Boolean Equi-propagation for Concise and Efficient SAT Encodings of Combinatorial Problems

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Abstract

We present an approach to propagation-based SAT encoding of combinatorial problems, Boolean equi-propagation, where constraints are modeled as Boolean functions which propagate information about equalities between Boolean literals. This information is then applied to simplify the CNF encoding of the constraints. A key factor is that considering only a small fragment of a constraint model at one time enables us to apply stronger, and even complete, reasoning to detect equivalent literals in that fragment. Once detected, equivalences apply to simplify the entire constraint model and facilitate further reasoning on other fragments. Equi-propagation in combination with partial evaluation and constraint simplification provide the foundation for a powerful approach to SAT-based finite domain constraint solving. We introduce a tool called BEE (Ben-Gurion Equi-propagation Encoder) based on these ideas and demonstrate for a variety of benchmarks that our approach leads to a considerable reduction in the size of CNF encodings and subsequent speed-ups in SAT solving times.