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Tractable Classes for CSPs of Arbitrary Arity: From Theory to Practice

Achref El Mouelhi

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Abstract The research of this thesis focuses on the analysis of polynomial classes and their practical exploitation for solving constraint satisfaction problems (CSPs) with finite domains. In particular, I worked on bridging the gap between theoretical works and practical results in constraint solvers. Specifically, the goal of this thesis is to find explanation for the effectiveness of solvers, and also to show that studied tractable classes are not artificial since several real-problems among the ones used in the CSP 2008 Competition belong to them.

Our work is organized into three main parts. In the first part, we proposed several types of microstructures for CSPs of arbitrary arity which are based on some knwon binary encoding of non-binary CSPs like, dual encoding, hidden-variable transformation and mixed (or double) encoding. These theoretical tools are designed to facilitate the study of tractable classes, sets of CSP instances which can be solved in polytime, when the constraints are non-binary. After that, we propose a new tractable classes of CSPs whose the highlighting should allow on the one hand to explain the effectiveness of solvers of the state of the art namely FC, MAC, RFL and on the second hand to provide the opportunities for easy integration in these solvers. These would include the definition of new tractable classes without using of an ad hoc algorithms as in the traditional case. These new tractable classes are related to the number of maximal cliques in the microstructure of binary or non-binary CSP. In the last part, we focus on the presence of instances belonging to polynomial classes in classical benchmarks used by the CP community. We study in particular the Broken-Triangle Property (BTP) and its extension DBTP to CSP of arbitrary arity. Next, we prove that BTP can also be used to reduce the size of the search space by merging pairs of values on which no broken triangle exists. Finally, we introduce a formal framework, called transformation, and we develop the concept of hidden tractable class that we exploit from an experimental point of view.

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Link to full text: http://afpc.greyc.fr/web/memoire/elmouelhi.pdf

Notes: two awards obtained during my thesis:
Best technical track paper for the paper "On Broken Triangles", 20th International Conference on Principles and Practice of Constraint Programming, CP'2014.
Best Paper of the SAT/CSP Special Track for the paper "A Hybrid Tractable Class for non-Binary CSPs", IEEE 25th International Conference on Tools with Artificial Intelligence, ICTAI'13.