Planning Research Review

STRIPS

The early days of planning research were dominated by a focus on applying theorem-proving to solve various AI problems due to the prominence of reasoning spurred by the desire to create a human-like intelligence[1]. This focus led to the development of situational calculus, but the enormity of completely defining all the action effects and particularly frame axioms, which describe all states unaffected by actions, for any non-trivial problem was a serious limitation[1]. In 1971, Richard Fikes and Nils Nilsson introduced STRIP (STanford Research Institute Problem Solver). Among the most important and lasting contribution of this system is the assumption that most state representations of the planning problem (referred to in the paper as well-formed formulas, or wffs), does not change in-between actions[2]. With this assumption, STRIPS ignore frame axioms and defined actions as composing of three clauses: preconditions, adds, and deletes. Preconditions are requirements that must be true before an action can happen. Adds are states that the action creates in the problem world, and Deletes are states that an action removes from the problem world. These concepts remain in use today despite enormous advances in planning over the intervening decades[1].

GRAPHPLAN

Graphplan introduced the use of a compact representation of the state space called a planning graph. Planning Graphs are compact encoding of the planning problem, have polynomial size, and can be built in polynomial time[3]. Planning graphs consists of alternating levels of propositions, conditions true at a particular time step, and levels of actions whose preconditions are among the preceding proposition level[3]. A key feature of planning graphs are the detection of mutually exclusive actions. The paper identifies two conditions of action mutual exclusion: (1) interference: either action deletes an add-effect (per STRIPS) of the other, and (2) competing needs: if the preconditions of two actions are mutually exclusive in the corresponding proposition level[3]. These constraints greatly reduce the number of possible action at each action level and thus drastically reduce the size of the exponential search space. Once the planning graph is completed, Graphplan employs a backward search from the goal is performed to find a plan that achieves the goal[1]. These steps provide Graphplan with the property of completeness, meaning it will find an efficient plan to the goal if one exists[3]. Graphplan also introduced the *grounding* of all the actions, the process of specifying all possible parameter combinations in all possible actions, which has become a common feature in subsequent planning approaches[1].

RELAXED PLANNING

A fundamental aspect to planning in any domain is the search for a good or optimal plan. While a variety of suitable search methodologies are available (e.g. A*), their performance in any given domain often depends on the selection of a proper heuristic to guide the search. Good heuristics are hard to find and are often suitable to only specific aplications, thus limiting their usefulness. Drew McDermott along with Hector Geffner and Blai Bonet discovered the powerful notion of relaxed planning, where the number of actions necessary to achieve the goal, or the subgoals that comprise the overall goal, without any consideration of the deletive effects of those actions, make a surprisingly good domain-independent heuristic for guiding the planning search[1]. This powerful idea was clearly by the very simple "no precondition" heuristic as the H for the G + H cost heuristic of the A* search in this project. The level sum heuristic used for guiding the search with the planning graph also seems to be a variation on this idea.

References

1. Progress in AI Planning Research and Applications, Derek Long, Maria Fox, 2002.
2. STRIPS: A New Approach to the Application of Theorem Proving to Problem Solving, Richard E. Fikes, Nils J. Nilsson, 1971
3. Fast Planning Through Planning Graph Analysis, Avrim L. Blum, Merrick L. Furst, 1997