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A Randomized Variable Neighborhood Descent Heuristic to Solve the Flying Sidekick Traveling Salesman Problem

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Abstract

Unmanned aerial vehicles (UAV), or drones, have the potential to reduce cost and time in last mile deliveries. This paper presents the scenario which a drone works in collaboration with a delivery truck to distribute parcels. This Traveling Salesman Problem (TSP) variant has some particularities that make the originals constraints insufficient. In more detail must be considered the flying time-limit of the drone that inhibits them from visiting all customers and the parcel must not exceed the payload of the drone. To solve the problem, the initial solution is created from the optimal TSP solution obtained by the Concorde solver. Next, an implementation of the Randomized Variable Neighborhood Descent (RVND) heuristic is used as a local search to obtain the problem solution. To test the proposed heuristic, 11 instances based on the well-known TSP benchmark set were created. Computational experiments show the use of drones for last mile delivery can reduce the total delivery time up to almost 20%. Moreover providing a faster delivery this system has a positive environmental impact as it reduces the truck travel distance.

Keywords: Unmanned aerial vehicle, Traveling Salesman Problem, Drone Delivery, last mile delivery, Randomized Variable Neighborhood Descent.

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1 Introduction

An annual survey by the analytic firm comScore and UPS found that consumers are now buying more products online than in stores. As shopping online accelerates, companies are trying to make the purchase process more efficient, offering different delivery options to the customer. Thus, at the end of 2013, Amazon, one of the biggest online retailers, announced that the company was testing drone parcel delivery, a project called Amazon Prime Air. Since that, many companies started drone parcel delivery projects. For example, the German company DHL, developed a project called Parcelcopter for last mile delivery4 Additonally, the Chinese company JD.com envisioned a network which will be able to economically transport goods between cities and even between provinces Providing reduced costs and efficient services is essential to the logistics companies and their customers. Therefore, both the logistic companies as well as the automobile companies are a part of the delivery involving the drone. Mercedes-Benz, on September 2016, announced a huge investment in a startup company designed to develop a drone-equipped delivery van Unlike the other projects, Mercedes-Benz plan consisted of a van that gives all of the necessary support to the drone. Thus, allowing an easier way to load the parcel onto the drone and for the driver to grab a package without going to the back of the vehicle.

The use of drones, Unmanned Aerial Vehicle (UAV), in last mile delivery is a new problem. Thus, the literature related to problem is scarce. In this article, two interesting papers using UAV delivery are presented. Murray & Chu, 2015 [4] article discusses the Flying Sidekick Traveling Salesman Problem (FSTSP). The FSTSP consists of delivering parcels using a truck and a UAV, where some customers are attended by the truck and others by the UAV. Both the truck and UAV leave the depot in tandem. During the trip, the UAV can be launched at a customer node to delivery a parcel and then recovered at another node. To solve the FSTSP, the authors used traditional heuristics as savings [1], nearest neighbor and sweep, beyond that they also used an integer programming formulation. A different problem, named Drone Delivery Problem (DDP), was introduced by Dorling, 2017 [2]. The DDP uses only UAVs for delivering the parcels, thus requiring multiple trips from the depot in order to deliver the parcels. Concerning the DDP objective, the author studied two variants: one minimizing the overall cost and the second minimizing the delivery time. Both variants are solved by a Simulated Annealing heuristic (SA) and a Mixed Integer Linear Program (MILP).

This article addresses the FSTSP, a variant of the classic TSP, both of