

Research Review

AI planning started from investigations into state-space search, theorem proving and control theory and from the practical needs of robotics, scheduling, and other domains (Norvig and Russell 2010). Since its inception, AI planning has undergone several developments in its approach to solving planning problems. The main approaches used in AI planning are state-space planning, plan-space planning and search-space planning algorithms.

The earliest set of algorithms used in AI planning is the state-space algorithms, which includes forward (progression), back (regression) and STRIPS (Stanford Research Institute Problem Solver). The STRIPS algorithm borrows an element of both the forward and backwards algorithm. Richard Fikes and Nils Nilsson developed it in 1971 at SRI international (Wikipedia). It is an algorithm in which the search space is a subset of the state-space. Each node corresponds to a state of the world, each arc corresponds to a state transition, and the current plan corresponds to the current path in the search space (Ghallab et al. 2004). Strips improved planning efficiency by reducing the size of the search space. It accomplished this by considering only subgoals eligible to be worked on that are preconditions of the last operator added to the plan. This reduced branching substantially. However this approach made STRIPS incomplete making it unable to find a solution at all times and if it finds a solution there is no guarantee of the solution being optimal. An example of this problem is applying STRIPS to the Sussman anomaly.

The problem observed in STRIPS led to the development of plan-space planning, in which the planning system searches through a space where nodes are partial plans rather than states of the world, and a partial plan is a partially ordered sequence of partially instantiated actions rather than a totally ordered sequence. Some algorithms under plan-space search are the PSP and POP procedure algorithms. The ideas underlying partial-order planning algorithms include the detection of conflicts and the protection of achieved conditions from interference. The construction of partially ordered plans was pioneered by the NOAH planner and by the Tate's NOALIN system (Norvig and Russell 2010).

The plan-space dominated the next 20 years of research until Avrim Blum and Merrick Furst (1995,1997) revitalized the field of planning with a search-space planning algorithm called the

GRAPHPLAN system. It was order of magnitude faster than partial-order planners of the time. Its main advantage is that it provided accurate heuristics to guide searches. Solutions are searched in the space formed by a planning graph using the GRAPHPLAN algorithm.

There have been improvements and variations to the various approaches to AI planning and there is debate about which approach is better. Helmet (2000) analysed several classes of planning problems and showed that search-space based approaches such, as GRAPHPLAN are best for NP-hard domains, while state-space / plan space approach do better in domains where feasible solutions can be found without backtracking