Lecture 3: SAT Solvers & Local Search

Adam Hawley

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1 Giving Up On Completeness

SAT is NP-Complete and is hard. One option for the impatient is to maintain soundness but give up on completeness. So search for a satisfying assignment if we find one then CNF is satisfiable and if not then we don't know either way.

2 Local Search

Look for *good* states *near* the current state. Goal states are particularly good! Don't bother remembering where you have been so little memory is required.

3 Local Search for SAT

- States are completely defined models, not partially-defined ones.
- Search is for a satisfying model: these are goal states.
- Natrual evaluation function is: number of unsatisfied clauses.
- Clearly the goal is to minimise this function.

3.1 Min-Conflicts Step

Choose a symbol such that **flipping** its truth-value minimises the number of unsatisfied clauses. Only one symbol is affected and this is the reason that this method is considered *local*.

3.2 Random Walk Step

In a random walk step, a symbol is chosen at random. Its truth-value is flipped. This can help the searchh escape a local minimum.

3.3 WalkSAT Algorithm

For each local move only flip symbols appearing in an unsatisfied clause. Choose random walk step with probability p and min-conflict step with probability 1-p. p is usually set to be about 0.5.

3.3.1 Features of the WalkSAT Algorithm

- If p>0, max_flips = ∞ and the CNF is satisfiable then WalkSAT will (eventually) find a model.
- But if max_flips = ∞ and the CNF is unsatisfiable it will never terminate.

WalkSAT is therefore a good option when we know (or at least suspect) that the CNF is satisfiable, but want to find a satisfying model.

4 Under and Over-Constrained SAT Problems

More symbols means more models, increading the *chance* of find = ∞ and the CNF is unsatisfiable it will never terminate. WalkSAT is therefore a good option when we know (or at least suspect) that the CNF is satisfiable, but want to find a satisfying model.

5 Under and Over-Constrained SAT Problems

More symbols means more models, increasing the *chance* of finding one that satisfies the CNF. More clauses means fewer models, decreasing the *chance* of finding one that satisfies the CNF. This is why the $\frac{clause}{symbol}$ ratio matters. If it is low then the problem is underconstrained, if high then it is overconstrained.

See lecture slides for proof.