

Air-Ground Coordinated Last-Mile Delivery Optimization: Collaborative Vehicle-Drone Delivery Integrating Social Vehicles

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Abstract

The low-altitude economy presents new opportunities for urban last-mile instant delivery. However, existing studies typically assume vehicles are company-owned assets subject to centralized dispatch, and fail to incorporate social vehicles as independent decision-making agents into the collaborative delivery framework. This report proposes a vehicle-drone collaborative delivery model that integrates social vehicles, modeling them as market-oriented agents acquired through a quotation-negotiation mechanism. We develop an integrated mathematical model that combines goods grouping, route pre-planning, and quotation/interaction processes, and design an Event-Driven Hybrid Heuristic (EDHH) framework to achieve closed-loop decision-making involving grouping optimization, route estimation, and multi-level quotation negotiation in dynamic environments. Experimental results demonstrate that EDHH significantly outperforms several baseline algorithms in terms of net profit and delivery success rate, exhibiting strong robustness. This work provides a theoretical framework and algorithmic support for transitioning low-altitude logistics from centralized dispatch to market-driven collaboration.



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