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Research Review on Historical Key Developments in Planning and Search

Since its birth in the early 1970s, significant progress has been made in the field of AI planning research for over three decades [1]. This review highlights three key developments in the field, namely STRIPS, Graphplan, and HSP.

In 1971, planning emerged as a subfield of AI, heavily influenced by the work of Fikes and Nilsson on the STanford Research Institute Problem Solver (STRIPS). Its contribution to planning research was to introduce the STRIPS assumption, which was a way of reducing the complexity of the frame problem in situation calculus. McCarthy earlier developed situation calculus as a way to frame the planning problem space by describing situations that are affected by actions. After an action is applied to a situation, effect axioms describe what changed, while frame axioms describe what remains unaffected. Given a non-trivial planning problem, it is difficult to define all the frame axioms upfront—this is the frame problem in situation calculus. STRIPS makes the assumption that the only changes from applying an action to a situation are the specified positive effects of an action, and that all other relations and predicates would remain in the successor situation. Regardless of decades of advancements in planning research, the STRIPS assumption is regarded as a fundamental principle in modeling planning problems and is the basis upon which the Planning Domain Description Language (PDDL) has been built [1].

The Graphplan algorithm, yet another key contribution to the field of planning, was later introduced in the early 1990s, inciting interest because of its radical new approach. Graphplan constructs a representation of the problem space and then searches it: first, it constructs a plan graph of states and actions, and second, it searches backwards from the goals to find a subset of actions that can achieve the goals. The plan graph also displays mutually exclusive pairs of states and actions (such as, the light switch cannot both be on and off). During the search phase, the graph is extended and searched again if no plan is found. Hence, Graphplan performs an iterative depth-first search, which is beneficial due to lower overhead memory costs, but fails if its computational resources exceeds the number of search iterations required to find a plan. Nevertheless, Graphplan at the time achieved great success due to its performance, such that a number of re-implementations and extensions have been made on top of it [1].

A third crucial contribution to planning is the Heuristic Search Planner (HSP), developed by Geffner and Bonet in 1997. The idea is to use a heuristic to guide the search for a plan; however, before HSP, heuristics were nothing new. Nevertheless, earlier planners faced difficulty in the actual application of heuristic functions because they were hand-coded and unreliable. In contrast, HSP allows heuristic functions to be built automatically by estimating the work that remains to be accomplished upon consideration of adding each action to a plan. This can be done by measuring the required number of actions to achieve the remaining unmet goals, given that any destructive effects of those actions are ignored. In essence, this is what relaxed planning is about—to ignore the destructive effects of actions, and luckily, finding arbitrary relaxed plans is relatively easy [1]. For the first time, due to the work on HSP, it became practical to use state-space search for large planning problems [2].

Even today, techniques from STRIPS, Graphplan, and HSP are utilized in the field of planning, and the scope of planning technology continues to increase. There is always room for growth, since by nature, planning is a difficult problem, even when reduced to its bare form [1].

References

[1] Long, Derek, and Maria Fox. "Progress in AI Planning Research and Applications." *Upgrade: The European Online Magazine for the IT Professional*, vol. 3, no. 5, Oct. 2002, pp. 10–24.

[2] Russell, Stuart J., and Peter Norvig. *Artificial Intelligence: A Modern Approach*. 3rd ed., Pearson, 2010.