QMAXSAT in MaxSAT Evaluation 2018

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QMAXSAT is a satisfiability-based solver, which uses CNF encoding of pseudo-Boolean (PB) constraints [1]. The efficiency of MaxSAT solvers depends on critically on which SAT solver we use and how we encode the PB constraints. The QMAXSAT is obtained by adapting a CDCL based SAT solver GLUCOSE 3.0 [2], [3]. In addition, we introduce a new encoding method, called n-level modulo totalizer encoding in to our solver. This encoding is a hybrid between Modulo Totalizer (MTO) [4] and Weighted Totalizer (WTO) [5], incorporating the idea of mixed radix base [6].

Let $\phi = \{(C_1, w_1), \ldots, (C_m, w_m), C_{m+1}, \ldots, C_{m+m'}\}$ be a MaxSAT [7] instance where C_i is a soft clause with weight w_i $(i = 1, \ldots, m)$ and C_{m+j} is a hard clause $(j = 1, \ldots, m')$. We added a new blocking variable, b_i, to each soft clause $C_i(i = 1, \ldots, m)$. Solving the MaxSAT problem for ϕ is reduced to finding a SAT model of $\phi' = \{C_1 \vee b_1, \ldots, C_m \vee b_m, C_{m+1}, \ldots, C_{m+m'}\}$, which minimizes $\sum_{i=1}^{m} w_i b_i$.

Such SAT models are obtained using a SAT solver as follows: Run the SAT solver to get an initial model and calculate $k = \sum_i w_i b_i$ in it, add PB constraint $\sum_i w_i b_i < k$, and run the solver again. If ϕ' is unsatisfiable, then ϕ is also unsatisfiable as the MaxSAT problem. Otherwise, the process is repeated with the new smaller solution. The latest model is a MaxSAT solution of ϕ. QMAXSAT leaves the manipulation of the PB constraints to GLUCOSE by encoding them into SAT.

We introduce a hybrid encoding [8] which inherits modular arithmetic from MTO and distinct combinations of weights from WTO. The latter is essentially the same as Generalized Totalizer, which only generate auxiliary variables for each unique combination of weights. We also enhanced the encoding by multi-level modulo arithmetic based on a mixed radix numeral system [9]. This encoding method always produces a polynomial-size CNF in the number of input variables.

It is important to find a suitable mixed radix base with low time-consumption that reduces the number of auxiliary variables for our new encoding. We select the integer whose rate of divisibility is the highest for all weights[1] as the suitable modulus for each digit. Furthermore, we also add other heuristics tailored in our implementation, such as evaluating and voting for the candidates of modulus, dynamically adjusting the lower limit of the required rate of divisibility, etc.

[1]Before selecting the next modulus, we update all the weights to their quotients of dividing the previous selected modulus.

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