COMP2111 Week 5
Term 1, 2019
Predicate Logic: Tools

Logic, computationally

- Easy problems: verifying a proof, checking a satisfying model
- Hard problems: finding a proof, finding a satisfying model

Summary

- Theorem provers
- SMT solvers
- Knowledge Based Systems

Summary

- Theorem provers
- SMT solvers
- Knowledge Based Systems

Theorem provers

Proof assistants:

- Interactive/directed theorem proving
- Some have automated theorem proving
- Minimal default behaviour
  - Can implement a wide range of logical systems
  - Can prove correctness from foundations
- Some can extract code from specifications (e.g. Coq)

Theorem provers: Examples

- Coq (used to prove 4-colour theorem)
- Isabelle (proved functional correctness of seL4 microkernel)
- HOL (proved Kepler conjecture)
- Natural deduction prover

Summary

- Theorem provers
- SMT solvers
- Knowledge Based Systems

Satisfaction Modulo Theories

- SAT solvers for (fragments of) Predicate Logic
- Theories force certain interpretations (e.g. arithmetic)
- Two main approaches:
  - Convert everything into SAT
  - Combination of SAT solver and Theory-specific solvers

Advantages

- Tend to be very fast
- Good at handling domain-specific logic (e.g. arithmetic)

Disadvantages

- Restricted to quantifier-free fragments
- Unwieldy statements

SMT solvers: Examples

- Z3
  - Wide range of built-in theories
  - Backend for verification tools such as Dafny (see SENG2011)
- OpenSMT
- CVC4

Example usage

Logic puzzles (e.g. Zebra puzzle)

Example

- The Spaniard lives to the right of the red house
- The Norwegian lives in the blue house
- The Italian lives in house #2

Question: Who lives in the white house?

Summary

- Theorem provers
- SMT solvers
- Knowledge Based Systems

Knowledge Based Systems

Build up "knowledge" from base facts and inference rules

Advantages

- Works with unrestricted Predicate logic
- Simpler statements

Disadvantages

- More fine-tuning of constraints required
- Can be quite slow

KBS: Example

IDP: Knowledge Based System for Predicate Logic

Example usage

Logic puzzles (e.g. Zebra puzzle)

Example

- The Spaniard lives to the right of the red house
- The Norwegian lives in the blue house
- The Italian lives in house #2

Question: Who lives in the white house?