A Genetic Algorithm for Rich Vehicle Routing Problems Optimization

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Abstract. The purpose of this paper is to study a rich vehicle routing problem (VRP), involving the number and capacity limitation of vehicles, time constraints including ready and due dates of each customer, heterogenous vehicle fleet and different warehouses for vehicles. A genetic algorithm (GA) is proposed to tackle this highly constrained problem. It is noticeable that, no GA-type method has been previously proposed for a multi-depot heterogenous limited fleet VRP with time windows. The proposed algorithm is tested on benchmark instances, showing good computational results, and thus proving to be promising in addressing other complex case of VRPs.

Keywords: Rich Vehicle Routing Problem, Combinatorial Optimization, Genetic Algorithm, MDHVRPTW, VRPLIB.

1 Introduction

The vehicle routing problem (VRP) is one of the most challenging combinatorial optimization problems, which continues to draw the attention of both academia and professionals in many fields, especially in transportation and logistics, biology, finance, etc. The role of a VRP is to find an optimal set of routes, over a single period, for a fleet of vehicles starting and ending at a central depot, to serve each customer exactly once. The objectives of VRP are, for the most part, to minimize the travel and the vehicle costs (respectively the time spent during the transportation system, the total travel distance, the number of vehicles used, the fuel consumption) or to maximize the profits.

In this paper, we consider a model of a practical VRP, which can be defined as follows: Given a limited fleet of vehicles with heterogeneous capacities, parked in multiple central depots. The vehicles must serve several customers geographically scattered with different demands, while respecting capacity and time constraints, and must define several routes with a minimum transportation distance. All itineraries start and end at the same depot and each customer is served only once by just one vehicle with a compatible capacity. In the current work, we focus on solving the multi depot heterogenous VRP with time windows (MDHVRPTW). A limited number of papers has tackled this multi attributes VRP by using both exact and heuristic methods since 2006 [2]. For recent survey on exact, heuristic and meta-heuristic methods that have been proposed to solve the Capacitated VRP, VRP with time windows, heterogenous VRP, the multi depot VRP, and MDHVRPTW, the reader is referred to the recent work of Rabbouch et al. [4]. The contribution of this study to the literature is threefold: First, an explicit definition and presentation of the Rich VRP is given. Then, to resolve the MDHVRPTW, a genetic algorithm approach is proposed. In comparison with its two best-known particular cases (MDHVRP and MDVRPTW), the new MDHVRPTW includes an heterogenous vehicle fleet. Consequently, an extra level of complexity related to this new constraint should be taken into account. To the best of our knowledge, no GA-type approach has been proposed for the MDHVRPTW so far. All attempts in this direction, such as the one of Ramalingam and Vivekanandan [5], was proposed to resolve the MDVRPTW without considering an heterogenous fleet. Finally, the proposed method is tested on the basis of a number of numerical experiments.

2 Genetic algorithm

The genetic algorithm is a class of stochastic population-based search and optimization technique, which is based on the principles of biological evolution, natural selection, gene recombination, and the survival of the fittest in living natural systems, to study artificial systems. It has been introduced by Holland [3] in 1975, and since, it continues attracting a great number of researchers and practitioners in different fields for various optimization problems. A basic genetic algorithm defines an initial population of randomly generated chromosomes (or using local search methods) representing possible solutions to the problem. The quality of chromosomes is then evaluated by a fitness function, which is deeply reliant to the objective function. Based on the fitness of each chromosome, a selection of two parents is carried out and these two parents are recombined using crossover and mutation operators. These steps will be repeated until a stop threshold is reached.

3 Experiment

The proposed approach is implemented in MATLAB R2015b running under an Intel core 2, i5 (2.30GHz), 8GB-RAM unit. The method is tested on five benchmark instances obtained from VRPLIB[4](online resource of University of Malaga, Spain). These instances were proposed by Cordeau et al. [1]. The specifications of the five instances, denoted pr01, pr02, pr03, pr04 and pr07, are shown in Table 1.

[4] http://neo.lcc.uma.es/vrp/vrp-instances/

	pr01	pr02	pr03	pr04	pr07
Number of customers	48	96	144	192	72
Number of depots	4	4	4	4	6
Number of vehicles	8	12	16	20	12
Capacity of each vehicle	200	195	190	185	200
Maximum route duration	500	480	460	440	500

Table 1. Description of the instances used in the numerical experiments.

4 Results

This study dealt with a multi depot VRP with time windows using an heterogenous limited fleet with maximum route duration constraints. Due to the high complexity of this problem, it is increasingly necessary to use a meta-heuristic framework for optimization. Therefore, we proposed a genetic algorithm, which succeeded to resolve the MDHVRPTW problem involving up to 190 customers in a reasonable execution time. The awesome results were especially obtained for the small instances and were compared in terms of percentage deviation to some state-of-the-art algorithms. In the near future, this problem with realistic constraints could be performed to real-world datasets, with a special focus on the bus routing problem of the Tunisian capital.

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