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Chapter III

Machine Learning for Adaptive Planning

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ABSTRACT

This chapter is concerned with the enhancement of planning systems using techniques from Machine Learning in order to automatically configure their planning parameters according to the morphology of the problem in hand. It presents two different adaptive systems that set the planning parameters of a highly adjustable planner based on measurable characteristics of the problem instance. The planners have acquired their knowledge from a large data set produced by results from experiments on many problems from various domains. The first planner is a rule-based system that employs propositional rule learning to induce knowledge that suggests effective configuration of planning parameters based on the problem's characteristics. The second planner employs instance-based learning in order to find problems with similar structure and adopt the planner configuration that has proved in the past to be effective on these problems. The validity of the two adaptive systems is assessed through experimental results that demonstrate the boost in performance in problems of both known and unknown domains. Comparative experimental results for the two planning systems are presented along with a discussion of their advantages and disadvantages.

INTRODUCTION

Domain independent heuristic planning relies on ingenious techniques, such as heuristics and search strategies, to improve the execution speed of planning systems and the quality of their solutions in arbitrary planning problems. However, no single technique has yet proved to be the best for all kinds of problems. Many modern planning systems incorporate more than one such optimizing technique in order to capture the peculiarities of a wider range of problems. However, to achieve the optimum performance these planners require manual fine-tuning of their run-time parameters.

Few attempts have been made to explain which are the specific dynamics of a planning problem that favor a specific planning technique and, even more, which is the best setup for a planning system given the characteristics of the planning problem. This kind of knowledge would clearly assist the planning community in producing flexible systems that could automatically adapt themselves to each problem, achieving best performance.

This chapter focuses on the enhancement of Planning Systems with Machine Learning techniques in the direction of developing Adaptive Planning Systems that can configure their planning parameters automatically in order to effectively solve each different planning problem. More specifically, it presents two different Machine Learning approaches for Adaptive Planning: (a) Rule learning and (b) Instance-based learning. Both approaches are described in detail and their performance is assessed through several experimental results that exhibit different aspects of the learning process. In addition, the chapter provides an extended overview of past approaches on combining Machine Learning and Automated Planning, two of the most important areas of Artificial Intelligence.

The rest of the chapter is organized as follows: The next section reviews related work on combining learning and planning and discusses the adopted learning techniques. Then the problem of the automatic configuration of planning systems is analyzed. The following two sections present the two learning approaches that have been used for the adaptive systems and present experimental results that compare them and show the gain in the performance over the initial planner. Finally, the last section discusses several issues concerning the two learning approaches, concludes the chapter and poses future research directions.

MACHINE LEARNING FOR AUTOMATED PLANNING

Machine Learning is the area of Artificial Intelligence concerned with the design of computer programs that improve at a category of tasks with experience. It is a very broad field with many learning methodologies and numerous algorithms, which have been extensively exploited in the past to support planning systems in many ways. Since it is a usual case for seemingly different planning problems to present similarities in their structure, it is reasonable enough to believe that planning strategies that have been successfully applied to some problems in the past will be also effective for similar problems in the future. Learning can assist planning systems in three ways: (a) to learn domain knowledge, (b) to learn control knowledge and (c) to learn optimization knowledge.

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