

Anytime and Exact Search for Planning Problems

How to Explore a DP-based State Transition Graph with A*, CP and LS?

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Abstract

Many planning problems may be solved with Dynamic Programming (DP) by decomposing the problem into subproblems which are recursively solved. These decompositions induce state transition graphs which are closely related to decision diagrams [5], and where optimal solutions correspond to best paths in these graphs. A* is a well known algorithm which extends Dijkstra's algorithm with heuristics for guiding the path search [4]. It is exact (provided that the heuristic function is admissible), but it is not anytime. In other words, it computes a best path but it does not output sub-optimal paths while computing it. Hence, when state transition graphs have exponential sizes, A* may run out of time or memory without producing any solution. Various anytime extensions of A* have been proposed to compute a sequence of paths of increasing quality until finding an optimal path and proving its optimality.

In this talk, we will provide an overview of these exact and anytime extensions of A*, with a more detailed focus on *Anytime Column Search* (ACS) [10], and *Iterative Memory Bounded A** (IMBA*) [6]. Both approaches iterate A* searches while bounding the number of states that are stored or expanded at each iteration. We will also show how to combine them with Local Search (LS) in order to find better paths faster, and with bounding and constraint propagation in order to prune the graph, as proposed in [3].

This will be illustrated using the Travelling Salesman Problem (TSP) as a running example. The DP formulation introduced by Bellman in [1] for the TSP has been extended to handle Time Windows (TWs) in [2], and Time Dependent (TD) cost functions in [7]. It has also been extended to Vehicle Routing Problems (VRPs) in [11] and to TD-VRPs in [8]. We will finish by presenting an experimental comparison with state-of-the-art approaches for solving the TSP with TWs on classical benchmarks and on a new benchmark which contains hard Euclidean instances located in the phase transition zone [9].

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