VEHICLE ROUTING PROBLEM FOR DRONE-BASED FOOD DELIVERY: A COMPARISON OF DRONE DELIVERY WITH TRADITIONAL DELIVERY METHODS

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ABSTRACT – This research proposes vehicle routing problem (VRP) models for food delivery using motorbikes and drones, with the aim of minimizing the total delivery time and distance. Payload capacity, maximum flying time, and the maximum time permitted per drone are considered constraints for drone delivery. Real-world instances were tested and, the implementation of VRP for both motorbike and drone deliveries resulted in substantial reductions in delivery time and distance compared to the traditional method of motorbike deliveries, where food orders were delivered randomly without any planned routing.

Keywords: Vehicle Routing Problem; Food delivery; Drones; Optimization

1. INTRODUCTION

Drone technology for food delivery has received a lot of interest recently because of its potential to increase the speed, efficiency, and sustainability of food delivery operations. One of the most difficult challenges in drone food delivery is creating a practical VRP that considers numerous limits. Previous research has proposed numerous VRP formulations for package delivery, with the primary goal of lowering delivery time, cost, or distance. However, as per my knowledge, no studies on VRP for on-demand food delivery have been done, and no studies in the local context have been identified. J. Zhang and Y. Li [1] proposed a perishable collaborative vehicle drone distribution network (CVDDN) optimization issue. The study suggests a bi-objective model that minimizes cost and value loss during distribution. This study aims to solve these limits in food distribution by creating a UAVRP (Unmanned Aerial Vehicle Routing Problem) model that considers practical constraints such as payload capacity, maximum flying time, and the maximum time permitted per drone [2]. The UAVRP's primary objectives are to reduce travel time and distance. A similar VRP model is created for motorbike delivery method considering the same constraints as in UAVRP. Furthermore, this work uses a heuristic algorithm for solving the UAVRP and VRP that can efficiently manage the problem's combinatorial complexity. The suggested models and heuristic method should provide valuable insights and suggestions for creating effective food delivery systems in real-world situations.

2. MATERIALS AND METHODS

2.1. Objectives and Constraints

The objectives of the study and the VRP models pertain to the reduction of both travel time and travel distance. In particular, the VRP models incorporates the payload capacity, maximum flying time, and the maximum time permitted per drone and motorbike as the constraints for delivery to achieve these objectives.

2.2. Algorithm Used for Solution

The generated VRP for drone food delivery is solved using a heuristic strategy in the research study. The heuristic method is based on the concept of constructive heuristics, which is a popular method for addressing combinatorial optimization issues. The used heuristic algorithm is assessed based on numerous performance criteria, including solution quality, computation time, and convergence, on a collection of randomly generated instances of the VRP.

Materials: The research will utilize the following materials:

- Google OR Tools to develop the optimization model and solve the problem.
- A programming language (Python) for heuristic algorithm.
- A set of randomly generated instances of the VRP will be used to test the performance of the used algorithm [3].
- A set of performance metrics, including solution quality, computation time, and convergence, to evaluate the effectiveness of the proposed algorithm [4].

The heuristic algorithm will be evaluated using the above materials to assess its efficacy in addressing the drone vehicle routing problem for food delivery.

2.3. Scenario Comparison

The overall delivery time and distance are discussed for three alternative scenarios. The three scenarios evaluated are food delivery by traditional motorbike delivery method, delivery by motorbikes using the VRP model for routing, and delivery by drones using the UAVRP model.

2.4. Data Set

The data set includes location coordinates for pizza orders received by a local pizza delivery outlet within a specific time window, package weight to compute payload capacity, customer demand and order preparation time of the outlet.

3. RESULTS AND DISCUSSION

The proposed VRP models for food delivery using motorbike delivery method and drones were constructed and evaluated in various real-world scenarios. The primary goal was to reduce overall delivery time and distance while considering limits such as the maximum payload of the drone, the maximum time allowed per drone, and the maximum flight period. The results reveal that the VRP model for motorbike delivery method and the UAVRP model for drones drastically cut delivery time and distance compared to traditional motorbike delivery method. Table 1 summarizes the results from the VRP model for motorbike delivery method:

Table 1. Summary of Results for VRP Model with motorbike delivery method

Objective	Traditional motorbike delivery	VRP with motorbike delivery method
Total Time	248 minutes	170 minutes
Total Distance	164.72 km	97.75 km

The suggested VRP model for motorbike delivery method, as shown in Table 1, was able to cut overall delivery time from 248 minutes to 170 minutes, representing a 31.5% reduction in delivery time. The overall distance travelled was lowered from 164.72 km to 97.75 km, a distance reduction of 40.7%.

Table 2. Summary of Results for UAVRP Model with Drones

Objective	Traditional motorbike delivery	UAVRP with Drones delivery method
Total Time	248 minutes	84 minutes
Total Distance	164.72 km	67.67 km

The suggested UAVRP model for drones, as shown in Table 2, reduced overall delivery time from 248 minutes to 84 minutes, representing a 66.1% reduction in delivery time. The overall distance travelled was lowered from 164.72 km to 67.67 km, a 58.9% decrease in distance.

4. CONCLUSION

The study proposed and tested VRP models for food delivery on motorbike delivery method and with drones. Both instances significantly reduced delivery time and distance compared to traditional motorbike delivery techniques. The VRP model cut delivery time and distance by 31.5% and 40.7% for traditional motorbike delivery method. The UAVRP model cut delivery time and distance by 66.1% and 58.9%, respectively. The significance of the study lies in the comparison of various modes of food delivery utilizing VRP as a means of analysis. Future studies will consider travel costs and other constraints, such as limited locations and weather conditions.

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