Chapter 8
Simulation of Vehicle-Scheduling Model in Logistics Distribution Center Based on Artificial Intelligence Algorithm

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Abstract The vehicle-scheduling problem of logistics distribution includes the optimization of goods collection route, goods loading and delivery route, which is the key to the optimization of logistics distribution system. The distribution vehicle scheduling problem is a NP (Non-deterministic Polynomial)-complete problem, which is usually solved by some heuristic algorithms and intelligent optimization algorithms. In this paper, the vehicle scheduling model of logistics distribution center is established based on AI (Artificial Intelligence) algorithm. The vehicle scheduling model of logistics distribution center is a very practical model, and the traditional model has the weakness of low solution accuracy or high consumption of computing resources and storage resources. Finally, an example is analyzed. From the calculation results of two examples, it is obvious that the average calculation time of the AI algorithm proposed in this chapter is much lower than that of GA (Genetic Algorithm). The average calculation time required in this paper is only 23 s, while GA takes 68 s. It can be seen that the algorithm proposed in this paper can effectively solve the logistics distribution vehicle scheduling problem. It can be seen that the algorithm in this paper effectively solves the optimal scheduling problem of logistics distribution vehicles with multiple distribution centers, multiple models and hard time windows.

8.1 Introduction

E-commerce has promoted the rapid development of the logistics industry, and with online shopping spreading to every corner of the world, the scale of logistics distribution is also constantly expanding. Logistics distribution optimization is mainly an optimization problem of distribution vehicle scheduling. It is a complex combinatorial optimization problem, which needs to consider multiple constraints

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and objectives and belongs to NP hard problem. Vehicle scheduling problems can be further divided into single-source point scheduling problems and multi-source point scheduling problems [1, 2]. The single source point scheduling problem refers to scheduling vehicles from only one source point to deliver goods to multiple demand points. The multi-source scheduling problem refers to scheduling vehicles from multiple source points to deliver goods to multiple demand points [3]. The vehicle-scheduling model of logistics distribution centers is a highly practical model, and traditional models have weaknesses such as low solving accuracy or high consumption of computing and storage resources. How to schedule existing vehicle resources more efficiently and quickly to maximize the effects brought by resources has become an urgent issue [4]. The scheduling problem of logistics distribution vehicles includes optimization of cargo collection routes, cargo loading and delivery routes, which is the key to optimizing the logistics distribution system. The delivery vehicle scheduling problem is an NP complete problem, usually solved using some heuristic algorithms and intelligent optimization algorithms. The key to using AI algorithm to solve logistics vehicle scheduling problems is to solve particle encoding and decoding methods for scheduling problems. AI algorithm is different from other evolutionary algorithms. AI algorithm has an explicit computing model, which is easy to program and simple to implement. Once proposed, it has been widely used, especially when solving continuous function optimization problems, it shows good optimization performance [5]. This article establishes a vehicle scheduling model for logistics distribution centers, which has the characteristics of high computational efficiency and moderate solution accuracy.

8.2 Model Building

8.2.1 Model Hypothesis

Reasonable vehicle scheduling in logistics distribution center is based on the overall goal of logistics distribution center, using systematic principles and methods, making full use of all kinds of scheduling, selecting reasonable routes and means of transportation, and organizing goods transportation activities with the path, the least links, the fastest speed and the least labor consumption. This chapter will introduce AI-based algorithm to build and study the vehicle scheduling model of logistics distribution center. The left half of the AI algorithm can mainly determine the prerequisite for the application of the rule, and the right half describes the actions taken or conclusions drawn by applying the rule [6, 7]. After a rule meets the preconditions of application, the database can be operated to make it change.

The problem to be solved in vehicle smoothness is that vehicles start from the logistics distribution center to complete some distribution tasks. When the amount of each task is small, such as less than the capacity of one vehicle, in order to improve the utilization rate of vehicles, several vehicles can be arranged to perform several transportation tasks, and how to arrange the route of vehicles can meet the needs of each task and minimize the total cost [8, 9]. The weight of each car is certain, so it is required to arrange the car route reasonably to make the total distance. In order to facilitate the modeling, the following assumptions need to be made on the model:

(1) The supply of goods in each distribution center is sufficient;
(2) The volume and rated load of vehicles are the same, the number of vehicles in each distribution center is limited, and the total number of vehicles is sufficient;
(3) Goods without special loading requirements, that is, all goods can be mixed together;
(4) The demand of each demand point must be met, and can only be delivered by a car;
(5) The distance between distribution center and customers and between customers is known and fixed;
(6) Only consider the delivery process between the distribution center and customers.

This paper studies a basic problem of vehicle scheduling, that is, the route optimization of transport vehicles under the constraints of cargo demand, delivery volume and vehicle capacity. On the premise of meeting the needs of users, the target values, such as distance, time, cost and number of vehicles, are optimized to a certain extent, and finally the minimum consumption of logistics distribution costs is achieved [10]. Among them, the openness is reflected in: the vehicles that have completed the distribution task can not return to the original parking lot; the multi-objective is reflected in: the optimization objective can be different single objectives or a combination of multiple objectives.

8.2.2 Modeling

Generally speaking, meeting customer requirements for transportation time, short transportation mileage, low transportation costs, and optimizing a single goal, which cannot meet the overall benefits [11]. The AI algorithm evolves towards a more optimal solution through repeated operations until the optimization convergence conditions are met. The AI algorithm is a repetitive search process, but this process is not simply a repetitive search, but a search with "memory". The algorithm itself prevents the search from evolving towards a lower region [12]. Use AI algorithm to identify interference prone points in logistics distribution roads and optimize vehicle paths. As shown in Fig. 8.1.

The increase in delivery frequency not only leads to an increase in the starting and total shipping costs, but also increases the ancillary activities of transportation, resulting in a decrease in various technical and economic indicators. Set up a distribution center with a total of vehicles participating in the scheduling, and the transportation distance from the customer area to is. Based on this, establish the following mathematical model:

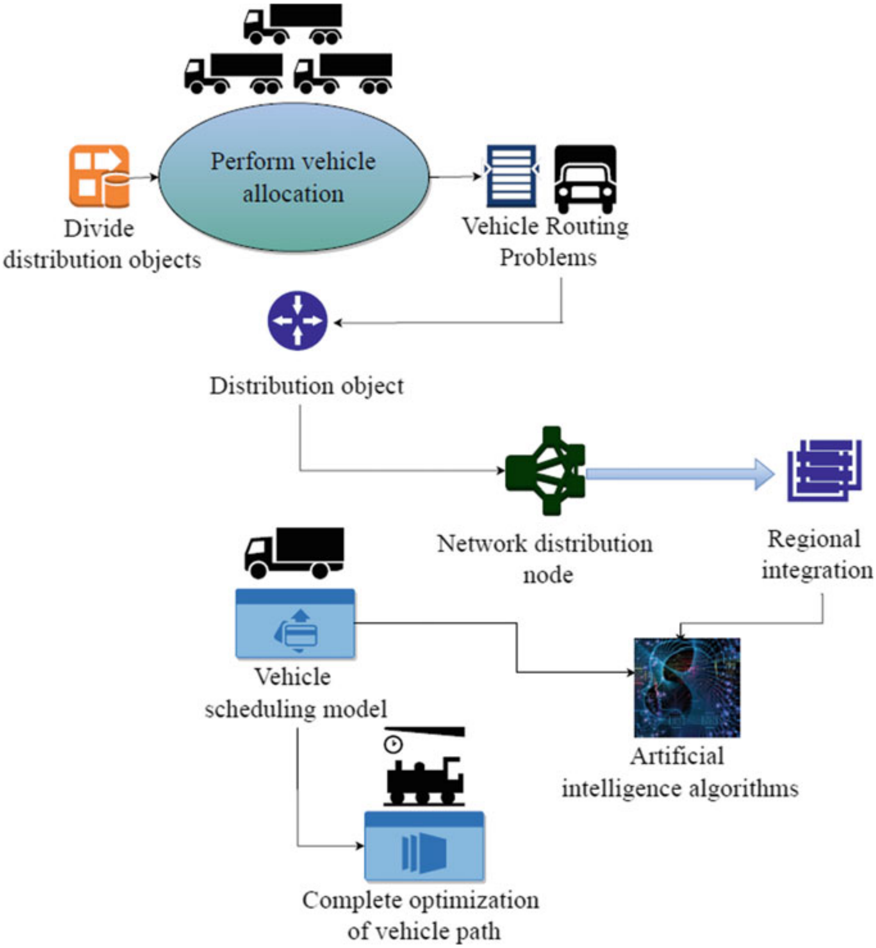

Fig. 8.1 Logistics distribution center vehicle scheduling model

$$\min F = \sum_{k=1}^{m} \sum_{i=0}^{n} c_k x_{ij} d_{ij} \tag{8.1}$$

Constraints:

$$\sum_{i=0}^{n} \sum_{k=1}^{m} x_{ijk} = \begin{cases} m & i = 0 \\ 1 & i = 1, 2, 3, \ldots, n \end{cases} \tag{8.2}$$

$$\sum_{i=0}^{n} \sum_{k=1}^{m} x_{ijk} = \begin{cases} m & j = 0 \\ 1 & i = 1, 2, 3, \ldots, n \end{cases} \tag{8.3}$$

$k = 1$ in Formula (8.1) represents the customer point that each vehicle is responsible for; $i = 0$ represents the total volume of goods demand; c_k represents the maximum volume of the vehicle; The freight volume represented by x_{ij}; d_{ij} stands for all tasks away from vehicle distribution; The x_{ijk} in Formulas (8.2) and (8.3) indicates that each customer can only be delivered by one car, and there must be another customer point i for customer point j, from customer point KK to customer point j.

How to arrange the route of the vehicle can not only meet the needs of each task, but also minimize the total cost selecting reasonable routes and means of transportation, and organizing goods transportation activities with the path, the least links, the fastest speed and the least labor consumption because of their scattered distribution, large distribution volume and fixed location [13]. If the decoded scheduling scheme is not feasible, it violates the constraints, such as the total demand of each receiving point on a certain path exceeds the capacity of delivery vehicles on this path, or there are vehicles in the scheduling scheme that are not assigned to receiving points.

8.3 Optimization Objectives for Logistics Delivery Vehicle Scheduling

Generally speaking, meeting customer requirements for transportation time, short transportation mileage, low transportation costs. After customer regionalization integration and vehicle allocation, the customer area to be delivered to each vehicle is fixed. After integrating distribution objects and allocating vehicles, the network nodes or customer areas that each vehicle needs to deliver are fixed [14]. An important issue in the routing problem of vehicles between fixed areas is the interference of road interference on logistics distribution optimization caused by frequent occurrence points. Calculate the distance between each demand point and each distribution center, classify and group according to the principle of proximity, that is, classify each demand point into the closest distribution center. Determine whether the total volume of goods required by all demand points within each group exceeds the total volume of all vehicles, or whether the total weight of goods required by demand points exceeds the total volume weight of all vehicles. Consider all distribution centers without assigned vehicles and calculate their geographical center of gravity. If there is a supersaturated group, priority should be given to assigning vehicles within the supersaturated group to perform distribution tasks; otherwise, assign vehicles to the group corresponding to the distribution center with the farthest distance from the center of gravity to perform the distribution task [15].

The problem of vehicle routing between fixed areas is transformed into a pure problem of freight forwarders. However, previous research on vehicle scheduling and distribution routes has mostly focused on optimizing a single objective, which cannot meet the overall benefits. The single source point scheduling problem refers to scheduling vehicles from only one source point to deliver goods to multiple demand points. The multi-source scheduling problem refers to scheduling vehicles from multiple source points to deliver goods to multiple demand points. The vehicle-scheduling model of logistics distribution centers is a highly practical model, and traditional models have weaknesses such as low solving accuracy or high consumption of computing and storage resources. This chapter proposes the following optimization objectives.

(1) Minimum empty load rate of delivery vehicles

Can achieve the maximum load utilization rate of delivery vehicles. This can complete specific delivery tasks with the minimum number of vehicles and improve vehicle utilization.

(2) Deliver according to customer requirements to improve logistics service quality

Being able to meet customer requirements can enhance the reputation of the logistics distribution center, retain the company's customers, and is the fundamental guarantee for the logistics distribution center to achieve efficiency.

(3) Reasonably arrange logistics delivery to achieve the lowest delivery cost

The basic requirement for improving economic efficiency is to minimize costs, which can be another important goal second only to time accuracy.

Based on road condition information and vehicle information that can participate in scheduling, calculate the cost savings between each point pair, and then construct a line. When constructing a connecting point pair, check and constrain the maximum allowable advance time or maximum allowable delay time of points on the line to meet the requirements of hard time windows. Determine the customers served by each vehicle, develop vehicle driving routes, and display vehicle route graphics.

8.4 Simulation Experiment

Reasonable vehicle scheduling in logistics distribution center is based on the overall goal of logistics distribution center, using systematic principles and methods, making full use of all kinds of scheduling, selecting reasonable routes and means of transportation, and organizing goods transportation activities with the path, the least links, the fastest speed and the least labor consumption. Due to the constraints in solving the model, such as the number of vehicles starting from a parking lot must be the same as the number of vehicles returning to this parking lot, and each vehicle only corresponds to a starting parking lot and an ending parking lot.

Computer processing is the core of the system, mainly according to the realization of mathematical models and algorithms in the computer, and according to the given distribution users, distribution goods, collection points and vehicle conditions, the route arrangement and travel time arrangement of the dispatched vehicles and each vehicle are determined. In order to test the effectiveness of this algorithm, the vehicle scheduling model of logistics distribution center established in this paper is used to solve the situation consisting of one parking lot and six demand points. The load

Table 8.1 Coordinates and freight quality units of 6 demand points in 1 depot

Demand point	1	2	3
(x, y')	(− 4, 13)	(24, 35)	(− 7, 21)
gi	40	60	50
Demand point	4	5	6
(x, y')	(15, 38)	(− 24, 30)	(8, − 9)
gi	60	50	70

of each vehicle is 200 units and the coordinates of the parking lot are (0, 0). The specific data are shown in Table 8.1, where x and y represent the coordinates of demand points, relative to the parking lot, the quality unit of goods expressed by gi. As a result, the total transportation distance of vehicles is required to be the shortest.

The algorithm proposed in this paper and the genetic algorithm were used to calculate the example simultaneously, with a maximum iteration count of 290. The convergence speed of the algorithm proposed in this paper was compared with that of the genetic algorithm, and the experimental results are shown in Fig. 8.2. From Fig. 8.2, it can be seen that during the optimization process, the algorithm in this paper can reach the optimal value after 170 iterations, while GA requires 230 iterations, indicating that the algorithm in this paper can quickly converge to the optimal value.

Similarly, the above methods were used to test the number of optimal values and the average calculation time, and the experimental results are shown in Figs. 8.3 and 8.4.

From the calculation results of the above two examples, it can be seen that the AI algorithm proposed in this article has an optimal number of times in the optimal value test, which can reach 264 times, while GA only has 165 times. It is evident from the test results of the average computation time that the required average computation of

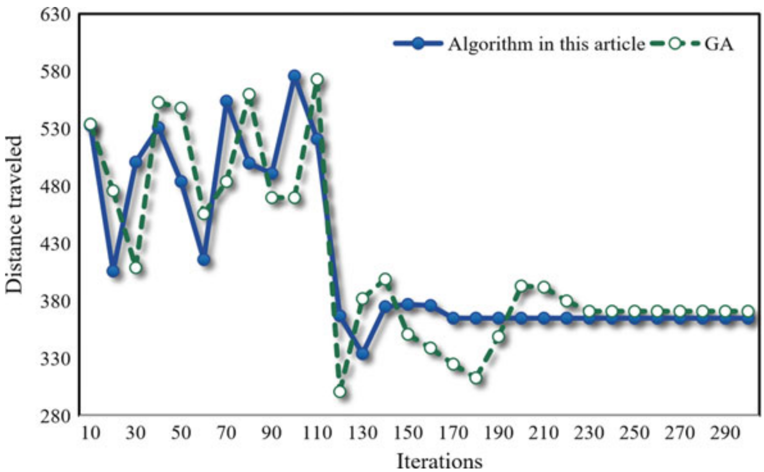

Fig. 8.2 Comparison of convergence rates

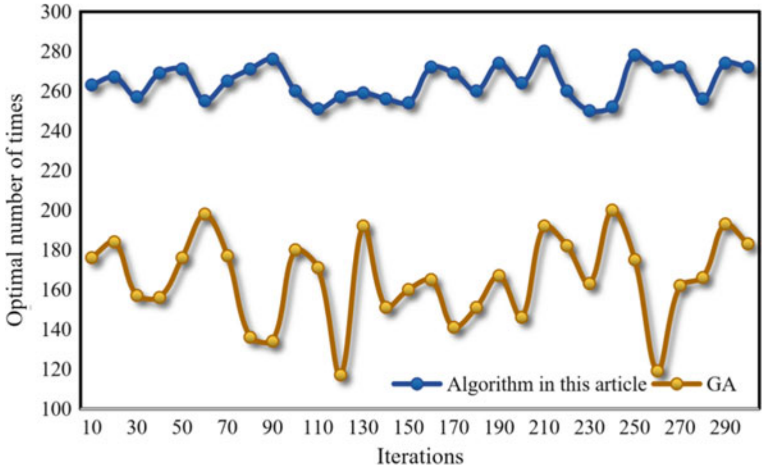

Fig. 8.3 Comparison of the number of optimal values

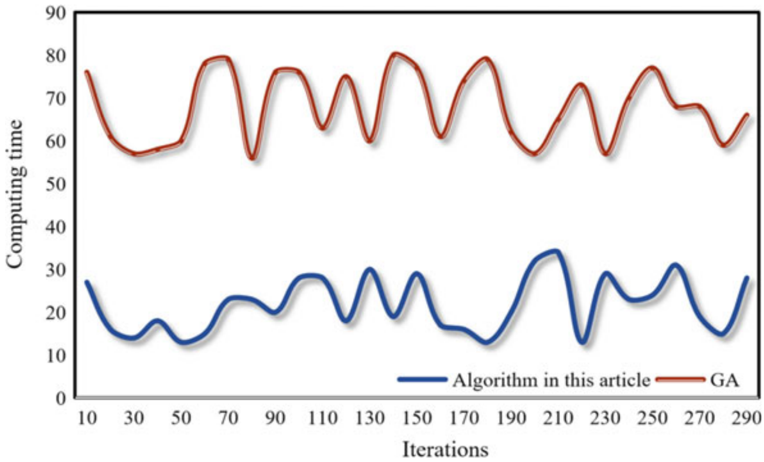

Fig. 8.4 Average calculation time

the algorithm in this paper is much lower than that of GA. The average calculation time required for this article is only 23 s, while GA takes 68 s. It can be seen that the algorithm proposed in this article can have a more significant effect on the scheduling problem of logistics delivery vehicles.

8.5 Conclusions

In this paper, the vehicle scheduling model of logistics distribution center is established based on AI algorithm, and an example is analyzed. Reasonable vehicle scheduling in logistics distribution center is based on the overall goal of logistics distribution center, using systematic principles and methods, making full use of all kinds of scheduling, selecting reasonable routes and means of transportation, and organizing goods transportation activities with the path, the least links, the fastest speed and the least labor consumption. The delivery vehicle scheduling problem is an NP complete problem, usually solved using some heuristic algorithms and intelligent optimization algorithms. The key to using AI algorithm to solve logistics vehicle scheduling problems is to solve particle encoding and decoding methods for scheduling problems. AI algorithm is different from other evolutionary algorithms. AI algorithm has an explicit computing model, which is easy to program and simple to implement. This paper will introduce AI-based algorithm to build and study the vehicle scheduling model of logistics distribution center. From the calculation results of two examples, the optimal times of the AI algorithm proposed in this paper can reach 264 times, while GA is only 165 times. In the test results of average calculation time, it can be clearly found that the average calculation required by this algorithm is much lower than that of GA. The average calculation time required in this paper is only 23 s, while GA takes 68 s. At the same time, the algorithm has the advantages of reverse application, such as changing the tasks and requirements of customers to those of suppliers, which becomes the optimal scheduling problem of goods-collecting vehicles. The AI algorithm can solve the problem of vehicle scheduling with integrated collection and delivery. The work done in this paper is a preliminary exploration in this direction, but only some relatively simple VSP, cargo loading and location positioning are studied, and there is still a lot of work to be done.

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