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Historical Developments of Planning and Search Research Review

Planning and Search is a major sub-field of Artificial Intelligence due to its many areas of practical importance such as, logistics, robotics..etc. Over the past couple of decades, the Planning and Search community has made significant strides in terms of the performance of their solvers. Up until 1995 when the Graphplan was introduced [1], the research was focused on non-linear and partial-order planning algorithms [2]. There were a few advantages associated with the new Graphplan: 1) The lengths of the plans are incrementally increased until a solution is found, 2) reachability information is used for pruning the tree. These led to unprecedented performance enhancements. Later, came a general-purpose satisfiability algorithm that could outperform even the Graphplans [3]. This inspired researchers in the field to look into translating planning/search problems to other types of problems that could be solved with different techniques. For example, HSP planners use plain-forward or backward chaining that use effective heuristics. This further motivated the researchers to look more deeply into developing different heuristics that estimate the distance between the states. Effective domain-independent distance heuristics are shown to significantly increase the efficiency of the search. The heuristics are effectively evaluation functions where each state is assigned a value indicating how good the state is. The search is then guided (for example using greedy algorithms) by these heuristics. To derive such heuristics, often the problem is simplified by removing the negative effects of all operators. The development of effective heuristics for cases where ignoring negative effects doesn't work as well is still an active area of research.

As examples, here are 2 planning frameworks currently in use along with a very brief summary:

STRIPS (Stanford Research Institute Problem Solver)

This automated planner was developed by Fikes and Nilsson [4]. The new representation language developed enabled the iterative transformation of an initial state to a goal state much like the classical planning languages.

PDDL (Planning Domain Definition Language)

This is currently one of the most dominant frameworks used. The creation of the PDDL was inspired by STRIPS. However, due to its simpler 'Action Description Language', more complex problems can be encoded using PDDL. Effective use of Heuristics (made by relaxing the negative effects) is made in PDDL often with state-of-the-art results [5].

The planning and search still remains an important part of AI. With recent increases in the scale of the problems due in part to globalization, the demand for more efficient algorithms to address common practical problems (e.g., logistics) has never been as high.

[1] Avrim L. Blum and Merrick L.Furst. Fast planning through planning graph analysis. Artificial Intelligence, 90(1-2):281–300, 1997.

[2] David A. McAllester and David Rosenblitt. Systematic nonlinear planning. In T. L. Dean and K. McKeown, editors, Proceedings of the 9th National Conference on Artificial Intelligence, volume 2, pages 634–639. AAAI Press / The MIT Press, 1991.

[3] Henry Kautz and Bart Selman. Pushing the envelope: planning, propositional logic, and stochastic search. In Proceedings of the Thirteenth National Conference on Artificial Intelligence and the Eighth Innovative Applications of Artificial Intelligence Conference, pages 1194–1201, Menlo Park, California, August 1996. AAAI Press.

[4] Richard E. Fikes and Nils J. Nilsson, "STRIPS: A New Approach to the Application of Theorem Proving to Problem Solving," (1971)

[5] Stuart J. Russel, Peter Norvig, Artificial Intelligence: A Modern Approach (3rd Edition) (2010).