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Study on Distribution Routing Optimization for Part-Time Riders Under Crowdsourcing Ordering Takeout

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Abstract. In recent years, "Ordering takeout" has become an important part of today's fast-paced life, so the crowdsourcing takeout delivery platform has been born. In this paper, we considers the characteristics and distribution process of part-time riders, takes path minimization as the objective function and distribution cost as the constraint condition, establishes a delivery crowdsourcing part-time rider distribution model, To win over Excel "planning solution" function. Combined with VLOOKUP and INDEX functions, the method of adding All Different constraint conditions to the mathematical model was optimized for the distribution path of external sales. This method reduces the high cost of purchasing professional programming software, making the optimization of delivery route become a routine office affair, and improving the overall optimization efficiency of the delivery enterprise.

Keywords. Takeout crowdsourcing; Part-time riders; Routing optimization; Excel Solver

1. Introduction

In recent years, people's living habits have gradually changed, especially the young people born in the 1990s, who enjoy eating all kinds of food without leaving home. Therefore, the takeout delivery mode of online ordering and offline delivery continues to expand.Take “Meituan Takeout” as an example, from its launch in November 2013 to March 2017, daily order exceeded 10 million and the number of active riders exceeded 500,000 in just three years. In May 2018, order exceeded 20 million in just 14 months. At the end of December 31, 2021, the number of users of Meituan was 690 million, up to 35.2% from 510 million in the same period last year. In the face of such rapid growth and huge orders, only relying on full-time riders can not meet the demand, so crowdsourcing emerged in Takeout crowdsourcing. Crowdsourcing is composed of part-time riders, with simple registration, low entry threshold, lax platform management, and no professional training. The distribution routing of orders are carried out only by personal experience. The efficiency and quality of distribution are difficult to control, which to some extent hinders the development of takeout crowdsourcing distribution. Based on this, in the current rapid development of takeout, this paper takes Meituan Takeout as the research object and Tianjin Jinnan District as the research scope. On the premise of guaranteeing the quality of delivery service, this paper studies how to reasonably optimize the distribution routing of part-time riders and promote the better development of takeout crowdsourcing mode.

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Based on the review of scholars' researches on path optimization, Zhangyue Wang(2020) established a vehicle path optimization model with time window, took maximizing customer satisfaction as the objective function, and solved the model with improved genetic algorithm[1]. Rui Tong (2019) conducted research on the optimization of delivery routing and emergency management of emergencies[2]. In order to solve the problem of Tenaga University campus bus access to students, Mohammed(2017) adopted the improved ant colony algorithm to find the best path of VRP problem [3]. Mingyu He(2019) simplified the optimization of the distribution routing to the problem of travel agent, established the TSP model, and optimized the distribution route by using EXCEL model and planning solution tools[4]. Zhihong Jin(2020) constructed a mathematical model for routing optimization of multiple pick and multiple delivery, which taking into account riders' familiarity with the road network[5]. Xiangnan Zhao(2020) considered the uncertain factors, analyzed the problems of takeout delivery, proposed to minimize the total operating cost as the objective function, established the optimization problem of takeout delivery routing[6]. Hongmei Li et al. (2021) established an order allocation and path optimization model for instant delivery based on VRP and improved genetic algorithm[7]. Hyungbin Park et al. (2021) proposed a waiting strategy for the vehicle routing problem of simultaneous pickup[8]. Rigakis Manousos et al. (2021) proposed the vehicle routing problem of tourist groups and solved it by combining game theory and meta-heuristic method.This method can provide efficient and satisfactory travel schedule for heterogeneous groups [9]. Haiyan Yu et al. (2021) established an optimization model of fresh takeout instant delivery path for the purpose of minimizing delivery distance, aiming at the characteristics of fresh takeout orders from online to offline with high dynamics and delivery service timeliness [10].

It can be seen that most literatures use time-window constraint model, genetic algorithm and simulated annealing judgment criterion for research, and most of these models need to purchase professional software for solving, which increasing the cost of enterprises. This paper adopts Excel office software, from the perspective of actual enterprise optimization, uses the function of "planning solution", and combines VLOOKUP and INDEX functions to add AllDifferent constraints to the mathematical model to optimize the external distribution path, simplifying the operability of the optimization algorithm. Enterprise personnel can complete the optimization algorithm in a short time, reducing the optimization cost.

2. Part-time Rider Delivery Problem Description

2.1. Order Features

Take "Meituan" as an example. This is the statistics of the order quantity in a day, as shown in Figure 1. As can be seen from the figure, around 11:00 AM and 18:00 PM are the two peak periods of orders, while the orders at noon is higher than that at night and more concentrated.

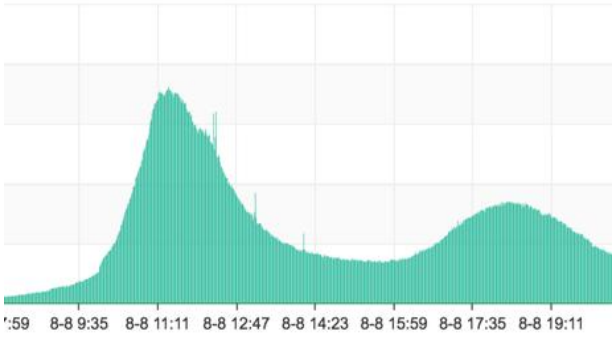

Figure 1. Order quantity statistics of Meituan in a day.

For part-time riders, takeaway orders from the platform are concentrated in peak hours, and 3-5 orders are delivered at the same time. However, in off-peak hours, riders spend more time waiting for orders than delivery. Takeout crowdsourcing rider single time period, stay in the afternoon peak 11:00-14:00 AM and 17:00-19:00 PM. Every industry has its particularity. Compared with full-time

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riders, part-time riders can earn money only during the afternoon and evening rush hours, when orders are more concentrated.

2.2. Distribution process analysis

Part-time riders starting from the distribution center, who meet the constraints such as takeout order quantity, a certain speed and a certain point, deliver the akeout order to different locations designated by different consumers after reasonably planning routeing under the constraints of timeliness. In this process, in order to improve distribution efficiency and maximize their income, part-time riders may deliver orders for multiple times during peak periods, which the maximum amount of orders, and return to the distribution center after delivery.

Takeout order is time-sensitive business. If it is out of time, consumer satisfaction will be reduced. Therefore, improving efficiency and saving time cost are the key to crowdsourcing takeout delivery service. From receive orders for food preparation to delivery to the consumers, it takes a long time in the whole process of food preparation and distribution, so the distribution will be the focus. In the process of takeout delivery, part-time riders often deliver in when the amount of order reaches a relatively high level, leading to the simultaneous delivery services of multiple consumers. However, the complexity of urban roads and reasonable routing not only affect the overall service quality, but also increase the burden of urban traffic.

3. Part-Time Riders Delivery Model

It is assumed that riders deliver to consumers in a certain route which reaching the maximum amount. After the delivery, rider returns to the restaurant to pick up a new order, then carry out a new round of delivery service. This is the typical Traveling Salesman problem (TSP).

3.1. Basic mathematical model

A 0-1 variable $X_{ij}(x \neq j)$ is introduced,

so that, $X_{ij}\begin{cases}1, \text{the distance between two delivery points i and j}\\ 0, other\end{cases}$

Assuming d_{ij} is the distance between two distribution point s i and j, a formula for the minimum total delivery distance can be obtained, then:

$$minC = \sum_{i,j=0}^{n} d_{ij}x_{ij}\ (i \neq j)$$

$$\text{s.t.}\sum_{i=0}^{n} x_{ij} = 1(i = 0, ..., n)$$

$$\sum_{j=0}^{n} x_{ij} = 1(j = 0, ..., n)$$

$$x_{ij} = 0 \text{ or } 1, (i, j = 0, ..., n)$$

3.2. Example analysis

Assume that a part-time rider with a maximum orders, which are about 6-8, and then carry out takeout delivery to Tianjin Jinnan, such as The Sino-German University of Applied Technology, Lu Fu Square, Jinnan Campus of Nankai University and several major communities near the Leisure Park.

First JinGu is defined as V_0, Tianjin Sino-German University of Applied Sciences, Louvre square, Jinnan campus of NanKai university, Xianshuigu No.1 Middle School, JieFangLi community, ShiMao-YuLongWan community are respectively defined as V_1、V_2、V_3、V_4、V_5、V_6. As shown in the above, according to the map, Euclidean distance are shown in table 1 below.

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Table 1. Euclidean distance between the business center.

	V_0	V_1	V_2	V_3	V_4	V_5	V_6
V_0	0	2.3	1.5	3.1	1.3	0.7	1.4
V_1	2.3	0	1.3	3.8	2.9	1.4	2.2
V_2	1.5	1.3	0	2.6	1.6	0.8	2.2
V_3	3.1	3.8	2.6	0	1.8	3	4.4
V_4	1.3	2.9	1.6	1.8	0	1.4	2.7
V_5	0.7	1.4	0.8	3	1.4	0	1.5
V_6	1.4	2.2	2.2	4.4	2.7	1.5	0

Due to the complex road situation, the distribution points are scattered, the distance between each distribution point is set as Euclidean distance, using Excel solving function, combined with the application of VLOOKUP and INDEX function to optimize the external distribution path. The solution process is as follows:

1) Set decision variables

Assuming that a part-time rider starts from the Leisure park defined 0, and C14:C19 as the decision variable, it means that each distribution point is sorted mathematically by the corresponding number. When finishing the final order, the rider returns to the Leisure park, and C20 does not participate in the decision. The significance of setting B14 as the initial point is a variable in C14 that the distance from whichever distribution point is chosen. Since you want to ensure that the next starting point is the end point of the previous one, enter the formula "=C14" in B15 and copy down to B20.

2) Establish the objective function

Enter the formula "=INDEX($D$4:$J$10, B14+1, C14+1)" in D14 to obtain the distance from V_i to V_j. Enter the formula "=SUM (D14:D20)" in D21 to calculate the total distances and take it as the target of the programming solution.

Enter the formula "=VLOOKUP(B14,$B4$:$C$10,2)" in F14 and copy down to F20; In the similar, enter the formula "=VLOOKUP(C14,$B4$:$C$10,2) " in G14 and copy down to G20.

3) Set the parameters of the solution and start the calculation

Click cell D21, select Excel solving function, set the target as D21, select the minimum value, select variable as C14:C19, select Add in compliance constraints, and add constraints as follows:

Condition 1: C14: C19=AllDifferent

The model selects evolution engine for solving non-smooth programming problems, and the solution method selects evolution to obtain the final result.

According to the above solution results, the shortest distance is 11.3km, the shortest path is $V_0 \rightarrow V_4 \rightarrow V_3 \rightarrow V_2 \rightarrow V_1 \rightarrow V_5 \rightarrow V_6 \rightarrow V_0$.

4. Summary

This paper investigated the takeout crowdsourcing part-time riders market and chose the afternoon peak and evening peak as the research scope. In the peak of orders, the rider began to deliver each order after receiving the maximum delivery quantity. Under this assumption, the delivery problem was regarded as the TSP model. Considering the characteristics and distribution process of part-time riders, taking routing minimization as the objective function and distribution cost as the constraint condition, a delivery crowdsourcing part-time rider distribution model was established, and the solving function of Excel was proposed. Combined with VLOOKUP and INDEX functions, the method of adding All different constraints to the mathematical model was optimized to reduce the procurement cost of professional software and the basic ability of computer language management personnel.

However, there are also limitations in this paper. Urban roads are complicated and traffic conditions are changing all the time. Therefore, the safety of many part-time riders is a constraint to be considered in the future.

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