UAV Last-Mile Delivery Model For City Logistics

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도시 물류를 위한 UAV 라스트 마일 배송 모델

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Abstract

Unmanned aerial vehicles (UAVs) show great promise for last-mile delivery due to their efficiency, low cost, environmental benefits, and contactless operation. However, challenges such as no-fly zone avoidance, fragile cargo handling, and strict motion constraints remain. This paper proposes a last-mile delivery model (LMDM) that integrates these factors—along with energy minimization—into UAV trajectory planning. To optimize the LMDM we propose a constraint aware evolutionary computation (EC) method in this paper.

Ⅰ. Introduction

Nowadays, due to the increasing constraints on ground transportation resources, unmanned aerial vehicles (UAVs) have emerged as an important means of cargo transport in urban areas. A key challenge in urban UAV logistics is planning an efficient transportation trajectory from the loading point to the delivery point, known as last-mile delivery. In this paper, we propose a last-mile delivery model (LMDM) that accounts for no-fly zone avoidance [1] and UAV motion limitations. Since the formulated problem is non-convex, a constraint-aware evolutionary computation (EC) method is developed to optimize it.

In the proposed model, the objective is to minimize the UAV's energy consumption [2]. During flight, the UAV's speed must not exceed the maximum allowable value. To protect the cargo, the UAV's acceleration is also constrained within a safe range. Moreover, the UAV is required to come to a complete stop at both the loading and delivery points. Throughout the trajectory, the UAV must avoid all designated no-fly zones.

Ⅱ. Simulation Results

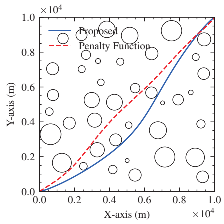

Fig. 1. The trajectories optimized by the constraint aware EC and penalty function EC method.

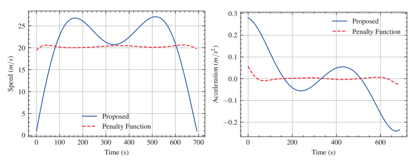

Fig. 2. The speeds and accelerations via constraint aware EC and penalty function EC method.

We compare the proposed method with the conventional penalty function approach. As illustrated in Fig. 1, both trajectories optimized by the proposed EC method and the penalty-based EC method successfully avoid the no-fly zones. However, as shown in Fig. 2, the penalty-based method fails to ensure that the UAV satisfies the speed and acceleration constraints, whereas the proposed method effectively maintains feasibility.

Ⅲ. Conclusion

This paper proposes a last-mile LMDM for UAVs that considers no-fly zones, motion constraints, and energy minimization. A constraint-aware EC method is developed to solve the non-convex problem. Results show that the proposed method achieves feasible, energy-efficient trajectories and outperforms the penalty function approach in constraint handling.

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