AI planning and search review

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1 Total Order Planning

AI planning arose from investigations into state-space search, theorem proving, and control theory and from the practical needs of robotics, scheduling, and other domains. Planners in the early 1970s generally considered totally ordered action sequences: problem decomposition was achieved by computing a subplan for each subgoal and then stringing the subplans together in some order. The first of this kind of planners was STRIPS [1]. The same name was later used to refer to the formal language of the inputs to the planner.

This approach, called total-order planning, or linear planning by Sacerdoti [2], was soon discovered to be incomplete: a complete planner must allow for interleaving of actions from different subplans within a single sequence. One solution to the interleaving problem, introduced by Waldinger in 1975, was goal-regression planning. This was also used by Warren's 1974 WARPLAN, and Tate's Interplan in 1974 [4]. Other issue with total-order planners, as argued by Barret and Weld [3], is that they are not as efficient as the partial-order representation: the partial-order representation yields superior performance because it more frequently produces trivial serializability.

2 Partial Order Planning

Partial-order planning leaves decisions about the ordering of actions as open as possible. Given a problem in which some sequence of actions is required in order to achieve a goal, a partial-order plan specifies all actions that need to be taken, but specifies an ordering of the actions only where necessary.

The construction of partially ordered plans (then called task networks) was pioneered by the NOAH planner, by Sacerdoti in 1975 through 1977, and by Tate's NONLIN system in 1975 through 1977. The first clear formal exposition was TWEAK, by Chapman in 1987, a planner that was simple enough to allow proofs of completeness and intractability of various planning problems. This planner led to further advances in the area through the planner presented by McAllester and Rosenblitt in 1991, or UCPOP introduced by Penberthy and Weld in 1992 [6]. Even though partial-order planning dominated around 20 years of research, it fell out of favor in the late 1990s as faster methods emerged.

3 Heuristic search planning

The idea of extracting heuristics from declarative problem representations for guiding the search in planning was pioneered by Drew McDermott's UNPOP program in 1996, which was the first to suggest the ignore-delete-list heuristic. Bonet and Geffner's Heuristic Search Planner (HSP) and its later derivatives were the first to make state-space search practical for large planning problems. HSP searches in the forward direction while HSPR, by Bonet and Geffner in 1999, searches backward.

The most successful state-space searcher to date is FF [5], which relies on forward state space search, using a heuristic that estimates goal distances by ignoring delete lists. Nguyen and Kambhampati demonstrated with their planner REPOP, in 2001, that with accurate heuristics derived from a planning graph, planners could scale up much better in parallelizable domains. FAST DOWNWARD, by Helmert in 2006, is a forward state-space search planner that preprocesses the action schemas into an alternative representation which makes some of the constraints more explicit. FAST DOWNWARD won the 2004 planning competition, and LAMA, by Richter and Westphal in 2008, a planner based on FAST DOWNWARD with improved heuristics, won the 2008 competition.

References

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