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2009 CAV award announcement

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Abstract The 2009 CAV (Computer-Aided Verification) award was presented to seven individuals who made major advances in creating high-performance Boolean satisfiability solvers. This annual award recognizes a specific fundamental contribution or series of outstanding contributions to the CAV field.

Keywords Computer-aided verification · Boolean satisfiability

1 Introduction

The 2009 CAV (Computer-Aided Verification) award was presented on June 29, 2009 at the 21st annual CAV conference in Grenoble, France to seven individuals:

– Conor F. Madigan, Kateeva, Inc.
– Sharad Malik, Princeton University
– João P. Marques-Silva, University College Dublin, Ireland
– Matthew W. Moskewicz, University of California, Berkeley
– Karem A. Sakallah, University of Michigan

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- Lintao Zhang, Microsoft Research
- Ying Zhao, Wuxi Capital Group

They were recognized for having made major advances in creating high-performance Boolean satisfiability solvers. The CAV award, given annually, recognizes a specific fundamental contribution or series of outstanding contributions to the CAV field. The award includes a $10,000 prize and was presented with the citation: "For fundamental contributions to the development of high-performance Boolean satisfiability solvers."

The CAV conference is the premier international event for reporting research on Computer Aided Verification, a subdiscipline of Computer Science that is concerned with ensuring that software and hardware systems operate correctly and reliably. The CAV award was established in 2008 by the conference's steering committee and was given this year for the second time.

2 Boolean satisfiability

The seven recipients of this year's award worked in two different teams, one at the University of Michigan and one at Princeton University, where they created powerful programs for checking whether a propositional logic formula has a consistent solution. Their work touched off a flurry of activity that continues to this day. Teams from around the world compete to produce new satisfiability solvers, or "SAT solvers," that can solve the most difficult problems, and to find new ways to apply these solvers to a variety of practical problems.

SAT solvers can be applied to problems where many constraints are imposed, and a solution is desired that satisfies all of them. For example, the rules for a 9×9 Sudoku puzzle can be expressed as a number of constraints: that each square is assigned a number between 1 and 9, that no row or column contain any repeated digits, that no 3×3 square contain any repeated digits, and that some of the squares have predetermined values. These rules can all be expressed as a collection of around 12,000 constraints, which can readily be solved in around 0.01 seconds using a modern SAT solver [5].

In addition to solving puzzles, SAT solvers have had profound impact on the field of computer-aided verification, which is dedicated to the creation of tools that allow hardware and software designers to detect possible flaws in their systems and programs.

3 The GRASP program

Marques-Silva and Sakallah's GRASP solver [3], developed at the University of Michigan, started with a classic algorithm, devised by Davis, Putnam, Logemann, and Loveland (hence known as "DPLL") in the 1960s [1, 2]. DPLL applies backtracking search to enumerate different assignments to the variables of a formula until either a solution is found or the set of possible solutions is exhausted. Sakallah and Marques-Silva modified the DPLL algorithm to more effectively detect large classes of assignments that cannot possibly yield satisfying solutions. In doing so, they shifted the core strategy of SAT solvers from one of searching for a solution to one of pruning away the unsatisfying assignments. This change in strategy was critical to the successful application of GRASP to verification problems, where formulas typically have very few, if any, satisfying solutions (because such solutions signify errors in the system being verified). They also changed the method of measuring SAT solver performance away from solving randomly generated problems to one of solving benchmark problems arising from real-world examples. This shift favors tuning SAT solvers to take advantage of structures and characteristics found in actual systems.

4 The Chaff program

The Chaff solver [4], developed by Moskewicz, Madigan, Zhao, Zhang, and Malik at Princeton University, built upon the ideas of GRASP but also introduced a more careful, engineering-based approach to solver design. They identified memory performance as a critical bottleneck in DPLL SAT solvers and devised clever data structures to reduce the portions of a formula that must be rechecked as the effects of the variable assignments are propagated. Chaff was able to handle SAT problems of far greater size than anyone had imagined possible.

5 Impact of their work

GRASP and Chaff touched off what is often referred to as the “SAT Revolution,” involving both a continued evolution of more powerful SAT solvers and the use of SAT solvers as the core “engine” in a number of applications. SAT solvers have followed a trend reminiscent of the Moore’s Law trend for semiconductor technology, improving in both capacity and speed at an exponential rate. The most successful solvers are still based on DPLL, with both algorithmic and engineering enhancements inspired by GRASP and Chaff. In the area of verification, SAT solvers have enabled the verification of large-scale hardware and software systems via different forms of *model checking*, where the possible ways a system could hit an error condition are encoded as an SAT formula, and the checker either finds such a case or shows that these errors cannot occur.

Many research projects and many industrial verification tools have been devised with SAT solvers at their core. The impact of GRASP and Chaff on the CAV community has indeed been profound, and for this reason the 2009 CAV Award recognizes the contributions of these individuals to our field.

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