

## PREFACE

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Imbuing machines with intelligence is a long-standing intellectual goal. Logical reasoning is one of the hallmarks of human intelligence, yet human beings find long chains of logical inference as challenging as long sequences of calculation. The automation of reasoning is more than an attempt to scratch a scientific itch, it has many important applications including knowledge representation, constraint solving, automated proof checking, database query optimization, and software and hardware verification. Advances in automated reasoning have always combined important theoretical insights in logic and algorithmics with hard-won practical implementation techniques and heuristics. The International Joint Conference on Automated Reasoning (IJCAR) brings together all the different strands of automated reasoning including logical foundations, automated proof search, interactive proof checking, and applications under one umbrella. The IJCAR 2006 meeting was held under the auspices of the Federated Logic Conference at Seattle, USA, during August 16-21, 2006. IJCAR 2006 combined several individual conferences including

- CADE (International Conference on Automated Deduction)
- TABLEAUX (International Conference on Automated Reasoning with Analytic Tableaux and Related Methods)
- FTP (International Workshop on First-Order Theorem Proving)
- FroCoS (Workshop on Frontiers of Combining Systems)
- TPHOLs (International Conference on Theorem Proving in Higher-Order Logics).

Following the conference, the best papers were selected for publication in extended form. These papers included a good balance of theory and practice. The more theoretical papers were selected for publication in the current issue of Logical Methods in Computer Science, while the more practical papers were published in the Journal of Automated Reasoning. Gentzen's sequent calculus has played a central role in automated reasoning. Sequents have the form  $\Gamma \vdash \Delta$  where  $\Gamma$  and  $\Delta$  are sets of formulas. Such a sequent is interpreted as asserting the provability  $\bigwedge \Gamma \implies \bigvee \Delta$ . The proof rules for the sequent calculus includes the axiom  $\frac{}{\Gamma, A \vdash A, \Delta}$  and the cut rule  $\frac{\Gamma, A \vdash \Delta, \Gamma' \vdash A, \Delta'}{\Gamma \cup \Gamma' \vdash \Delta \cup \Delta'}$ , along with rules for introducing each connective or quantifier in the left or the right of the conclusion sequent. The paper *Canonical calculi with  $(n, k)$ -ary quantifiers* by Avron and Zamansky examines a generalization of the sequent calculus with quantifiers that bind  $k$  variables over  $n$  formulas. The propositional connectives are instances where no variables are bound and hence  $k = 0$ , but the definition also covers universal and existential quantification and partially ordered (Henkin) quantifiers. The central result of the paper is that for  $k \in \{0, 1\}$ , there is an equivalence between

1. The coherence of the proof rules for an  $(n, k)$ -ary quantifier, a decidable property that verifies the duality of the left and right proof rules

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All articles have already been published in the regular issues of Logical Methods in Computer Science.

2. A strong form of semantic soundness and completeness of the proof system relative to a semantics for the quantifiers given in terms of nondeterministic matrices (truth tables)
3. The strong cut elimination property for the proof system where derivations using the cut rule can be replaced with ones without cut.

Benzmueller, Brown, and Kohlhasé’s paper on *Cut-simulation and Impredicativity* shows that the addition of certain comprehension and extensionality axioms to higher-order logic make it possible to simulate the cut rule. Constructing a proof with cuts for a formula is difficult since the cut formula is not constrained by the goal formula. The eliminability of the cut rule makes it possible to find proofs by systematically constructing a cut-free proof tree starting from the conclusion sequent. However, introducing axioms that can simulate the cut rule get in the way of proof search. The paper demonstrates how these axioms can be incorporated into the inference rules for Church’s higher-order logic in a manner that is conducive to effective proof search.

Given two formulas  $A$  and  $B$  such that  $A \implies B$ , an interpolant is a formula  $I$  in the symbols shared between  $A$  and  $B$  such that  $A \implies I$  and  $I \implies B$ . A theory identifies a class of models. Some theories have ground (i.e., quantifier-free) interpolants when  $A$  and  $B$  are ground. Interpolant generation is a key technique in computer-aided verification for approximating the reachable states of a system and in refining abstractions. Sofronie-Stokkerman’s paper *Interpolation in local theory extensions* describes a modular construction for generating quantifier-free interpolants from *local* theory extensions to a base theory that is convex and has an interpolation procedure.

Constructive logics have played an important role in automated reasoning. These logics pose significant challenges since proofs are more difficult to find, but such proofs also yield more information in the form of constructive witnesses for existential claims. Constable and Moczydlowski’s paper *Extracting programs from constructive HOL proofs via IZF set-theoretic semantics* provides a constructive set theoretic semantics for the constructive fragment of higher-order logic (CHOL). The semantics is defined within the intuitionistic set theory IZF which is based on an intuitionistic first-order logic with axioms similar to those for Zermelo-Fraenkel (ZF) set theory. The soundness argument also yields a method to extract the constructive content of existence proofs in CHOL.

Benjamin Werner’s paper on *Proof irrelevant type theories* presents a variant of the Extended Calculus of Constructions where certain proof components can be tagged as irrelevant in the sense that the meaning of the expression only depends on the existence of a proof and not the actual proof itself. Proof irrelevance is built into the conversion rules. He shows how this type theory can simulate subset types that have been used to good effect in other type systems.

Daria Walukiewicz-Chrzaszcz and Jacek Chrzaszcz, in their paper on *Consistency and completeness of rewriting in the Calculus of Constructions*, examine the question of using rewrite rules within a proof system based on the Curry-Howard isomorphism between propositions and types. The paper presents a sound algorithm for checking that a function definition given by terminating and confluent rewrite rules is conservative.

Collectively, these papers present elegant results that have practical significance for the challenges of supporting mathematical expressiveness with effective automation.

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