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Jörg Hoffmann

Utilizing Problem Structure in Planning

A Local Search Approach

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Foreword

Planning is a crucial skill for any autonomous agent, be it a physically embedded agent, such as a robot, or a purely simulated, software agent. For this reason, planning is one of the central research areas in Artificial Intelligence. The area is concerned with the automatic construction of plans that map a given initial situation into a target situation that satisfies some given goal conditions. Here, plans are usually sequences of deterministic actions.

While there has been a lot of research in this area since the beginning of the 1970s, only recently has the practical efficiency of planning methods come into the focus of the research community – most probably partially caused by the biennial international competition of planning systems, which started in 1998.

Planning is known to be a computationally quite demanding problem. Even in its simplest form – planning for basic propositional STRIPS – planning is PSPACE-complete. However, the planning problems humans and artificial agents are asked to solve are often much easier than the general problem. Based on this observation, Jörg Hoffmann investigated the structure of such planning tasks. Starting with the planning tasks used in the first planning competition, he developed his planning methodology to be able to cope with these and other problems published in the planning literature. So, instead of developing a new general planning method that might also solve the problems at hand, Jörg developed his planning methodology having in mind the concrete planning tasks.

The main ingredient of Jörg's planning methodology is the view of planning as a heuristic search, as developed by Geffner and Bonet. This approach is based on extracting informative heuristics, i.e., estimations of a search state's goal distance, automatically from the problem encoding.

Based on this work, Jörg develops a new heuristic that takes into account positive interactions between different actions, he designs a new local search technique, and he introduces a new pruning technique. These three techniques are the main methods used in the planning system FF, whose performance, measured on a large range of benchmark problems, is well above most of the other known planning systems. In fact, FF was the clear winner of the international planning competition in 2000 and is now one of the main references in the area of planning.

This success raised the question of what the structural properties of the benchmark problems are that allow us to solve them so easily. Based on earlier work in the area of propositional satisfiability, Jörg analyzes the landscape of the problems that are induced by the heuristic estimate. He is able to show

that the empirical hardness is dependent on the number and size of local minima and plateaus and on the number and distance of improved exits for the latter. The analysis is carried out both theoretically and empirically, and divides the current planning benchmarks into a taxonomy of classes that differ in terms of how easily they can be solved using heuristic planners such as FF. These results are very useful for evaluating domains and for improving local search algorithms.

In summary, this work's two contributions to the state of the art in planning are so significant that the dissertation this book is based on received the prestigious ECCAI award for the best European Ph.D. thesis in 2002.

July 2003 Bernhard Nebel

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I dedicate this book to my family and friends.

July 2003 Jörg Hoffmann

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