

# Review of Developments in AI Planning and Search

In this report, we will briefly review three important developments in AI planning and search, UCPOP, GRAPHPLAN and RePOP.

## Universal Conditional Partial-Order Planner (UCPOP) [1]

Between the mid 1970s to the mid 1990s, a majority of the algorithms for planning were based on the partial-order planning (POP) which does not fully specify an ordered sequence of actions. Among various approaches based on POP, one of the famous algorithms is Universal Conditional Partial-Order Planner (UCPOP) proposed by Penberthy and Weld in 1992. UCPOP uses the number of unsatisfied goals as a heuristic. While UCPOP is sound and complete, it is slow (though it is faster compared to the other algorithms based on the partial-order planning at that time) and requires a lot of computational power for implementation.

## GRAPHPLAN [2][3]

The algorithms based on POP proposed in mid 1990s or before such as UCPOP were too slow to be used for complicated problems. One of the reasons for the poor performance of these algorithms is the inaccuracy of heuristic used in these algorithms. GRAPHPLAN proposed by Blum and Furst (1995, 1997) overcomes this issue by using an algorithm based on a data structure called a planning graph. GRAPHPLAN is a propositional planner (i.e. works for problems without any variables) and the planning graph encodes what can take place in future until a given step (or level). Then the information of the structure of the graph helps to construct a good heuristic. GRAPHPLAN always finds, if exists, a shortest-possible partial-order plan and is by far faster than UCPOP.

## RePOP [4]

After the GRAPHPLAN had proposed, various planning algorithms based on other graph planning systems were proposed. In addition, state-space planning based algorithms were revived (UnPOP [5] for example) and they outperformed POP-based planners. This however does not mean that POP-based algorithms are completely abandoned. Nguyen and Kambhampati (2001) proposed a POP-based algorithm called Revived Partial-Order Planning (RePOP). This is a variant of UCPOP, but one of the crucial improvements is that RePOP uses an effective distance-based heuristic. This RePOP outperforms GRAPHPLAN and is competitive with the state-space planner in various domains.

## References

- [1] "UCPOP: A Sound, Complete, Partial-Order Planner for ADL", J. .S. Penberthy and D. Weld, Proc. of KR-92 (1992)
- [2] "Fast planning through planning graph analysis", A. Blum and D. Weld, Proc. of IJCAI (1995), 1636-1642
- [3] "Fast planning through planning graph analysis", A. Blum and D. Weld, Artificial Intelligence, vol.90, 281-300 (1997)
- [4] "Reviving Partial Order Planning", X. Nguyen and S Kambhampati, Proc. of IJCAI (2001), 459-464
- [5] "A Heuristic Estimator for Means-Ends Analysis in Planning", D. McDermott, Proc. of AIPS (1996), 142 - 149
- [6] "Artificial Intelligence: A Modern Approach" (Chapter 11), S. Russel and P. Norvig, Prentice Hall