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Blocking as a middle-ground for step-order Commitments in Planning

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Partial order planners commit only to the relative positions of the steps in the plan, and leave both their absolute positions as well as the relative distance between the different steps unspecified until the end of planning. Although this is seen as an advantageous feature of partial order planning, it can sometimes be a mixed-blessing. Because the relative distances between the steps are unspecified, any unordered step may be able to come between any existing steps and cause interactions and the planner may spend inordinate effort considering all possible interleavings of the subplans of the individual goals. This happens in cases where top-level goals are serializable but have long sub-plans which have internal interactions, plan-space planners would consider all simple-establishments and threats between steps of a the subplan of a top-level goal g_i (represented by P_{g_i}) and P_{g_j} which could affect its performance drastically. State-space planners, on the other hand, fix both the distance and position, and this is often more commitment than is needed, causing extensive backtracking (Barrett & Weld 1994).

We are investigating a middle ground between these two approaches, that we call "blocking" refinement. The essential idea is to work on individual subgoals one after another in LIFO fashion using the plan-space refinements. Once the complete subplan for one individual toplevel goal is constructed, the steps comprising that goal are "blocked" together by posting contiguity constraints between steps (Kambhampati & Srivastava 1995). To ensure completeness, we also leave the un-blocked version of the plan in the search space. Since no other steps can come between blocked steps, the planner will not waste time considering all possible interleavings of the subplans. Once all the top level goals are handled this way, any inter-block interactions between the blocked subplans are resolved (thereby implicitly sequencing the subplans of the individual goals). Notice that in contrast to partial order planning this approach fixes the distance between two steps in P_{g_i} but not the position of P_{g_i} with respect to P_{g_j}.

Variant of D^1S^2 domain			
Op	Prec	Add	Del
A_i (i odd)	I_i	M_i, he	hf
A_i (i even)	I_i	M_i, hf	he
B_i (i odd)	M_i, he	G_i	he
B_i (i even)	M_i, hf	G_i	hf

We implemented blocking on Universal Classical Planner (UCP). The implementation required distinguishing

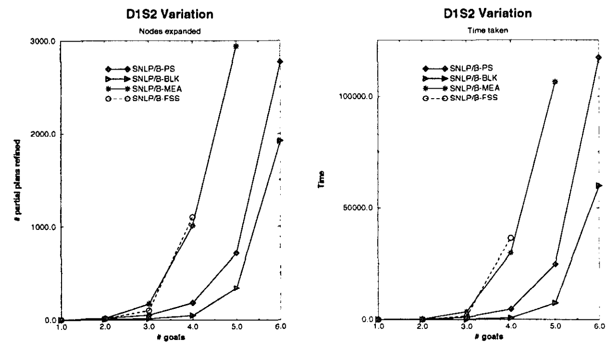

Figure 1: Plots illustrating the performance of blocking in D^1S^2 variation. Blocking performed the best among PS, Blocking, FSS and MEA

between inter-step, inter-block, and block-step conflicts in the plan and handling them at appropriate times. We tested the effectiveness of this approach in a variation of the D^1S^2 domain used in (Barrett & Weld 1994). Our domain contains a set of goals of the form g_i which can be achieved by action B_i. B_i in turn needs condition M_i given by action A_i. A_i also provides he to B_i, and B_i deletes he. Because of this latter condition, the subplans for individual toplevel goals will have many interactions, even though the overall plans are serializable. Figure 1 shows that blocking of steps of a top-level goal in a serializable domain improves performance over plan-space (PS) refinement. As UCP allows forward state-space (FSS) and means-ends analysis (MEA) refinements, we also tested them on this domain. Blocking not only visits lesser nodes than FSS, MEA and PS refinements, but also takes lesser time.

These results show the promise of the blocking refinement as a middle-ground between state-space and plan-space approaches in terms of step order commitment. In our future work, we will attempt to provide a better characterization of the classes of domains which could benefit from blocking, using theoretical and empirical analyses.

References

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