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A hybridisation of adaptive variable neighbourhood search and large neighbourhood search: Application to the vehicle routing problem

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ABSTRACT

In this paper, an adaptive variable neighbourhood search (AVNS) algorithm that incorporates large neighbourhood search (LNS) as a diversification strategy is proposed and applied to the capacitated vehicle routing problem. The AVNS consists of two stages: a learning phase and a multi-level VNS with guided local search. The adaptive aspect is integrated in the local search where a set of highly successful local searches is selected based on the intelligent selection mechanism. In addition, the hybridisation of LNS with the AVNS enables the solution to escape from the local minimum effectively. To make the algorithm more competitive in terms of the computing time, a simple and flexible data structure and a neighbourhood reduction scheme are embedded. Finally, we adapt a new local search move and an effective removal strategy for the LNS. The proposed AVNS was tested on the benchmark data sets from the literature and produced very competitive results.

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1. Introduction

The vehicle routing problem (VRP) was first introduced by Dantzig and Ramser (1959) as the Truck Dispatching Problem, which has been extensively studied thereafter because of its high practicability in transportation logistics. The VRP is concerned about the determination of a set of routes for a fleet of vehicles such that each vehicle starts and ends at a single depot, while satisfying all the customers'requirement and operational constraints with the objective of minimising the total transportation cost.

Due to the limited success of exact methods in handling large size problems, most research on the VRP have devoted to the use of heuristic approaches. Among the most popular metaheuristics include tabu search, simulated annealing, genetic algorithm, large neighbourhood search and variable neighbourhood search. Since there is a tremendous amount of work devoted to the classical VRP, we only discuss some of the research which has proven to show relatively good results in solving the problem. Toth and Vigo (2003) proposed the granular tabu search strategy based on the concept of restricted neighbourhoods. Golden, Wasil, Kelly, and Chao (1998) and Li, Golden, and Wasil (2005) combined the record-to-record travel with variable-length neighbourhood list and found a number of new best results. Mester and Bräysy (2005) put forward the active guided evolutionary strategies (AGES) and obtained many best known results. This is partly due to the use of a good quality initial solution. Other methods such as the Greedy Randomized Adaptive Search Procedure (Prins, 2009) and the threshold accepting algorithm of Tarantilis and Kiranoudis (2002) have also been successfully applied. Variable neighbourhood search (VNS) has proved to be one of the most successful metaheuristics for solving different variants of the VRP (Chen, Huang, & Dong, 2010; Fleszar, Osman, & Hindi, 2009; Imran, Salhi, & Wassan, 2009; Kytöjoki, Nuortio, Bräysy, & Gendreau, 2007; Polacek, Hartl, Doerner, & Reimann, 2004; Polat, Kalayci, Kulak, & Günther, 2015). VNS is also known to be competitive at solving many other combinatorial optimisation problems. For instance among the very recent studies include the train scheduling and timetabling problem (Hassannayebi & Hessameddin, 2016; Samà, Ariano, Corman, & Pacciarelli, 2016) and a related VRP known as the swap-body VRP (Todosijević, Hanafi, Urošević, Jarboui, & Gendron, 2016).

The metaheuristics are capable to provide satisfactory results within a reasonable time. However, these approaches face the challenges of dealing with premature convergence. One way to overcome such limitation is by developing hybrid approaches, which have the added advantage of considering the strengths of more than one metaheuristic. Xiao, Zhao, Kaku, and Mladenovic (2014) proposed an interesting hybridisation of the VNS with sim-

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