

Title: Boolean techniques in Knowledge representation

Author: Miloš Chromý

Department: Department of Theoretical Computer Science and Mathematical Logic

Supervisor: Doc. RNDr. Ondřej Čepek, Ph.D., Department of Theoretical Computer Science and Mathematical Logic

Abstract: In this thesis we will investigate switch-list representations of Boolean function and we will explore the biclique satisfiable formulas.

Given a truth table representation of a Boolean function f the switch-list representation of f is a list of Boolean vectors from the truth table which have a different function value than the preceding Boolean vector in the truth table. We include this type of representation in the Knowledge Compilation Map [Darwiche and Marquis, 2002] and argue that switch-lists may in certain situations constitute a reasonable choice for a target language in knowledge compilation. First, we compare switch-list representations with a number of standard representations (such as CNF, DNF, and OBDD) with respect to their relative succinctness. As a by-product of this analysis we also give a short proof of a long standing open question from [Darwiche and Marquis, 2002], namely the incomparability of MODS (models) and PI (prime implicates) representations. Next, using the succinctness result between switch-lists and OBDDs, we develop a polynomial time compilation algorithm from switch-lists to OBDDs. To finalize the switch-list representation analysis, we describe which standard transformations and queries (those considered in [Darwiche and Marquis, 2002]) can be performed in polynomial time with respect to the size of the input if the input knowledge is represented by a switch-list. We show that this collection is very broad and the combination of polynomial time transformations and queries is quite unique. Some of the queries can be answered directly using the switch-list input, others require a compilation of the input to OBDD representations which are then used to answer the queries.

A biclique satisfiable formula is a CNF formula whose incidence graph admits a cover by distinct bounded bicliques. The class of biclique satisfiable formulas was introduced in [Szeider, 2005] where it was also shown that it is NP-complete to check if a formula is biclique satisfiable. In [Chromý, 2015], a heuristic for checking biclique satisfiability was introduced and it was experimentally checked that property of being biclique satisfiable exhibits a phase transition behaviour. The heuristic algorithm presented in [Chromý, 2015] runs in polynomial time, but it is incomplete. In this thesis, we propose a SAT based approach to checking biclique satisfiability which is complete, but not polynomial time. We compare both approaches experimentally.

References:

Adnan Darwiche and Pierre Marquis. A Knowledge Compilation Map. *Journal Of Artificial Intel lence Research*, 17:229–264, 2002.

Miloš Chromý. Rozšíření matched formulí. Master’s thesis, Charles University, Faculty of Mathematics and Physics, 2015.

Stefan Szeider. Generalizations of matched CNF formulas. *Annals of Mathematics and Artificial Intelligence*, 43(1):223–238, 2005.