Optimization of Collaborative Truck-Drone-Subway Delivery for Urban Logistics

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Abstract

The truck-drone hybrid delivery system has been proposed as an alternative for urban logistics due to its advantages in fast delivery, cost-efficiency, and environmental benefits. However, UAVs face limitations in battery capacity and payload, which make it challenging to meet the increasing demand for logistics services. Additionally, there are constraints in building new logistics facilities in urban areas. Underground logistics has emerged as an alternative solution to address these problems. By utilizing the subway network, the system can avoid urban traffic congestion and manage logistics flows efficiently. Moreover, it minimizes the cost of establishing new facilities by making the most of existing infrastructure. In this study, we propose a new urban delivery system that combines the existing truck-drone hybrid model with the subway network. The established subway network and stations are used to transport goods from suburban areas to urban areas, where they also function as urban logistics hubs. A truck and drones handle the last-mile delivery to customers from the subway stations. Both the truck and multiple drones operate independently; the truck does not act as a mothership for the drones, and they perform deliveries across multiple logistics depots. We developed a mathematical optimization model for a multi-depot, multi-trip vehicle routing problem with time windows. The developed model was validated through numerical experiments, demonstrating its practical applicability to urban delivery services.

Keywords
3-Dimension space, Mathematical optimization model, Urban logistics system, Vehicle routing problem

Biographies
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Byung Duk Song received the B.S. degree from the Department of Industrial Management Engineering, Korea University, in 2009, and the M.S. and Ph.D. degrees from the Department of Industrial and Systems Engineering, Korea Advanced Institute of Science and Technology (KAIST), in 2011 and 2015, respectively. He is currently with Korea University as an Associate Professor. His major research interests include operations research and optimization, system and service design, movable UAV system design and operation, location and allocation problem, supply chain management, quantitative approaches for the hotel and tourism industry, and urban logistics system design.