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Research on Vehicle Routing Optimization Problem of Urban Real-time Traffic Road Network

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Abstract: In view of the increasingly prominent urban traffic congestion problem, on the basis of comprehensive consideration of distance, load weight, time and fuel-to-cost impact, the problem of time-varying vehicle path optimization is studied, and the method of calculating distribution cost across time domain is proposed to establish cost-oriented Urban distribution optimization model. In order to improve the quality and efficiency of the algorithm, an improved genetic algorithm is adopted, and two sides of the operator are designed successively. Finally, combined with Jingdong's distribution example in Chongqing, the impact of vehicle departure time on cost is analyzed, and the flexibility of path selection is considered and the route is adjusted in time. The example verifies the applicability of the model in urban distribution.

1. Introduction

With the urbanization process and the rapid development of the automobile industry, the urban population and car ownership have increased sharply, and the urban distribution demand has also expanded. Therefore, traffic congestion, environmental pollution and other issues have become increasingly serious, and urban distribution issues have received more and more attention. . Traffic congestion leads to low vehicle distribution efficiency, fuel consumption and carbon dioxide emissions. To alleviate traffic congestion, local governments have introduced traffic restriction policies to promote truck peak travel and nighttime distribution. However, urban distribution needs arise during the day, and it is clear that it is difficult to solve the actual demand for urban distribution simply by night delivery. At present, China has become the country with the largest carbon emissions in the world. How to design environmentally friendly and efficient distribution programs has become a topic for scholars to study[1].

The time-varying vehicle routing problem is an extension of the traditional vehicle routing problem. The driving speed in the time-varying vehicle routing problem is instantaneous, which is affected by the departure time on the one hand and the road traffic condition on the other hand. In recent years, domestic and foreign scholars have a great interest in TDVRP, but the research mainly focuses on the time dependence of driving speed, and there are few researches on road traffic conditions. Few scholars consider these two factors at the same time. For example, Jabali et al.

analyze time-varying vehicle routing problems with travel time and CO2 emissions, and establish models that consider travel time, fuel consumption, and CO2 emissions costs, and reduce CO2 emissions by limiting speed and avoiding peak travel. Under normal circumstances, the model with the shortest driving time as the optimization target performs poorly in terms of fuel consumption and generates more CO2 emissions. Conversely, the model with the least CO2 emission as the optimization target, in order to avoid frequent acceleration of the vehicle or Deceleration, so driving time is long, how to balance the relationship between driving time and CO2 emissions is particularly important. Soysal considers vehicle type, driving distance, load capacity, multiple time domains and emissions, analyzes the speed over time, and obtains an environmentally friendly distribution solution. Xiao Yiyong designed a new hybrid MIP model considering the effects of time-varying traffic, time window constraints and vehicle loading on emissions. At the same time, some scholars have studied the extension of some time-varying vehicle routing problems. For example, Afshar Nadjafi proposes a time-varying vehicle path problem for multiple yards, assuming that the vehicle travel time and speed depend on the departure time and limits the maximum number of vehicles in the distribution center and the hard time window with service. Naderipour proposes an open time-varying vehicle routing problem where the vehicle is leased and does not need to be returned to the distribution center. Li Yufeng uses a cross-period method that satisfies the “first in, first out” criterion to calculate driving time, but there is a risk of increasing fuel consumption and cost with the shortest return time as the optimization goal. Based on the traditional TDVRP, Zhang Ruyun analyzed the low-carbon and cost-saving urban distribution problems and built the E-TDVRP model.

In view of this, this paper considers the real-time road traffic conditions, combined with the law of driving speed changing with time, proposes a method of calculating time across time domains, establishes a city distribution model with distribution cost as the optimization target, and obtains optimal by multi-path selection. Delivery route. Design improved genetic algorithm, and finally validate the validity of the model and algorithm combined with real road data[2].

2. Problem Description

2.1. Consider the impact of departure time on driving speed

In a real-time road network, the speed of the vehicle changes with the departure time, and the speed in different time domains also changes. This paper considers the change in the speed of the morning peak and the evening peak in the day. The following is an analysis of the morning time period. According to historical traffic data, the morning is divided into five different time domains: 16:00-7:00 is the Pingfeng section; 27:00-8:00 gradually increases the number of vehicles, and the average speed slows down. 38:00-9:00 is the peak period; after the peak period of 49:00-10:00, the number of vehicles begins to decrease, the average speed increases; 510:00-12:00 returns to the peak state. Since the driving speed is different due to different departure time of the vehicle, the calculation of the driving time should be handled according to different time domains. In the first case, the time when the vehicle leaves the customer and arrives at the customer j belongs to a time domain. The second case When the vehicle is delivered, the time of leaving the customer i to reach the customer j belongs to the time domain, and the two cases are considered to be more in line with the actual delivery[3].

2.2. Adjust routes with real-time traffic conditions

The traditional vehicle routing problem considers that the path between two customers is fixed and finds the optimal route by changing the order of serving customers. In the actual road network, there are often multiple paths between two customers. In the same time period, the traffic conditions of different paths are different, so it is easier to find the optimal route by adjusting the route. The traffic flow of the main roads of the city is generally the largest, the most prone to traffic congestion, prolonging the travel time, and reducing the efficiency of distribution. The road grade is divided into main roads, secondary trunk roads and branch roads. Therefore, in order to avoid the main roads Congestion, timely adjustment of routes, and selection of secondary or bypass roads for distribution can reduce travel time and cost.

3. Establish a mathematical model with cost optimization goals

The speed in a traffic jam environment changes with time. If the distance or time is used as the optimization goal, the actual road network situation is neglected, and the vehicle distribution scheme cannot be fully optimized. To this end, the urban distribution model with cost optimization is proposed, and the influence of distribution distance, time variation of speed, fuel consumption and fuel price on distribution cost is considered, and the goal of energy saving and emission reduction is realized, and low-cost and high-efficiency urban distribution is proposed. model. In the actual distribution operation, the cost is mainly composed of the fuel consumption cost and the fixed cost of the vehicle, and the fuel consumption is closely related to the speed and the load. Laporte is based on Barth (2005) and Barth (2008) The basic fuel consumption model proposes a simplified calculation formula: $LD_2 = \max_{\{\omega_t\}} \{L_2\}$ .In the above formula, k represents the engine friction coefficient, N represents the engine speed, V represents the engine displacement, Pt represents the traction force acting on the vehicle, ε represents the vehicle rotation efficiency, Pa represents the energy required for the accessory associated with the vehicle, and η represents Diesel engine efficiency, η, U is a constant.

Demir improved the above formula and proposed a model of fuel consumption rate:

$$L_3 = \min \left\{ \begin{aligned} & -\sum_{t=1}^{T}\sum_{i=1}^{B}\pi_i^T\left(w_i^T - w_i^{T-1}\right) + \alpha\sum_{t=1}^{T}\sum_{i=1}^{B}\sum_{j=1}^{B} d_{ij}G_{ij}^t + \beta\sum_{i=1}^{B}\sum_{j=1}^{B} d_{ij}Z_{ij}^T + \\ & \sum_{t=1}^{T}\lambda_t\left[\sum_{i=1}^{B} c_i\left(w_i^t - w_i^{t-1}\right) - C_{max}\right] + \sum_{t=1}^{T}\mu_t\left[-\sum_{i=1}^{B} c_i\left(w_i^t - w_i^{t-1}\right) + C_{min}\right] \end{aligned} \right\}$$

.Wherein, equation (2) represents the fuel consumption rate, equation (3) represents the engine's output power per second, equation (4) represents the total traction power of the driving vehicle, ξ represents the fuel air mass ratio, κ represents a constant, and ηtf represents the vehicle rotation. Efficiency, assuming Pacc is zero. M represents the sum of the vehicle's own weight and load, v represents the vehicle speed, τ represents the acceleration, θ is the road bend, g is the gravitational constant, Cd and Cr are the air resistance coefficient and the rolling resistance coefficient, ρ is the air density, and A is the vehicle. Positive.

4. Algorithm design

4.1. Chromosome coding and initial population generation

In order to improve the search range of the initial population, a random full arrangement is used to generate the initial population. Randomly generate natural numbers no more than the number of customers, accumulate customer demand, meet the customer's demand and do not exceed the vehicle load constraints, and join the customer as much as possible, until the overload can no longer join the new customer, at this time record the customer location, Insert 0 at the beginning and end of the subpath; repeat the above steps to ensure that all clients are divided into sub-paths, and finally merge the sub-paths, and so on, to generate the initial population. For example, a chromosome code 572431698 is randomly generated and decoded under the condition of satisfying customer demand and vehicle load weight, and finally three sub-paths are formed, path 1: 0-5-7-2-0, path 2: 0-4 -3-1-0, path 3: 0-6-9-8-0.

4.2. Selection operator

The purpose of the selection is to select excellent individuals from the group, and the chromosomes are sorted and numbered according to the adaptation values from small to large. Suppose the population is n, the chromosome with the smallest adaptation value is 0, and the chromosome with the largest adaptation value is n-1. First, a number r that satisfies the standard normal distribution is randomly generated. From the normal distribution, the probability that r falls in [-3, 3] is 99.9%. If r>3, r is regenerated. Take r*= r4 (3 may have an infeasible solution, 5 is easy to premature), then r* ∈[0,1), let m=r*(n-1), select the mth chromosome to enter the new population. As shown in Fig. 4, it can be seen from the characteristics of the normal distribution that the closer the selected chromosome is to 0, the larger the probability value, and the higher the probability of selecting a better chromosome.

4.3. Crossover operator

When the genetic algorithm solves the vehicle routing problem, if the same situation occurs in the father, the traditional crossover operator can no longer generate new individuals. In order to improve the search ability of the algorithm, an improved crossover operator is proposed. When selecting the intersection, look for the 0 gene code, that is, the location of the distribution center. When crossing, first select the sub-path with the highest actual load rate of the parent individual vehicle, and when crossing, do not directly copy the sub-path, but move to the first place. This not only effectively protects the excellent substrings that have been generated, but also avoids the problem of not generating new individuals when the parents are the same. The specific operations are as follows:

Step 1: Select the sub-path with the highest actual load rate of the vehicle in the parent a and the parent b, and set the marked area;

Step 2: Extract the sub-path selected in the parent b, and then place it in front of the parent a. Similarly, extract the sub-path selected in the parent a, and put it in front of the parent b.

Step 3: Delete the same genetic code as the marked area in parent a and parent b, respectively;

Step 4: Randomly arrange the remaining genes to obtain progeny A and progeny B.

5. Conclusions

On the basis of considering the impact of road traffic conditions on urban distribution, according to the time-varying of the traffic network, the vehicle speed changes in different time domains, and the method of calculating the distribution cost across time domains is proposed, taking into account distance, time, load capacity and fuel. For the impact of cost, establish a city distribution model with cost as the optimization goal. In the aspect of solving the algorithm, the initial population is generated by random full arrangement, the intersection and mutation operators are improved, and the customer position is exchanged by the two sides of the successive correction operator to improve the performance of the algorithm. Finally, combined with Jingdong's distribution case in Chongqing, comparing four models with distance, time, fuel and cost as optimization objectives, the fuel optimization model yields an environment-friendly solution, and the cost optimization model yields a logistics-efficient solution; The time and space of the vehicle routing problem are studied by changing the departure time of the vehicle and considering the flexibility of the path and adjusting the route in time. The experimental results show that this paper proposes that the cost is the optimization goal, which is more in line with the actual situation and can effectively alleviate the environment. Pollution and reducing logistics costs have also achieved good results in terms of algorithms.

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References

[1] Geir Hasle,. (2017) Preface: logistics, optimization and transportation—in memory of the late Arne Løkketangen Annals of Operations Research, 2，709-711

[2] A. A. Vasin. (2017) Optimization of an energy market transportation system Doklady Mathematics 1, 411-414.

[3] Deepika Rani. (2017) A Fuzzy Logic Controller for a Traffic Junction International Journal of Fuzzy Systems, 3, 739-750.