most general unifier; no proofs required),
lifting lemma (idea),
saturation of sets of general clauses, refutational completeness of general resolution (idea), ordered resolution with selection, redundancy
- Herbrand's theorem, Craig Interpolation, the theorem of Löwenheim-Skolem (only statements)

3. Decidable fragments of first-order logic

- Variable-free formulae
- The Bernays-Schoenfinkel class
(definition, main idea in decidability proof)
- The Ackermann class
(definition, rough idea of decidability proof presented in the lecture)

- The monadic class (definition, idea of decidability proof presented in the lecture)
4. **Satisfiability with respect to a theory**
- T-validity vs. T-satisfiability.
5. **Decision procedures for checking satisfiability with respect to a theory for conjunctions of literals**
- **Single theories**
 - Theory of uninterpreted function symbols (validity of univ. formulae; satisfiability of ground formulae)
Satisfiability check using congruence closure on DAGs (the algorithm presented in the lecture)
 - Difference logic (method for checking satisfiability, idea of proof)
 - Linear arithmetic over \mathbb{Q} and \mathbb{R} :
 - * Fourier-Motzkin Quantifier Elimination
 - **Combinations of theories**
 - Combinations of theories (definition: syntactical vs. semantical view; examples)
 - The Nelson/Oppen procedure for reasoning in combinations of theories over disjoint signatures
 - * the method (purification; propagation - guessing version vs. backtracking version)
 - * soundness and completeness (completeness: definition of stable infinity; role of stable infinity; idea of completeness proof)
 - * deterministic version and convexity
6. **Satisfiability modulo a theory for sets of clauses**
- DPLL(T)
7. **Theories of data structures**
- The array property fragment (definition; decision procedure (the 7 steps)).