Research Review
Sashank Santhanam

An overview of recent algorithms for AI planning

Abstract - An overview of the techniques and recent developments in the field of planning systems.

Introduction

GRAPHPLAN algorithm changed the way planning in AI field was done [2] and before the introduction of this, planning focussed on non linear and partial order planning [1]. Once GRAPHPLAN algorithm was introduced, there was an influx of algorithms which improved the performance, specifically the algorithm designed by Kautz and Selman. In this report we show three of the advancements in the field of AI planning.

Planning as a Constraint Satisfaction Problem

In this section, we show different search techniques and how to constraint a problem.

a. Search Techniques:

1. GRAPHPLAN algorithm uses backward chaining[2] and inorder to reduce the amount of search being done, the authors introduced memoization and information from failed subgoals are recorded so that isomorphic subtrees of the search tree will not be traversed several times. Other alternatives such as integer programming[4], mixed linear programming[5] have been established and these algorithms perform with the same magnitude of satisfiability problems.
2. Direct solution was proposed by Rintan[6] using a constraint solver and he made of specific problem instance properties and can be taken advantage of and having much smaller memory consumption.

Declarative Control Information

Most of the planning algorithms work by incremental approach and then backtrack when they cant find an optimal plan [7] and to avoid this, we can prune the search tree by reducing the number of back-tracking points. Declarative control information can be helpful in reducing the search space. Invariants is an important form of control information that can be derived from operations definitions.Invariants can be used to characterize the set of reachable states of the planning problem. Symmetry can also be as a part of the declarative control information.Many planning problems have high interchangeably states which are symmetric and this can be used to reduce the search space. Joslin and Roy [8] give an algorithm that detects symmetries in schematic representations of planning problems.

Domain Independent distance heuristics

Heuristic planner based on ignoring the negative effects have been able to achieve tremendous improvements in runtime behavior and are commonly used as benchmarks for planning domains. Automatic planners developed were all based on the approach developed by Bacchus and Nau[9] and these planners made use of the Naive search paradigm.

Planning with ordered Binary decision diagrams(OBDD)

The usefulness of OBDD in transition systems was discovered by MacMillan et al[10]. An OBDD-planner can be constructed on the basis of preimage computation. The traversal of the state space uses the Breadth First Search and there is an choice between forward and backward traversal from the initial or goal respectively. OBDD are very helpful when there is uncertainty involved. Cimatti et al [11] generalized work to universal / reactive / conditional planning with several initial states, nondeterministic operators and environment. In this work proposed, full observability and none of the fluents states are observable.Plan construction is based on representing sets of sets of possible current states (sets of belief states) as OBDDs. Each operator maps belief states to belief states, and plans are found by backward chaining from the goal states.

References

1. David A. McAllester and David Rosenblitt.Systematic nonlinear planning. In T. L. Dean and K. McKeown, editors, Proceedings of the 9th National Conference on Artificial Intelligence, volume 2, pages 634–639. AAAI Press / The MIT Press, 1991.
2. Avrim L. Blum and Merrick L. Furst. Fast planning through planning graph analysis. Artificial Intelligence, 90(1-2):281–300, 1997.
3. Henry Kautz and Bart Selman. Pushing the envelope: planning, propositional logic, and stochastic search. In Proceedings of the Thirteenth National Conference on Artificial Intelligence and the Eighth Innovative Applications of Artificial Intelligence Conference, pages 1194–1201, Menlo Park, California, August 1996. AAAI Press
4. Thomas Vossen, Michael Ball, Amnon Lotem, and Dana Nau. On the use of integer programming models in AI planning. In Thomas Dean, editor, Proceedings of the 16th International Joint Conference on Artificial Intelligence, volume I, pages 304–309. Morgan Kaufmann Publishers, 1999.
5. Steven A. Wolfman and Daniel S. Weld. The LPSAT engine & its application to resource planning. In Thomas Dean, editor, Proceedings of the 16th International Joint Conference on Artificial Intelligence, volume I, pages 310–315. Morgan Kaufmann Publishers, 1999.
6. Jussi Rintanen. A planning algorithm not based on directional search. In A. G. Cohn, L. K. Schubert, and S. C. Shapiro, editors, Principles of Knowledge Representation and Reasoning: Proceedings of the Sixth International Conference (KR '98), pages 617–624. Morgan Kaufmann Publishers, June 1998.
7. Rintanen, Jussi, and Jörg Hoffmann. "An overview of recent algorithms for AI planning." *KI* 15.2 (2001): 5-11.
8. David Joslin and Amitabha Roy. Exploiting symmetry in lifted CSPs. In Proceedings of the 14th National Conference on Artificial Intelligence (AAAI- 97) and 9th Innovative Applications of Artificial Intelligence Conference (IAAI-97), pages 197–202, Menlo Park, July 1997. AAAI Press.
9. Fahiem Bacchus and Dana Nau. The AIPS-2000 planning systems competition. AI Magazine, 2001. to appear.
10. J. R. Burch, E. M. Clarke, D. E. Long, K. L. MacMillan, and D. L. Dill. Symbolic model checking for sequential circuit verification. IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, 13(4):401–424, April 1994
11. Alessandro Cimatti, Marco Roveri, and Paolo Traverso. Automatic OBDD-based generation of universal plans in non-deterministic domains. In Proceedings of the Fifteenth National Conference on Artificial Intelligence (AAAI-98) and the Tenth Conference on

Innovative Applications of Artificial Intelligence (IAAI-98), pages 875–881. AAAI Press, 1998.