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Research Review

The report includes a summary of some key developments in the field of AI planning and search.

Planning research has been central to AI since its inception, and papers on planning are a staple of mainstream AI journals and conferences. 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.

The International Conference on Automated Planning and Scheduling (ICAPS, former AIPS) is the premier forum for researchers and practitioners in planning and scheduling - two technologies that are critical to manufacturing, space systems, software engineering, robotics, education, and entertainment [1].

The most successful state-space searcher to date is Hoffmann's (2000) Fast Forward or FF, winner of the ICAPS (AIPS) 2000 planning competition. FF uses a simplified planning graph heuristic with a very fast search algorithm that combines forward and local search in a novel way[2]. The winner of the 2002 ICAPS (AIPS) planning competition, LPG (Gerevini and Serina, 2002, 2003), searched planning graphs using a local search technique inspired by WALKSAT[3]. Fast Downward (Helmert, 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 [3]. Fast Downward has proven remarkably successful: It won the "classical" (i. e., propositional, non-optimising) track of the 4th International Planning Competition at ICAPS 2004, following in the footsteps of planners such as FF and LPG [6].

Fast Forward

Fast-Forward was the most successful automatic planner in the AIPS-2000 planning systems competition. Like the well known HSP system, FF relies on forward search in the state space, guided by a heuristic that estimates goal distances by ignoring delete lists. It differs from HSP in a number of important details.

Though its performance clearly distinguished it from the other planners, the idea behind the approach is not new to the planning community. In fact, the basic principle is that of the HSP system, first introduced by Bonet (Bonet, Loerincs, & Geffner 1997). Planning problems are attacked by forward search in state space, guided by a heuristic function that is automatically extracted from the domain description. To arrive at such a function, both planning systems relax the planning problem by ignoring parts of its specification, i.e., the delete lists of all actions. FF can be seen as an advanced successor of the HSP system, which differs from its predecessor in a number of important details:

1. A more sophisticated method for heuristic evaluation, taking into account positive interactions between facts.

2. A novel kind of local search strategy, employing systematic search for escaping plateaus and local minima.

3. A method that identifies those successors of a search node that seem to be — and usually are — most helpful in getting to the goal [4].

LPG

LPG has implemented some techniques for planning in temporal domains specified with the recent standard languange PDDL2.1. LPG is a fully-automated system, planner based on a stochastic local search method and on a graph-based representation called "Temporal Action Graphs" (TA-graphs). LPG presents some new heuristics to guide the search in LPG using this representation. An experimental analysis of the performance of LPG on a large set of test problems used in the competition shows that techniques can be very effective, and that often the planner outperforms all other fully-automated temporal planners of that time [5].

Fast Downward

Fast Downward is a classical planning system based on heuristic search. It can deal with general deterministic planning problems encoded in the propositional fragment of PDDL2.2, including advanced features like ADL conditions and effects and derived predicates (axioms). Like other well-known planners such as HSP and FF, Fast Downward is a progression planner, searching the space of world states of a planning task in the forward direction. However, unlike other PDDL planning systems, Fast Downward does not use the propositional PDDL representation of a planning task directly. Instead, the input is first translated into an alternative representation called multivalued planning tasks, which makes many of the implicit constraints of a propositional planning task explicit.

Fast Downward uses hierarchical decompositions of planning tasks for computing its heuristic function, called the causal graph heuristic, which is very different from traditional HSP-like heuristics based on ignoring negative interactions of operators.

Fast Downward presents some novel techniques for search control that are used within best-first search algorithm: preferred operators transfer the idea of helpful actions from local search to global best-first search, deferred evaluation of heuristic functions mitigates the negative effect of large branching factors on search performance, and multi-heuristic best-first search combines several heuristic evaluation functions within a single search algorithm in an orthogonal way. Fast Downward efficient data structures for fast state expansion (successor generators and axiom evaluators) and present a new non-heuristic search algorithm called focused iterative-broadening search, which utilizes the information encoded in causal graphs in a novel way.

References

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