Partial Order Planning

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Overview

Partial order planning is a branch of planning and search algorithm that, unlike its predecessor - total order planning (a.k.a linear planning) which explores strict linear sequences of actions connecting start and goal, splits the planning problem into multiple sub goals and solves them independently before merging them back to find an optimal global plan. In other word, a planning algorithm considered partial-order if it can place more than one actions into a plan without specifying their order.

In contrast to linear planner, partial-planners are known to easily solve the Sussman anomaly (reference the AI book), where the optimal plans requires the interleaving of action sequences.

This document reviews 3 partial-order planning algorithm, SNLP, TWEAK and RePOP. SNLP and TWEAK are used in many planners whereas RePOP is a partial-planning improvement from the previous linear-planner POP.

Systematic Non-Linear Planning (SNLP)

The main idea of SNLP is the use of causal link to connect actions by joining the precondition of one action with the post-condition of another. This was not a novel idea, as previously explored in NONLIN. However, the SNLP is simpler to implement than its predecessors (Weldi, 2010).

The SNLP algorithm starts with a set of all Goals and Threats and terminates when both sets are empty. Assuming a causal link X→s→Y where X and Y are states and s is the link (pre/post condition), any actions that add or delete s is considered a threat. At each recursive step, the algorithm aims to eliminate such threats by adding ordering or binding constraints. A full description of SLNP and TWEAK algorithms can be found in (Knoblock & Yang, 1993).

TWEAK (1987)

The TWEAK algorithm uses causal links between propositions. However it is not as efficient as SNLP due to its use of Modal Truth Criterion (MTC) for the termination check, resulting in a O(n^3) run-time instead of SNLP's O(1). There are also no ordering constraints imposed during thread resolution and therefore the MTC may accidentally pick a goal by identifying a precondition for an incorrect step. TWEAK also needs to re-establish the causal link if it is clobbered (due to the lack of order).

It is important to note that TWEAK was invented before SNLP.

Revisited Partial order Planning (RePOP, 2001)

RePOP (Nguyen & Kambhampati, 2001) is a partial order planning algorithm that improves upon earlier POP algorithms, particularly UCPOP, and addressed the issues raised in UNPOP (McDermott, 1996), which started the era of heuristic state search. RePOP revived some interests back into the field of partial-order planning.

RePOP algorithm has 3 key ideas: ranking of partial plans using distance-based heuristic, using invariants to identify implicit conflicts within the plan, and resolving unsafe links by adding disjunctive ordering constraints directly into the plan.

In addition to the algorithm in the original paper, the authors also provide a good presentation summary at http://rakaposhi.eas.asu.edu/repop-talk.pdf.

References

Knoblock, C. A., & Yang, Q. (1993, 3). A Comparison of the SNLP and TWEAK Planning Algorithms. *AAAI Technical Report*, pp. 73-77.

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Weldi, D. S. (2010). Systematic Nonlinear Planning. *AI Magazine.*