World Academy of Science, Engineering and Technology
International Journal of Industrial and Systems Engineering
Vol:18, No:09, 2024

Stochastic Fleet Sizing and Routing in Drone Delivery

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Abstract : Rural-to-urban population migrations are a global phenomenon, with projections indicating that by 2050, 68% of the world's population will inhabit densely populated urban centers. Concurrently, the popularity of e-commerce shopping has surged, evidenced by a 51% increase in total e-commerce sales from 2017 to 2021. Consequently, distribution and logistics systems, integral to effective supply chain management, confront escalating hurdles in efficiently delivering and distributing products within bustling urban environments. Additionally, events like environmental challenges and the COVID-19 pandemic have indicated that decision-makers are facing numerous sources of uncertainty. Therefore, to design an efficient and reliable logistics system, uncertainty must be considered. In this study, it examine fleet sizing and routing while considering uncertainty in demand rate. Fleet sizing is typically a strategic-level decision, while routing is an operational-level one. In this study, a carrier must make two types of decisions: strategic-level decisions regarding the number and types of drones to be purchased, and operational-level decisions regarding planning routes based on available fleet and realized demand. If the available fleets are insufficient to serve some customers, the carrier must outsource that delivery at a relatively high cost, calculated per order. With this hierarchy of decisions, it can model the problem using two-stage stochastic programming. The first-stage decisions involve planning the number and type of drones to be purchased, while the second-stage decisions involve planning routes. To solve this model, it employ logic-based benders decomposition, which decomposes the problem into a master problem and a set of sub-problems. The master problem becomes a mixed integer programming model to find the best fleet sizing decisions, and the sub-problems become capacitated vehicle routing problems considering battery status. Additionally, it assume a heterogeneous fleet based on load and battery capacity, and it consider that battery health deteriorates over time as it plan for multiple periods.

Keywords : drone-delivery, stochastic demand, VRP, fleet sizing
Conference Title : ICLAO 2024 : International Conference on Logistics Analytics and Optimization
Conference Location : Amsterdam, Netherlands
Conference Dates : September 12-13, 2024

Open Science Index, Industrial and Systems Engineering Vol:18, No:09, 2024 publications.waset.org/abstracts/182292.pdf