AIND-Planning: Research Review
Shiv Shah

The historical research and developments in the field of AI planning and search unveiled new ways of solving problem for an AI agent. One of the very first developments in AI planning was STRIPS (Stanford Research Institute Problem Solver) introduced by Fikes and Nilsson in 1971 (Fikes and Nilsson, 1971). STRIPS was a completely new program-solving program at that time, which used techniques like theorem proving, first-order predicate calculus and means-ends analysis to find solution. In STRIPS, the problem space is defined by the initial world model, the set of available operators, and the goal statement. The world model is represented by a set of logic statements, where statements could be either true or false. The available operators are grouped into schemata, where each consists of two main parts: the condition under which the operator is applicable and the effects of the operator. It is assumed that given an initial and goal world model, there exists a set of applicable operators, each of which transforms the world model to some other world model. So, the goal is to find composition of action to transform initial state into goal state. And to do that, it uses the resolution theorem prover as a key part of the mechanism in attempt to apply those operators that are relevant to reducing a difference between a world model and a goal or subgoal. This technique of using logic to represent complex world state and find solution through deduction became a framework for future research in artificial intelligence. STRIPS was a very useful technique for robotic systems – in re-arranging objects and navigating. It was able to represent the complex and general world models that previous programs failed to do.

The introduction of STRIPS was followed by several other techniques in planning algorithms like PDDL that improved upon STRIPS. In 1997, Blum and Furst at Carnegie Mellon University, introduced a new approach to planning called Graphplan, which plans in STRIPS-like domains based on constructing and analyzing a compact structure called Planning Graph (Blum and Furst, 1997). In this approach, instead of directly searching for the sequence of action that achieves goal, the algorithm first constructs a compact structure called a Planning Graph. This graph is a simpler version of the exponential problem space graph, and can be constructed in polynomial time, and allows the search to be done much faster by discovering inherent constraints in the problem. Even though STRIPS planning brought efficient representation of the world for the robots, searching for the problem was still quite complex and could be slower and impractical. The introduction of planning graph and Graphplan provided a quite substantial improvement in running time, provided a practical value in solving planning problems. Another valuable feature of this algorithm is that it guarantees it will find the shortest plan in case of independent actions.

Another important development that followed STRIPS and Graphplan was heuristic search planner. Heuristic Search Planner was first introduced in AIPS98 Planning Contest in 2000, where it solved maximum number of problems competing against Graphplan and SAT planners (Bonet and Geffner, 2000). So, this technique is competitive with Graphplan. This technique transform planning problems into problems of heuristic search by automatically extracting heuristc from the problem declaration, which make its appealing.HSP performs forward search from an initial state to a goal state using an heuristic function that provides an estimate of the distance to the goal. The heuristic has to be derived from the high-level representation of the actions and goals. A common way to derive a heuristic

function for the given problem is by relaxing the problem into simpler problem whose optimal solution can be computed efficiently. Then, the optimal cost for solving this relaxed problem can be used as heuristic for solving the original problem. The only problem could be that the relaxed problem is NP-Hard. In STRIPS planning, the heuristic values for a planning problem can be obtained by relaxing problem in which all delete lists are ignored. So, action may add new one, but not remove existing ones. This heuristic allows to implement A* search with the STRIPS planning.

The three major developments discussed above have significant impact in the field of artificial intelligence. While STRIPS pioneered the autonomous robots, Graphplan and HSP has made it possible to build more intelligent autonomous agents. Factory robots, intelligent vacuum cleaners, space exploring robot, autonomous cars and drones are few of many areas these algorithms have contributed to. With the need for problem solving and planning deeply rooted in our lives, these algorithms will continue to shape our future.

References:

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