

Logic in CS – CS in Logic

Lectures for CS311, Big Ideas in CS

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1 Intro

A very high-level survey of (up to) four topics illustrating deep interactions between logic and computer science.

General references:

Handbook of Theoretical Computer Science, Volume B: Formal Models and Semantics, Jan Van Leeuwen, Ed., Elsevier, 1990.

Handbook of Logic in Computer Science, Vols I – 7, Oxford University Press

Vol 1. Background: Mathematical Structures

Vol 2. Background: Computational Structures

Vol 3. Background: Semantic Structures

Vol 4. Semantic Modelling

Vol 5. Algebraic and Logical Structures

2 Programming Logics: Floyd, Hoare, Dijkstra, Pratt, etc.

Hoare Logic

Dijkstra's weakest preconditions

Predicate transformers

Programming Logics

References:

R. W. Floyd, Assigning Meanings to Programs, in *Mathematical Aspects of Computer Science*, AMS, 1967.

C. A. R. Hoare, An Axiomatic Basis for Computer Programming, *CACM*, 14(1), pp. 39–45, 1969.

E. W. Dijkstra, Guarded commands, nondeterminacy and formal derivation of programs, *CACM* 18(8), pp. 453–457, 1975.

E. W. Dijkstra, *A Discipline of Programming*, Prentice-Hall, 1976.

David Gries, *The Science of Programming*, Springer-Verlag, 1981.

Wikipedia URLs:

http://en.wikipedia.org/wiki/Hoare_logic

http://en.wikipedia.org/wiki/Weakest_precondition

http://en.wikipedia.org/wiki/Dynamic_logic_%28modal_logic%29

Hoare Logic Weakest preconditions Predicate transformers Axiomatic semantics of programming languages Dynamic Logic (Pratt)

3 Mechanized proof

Automath Project (deBruijn, et al)

Proof Checker for fully formalized mathematics (type theory)

Resolution Theorem Proving (J. Alan Robinson, Larry Wos (Argonne))

Decidable theories and decision procedures E.g. Pressburger arithmetic, quantifier elimination algorithms

Boyer-Moore Theorem provers: Lisp as a logic ACL2

PVS (SRI)

Proof Assistants: Type-theory based logics LCF (Milner, et. al) HOL (Gordon, et. al) COQ (Calculus of Constructions, Gerard Huet) NuPRL (Constable, et. al) Isabelle (Paulson) ELF (Edinburgh Logical Framework), TWELF

Wikipedia URLs:

http://en.wikipedia.org/wiki/Automated_theorem_proving

http://en.wikipedia.org/wiki/LCF_theorem_prover

http://en.wikipedia.org/wiki/HOL_theorem_prover

http://en.wikipedia.org/wiki/Isabelle_theorem_prover

<http://en.wikipedia.org/wiki/Coq>

<http://en.wikipedia.org/wiki/Twelf>

http://en.wikipedia.org/wiki/ACL2_theorem_prover

http://en.wikipedia.org/wiki/Prototype_Verification_System

4 Martin-Löf Type Theory

aka: Intuitionistic Type Theory

Curry-Howard Isomorphism

Dependent types

References:

Per Martin-Löf, *Intuitionistic Type Theory*, Bibliopolis, 1984

Nordström, Petersson, Smith, *Programming in Martin-Löf's Type Theory*, Oxford University Press, 1990.

Handbook of Logic in Computer Science, Vol 5; Chapter 1. Martin-Löf Type Theory

Wikipedia URLs:

http://en.wikipedia.org/wiki/Intuitionistic_Type_Theory

http://en.wikipedia.org/wiki/Per_Martin-Lf

<http://en.wikipedia.org/wiki/CurryHoward>

5 Modal Logics: Linear Temporal Logic

References:

Handbook of Theoretical Computer Science, Vol B, Chapter 16: Temporal and Modal Logic, E. A. Emerson

Wikipedia URLs:

http://en.wikipedia.org/wiki/Linear_temporal_logic

6 Related Topics

Logic programming (Prolog)

Logic in Artificial Intelligence

Logic in Databases (e.g. Datalog)