Logic Solvers and Machine Learning: The Next Frontier

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Abstract

Over the last two decades, software engineering (broadly construed to include testing, analysis, synthesis, verification, and security) has witnessed a silent revolution in the form of Boolean SAT and SMT solvers. These solvers are now integral to many testing, analysis, synthesis, and verification approaches. This is largely due to a dramatic improvement in the scalability of these solvers vis-a-vis large real-world formulas. What is surprising is that the Boolean satisfiability problem is NP-complete, believed to be intractable, and yet these solvers easily solve industrial instances containing millions of variables and clauses in them. How can that be?

In my talk, I will address this question of why SAT solvers are so efficient through the lens of machine learning (ML) as well as ideas from (parameterized) proof complexity. While the focus of my talk is almost entirely empirical, I will show how can we leverage theoretical ideas to not only deepen our understanding but also to build better SAT solvers. I will argue that SAT solvers are best viewed as proof systems, composed of two kinds of sub-routines, ones that implement proof rules and others that are prediction engines that optimize some metric correlated with solver running time. These prediction engines can be built using ML techniques, whose aim is to structure solver proofs in an optimal way.

Keywords

SAT solvers, SMT solvers, Machine learning

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