論文 / 著書情報
Article / Book Information

題目(和文)	古典的STRIPSプランニング問題のためのヒューリスティックアルゴリズム
Title(English)	Heuristic Algorithms for Classical STRIPS Planning Problems
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出典(和文)	学位:博士（理学）, 学位授与機関:東京工業大学, 報告番号:甲第9745号, 授与年月日:2015年3月26日, 学位の種別:課程博士, 審査員:渡辺　治,増原　英彦,田中　圭介,福田　光浩,脇田　建,Fukunaga　Alex
Citation(English)	Degree:, Conferring organization: Tokyo Institute of Technology, Report number:甲第9745号, Conferred date:2015/3/26, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	数理・計算科学　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　理学　）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Automated planning is used for constructing strategies of intelligent agents. To achieve the given goal a planning agent automatically computes a plan based on knowledge of its abilities and of environments in which it participates. Planning is one of the most important tasks related to artificial intelligence. Research of automated planning has been contributing to the progress of both theory and practice of not only planning research but also other fields of artificial intelligence research.

A class of planning problems corresponds to a model to define the properties of the world and the task of an agent. In this doctoral dissertation, two new algorithms are proposed for a class of planning problems called STRIPS planning.

The STRIPS planning class is one of the most classical and famous classes of planning problems. Although STRIPS planning is the smallest and easiest class, it is however known that even deciding whether an in- stance of the model of STRIPS planning tasks has a feasible plan to achieve the given goal or not is PSPACE-complete. This is caused by the high expressiveness of the model of the STRIPS planning class, and it is one of the reasons that researchers have still been improving STRIPS planning algorithms.

In recent years algorithms based on the reduction to a pathfinding problem on a weighted directed graph have been one of the central methods to solve STRIPS planning problems. It is known that the sizes of the weighted directed graphs are usually exponentially large compared with the original instances of STRIPS planning problems. Classical brute force pathfinding algorithms cannot solve the problems in permissible time, and hence, researchers have been trying to develop efficient heuristic pathfinding algorithms visiting only a small part of the entire graph. A heuristic pathfinding algorithm is mainly composed of two key elements called a heuristic function and a heuristic search algorithm. A heuristic function estimates the cost to go from a vertex to an end vertex based on information of the instance of the original problem before the reduction to a pathfinding problem. A heuristic search algorithm seeks an end vertex and a path to that end vertex while speculating costs from vertices to an end vertex by heuristic functions.

In this dissertation a new heuristic search algorithm, for finding a feasible plan for the satisficing STRIPS planning problem, is proposed. This dissertation also proposes a new heuristic function for

estimating lower bounds of the optimal costs from vertices to an end vertex, for the cost-optimal STRIPS planning problem.

For the satisficing STRIPS planning problem, whereas some previous heuristic search algorithms blindly trust heuristic functions, the proposed search algorithm stochastically goes towards various directions by probabilities computed from estimations of a heuristic function. The algorithm is designed to avoid misleading by heuristic functions, and as a result, the algorithm tends to find a feasible plan faster than other heuristic search algorithms. Experimental evaluations compared the proposed algorithm with several search algorithms and some practical planning algorithms in terms of the number of solved benchmark instances, running time, the number of visited vertices, and plan quality. The proposed search algorithm outperforms the previous search algorithms and is competitive with the practical planning algorithms.

For the cost-optimal STRIPS planning problem, tightening the lower bound estimations of heuristic functions is one of the central issues. In this dissertation, a new integer linear programming model of a relaxation problem, called the delete relaxation, is proposed. In addition, some enhancements for the model such as variable elimination technique are proposed by incorporating with previous work. The proposed enhancements reduce the size of instances of the proposed model and tighten the optimal cost of the linear programming relaxation of the instances. Experimental results show that the lower bound estimation of the linear programming relaxation of the enhanced model is much tighter than lower bound estimations of heuristic functions in some previous work. Moreover, a heuristic function to compute the optimal cost of the linear programming relaxation of the enhanced model decreases on a large scale the number of visited vertices by heuristic search algorithms. A* search based pathfinding algorithm with the proposed heuristic function is competitive to some state-of-the-art algorithms in terms of the number of solved standard benchmark instances, and outperforms them in terms of number of vertex evaluations.

In the first chapter an overview of automated planning and the contribution are given. The STRIPS planning class and some basic pathfinding algorithms are defined in the second chapter, and in the third chapter recent related work is explained. In the fourth chapter the proposed heuristic search algorithm for the satisficing STRIPS planning problem is defined, and its experimental evaluations are given. The proposed heuristic function for the cost-optimal STRIPS planning problem and its experimental evaluations are shown in the fifth chapter. In the last chapter the conclusion and future work are discussed.