

Research Article

Path Planning for Multi-Vehicle-Assisted Multi-UAVs in Mobile Crowdsensing

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Due to the capability of fast deployment and controllable mobility, unmanned aerial vehicles (UAVs) play an important role in mobile crowdsensing (MCS). However, constrained by limited battery capacity, UAVs cannot serve a wide area. In response to this problem, the ground vehicle is introduced and used to transport, release, and recycle UAVs. However, existing works only consider a special scenario: one ground vehicle with multiple UAVs. In this paper, we consider a more general scenario: multiple ground vehicles with multiple UAVs. We formalize the multi-vehicle-assisted multi-UAV path planning problem, which is a joint route planning and task assignment problem (RPTSP). To solve RPTSP, an efficient multi-vehicle-assisted multi-UAV path planning algorithm (MVP) is proposed. In MVP, we first allocate the detecting points to proper parking spots and then propose an efficient heuristic allocation algorithm EHA to plan the paths of ground vehicles. Besides, a genetic algorithm and reinforcement learning are utilized to plan the paths of UAVs. MVP maximizes the profits of an MCS carrier with a response time constraint and minimizes the number of employed vehicles. Finally, performance evaluation demonstrates that MVP outperforms the baseline algorithm.

1. Introduction

In recent years, due to the massive increase in sensor-rich mobile devices, mobile crowdsensing (MCS) [1] has emerged as a new way of sensing, which relies on a crowd of personal mobile phones, tablet computers, and other smart gadgets to perform large-scale tasks. While traditional sensing technologies incur large overheads due to the deployment of lots of sensors, MCS just needs to pay some incentive rewards to attract individuals to perform sensing tasks, which is obviously more cost-effective. Therefore, MCS has been used in a lot of valuable applications recently, such as detecting air quality and collecting traffic information [2, 3].

In addition, tremendous progress in the research of microelectromechanical systems has enabled UAVs to enter the civilian market. Since UAVs are economical, flexible, and easy to operate, they have been widely used in agriculture, geological exploration, military, and other fields [4–6]. Due to the high mobility and fast deployment, UAVs can collect

various data anywhere and anytime when equipped with rich sensors. They could also be used to collect data in regions where ground vehicles are difficult to reach, e.g., flood hazard areas. With the increasing popularity of UAVs, more and more researchers began to introduce UAVs into the MCS to get better performance.

Despite the mentioned benefits, the hovering time of UAVs is quite constrained by limited battery capacity, which prevents them from serving a wide area. To solve the problem, in practice, ground vehicles are utilized to transport UAVs to collect data. In addition, UAVs will fly back to a ground vehicle to charge themselves after completing sensing tasks. The so-called vehicle-assisted UAV sensing benefits from both the long driving distance of the vehicle and high flexibility of UAVs [7].

After introducing the ground vehicle, efficient path planning and scheduling of drones and ground vehicle become a key issue. There are lots of researches that are dedicated to optimizing the routing and scheduling of vehicle-assisted UAVs for the transporting of parcels [8–10], wherein

