

Energy-Efficient Robotic Disassembly and Vehicle Routing

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Abstract

This study addresses the integration of energy-efficient robotic disassembly with vehicle routing within a single unified optimization model. The disassembly process is represented through a transformed AND/OR graph, which captures the precedence relationships and alternative disassembly sequences of end-of-life products. The proposed framework links disassembly decisions directly to the transportation of recovered parts, where the energy consumption of robotic disassembly operations is accounted for alongside routing costs. This is the first study to incorporate robot energy consumption within an integrated disassembly and vehicle routing system, constituting the main novelty of this work. A mixed-integer programming formulation is developed that jointly determines task allocations, robot assignments, disassembly sequences derived from the transformed AND/OR graph, and vehicle routes. The objective minimizes total cost, capturing the trade-off between the energy efficiency of disassembly operations and the routing of recovered components. By coupling these two traditionally separate decision domains, the model enables coordinated planning that reduces overall energy consumption while satisfying routing and demand requirements. Computational experiments demonstrate the effectiveness of the proposed approach and provide managerial insights into how energy-aware disassembly decisions influence routing structures and total system cost. The results highlight the value of jointly optimizing disassembly and distribution activities for sustainable remanufacturing and reverse logistics systems.

Keywords

Robotic disassembly; Energy efficiency; Vehicle routing problem; Sustainable remanufacturing

Biography

Ömer Nedim Kenger completed his undergraduate studies in Industrial Engineering at Sakarya University. He received his master's and doctoral degrees in Industrial Engineering from Gaziantep University. His primary research areas include machine learning and mathematical modelling. Dr. Ömer Nedim Kenger currently works at Gaziantep University. Prior to his academic career, he held various industry positions, including Production Planning Manager, Procurement Manager, and Business Process Director. His professional background provides him with extensive practical industry experience, which he integrates into his academic and research activities. Dr. Ömer Nedim Kenger has contributed to academia through numerous journal articles and conference papers. His research interests focus on artificial intelligence, machine learning, and mathematical modelling. During his doctoral studies, he was supported by the YÖK 100/2000 Doctoral Scholarship Program.