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An Analysis of Methodologies for Solving Green Vehicle Routing Problem: A Systematic Review of Literature

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1. Introduction

The Vehicle Routing Problem (VRP) can be described as the problem of finding optimal routes for delivery to or pick-up from one or more depots to many customers who are geographically dispersed. This problem has been at the core of many operations research problems. Later the focus has shifted to sustainable business practices with a novel category of VRP, known as the Green VRP. In this category, the objectives are different from the original VRP: it focuses on minimising the impact on the environment as opposed to merely minimising costs and the distance travelled.

2. Methodology

Energy Minimising VRP (EMVRP) has been developed to minimise the energy consumption of a fleet while serving all customers. It has been identified that energy consumption has a direct impact on carbon dioxide emissions.

Heuristics, often referred to as 'rules of thumb', has the meaning of discovering techniques for problem solving. The algorithmic community has gone one step beyond, and developed a class of Heuristics named 'Metaheuristics' which is heavily used in combinatorial optimisation. Normally these problems are found to be np-hard, which cannot be optimally solved in polynomial time. VRP is among the most known np-hard problems, thus, Metaheuristics is widely used in finding near optimal solutions. The most widely used exact methods are Linear Programming and variations of branch and bound methods. Problem formulations of Green VRP have been extensively reviewed in literature, but not the solving methods. Refer to Table 1 for a detailed analysis of the heuristics being used to solve Green VRPs and Pollution Routing Problem (PRP).

Table 1- Heuristics-Based Solving Methods Used for Solving Green VRP Variants

Research Study	Solving Method
A Green Vehicle Routing Problem	Modified Clarke and Wright Savings algorithm (MCWS) and Density Based Clustering Algorithm (DBCA)
A Variable Neighbourhood Search Branching for the Electric Vehicle Routing Problem with Time Windows	Developed a variable neighbourhood search branching algorithm to solve formulated electric vehicle routing problem with time windows
Green logistics at Eroski: A case study	Used Mole and Jameson (1976) method to solve CVRP and Nearest neighbour insertion algorithm (Bodin et al. 1983) to solve VRPB
Solving the Capacitated VRP with Environmental Criteria Based on Real Estimations in Road Transportation: A Case Study	Developed Mole and Jameson algorithms based Algorithms with Environmental Criteria (AWEC)
A block recombination approach to solve green vehicle routing problem	Used a block recombination approach to solve formulated problem

3. Conclusions

Table 2- Metaheuristics-Based Solving Methods Used to Solve Green VRP Variants

Research Study	GVRP Category	Solving Method
Development of a fuel consumption optimisation model for the capacitated VRP	Green VRP	Developed a string-model based simulated annealing algorithm with a hybrid exchange rule.
Using simulated annealing to minimise fuel consumption for the time-dependent VRP	Green VRP	Developed a simulated annealing algorithm to solve the formulated TDVRP
The electric vehicle-routing problem with time windows and recharging stations	Green VRP	Hybridization of Variable Neighbourhood Search and Tabu Search
A Memory Structure Adapted Simulated Annealing algorithm	Green VRP	Developed a Memory Structure Adapted Simulated Annealing (MSA-SA) algorithm to solve Green VRP with time windows
An Adaptive Large Neighbourhood search heuristic	PRP	Used Adaptive Large Neighbourhood Search (ALNS) algorithm and at the second stage used a Speed Optimisation Algorithm (SOA) on the resulting VRPTW solution to find the optimal speed on every arc
The bi-objective Pollution-Routing Problem	PRP	Used Adaptive Large Neighbourhood search algorithm and a speed optimisation procedure to solve the formulated bi-objective PRP

Metaheuristics are a more generalised cluster of Heuristics; its potential of use in efficiently solving Green VRP is demonstrated through this study.

Table 2 reviews the studies which use Metaheuristics-based solutions and we find that these solutions can be used effectively for solving larger and more complex instances of Green VRP. Metaheuristics perform better than other approaches mainly because of their ability to explore feasible solutions in a wider random search space.

The scrutiny identifies several knowledge gaps where new methodologies can be developed to solve Green VRP formulations, and develops propositions for future research. With the development of novel data mining and machine learning techniques, focus also needs to be directed to combining current methods to produce solutions for larger problem instances in a timely manner.

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