Research Review

Planning has been a key area of research in artificial intelligence for over five decades now and has been applied to diverse areas including robotics, process planning, web-based information gathering, autonomous agents and unmanned vehicles. In crux, a planning problem is to generate a plan guaranteed to reach the goal state conditioned upon the definition of the problem containing a set of initial states, desired goals and a set of possible actions.

STRIPS (STanford Research Institute Problem Solver) developed by Fikes and Nilsson in 1971 was the first major planning system developed as a planning component of the software of Shakey robot project. It's overall structure was modelled on the General Problem Solver which is a state space search system that uses mean-end analysis. Every decade STRIPS was revised and upgraded and optimized to give better results. As time progressed people started understanding the limitations of STRIPS and in 1986 Pedneault formulated the action description language or ADL which made to possible to encode more realistic problems. In the 70s, planners used the linear planning approach of decomposing every problem to get a subplan for each subgoal and concatenate them to derive the final plan. Later after realising the interleaving problem resulting from linear planning, regression planning technique was developed wherein the steps in completed ordered plan are reordered to avoid conflict between sub-goals. Partial order planning gained traction for next 2 decades post 70s. It was nothing but a plan which specifies all the action that need to be taken, but does not specify an order for those actions when the order doesn't matter. A partial order planner consists of four components; a set of actions; a partial order for the actions; a set of causal links; and a set of open preconditions. SNLP and TWEAK are some of the examples of the complete partial order planning algorithms. SNLP helped many researchers understand and experiment with partial order planning. Despite its benefits of solving problem quickly, it came at the cost of high computational power primarily due to the complex nature of the algorithms. During this time a partial order planning algorithm called UCPOP was developed for problems expressed in ADL. Despite being faster than SNLP, it was not able to obtain solution which would be over a dozen of steps.

Later in mid 90s an algorithm for automated planning was developed by Avrim and Merrick which came to be called as the GRAPHPLAN. GraphPlan took the planning problem as input in STRIPS language and produces a sequence of operations to reach the goal state. The graphplan was based on a data structure called planning graph which is nothing but a layered graph in which the layers of vertices form an alternating

sequence of literals and operators. Planning as Satisfiability also called SATPlan is a method of automated planning which converted the planning problem into an instance of boolean satisfiability problem, which is then solved using a method for establishing satisfiability such as the DPLL algorithm or WalkSAT. As GraphPlan and SATPlan have to create many actions, they face trouble in solving problems in domains having many objects. Helmert in his analyses of classes of modern planning algorithms shows that constraint based approaches like GraphPlan and SATPlan work best in NP-Hard domains while search based approaches work better in domains where optimal solution can be obtained without backtracking.

Finally i personally feel Planning research has a future in the coming days of AI and is currently also having a great impact in finance domain, transforming inventory management and many other such areas.

Citations:

- http://aima.cs.berkeley.edu/2nd-ed/newchap11.pdf
- https://en.wikipedia.org/wiki/Partial-order_planning
- http://planning.cs.uiuc.edu/node64.html
- https://en.wikipedia.org/wiki/Satplan
- https://web.stanford.edu/group/nasslli/courses/boutilier/Lecture1.pdf