Chapter 10
Fuzzy Greedy Search: An Algorithmic Approach for Combinatorial Optimisation

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ABSTRACT

In recent years, there has been a growth of interest in the development of systematic search methods for solving problems in operational research and artificial intelligence. This chapter introduces a new idea for the integration of approaches for hard combinatorial optimisation problems. The proposed methodology evaluates objects in a way that combines fuzzy reasoning with a greedy mechanism. In other words, a fuzzy solution space is exploited using greedy methods. This seems to be superior to the standard greedy version. The chapter consists of two main parts. The first part focuses on description of the theory and mathematics of the so-called fuzzy greedy evaluation concept. The second part demonstrates through computational experiments the effectiveness and efficiency of the proposed concept for hard combinatorial optimisation problems.

INTRODUCTION

In recent years, there has been a growth of interest in the development of systematic search methods for solving problems in operational research and artificial intelligence. Metaheuristics that are employed as strategies in optimisation are a fairly young research field. They are approaches that organise an interaction between solution improvement procedures and higher-level tactics in order to create a process capable of escaping from premature local optima and performing a robust search of a solution space. A metaheuristic can be viewed as a generic approach, for a type of hard optimisation problem. It is applicable to a wide set of different optimisation problems, with relatively few modifications needed to apply it to a specific problem. A much newer area of research is the hybridisation of metaheuristics. It has become evident that a skilled combination of general ideas from different methods can provide an efficient performance and high flexibility.

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The use of search techniques on a solution space are central to the design of metaheuristics. Indeed, adopting a robust search technique significantly improves the overall performance. In this chapter, we introduce a new idea for the integration of approaches for hard combinatorial optimisation problems. The proposed methodology evaluates objects in a way that combines fuzzy reasoning with a greedy mechanism. In other words, we exploit a fuzzy solution space (fuzzy set) using greedy methods. Our methodology also attempts to adapt its knowledge from previous experiments, thereby improving the exploration of the promising areas of the search space. The effectiveness and efficiency of this so-called fuzzy greedy evaluation concept are investigated for hard combinatorial optimisation problems.

The chapter consists of two main parts. The first part focuses on description of the theory and mathematics of the so-called fuzzy greedy evaluation concept. The second part demonstrates through computational experiments, the effectiveness and efficiency of the proposed concept for hard combinatorial optimisation problems. The text contains an extensive bibliography, which covers many relevant books and significant papers.

FUZZY GREEDY EVALUATION

Introduction

In recent decades there has been a growth of interest in methods for finding optimal solutions to a class of problems called combinatorial optimization. The subject is very wide and many books and articles have been published on its various aspects. Typical examples of combinatorial optimization problems are the travelling salesman (Lawler, 1985; Gutin and Punnen, 2002; Gutin, 2013), variants of the assignment problem (Cela *et al*, 2014), scheduling problems (Pinedo *et al*, 2015), the set covering (Beasley, 1990; Boschetti and Maniezzo, 2015), and vehicle routing problems (Coelho and Laporte, 2015). Combinatorial problems are normally easy to describe but difficult to solve (Korte and Vygen, 2012). The foundations for the theory of computational complexity are to be found in Cook's (1971) seminal paper. In his paper, Cook attempted to classify problems in practice as easy or hard. A problem is called easy if an algorithm can be developed which solves the problem to optimality in a polynomial-time (Du and Pardalos, 2005). A problem is called hard or intractable if such efficient algorithms do not exist or the solution cannot be found within a reasonable computational time bound.

Due to the practical importance of combinatorial optimization problems, many methods have been developed for solving them (Pulleyblank (2014); Martello and Ries (2015); Nishi *et al*, (2017)). These methods can be classified as either exact or approximate. Exact methods guarantee to find an optimal solution in a bounded amount of time. Of course, for those combinatorial optimization problems which belong to the class NP-hard (Garey and Johnson, 1979), exact methods need an exponential amount of time. Thus, approximation methods which usually called heuristics, are often considered to be the only practical tools available to solve hard combinatorial optimization problems.

This section overviews a new idea, so-called fuzzy greedy evaluation concept for the integration of approaches for hard combinatorial optimization problems. The section also provides a comprehensive discussion on mathematics of the proposed methodology. In this presentation, the proposed method can be seen as a generic heuristic for the integration of approaches to hard combinatorial optimization problems. Furthermore, the current work shows another application of the proposed method with different

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