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Redundant modeling in permutation weighted constraint satisfaction problems. (English)

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Summary: In classical constraint satisfaction, redundant modeling has been shown effective in increasing constraint propagation and reducing search space for many problem instances. In this paper, we investigate, for the first time, how to benefit the same from redundant modeling in weighted constraint satisfaction problems (WCSPs), a common soft constraint framework for modeling optimization and over-constrained problems. Our work focuses on a popular and special class of problems, namely, permutation problems. First, we show how to automatically generate a redundant permutation WCSP model from an existing permutation WCSP using generalized model induction. We then uncover why naively combining mutually redundant permutation WCSPs by posting channeling constraints as hard constraints and relying on the standard node consistency (NC^*) and arc consistency (AC^*) algorithms would miss pruning opportunities, which are available even in a single model. Based on these observations, we suggest two approaches to handle the combined WCSP models. In our first approach, we propose m-NC^*_c and m-AC^*_c and their associated algorithms for effectively enforcing node and arc consistencies in a combined model with m sub-models. The two notions are strictly stronger than NC^* and AC^* respectively. While the first approach specifically refines NC^* and AC^* so as to apply to combined models, in our second approach, we propose a parameterized local consistency $\mathrm{LB}(m, \Phi)$. The consistency can be instantiated with *any* local consistency Φ for single models and applied to a combined model with m sub-models. We also provide a simple algorithm to enforce $\mathrm{LB}(m, \Phi)$. With the two suggested approaches, we demonstrate their applicabilities on several permutation problems in the experiments. Prototype implementations of our proposed algorithms confirm that applying 2-NC^*_c, 2-AC^*_c, and $\mathrm{LB}(2, \Phi)$ on combined models allow far more constraint propagation than applying the state-of-the-art AC^*, FDAC^*, and EDAC^* algorithms on single models of hard benchmark problems.

MSC:

68T20 Problem solving in the context of artificial intelligence (heuristics, search strategies, etc.)

Keywords:

weighted constraint satisfaction; WCSP; constraint optimization; model redundancy

Software:

CSPLib

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