Planning Review for Udacity

by Victor BUSA

In the early development of planning research, the planning algorithms used, decompose a plan to reach a goal as a sequences of actions. This was supposed to be a realistic idea because plans are usually executed one step at a time. Yet, this idea quickly shows its limits when Gerald Jay Sussman show in his thesis paper[i] that even a simple problem cannot be achieve using linear planning (because we might need to do sub-task, that is to say other order planning before being able to do the main task). In 1975 Tate publishes a paper[ii] about the nonlinear nature of plans and how this non-linearity could be tackle. One possible solution to be able to handle non-linearity is to divide the main task into sub-task. However, if the sub-task are proved to be correct, the goal task might be achieve only by "concatenating" different sub-tasks and inconsistencies can occur. Tate details in his paper techniques to handle those inconsistencies (similar to the one we studied in course). Partial-order planning then dominated the world of planning research during 2 decades. This can be understood according to the result shows in the paper[iii] of Daniel S Weld. Actually this papers analyzes 3 different algorithms : POCL, TOCL and TOPI. While the first algorithm is a Partial-order algorithm, the two others are total-order algorithms. His results depict that POCL outperforms TOPI and TOCL in each of the tasks they were competing. Austin Tate releases a paper[iv] in 1976 that describes a system capable to solve planning problem using his system called NONLIN. This system his based on the NOAH (Net Of Actions Hierarchies developed by Sacerdoti) system and add some improvements like the abilities to find several different solutions or even the abilities to kept alternatives at each step.

In 1997, Avrim Blum and Merick Furst presented their system called GRAPHPLAN[v], unlike previous algorithms that try to solve a planning problem by iterating through the possible states of a graph, Avrim L. Blum and Merrick L. Furst have the good idea to work in a Planning Graph. According to their papers 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*.". As depicts in their paper, planning graphs outperforms other state-of-the-art algorithms in planning search at the time they released their paper. For example, using planning graph methodology, one can solve a problem with many more goals than using partial-order planning (and of course total-order planning). In parallel to planning graph algorithms, Henry Kautz and Bart Selman have developed a new technique[vi] that solves planning problem by converting it, first into a Boolean satisfiability problem and then by using local search algorithm or backtracking-based search algorithm. As it is highlighted in their paper, SATPLAN is not strictly superior to GRAPHPLAN. Actually, SATPLAN performs better on complex logistics domain while GRAPHPLAN tends to be better on other domains. Hence by unifying these two methods, Henry Kautz and Bart Selman showed that the resulting approach outperforms both SATPLAN and GRAPHPLAN alone.

In his recent paper[vii], Daniel S. Weld analyzes the latest planning search algorithms. Between the first study released in 1994 by Daniel S.weld and his latest study release in 1999, they had been a great breakthrough on the planning field. Actually GRAPHPLAN and SATPLAN allow to solve problems that were intractable using Partial-order planning and are used in real world application. For example, the NASA used a planning system to control their spacecraft, hence demonstrating that AI planning is matured enough to be used I real world applications.

i [A Computer Model of Skill Acquisition, GJ Sussman 1975]
ii [The nonlinear nature of plans, Earl D. Sacerdoti 1975]
iii [Partial-Order Planning: Evaluating Possible Efficiency Gains, Anthony Barret & Daniel S. Weld 1993]
iv [Project planning using a hierarchic non-linear planner, Austin Tate 1976]
v [Fast Planning Through Planning Graph Analysis, Avrim L. Blum & Merrick L. Furst, 1997]
vi [Unifying SAT-based and Graph-based Planning, Henry Kautz, Bart Selman, 1999]
vii [Recent Advances in AI Planning Daniel S. Weld 1999]