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Evaluation of Tomáš Balyo's Dissertation Thesis Entitled "Modelling and Solving Problems Using SAT Techniques"

This dissertation contributes to the core of artificial intelligence research by proposing novel algorithms for converting planning problem instances into instances of the well established satisfiability (SAT) problem. The focus of the thesis is timely mainly due to the remarkable current progress in developing unorthodox and ever faster SAT solvers. Mr. Balyo's contribution allows to harness this progress also for the sake of automated planning. I was puzzled as to why the title of the thesis does not include the word "Planning", making it overly general but that is just a minor glitch.

The main contributions are two novel sophisticated encodings of the planing problem into SAT: the reinforced encoding which combines some advantages of other two state-of-the-art encodings, and the *Exist Step* encoding which is appropriate for a special class of parallel-planning problems. These contributions are indeed deeply elaborated and their correctness is proven formally. I was not able to verify the proofs in their entirety but I was reasonably convinced of the quality of the encodings due to their experimental evaluation on established benchmark problems, as provided by the thesis.

Besides the above contributions, the author presents a heuristic for the automated choice among the encoding options leading to an indisputable performance superiority over other encoding approaches, as illustrated in Figure 3.6. Last but not least, the thesis contributes a new method for plan reduction.

Given the significance of the contributions commented, their diligent formal treatment and experimental evaluation, the good structuring and almost flawless language of the dissertation, I consider the latter a high-quality work which I happily recommend for the defense.

Nevertheless, I do have some reservations which should be addressed by the candidate.

While the thesis is generally well understandable and intuitive, an exception to this is Section 2.3.2 on parallel plans whose exposition I suspect to be counter-intuitive to anyone except total insiders. The problem begins with the definition of the $\exists$-step semantics: if the first two bullets of the definition are assumed then it seems to me that all permutations of actions in A_j should be equivalent. So, in my simple understanding, satisfaction of the $\exists$-step semantics should entail the same for the $\forall$ semantics? Clearly, I must be missing something but the author should have avoided this by providing enough intuition prior to just presenting the formal definition. Also the following two definitions (Relaxed and Relaxed-Relaxed semantics) suffer from the lack of adequate intuitive explanation: if we can assume that some action in A_j is *not* applicable in state s_j, then how on earth can it be applied in that state when executing the plan? (Note that other actions in A_j cannot render the action applicable as their effects are only applied in state s_{j+1}.)

Regarding minor flaws, the authors should be more careful when speaking about the problem reductions. To say (pg. 16, line 4) that we want to construct a formula "satisfiable *only if* there is a parallel plan" is apparently wrong since any contradiction is such a formula (yes, just the "if" part is missing). Similarly, more precision should have been given to Proposition 5 which does not assume that the plan be recovered from the satisfying assignment in *polynomial time* (otherwise, the encoding would not be useful, right?). Lastly, I do not see a reason to introduce another, more complex name ("perfectly justified") for something that already has a simple name ("non-redundant").

Finally, let me reiterate that apart from the non-fatal concerns stated above, the dissertation is of high-quality, addresses an important problem and is fully ripe for defense.

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