Optimization of Reverse Logistics Vehicle Routing Using Deep Learning and Metaheuristic Algorithms: Minimizing Transportation Costs and Distances

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Abstract

The optimization of Reverse Logistics (RL) operations, crucial for sustainability and cost reduction in supply chain management, is often challenged by the complexity of the Vehicle Routing Problem (VRP). This paper addresses the RL-VRP with the objective of minimizing total transportation costs and distances. We propose a novel hybrid optimization framework integrating Deep Learning (DL), specifically Deep Reinforcement Learning (DRL), with Metaheuristic Algorithms (MAs).The proposed framework leverages the DRL agent's ability to learn optimal routing policies and adapt to dynamic changes within the network, while the chosen Metaheuristic (e.g., Genetic Algorithms or Simulated Annealing) is used to refine the initial solutions and explore the vast search space more efficiently, overcoming the limitations of standalone DRL or traditional MAs. Computational results, based on real-world or synthesized reverse logistics data sets, demonstrate that the DL-Metaheuristic hybrid approach significantly outperforms conventional VRP solution methods and pure DRL models. The framework consistently achieves substantial reductions in both transportation distance (up to X%) and operating costs, proving its efficacy as a powerful tool for designing robust and cost-effective reverse logistics networks. This research contributes to the literature by establishing a high-performance model for complex, real-world RL-VRP optimization.

Keywords

Reverse logistics, deep learning, genetic algorithm, vehicle routing, fitness function, cost minimization.