Adaptive Metaheuristics for Combinatorial Optimization: A Reinforcement Learning-Guided Approach

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In this work, we present an advanced optimization framework that integrates Reinforcement Learning (RL) with the General Variable Neighborhood Search (GVNS) algorithm to solve the Capacitated Vehicle Routing Problem (CVRP). This combinatorial optimization problem is known for its complexity and practical significance in logistics and transportation. Our approach combines RL's adaptive decision-making capabilities with the systematic neighborhood exploration of GVNS, resulting in improved solution quality and computational efficiency. We utilize a multi-armed bandit mechanism to dynamically adjust neighborhood selection, enhancing the balance between exploration and exploitation. Extensive computational experiments demonstrate that our RL-VNS method outperforms traditional VNS approaches and other state-of-the-art algorithms, reducing travel costs by up to 26.5% within competitive timeframes. This study paves the way for future research into integrating pre-trained models and exploring new optimization challenges in various domains.

Keywords: Reinforcement learning, Multi-Armed Bandits, Intelligent Optimization, Bandit learning, metaheuristics, Variable Neighborhood Search, Vehicle Routing Problem