Tuning Randomization in Backtrack Search SAT Algorithms

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Propositional Satisfiability (SAT) is a well-known NP-complete problem, being fundamental in solving many application problems in Computer Science and Engineering. Recent work on SAT has provided experimental and theoretical evidence that the use of randomization can be quite effective at solving hard instances of SAT. First, randomization was used in local search SAT algorithms, where the search is started over again to avoid getting *stuck* in a locally optimal partial solution. Moreover, in the last few years randomization has also been included in systematic search algorithms. As a result, backtrack search is given more freedom either to find a solution or to prove unsatisfiability. Indeed, backtrack search algorithms, randomized and run with restarts, were shown to perform significantly better on specific problem instances.

A complete backtrack search SAT algorithm can be *randomized* by introducing a fixed or variable amount of randomness in the branching heuristic. The amount of randomness may affect the value of the selected variable or which variable is selected from the set of variables with the highest heuristic metric (or even within $x\%$ of the highest metric).

A *restart strategy* consists of defining a *cutoff* value in the number of backtracks, and repeatedly running a randomized complete SAT algorithm, each time the limiting cutoff value is reached. If restarts are used with a fixed cutoff value, then the resulting algorithm is *not* complete. On the other hand, if there is a policy for increasing the cutoff value (e.g. by a constant amount after each restart), then the algorithm is complete, and thus able to prove unsatisfiability.

More recently, the introduction of randomization in the backtrack step has also been proposed. Here, the conflict clause is used for *randomly* deciding which decision assignment variable is to be toggled. This contrasts with the usual non-chronological backtracking approach, in which the most recent decision assignment variable is selected as the backtrack point.

Nonetheless, the use of randomization entails, by definition, an unpredictable behavior. Consequently, tuning the use of randomization is not only a key aspect, but can also be a difficult and challenging task. The analysis of experimental results obtained for different configurations of randomized algorithms can certainly bring some key insights on this topic [1].

References

1. I. Lynce and J. P. Marques-Silva. Tuning randomization in backtrack search SAT algorithms. Technical Report RT/05/2002, INESC, June 2002.