

AI Planning and Search Evolution

Overview

AI Planning and Search research have been evolving since the 1960's. The objective of these research projects is to determine how to approach the problem and find the optimal solution. Three of the popular approaches (STRIPS, SATPLAN and GRAPHPLAN) will be discussed and try to answer the question: what impact did these approaches have on the AI Planning and Search field?

STRIPS

STanford **R**esearch **I**nstitute **P**roblem **S**olver (STRIPS) was developed in 1971 to help with Robot Research at SRI. The robots needed a mechanism to determine how to move around physical objects that are in the room or elsewhere. "Our primary interest here is in the class of problems faced by a robot in re-arranging objects and in navigating, i.e., problems that require quite complex and general world models compared to those needed in the solution of puzzles and games. In puzzles and games, a simple matrix or list structure is usually adequate to represent a state of the problem. The world model for a robot problem solver, however, must include a large number of facts and relations dealing with the position of the robot and the positions and attributes of various objects, open spaces, and boundaries."¹ STRIPS separated the processes of theorem proving and search through space of world models. This separation allowed Fikes and Nilsson to use different strategies on these two activities for better overall system performance. For searching, STRIPS used a means-end analysis strategy similar to GPS (General Problem Solver, Newell and Simon, 1961). STRIPS's problem space is defined by an initial world model, the set of operators and their effects on the world models and the goal statement. "Instead, we have adopted the GPS strategy of extracting "differences" between the present world model and the goal and of identifying operators that are "relevant" to reducing these differences [6]. Once a relevant operator has been determined, we attempt to solve the subproblem of producing a world model to which it is applicable. If such a model is found, then we apply the relevant operator and reconsider the original goal in the resulting model."² STRIPS begins by attempting to prove that the goal G_0 is reached from the set of M_0 wffs described in the initial model. If G_0 can be reached from M_0 then the problem has a trivial solution, otherwise it attempts to find operators that reduces the differences between G_0 and M_0 and search for new sub-goals. This continues until the problem is solved.

SATPLAN

Planning as Satisfiability (SATPLAN) was created by Henry Kautz and Bart Selman in 1992 while at Bell Laboratories to find alternatives to deduction based planning and search approaches. "We develop a formal model planning based on satisfiability rather than deduction. The satisfiability approach not only provides a more flexible framework for stating different kinds of constraints on plans, but also more accurately reflects the theory behind modern constraints-based planning systems. Finally,

¹ Fikes, Richard E. and Nilsson, Nils J., [STRIPS: A New Approach to the Application of Theorem Proving to Problem Solving](#), Pg. 190

² Fikes, Richard E. and Nilsson, Nils J., [STRIPS: A New Approach to the Application of Theorem Proving to Problem Solving](#), Pg. 193

we consider the computational characteristics of the resulting formula, by solving them with two very different satisfiability testing procedures.”³

GRAPHPLAN

“In this paper we introduce a new planner, Graphplan, which plans in STRIPS-like domains. The algorithm is based on a paradigm we call Planning Graph Analysis. In this approach, rather than immediately embarking upon a search as in standard planning methods, the algorithm instead begins by explicitly constructing a compact structure we call a Planning Graph. A Planning Graph encodes the planning problem in such a way that many useful constraints inherent in the problem become explicitly available to reduce the amount of search needed.”⁴

Conclusion

Three approaches were discussed. What impact did these approaches have on the AI Planning and Search field? STRIPS provided a new mechanism to describe the objects in the world and help the robots move around without bumping into the objects. SATPLAN used satisfiability instead of deduction to solve problems that were thought of as hard. All three approaches advanced research in the AI Planning and Search field and introduced ideas that challenged the known beliefs.

³ Kautz, Henry and Selman, Bart, [Planning as Satisfiability](#), Pg. 1

⁴ Blum, Avrim L. and Furst, Merrick L., [Fast Planning Through Planning Graph Analysis](#), Pg. 1