

## Hybrid Propositional Encodings of Planning \*

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Casting planning as propositional satisfiability has been recently shown to be a very promising technique of plan synthesis. Some challenges, one of which is the development of hybrid propositional encodings (that combine the important notions from the existing encodings) have also been posed to the community [1]. The existing encodings [3] are either entirely based only on the plan space planning (also known as “causal” or “least commitment” or “partial order” planning) or only on the state space planning. To answer this challenge, we have developed several hybrid encodings.

A key difference between state space planning and plan space planning is that state of the world is represented at each time step during the state space planning process and it is never available during the partial order planning process. This also holds for the corresponding propositional encodings. We bridge these extremes of not representing the state at all and maintaining the state at each time step, by controlling the number of time steps at which the state is represented. Our hybrid *unifying encoding* (Fig. 1) not only represents the world states, but also allows partial order on the plan steps that are “sandwiched” in the “regions” between the consecutive world states. We also developed several other hybrid encodings shown in Fig. 2. Since the hardness of solving an encoding is generally correlated with its size (especially in domain independent planning), we computed the number of clauses and variables in each of these hybrid encodings and theoretically proved [2] that no hybrid encoding can have fewer clauses or fewer variables than the currently smallest encoding (state space encoding with explanatory frame axioms [3]). Our future work involves an empirical evaluation of these hybrid encodings as well as their integer linear programming formulations.

[1] Subbarao Kambhampati, Challenges in bridging the plan synthesis paradigms, Proceedings of the International Joint Conference on Artificial Intelligence (IJCAI), 1997.

[2] Amol D. Mali, On the hybrid propositional encodings of planning, Technical Report TR-98-019, Dept. of computer science & engg., Arizona state university, 1998.

[3] Henry Kautz, David McAllester and Bart Selman, Encoding plans in propositional logic, Proceedings of the Knowledge Representation & Reasoning (KRR) conference, 1996.

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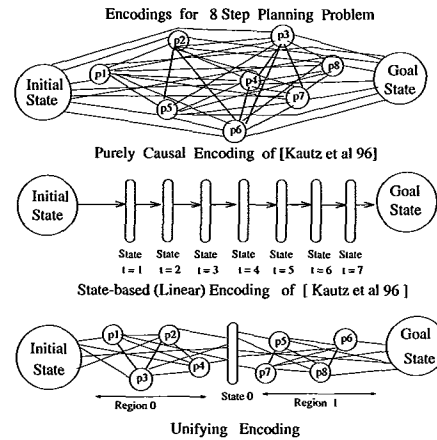


Figure 1: Propositional Encodings of Classical Planning Problems.

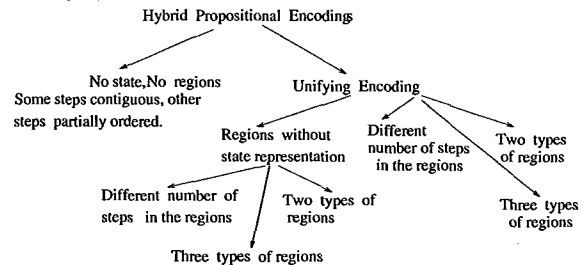


Figure 2: Hybrid Encodings of Classical Planning Problems. A region can be of one of the three types, based on the ordering of the steps in the region - 1. All steps are contiguous, 2. All steps are partially ordered, 3. Some steps are partially ordered, others are contiguous.