Decision Procedures and Verification

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Interpolation in verification

Craig Interpolants

Definition (Craig interpolant)

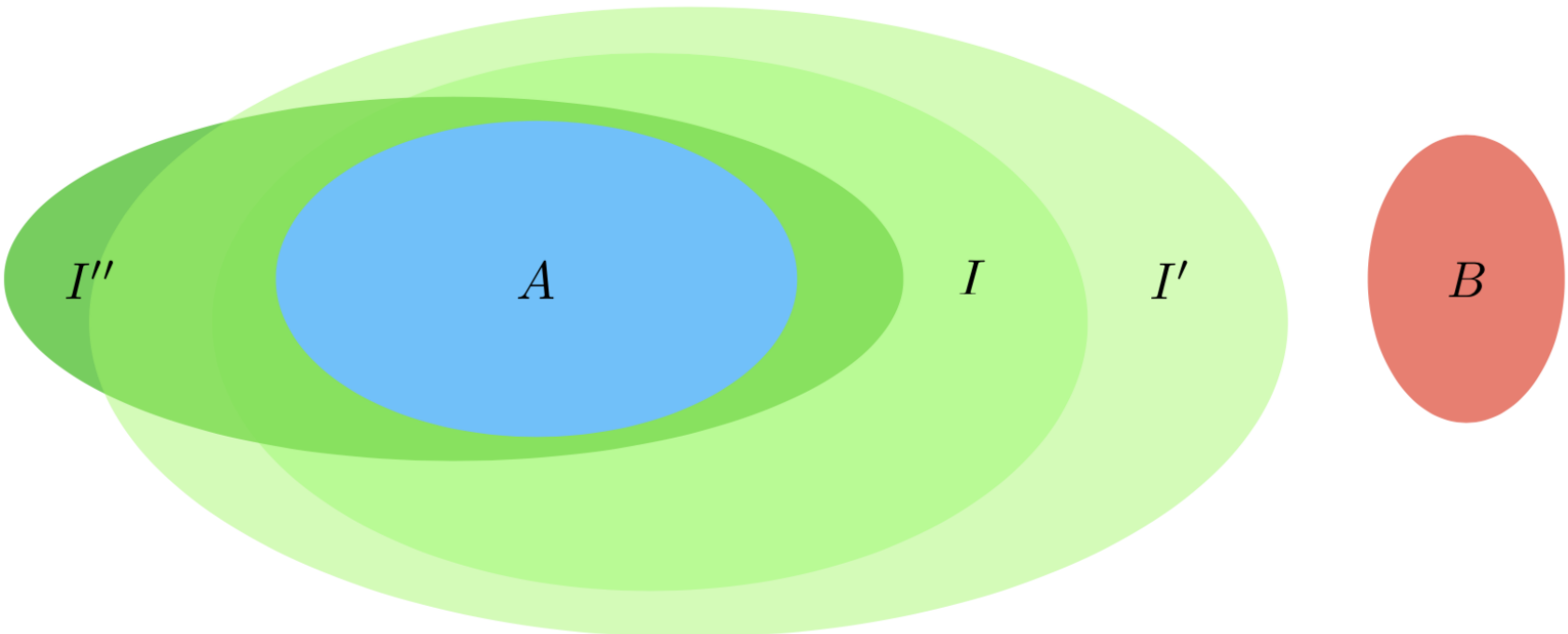
For A, B such that $A \wedge B \implies \bot$, I is a (Craig) interpolant when:

- $A \implies I$
- $I \wedge B \implies \bot$
- $\mathcal{L}(I) \subseteq \mathcal{L}(A) \cap \mathcal{L}(B)$

Theorem (Craig '57)

In first-order logic, if $\varphi \implies \psi$ and they share at least one atomic variable, then there exists ρ such that $\varphi \implies \rho$, $\rho \implies \psi$ and every nonlogical symbol in ρ occurs both in φ and ψ.

Set representation of Craig interpolation



Unbounded Model Checking

- Transition system
  - Finite state machine
  - Kripke structure
- Problem defined by triple (Initial state, Transition relation, Error state)
  - Goal: Check whether an error state is reachable from initial state
- Bounded Model Checking
  - Transition relation unwound k times.
- Unbounded Model Checking
  - Interpolants used to over-approximate the set of reachable states.
  - McMillan, *Interpolation and SAT-Based Model Checking*, 2003

Lazy Abstraction with Interpolants

- McMillan, *Lazy Abstraction With Interpolants*, 2006
- Basic idea:
  - Model-checking sequential programs
  - Looking for *safety invariant*
  - Unwinding control-flow graph
  - Labeling nodes of unwinding
  - Looking for *safe, complete, well-labeled* unwinding.
- Labels over-approximate set of reachable states at given point of the program.
- Can be computed using interpolants from proofs of unfeasibility of concrete paths.

Function Summaries

- Assumes functions define precise input-output relation.
  - Without side-effects.
- Function summary over-approximates function's input-output relation.
- Can be computed using interpolation from successful verification run.
- Useful in incremental and upgrade-checking scenario.
- Sery and al. *Interpolation-Based Function Summaries in Bounded Model Checking*, 2011