Research Review

This is a review of three important developments in the field of AI planning: STRIPS, GRAPHPLAN and SATPLAN based algorithms.

STRIPS is a problem solver developed by Richard Fikes and Nils Nilsson in 1971 at SRI International (Fikes and Nilsson, 1971). A world model is defined in STRIPS as follows: the initial state, the set of available operators (or actions) and their effects on the world models, and the goal statements. STRIPS employs a resolution theorem prover to answer questions of particular models and uses means-ends analysis to guide it to the goal satisfying model. STRIPS is considered to be the first major planning system for attacking the classic planning problem in which the world is regarded as being in a static state and is transformable to another static state only by a single agent performing any of a given set of actions (Fikes and Nilsson, 1993). Despite being limited in the scope of planning problems it could solve, STRIPS had a great impact on the automated planning research. In particular, the STRIPS language was used as a basis for modern action description languages (Gelfond and Lifschitz, 1998) like ADL or PDDL.

Another major milestone in the automated planning field was the development of the planning graph and the GRAPHPLAN algorithm (Blum, A. L. and Furst, M. 1995). Before GRAPHPLAN, most planning frameworks were based on searching in a space of partial plans. Blum and Furst introduced the planning graph which is a special data structure built in polynomial time that approximates the entire search tree and it is polynomial in size. The planning graph is a large source of information about the planning problem. For instance, using the planning graph one can determine if the problem is solvable at all. In the state-space search, the planning graph could be used as a tool for computing accurate admissible (or good non-admissible) heuristics, like the level-sum or set-level heuristic (Russell and Norvig). Alternatively, the planning graph could be used as part of the GRAPHPLAN searching strategy. GRAPHPLAN is a fast and elegant algorithm that builds a planning graph on phase 1 and then extracts a plan directly from the planning graph on phase 2. For many problems the GRAPHPLAN algorithm was orders of magnitude faster than the previous systems.

An alternative approach to automated planning is based on the SATPLAN algorithm (Kautz and Selman 1992). Kautz and Selman showed that that planning problems can be formalized based on satisfiability rather than deduction. Kautz, McAllester and Selman developed a strategy for translating STRIPS-style planning to SAT, in the form that can be solved by the SATPLAN algorithm (Kautz, McAllester and Selman 1996). SATPLAN outperforms many traditional AI planning systems thanks to fast SAT engines like WALKSAT. In fact, it was shown that the planning graph developed by Blum and Furst could be interpreted as propositional CNF formulas. The BLACKBOX planning framework (Kautz and Selman 1999) combines the best features of both systems: it creates a planning graph for a planning problem specified in a STRIPS notation, then the planning graph is converted to CNF well-formed formulas (wff) and simplified by a general CNF simplification algorithm, and then the wff is solved with a variety of fast SAT engines (e.g. WALKSAT or SATZ (Li and Anbulagan 1997)). It is worth noting that the original BLACKBOX implementation won the first International Planning Competition in 1998.

Bibliography

Fikes, R. E. and Nilsson, N. J. (1971). STRIPS: A new approach to the application of theorem proving to problem solving. AIJ, 2(3–4), 189–208.

Fikes, R. E. and Nilsson, N. J. (1993). STRIPS, a retrospective. AIJ, 59(1–2), 227–232.

Gelfond, M. and Lifschitz, V. (1998) Action Languages, *Linköping Electronic Articles in Computer and Information Science*, vol **3**, nr *16*.

Blum, A. L. and Furst, M. (1995). Fast planning through planning graph analysis. In IJCAI-95, pp. 1636–1642.

Russell S.J and Norvig P., Artificial Intelligence: A Modern Approach, Pearson Education, 2003

Henry Kautz and Bart Selman (1992). Planning as Satisfiability. Tenth European Conference on Artificial Intelligence (ECAI-92), Vienna, Austria, 1992.

Henry Kautz, David McAllester, and Bart Selman (1996). Encoding Plans in Propositional Logic. 5th International Conference on Knowledge Representation and Reasoning (KR-96), Cambridge, MA, 1996.

Selman, B., Kautz, H., and Cohen, B. (1994) Noise strategies for local search. Proceedings AAAI-94, Seattle, WA, 1994

Henry Kautz and Bart Selman (1999). Unifying SAT-based and Graph-based Planning. 16th International Joint Conference on Artificial Intelligence (IJCAI-99), Stockholm, Sweden, 1999.

Chu Min Li and Anbulagan: Heuristics Based on Unit Propagation for Satisfiability Problems. Proceedings of IJCAI, 366-371, 1997