Report on key developments in the field of AI planning and search.

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This report includes a summary of some key developments in field of AI planning and search. Selection of developments is based on pure subjective evaluation from point of view of the author. The field of planning is wide and includes applications ranged from robotics autonomy, self-driving cars on one end to the search of optimality in logistic and scheduling complex processes with many constraints on other side. The report is biased towards AI planning rather NP hard search of optimality.

First ground base work on AI planning was STRIPS – a practical implementation of AI search to enable robot "Shakey" perform sophisticated manipulations in real physical world autonomously, without human direct control [1]. In order to achieve it, STRIPS implemented logic-based representation of planning problem domain and separated search algorithm in that domain from logical theorem proving [2]. Ability to formulate specific planning goals for realistic problem was a fundamental shift that opened door of goal communication to the robots. Initially to overcome enormous complexity of real world representation, STRIPS used first-order predicate calculus representation, which has good expressive power but turned to be problematic in practical application. The later work shifted to use propositional logic, which trade off in expressiveness for speed and simplicity [3]. Now there are many variations of STRIPS-like representations that developed in form of Planning Domain Definition Language. See section 2.4.1 in Planning Algorithms [4] and section 10.1 in AIMA [5] for detailed overview.

Second giant break thru, developing notion of planning graph up to its practical application as Graphplan algorithm [6]. Early work in AI planning were performed as search in state space. Obvious limitations moved research into methods based on partial plans. As competition between these two increased the state search became more dependent on good problem specific heuristic. The partial plans lead to the notion of a planning graph, a data structure that is compact and informative description of possible transition between stages in the problem domain. Such information allows automatic heuristic construction by performing reachability analysis. Ability to take planning problem expressed in STRIPS as input and to derive effective heuristic independent from human is crucial in AI progress. The level of logic-based planning complexity that can be solved has moved up to the next level with help of planning graph heuristics and memorization. See section 2.5 in Planning Algorithms [4].

The final note of the report is dedicated to development of Heuristic Search Planner (HSP) [7]. The smart approach of using planning graph demonstrated in Graphplan influenced many researches to improve heuristic generation and search technique. HSP was the first to make domain independent state-space search practical for large planning problems. Original HSP (1998) was in forward direction (progression search) then HSPr (1999) in reverse direction (regression search). HSP 2.0 (2000) executes family of heuristic searches in both directions. Note, implementation details do matter. In AIPS2000 contest HSP lost, the winner was FF planner that based on similar ideas of improving Graphplan as HSP. FF uses progression search with more accurate automatic heuristic and good implementation of rule for discarding nodes without computing their heuristic values [9]. The advantage of HSP is better quality of search with solution close to the optimal. FF trades off accuracy for speed.

References

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