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Planning Research Review – Developments in the field of AI Planning and Search

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There have been numerous advances in the areas of AI planning and Search, the development of which is largely related to solving problems in other fields such as robotics and scheduling. The first such development can be seen in the first major planning system, STRIPS, a problem solver which was developed by Stanford's Research Institute. STRIPS belonged to a class of systems that took an initial state or "world model", performed some action on the world model to produce a new iteration, and then repeated the procedure using a selection of actions to eventually arrive at a world where a goal function could be evaluated to true (Fikes and Nilsson, 1971). In order to represent these world models, STRIPS used a set of what were termed "well formed formulas(wffs) of first order predicate calculus"(Fikes and Nilsson, 1971), which could be used to evaluate the status of a world at a given point in execution. This method of defining states with a representation language, coined as an Action Description Language, had a huge impact on the way that state space search and planning were performed and even paved the way for the current standard of description languages, the Problem Domain Description Language (PDDL). Although the PDDL has been updated over years of use, it along with the world model strategy are still instructed on in state space search and planning today.

Another important point of progress in the field of planning was the development of partial order planning. In partial order planning, the order in which actions are selected is left as open as possible, allowing a valid plan to consist of the required actions in any order. The requirement for reaching a goal state would consist of ensuring that the preconditions for each action selected are fulfilled by the effects of the actions in the plan. In the early 1970s, automated planners looked only at totally ordered sequences of actions, a strategy that was found to be unable to solve several simple problems (Sussman, 1975). Allowing the planner the capability to consider more open orderings provided better results as well as locate optimal solutions for the very problems that totally ordered sequences could not. Additionally, it was found that partial order planners were generally more efficient than their total order counterparts (Barret and Weld, 1993). Partial order planning would become a major focus of research for the Artificial Intelligence community for well into the next 20 years. This eventually led to the TWEAK planner (Chapman, 1987), which was a simple enough implementation allowing for proofs of completeness for partial order planners.

Over the next few years, work on planners dropped as researchers moved to focus on other topics. However, in 1995 a new graph planning system was introduced called GRAPHPLAN which was found to be significantly faster than any partial order planner at the time. Utilizing a new formulation of a planning graph, Avrim Blum and Merrick Furst were able to significantly reduce the amount of search required to find a solution.(A. Blum and M. Furst 1997). The orders of magnitude speed increase and constraint based nature of GRAPHPLAN, as well as other systems like it, resulted in these graph algorithms to be useful for approaching problem domains that are NP-Hard.

All of these developments have had profound impacts on the state of AI planning and search throughout the years. Each has brought a significant improvement to the way that planners are developed, with the initial conceptualization in STRIPS to the speed and power potential seen in systems like GRAPHPLAN, these advances have played a huge role in bringing artificial intelligence closer to solving harder and harder problems using automation. It will be exciting to see what new advances may appear in the years to come.

Citations

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