Open-WBO-Inc in MaxSAT Evaluation 2020

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I. Introduction

Open-WBO-Inc [1], [2] is developed on top of Open-WBO [3], [4], [5] and placed first and second on the weighted incomplete tracks for 60 and 300 seconds respectively in the MaxSAT Evaluation 2018, and third on both these tracks in the MaxSAT Evaluation 2019. For many applications that can be encoded into MaxSAT, it is important to quickly find solutions even though these may not be optimal. Open-WBO-Inc is designed to find a good solution[1] in a short amount of time. Since Open-WBO-Inc is based on Open-WBO, it can use any MiniSAT-like solver [6]. For this evaluation, we use Glucose 4.1 [7] as our back-end SAT solver.

II. Algorithms

For the MaxSAT Evaluation 2020, we restrict Open-WBO-Inc to the weighted category where it uses the novel approximation algorithms that have been recently proposed [1], [2]. In particular, we submitted three versions of Open-WBO-Inc: inc-bmo-complete, inc-bmo-satlike, and inc-bmo-satlike19.

All versions are based on bounded multilevel optimization [8] using a variant of linear search algorithm SAT-UNSAT [9]. The algorithms used in these versions consider n objective functions where n is the number of different weights in the MaxSAT instance. This is done by performing a sequence of calls to a SAT solver and refining an upper bound μ on the number of unsatisfied soft clauses. To restrict μ at each iteration, we need to encode cardinality constraints into CNF, for which incremental Totalizer encoding [4] has been used. Once the upper bound μ for a given objective function cannot be improved, it is frozen, and the next objective function in the order is optimized.

An optimal solution, if found when using this algorithm, is not necessarily an optimal solution for the input formula. inc-bmo-complete and inc-bmo-satlike versions differ between them when this occurs. inc-bmo-complete keeps the best-known solution and resumes the search using the LSU algorithm which can potentially find better solutions and prove optimality. In contrast, inc-bmo-satlike changes the search algorithm to SATLike [10], a MaxSAT stochastic algorithm. The best model found by the first phase is passed to SATLike as its initial starting model.

[1]By "good solution" we mean that it can be potentially suboptimal but is not far from the optimal solution.

The inc-bmo-satlike19 version corresponds to the best performing version of Open-WBO-Inc in the MaxSAT Evaluation 2019. For the versions of this year, we added a conflict limit of 10^7 on each SAT call when performing the multilevel optimization phase. This prevents the solver from being stuck in some optimization level and never entering the final phase. We have also included the Target-Optimum-Rest-Conservative (TORC) and Target-Score-Bum (TSB) heuristics [11]. The TORC heuristic changes the default polarity of the SAT solver to take into consideration the MaxSAT formula. Relaxation variables that may appear in the cardinality constraints of the multilevel optimization algorithm are always set to polarity *false*. For the remaining variables, the polarity is set according to the best model found during search. The TSB heuristic bumps the score of all relaxation variables to make them more likely to be picked at the beginning of the search. Additionally, we also now support printing a compact certificate using 0's and 1's instead of variable ids.

III. Availability

We submit the source of Open-WBO-Inc as part of our submissions to the MaxSAT Evaluations 2020. The inc-bmo-complete version and the full Open-WBO-Inc framework is available under a MIT license in GitHub at *https://github.com/sbjoshi/Open-WBO-Inc*.

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References

[1] S. Joshi, P. Kumar, R. Martins, and S. Rao, "Approximation Strategies for Incomplete MaxSAT," in *CP*. Springer, 2018.
[2] S. Joshi, P. Kumar, S. Rao, and R. Martins, "Open-WBO-Inc: Approximation Strategies for Incomplete Weighted MaxSAT," in *Journal on Satisfiability, Boolean Modeling and Computation*. IOS Press, 2019.
[3] R. Martins, V. Manquinho, and I. Lynce, "Open-WBO: a Modular MaxSAT Solver," in *SAT*, ser. LNCS, vol. 8561. Springer, 2014, pp. 438–445.
[4] R. Martins, S. Joshi, V. Manquinho, and I. Lynce, "Incremental Cardinality Constraints for MaxSAT," in *CP*. Springer, 2014, pp. 531–548.
[5] M. Neves, R. Martins, M. Janota, I. Lynce, and V. Manquinho, "Exploiting Resolution-Based Representations for MaxSAT Solving," in *SAT*. Springer, 2015, pp. 272–286.
[6] N. Eén and N. Sörensson, "An Extensible SAT-solver," in *SAT*. Springer, 2003, pp. 502–518.

[7] G. Audemard and L. Simon, "Predicting Learnt Clauses Quality in Modern SAT Solvers," in *IJCAI*, 2009, pp. 399–404.
[8] J. Marques-Silva, J. Argelich, A. Graça, and I. Lynce, "Boolean lexicographic optimization: algorithms & applications," *Annals of Mathematics and Artificial Intelligence*, vol. 62, no. 3-4, pp. 317–343, 2011.
[9] D. Le Berre and A. Parrain, "The Sat4j library, release 2.2," *Journal on Satisfiability, Boolean Modeling and Computation*, vol. 7, no. 2-3, pp. 59–6, 2010.
[10] Z. Lei and S. Cai, "Solving (Weighted) Partial MaxSAT by Dynamic Local Search for SAT," in *IJCAI*. ijcai.org, 2018, pp. 1346–1352.
[11] A. Nadel, "Anytime weighted maxsat with improved polarity selection and bit-vector optimization," in *Proc. Formal Methods in Computer Aided Design*, C. W. Barrett and J. Yang, Eds. IEEE, 2019, pp. 193–202.