Route Planning of Electric Freight Vehicles by Considering Internal and Environmental Conditions

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Abstract

Despite the advancements in battery technology, range anxiety still poses crucial limitations in logistics operations performed with electric vehicles (EVs). Accurate route planning by taking into account various conditions that effect energy consumption is of critical importance for operational efficiency. In this study, we extend the Electric Vehicle Routing Problem with Time Windows (EVRPTW) by considering different internal and environmental factors. In EVRPTW, EVs may need to visit stations for recharging their battery. Recharging may start and end at any battery state of charge, and its duration is proportional to the amount of energy transferred. The energy is consumed proportional to the distance traveled. In our case, the energy discharged during the trip depends on additional factors such as load carried, road gradient, on-board auxiliary systems, and ambient temperature. The impact of the first two factors has been addressed in the VRP literature. The last factor may increase the energy consumption due to cabin heating or cooling. In addition, battery efficiency reduces in cold temperatures. Furthermore, we consider recuperation which recovers the excess kinetic energy through a regenerative braking system. This may save significant energy particularly when a loaded EV moves downhill. Incorporating these factors in modeling makes the problem more complex; yet, neglecting them may result in a feasible solution to the model inapplicable in real business environment. We formulate this problem as a mixed integer linear program and solve small instances using CPLEX under different scenarios. Our goal is to present managerial insights to both researchers and practitioners.

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