Title: Improving Linear Search Algorithms with Model-based Approaches for MaxSAT Solving
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Reply to the Reviewers Comments

Dear Guest Editors and Reviewers,

We would like to thank the RCRA13 reviewers for the feedback and for the insightful comments our paper received.

In addition, we would like to clarify that the current version of the paper significantly extends the one that was published in the proceedings of RCRA13. Different model-based algorithms have been evaluated and a new hybrid model-based algorithm has been proposed. Moreover, we have extended the section regarding model-based algorithms with proofs of termination and correction. Additionally, we also present a study on the impact of incrementality in linear search algorithms for MaxSAT. Moreover, the experimental results have also been extended. The benchmark set has been extended to include more instances, and a comparison is made against several state-of-the-art MaxSAT solvers.

We attach below our reply to the reviewer's comments to the RCRA13 version of our paper. We have also introduced modifications in the paper resulting from comments made by the reviewers.

Reviewer #1

> *" The paper proposes a set of algorithms for solving MaxSAT problems and compares them on a few benchmarks. Three algorithms are proposed: - LinearMS which is a well known algorithm - ModelMS which is an adaptation of an existing algorithm originally proposed for solving MinSAT problems - PartMS which is an original algorithm introduced in the present paper*
>
> *The idea underlying PartMS is very interesting. It builds on both LinearMS (idea of an iterative solve of a SAT problem with a cardinality constraint) and ModelMS (idea to use less variables in the cardinality constraint as large cardinality constraints result in loose inference in the SAT engines) by trying to keep, as much as possible, the enforcement of satisfied clauses from the previous iteration. This results in a much tighter SAT problem. And when this tighter problem becomes unsatisfiable, PartMS relies on the production of certificate of unsatisfiability to move clauses in the cardinality constraint (from inactive to active relaxation variables).*
>
> *In the experimental section, the 3 algorithms are compared together and against QMaxSAT a solver that entered the Max-SAT 2012 Evaluation and behaved well on the partial MaxSAT industrial instances. Experiments show that ModelMS and PartMS are complementary and can be competitive with QMaxSAT.*

The paper is fairly relevant to the call for paper as it is about comparing algorithms from an experimental viewpoint although the focus seems to be more on the description of the algorithm than on the evaluation itself. The paper is well written and very clear. The reason is probably that the idea proposed in PartMS is in fact very simple and this is what makes it quite elegant. "

We thank the reviewer for the comments.

" In the context of an extended journal version of the paper, I think two aspects should be extended: - the idea to hybridize ModelMS and PartMS to better exploit their complementarity "

A new hybrid model-based algorithm has been proposed. This algorithm combines properties from "Model" (formerly denoted "ModelMS") and "Disabled" (formerly denoted "PartMS") and is presented in section 3.3.

" - an extension of the experimental study in particular on other types of MaxSAT instances and other state-of-the-art MaxSAT solvers (indeed, except for the partial MaxSAT industrial instances, QMaxSAT does not seem to behave that well on other benchmarks). "

The set of benchmarks has been extended to include all instances from the MaxSAT evaluations from 2009 to 2012. This increases the number of MaxSAT industrial instances from 55 to 121 and the number of partial MaxSAT industrial instances from 504 to 972. Moreover, a comparison is now made against more state-of-the-art MaxSAT solvers, namely, `QMaxSAT`, `MSUnCore` and `wpm1`.

Reviewer #2

" This paper presents two methods to partition the relaxation variables in a linear search based max-sat solver. They do that over a model based algorithm developed for min-sat. The authors explain the procedure quite in detail and providing nice examples. Results show the effectiveness of the methods proposed and that they are complementary.

The paper is in general well written, only few typos occur. "

We thank the reviewer for the comments.

" What I find the authors should improve is some more detailed description of the related work, i.e. which other techniques have been developed to improve linear search based solvers."

To the best of our knowledge, not many techniques have been proposed to improve linear search algorithms. Most improvements are focused on improving the effectiveness of cardinality encodings, i.e. reducing the number of auxiliary variables and clauses and improving their propagation properties.

However, after the RCRA13 submission we have found that a similar algorithm to the "Disabled" algorithm (formerly denoted "PartMS") has been proposed in the past for MaxSAT. Even though the related algorithm was presented using a different formalism, it also uses unsatisfiable subformulas to increase the set of active relaxation variables. In section 3.2 we explain the differences between our algorithm and the one that has been proposed in the past.

" And just tell a bit more about the 3rd party solver they used as reference. About this, since these techniques are complementary, a comparison with further solvers would be appreciated. "

The description of other state-of-the-art MaxSAT solvers has been extended. Moreover, we now compare our implementations against more state-of-the-art MaxSAT, namely, `QMaxSAT`, `MSUnCore` and `wpm1`.

" Another point that should be clarified is how incremental SAT solving is used. "

We have included a section where we discuss how we can use an incremental approach in our model-based algorithms. Moreover, experimental results compare the benefits of using an incremental approach against a non-incremental approach.

" For a journal publication, it may be very interesting to see how good a hybrid solver can affect the results. "

A new hybrid model-based algorithm has been proposed. The new hybrid model-based algorithm is the best performing algorithm on the close solution problem and outperforms state-of-the-art MaxSAT solvers when considering all problem instances.

" minor:

Example 1, first sentence out of the example

p9 rebuild → rebuilt

p13 worst → worse

Sort citations according to reference number "

The above suggestions have been considered.

Reviewer #3

" The authors introduce a search strategy for solving the MaxSAT problem. In particular, they focus on the partial MaxSAT problem, where a set of (hard) clauses MUST be satisfied, and the maximization is done on the other (soft) clauses. Typically, relaxation variables on soft clauses are introduced and a cardinality constraint on them is introduced and updated during the computation. The authors basically propose a local search strategy that, starting from a feasible solution, select a proper subset of the relation variables that allows to explore a subset of the search space, reaching a local minimum (in a sense, they move in the space of the same solution of the hard part, but the maximum can be based on another solution).

The paper is very well-written. However, reading the paper, it is not evident whether their approach is complete or not. This can be added in the presentation. Instances chosen in experiments are without hard clauses; these instances do not allow to clarify my doubt. "

We thank the reviewer for the comments. Model-based algorithms are complete MaxSAT algorithms that terminate and return the correct solution for a given a MaxSAT formula. To clarify this issue, we have extended section 3 to include proofs of termination and correction of model-based algorithms.

Reviewer #4

" This original full paper describes a new technique for solving MaxSAT problems, which refines the standard linear search approach by exploiting SAT solutions. Results are mixed but promising, and point the way to hybrid approaches in future work. The paper is interesting and well-written, and should be of interest to anyone working on MaxSAT. I found no errors and have little doubt that a journal publication will follow. "

We would like to thank the reviewer for the kind words and appreciation of the paper.

Lisbon, September 2013