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The Research on Optimization of Logistics Distribution Path Based on Genetic Algorithm

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Abstract: In the logistics activities, the distribution cost occupies a large proportion of the whole logistics cost, and the main factor that affects the cost is how to arrange the transportation route reasonably, so how to optimize the distribution route with reasonable methods is an important activity. Based on the establishment of the mathematical model of logistics distribution path optimization, this paper constructs the genetic algorithm to solve the problem. The results show that the optimal solution or approximate optimal solution can be obtained conveniently and effectively by using genetic algorithm to optimize the logistics distribution path, which is of practical significance for logistics enterprises to realize scientific and fast distribution scheduling and path optimization.

1. Introduction

As the "third profit source" of enterprises, logistics has become the most important field of competition. Reasonable planning and management of logistics will create huge economic benefits. Through the analysis and research, it is found that the distribution cost accounts for a high proportion in all the logistics costs. Therefore, for the distribution center, the reasonable optimization of the distribution path can not only simplify the distribution procedure and reduce the distribution frequency, but also reduce the distribution cost, which will bring greater benefits.

Dantzig and Ramser [1] first proposed the vehicle routing problem (VRP) and the corresponding mathematical programming model and solution in 1959. The vehicle routing problem has been one of the most basic problems in network optimization since it was proposed in 1959. VRP - can be described as: as a distribution center for a series of the demand of the customers to provide services, to meet the established constraints (such as customer demand, the maximum load distribution center storage, vehicles, service time, etc.), design a reasonable traffic route, achieving distribution optimization (shortest distance, the cost is the smallest and least time-consuming, cubed out the highest vehicle, etc). At present, there are many algorithms to solve the routing problem of distribution vehicles, such as branch definition method [2], dynamic programming method [3], C-W saving method [4], etc. but the most used are meta-heuristic algorithms, including genetic algorithm [5], ant colony algorithm [6], simulated annealing algorithm, etc. Meta-heuristic search algorithm is an effective method to solve complex optimization problems, which requires little or no prior information about the problem. Secondly, this algorithm has strong robustness and can obtain satisfactory solutions in most cases.

Genetic Algorithm (GA) is an optimization search method to solve complex global optimization problems based on Darwin's theory of natural evolution and genetic variation. It was first proposed by professor Holland of the university of Michigan in 1967. Genetic Algorithms start with a population representing a possible potential set of solutions to a problem, and a population is made up of a certain number of individuals encoded by genes. Original population is generated according to the principle of survival of the fittest and the evolution, each subsequent generation evolution produce better approximate solution, in each generation, according to the individual problem domain size to choose the fitness of individuals, and by means of natural genetics, genetic operators are combined crossover and mutation, produced on behalf of the new solution set of the population. This process will lead to natural evolution of the population. The epigenetic population is more adapted to the environment than the previous generation. After decoding, the optimal individuals in the last generation can be regarded as the approximate optimal solution of the problem. According to the characteristics of logistics distribution path, this paper constructs a mathematical model to solve the problem, and USES genetic algorithm to solve it.

2. Mathematical formulation

Logistics distribution path：The optimization problem of vehicle distribution path can be described as: multiple vehicles are used to distribute goods to customers from the distribution center. The location and demand of each customer point are known to us, and the loading capacity of vehicles is known to us. Therefore, it is required to reasonably arrange vehicle routes to seek for a good distribution plan, so as to minimize the total distance traveled [7].

Make the following assumptions about the actual problem:

(1) The location and demand of each customer is known;

(2) The goods required by each customer can be mixed, each customer's demand does not exceed the load of the largest model, and do not separate distribution;

(3) Distribution models are classified by deadweight. The total demand of each customer on each distribution path does not exceed the vehicle load. The distribution center will start the vehicle and return it;

(4) The length of each distribution path shall not exceed the maximum driving distance for a single distribution;

(5) Distribution center has enough resources for distribution, and has enough transportation capacity;

(6) The distance between the distribution center and the customer and the customer is known and constant.

The constraint conditions and optimization objectives of the above problems are fully considered, and the mathematical model of optimal distribution path is established.

Set the distribution center to 0, n for the specific customer is 1, 2, 3, ..., n.

Suppose the total amount of goods to be transported by the n customer is $g_i\,(i=1,2,3,\cdots,n)$, and the number of vehicles required to realize all the distribution is m, the serial number of each vehicle is $1,2,3,\cdots,m$, in turn, and the rated load of each distribution vehicle is $q_{\max}$: $q_{\max}=8000$.

Let the distance between customer i and customer j be $d_{ij}\,(i=1,2,3,\cdots,n;\ j=1,2,3,\cdots,n)$.

Variables are defined as follows:

$$x_{ijk}=\begin{cases}1,\text{Vehicle } k \text{ from customer } i \text{ to customer } j\\ 0,\text{Vehicle } k \text{ does not from customer } i \text{ to customer } j\end{cases}\quad i,j=0,1,\cdots,n;k=1,2,\cdots,m$$

$$y_{ki}=\begin{cases}1,\text{the requirements of customer } i \text{ fulfilled by vehicle } k\\ 0,\text{the requirements of customer } i \text{ not fulfilled by vehicle } k\end{cases}\quad i=1,2,\cdots,\mathrm{n};k=1,2,\cdots,\mathrm{m}$$

Total vehicle travel is $z=\sum_{i=0}^{n}\sum_{j=0}^{n}\sum_{k=1}^{m}d_{ij}x_{ijk}$

The actual carrying capacity of the vehicle k distribution is $q_k=\sum g_i y_{ki}$, $k=1,2,3,\cdots,\mathrm{m}$

The model is as follows:

$$\min z=\sum_{i=0}^{n}\sum_{j=0}^{n}\sum_{k=1}^{m}d_{ij}x_{ijk} \tag{1}$$

$$\text{s.t.}\quad \sum_{i=1}^{n} g_i y_{ki} \le q_{\max} \quad k = 1, 2, \ldots, \mathrm{m} \tag{2}$$

$$\sum_{k=1}^{m} y_{ki} = 1 \quad k = 1, 2, \ldots, \mathrm{m} \tag{3}$$

$$\sum_{i=1}^{n} x_{ijk} = y_{ki} \quad j = 1, 2, \ldots, \mathrm{n};\quad k = 1, 2, \cdots\cdots, \mathrm{m} \tag{4}$$

$$\sum_{j=0}^{n} x_{ijk} = y_{ki} \quad i = 1, 2, \ldots, n; k = 1, 2, \ldots, \mathrm{m} \tag{5}$$

$$\sum_{i=0}^{n}\sum_{j=0}^{n} d_{ij} x_{ijk} \le D_s \tag{6}$$

(1) is the objective function, the shortest total vehicle travel to complete the customer distribution task.

(2) as the limit of vehicle load, ensure that the total customer demand on all paths must not exceed the vehicle load.

(3) (4) (5) is to work together to ensure that all customer points have vehicles to serve them and that a single customer point only provides services through a single vehicle.

(6) Represents the constraint of the maximum driving distance of the vehicle.

3. Solution approach

3.1 The overview of Genetic Algorithm

Genetic Algorithm is a kind of "generate and test" iterative search algorithm, the idea is that in every generation, according to individual fitness value of each generation and iteration and optimization method of Genetic Algorithm to search and individual choice, new individual not only inherited the outstanding of the parents, and when the hybridization and mutation, will produce more genes with environmental adaptability. On this basis, the result is closer to the optimal solution than that of his parents. It operates on all individuals in a population, each of which corresponds to a solution to the problem.

3.2 The construction of Genetic Algorithm

(1) Genetic Coding. In this paper, the customer code is represented by a natural number, Natural number i represents the ith customer (0 represents the distribution center). Insert M-1 zeros in the customer sequence (M is the number of vehicles) and divide the customer sequence into M segments, each segment representing the path of a car. For example:

Let the first chromosome be: $G_k = [0,1,6,2,0,4,5,0]$, the path that he indicated is:

First car: $\{D,1,6,2,D\}$

Second car: $\{D,4,5,D\}$

(2) Fitness Function. According to the above coding rules, the driving route in the whole distribution process can be calculated for each feasible solution, and the reciprocal of the total driving distance is taken as the fitness function $F_i = 1/\sum_{i=0}^{n} d_{ij}$.

(3) Select Operation. The method adopted in this paper is roulette selection method. Roulette selection method is a playback random sampling method in which the selection probability of each

individual is proportional to its fitness value. Set the population size as n, and the fitness value of the individual as F_i, and the probability of being selected as $P_{si} = F_i / \sum_{j=1}^{n} F_j$.

(4) Cross Operation. The crossover method adopted in this paper is single point crossover. Single-point crossover refers to the random setting of an intersection point in an individual coding string, at which part of the chromosomes of two paired individuals are exchanged. In order to implement the sub-algorithm, the individuals should be randomly paired. If the population size is M, there are M/ 2 pairs of matched individual groups. Then, for each pair of individuals paired with each other, the position behind a certain locus is randomly set as the intersection point. If the length of the chromosome is n, there are a total of possible intersection points. Finally, for each pair of individuals who are paired with each other, part of the chromosomes of the two individuals is exchanged at the intersection point according to the set crossover probability, so that two new individuals are generated. In this paper, the value of crossover probability is $P_i = 0.8$.

Is assumed to be the intersection point, and the exchange of two individuals is:

$$X = (x_1, x_2, x_3, \cdots, x_n)$$

$$Y = (y_1, y_2, y_3, \cdots, y_n)$$

Then the two chromosomes generated after crossing:

$$X' = (x_1, x_2, \cdots, x_k, y_{k+1}, y_{k+2}, \cdots, y_n)$$

$$Y' = (y_1, y_2, \cdots, y_k, x_{k+1}, x_{k+2}, \cdots, x_n)$$

The schematic diagram of single-point crossover operation is shown in Fig. 1.

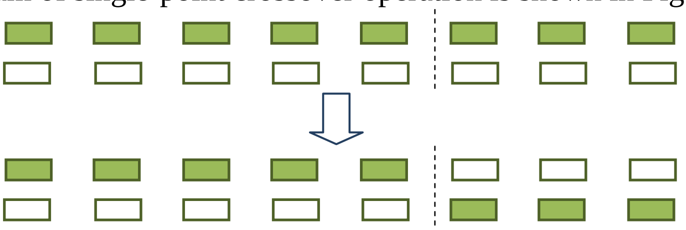

Figure 1. Single point crossing diagram

(5) Mutation Operation. The variation method adopted in this paper is uniform variation, which refers to replacing the original gene values of each locus in the individual coding string with a small probability by random Numbers that conform to the uniform distribution in a certain range. The value of variation probability in this paper $P_i = 0.05$.

4. Computational experiments

4.1 Company profile

A freight company is A third-party logistics company located in Qingdao, which mainly focuses on distribution, storage and transportation. Mainly engaged in the transportation and distribution business throughout the country. After several years of operation, A freight company as A transport enterprise has some problems, mainly including: the equipment level of freight, the professional level of transport is not high; Unable to completely reasonable planning of transport routes, resulting in a waste of resources.

Businesses began by adopting a frugal approach, suitable for less conditional-friendly, easy-to-operate routing problems, optimized to minimize the number of retail stores and route trips for each vehicle participating in the delivery. However, for more complex problems, the economization method is not as practical as the Genetic Algorithm.

4.2 The path optimization by Genetic Algorithm

A freight company has delivered to 19 customers in Qingdao, the carrying capacity of the vehicles is 8×10^3kg, and the maximum driving distance for each delivery is 40km. The coordinates of the customers are shown in the Table1: coordinates of the distribution center (72, 40).

Table.1. Customer coordinate points

Customer number	Abscissa X (km)	Ordinate Y (km)	Demand for goods (kg)
Distribution center	72	40	
1	62	60	100
2	89	83	400
3	76	24	1200
4	90	30	1500
5	75	47	800
6	22	50	1300
7	52	62	1700
8	45	60	600
9	61	89	1200
10	68	77	400
11	35	21	900
12	77	87	1300
13	14	59	1300
14	82	49	1900
15	38	92	1700
16	5	85	1100
17	60	10	1500
18	66	30	1900
19	34	72	1700

The optimal scheme of A freight company based on economy method is shown in Table 2, with A total travel distance of 778km.

Table.2. Distribution path of company A using economy method

van	Route	The length of the routing	Loading rate
1	0→4→3→17→11→0	175	63.75%
2	0→5→14→2→12→9→10→7→1→0	296	97.5%
3	0→8→19→15→16→13→6→0	281	96.25%
4	0→18→0	26	20%

According to the Genetic Algorithm, the sequential coding method of natural Numbers was adopted, the population size was 50, the crossover probability was 0.8, and the mutation probability was 0.05. Use the double judgment to stop, set the best result to be 778, stop when the best value is greater than 778, and set the number of evolutions to be 100. Through calculation, the best scheme is 465, as shown in Table 3.

Table.3. Optimized path with genetic algorithm

van	Route	The length of the routing	Loading rate
1	0→16→15→19→13→06→11→0	158	100%
2	0→17→05→10→12→02→09→08→07→01→0	239	100%
3	0→18→03→04→14→0	68	77.5%

The optimal value parameter was set to 778, and the evolutionary algebra judgment parameter was set to 100. The results were randomly run for 10 times, as shown in Table 4:

Table.4. Genetic Algorithm results of logistics distribution path optimization problem

Calculate the order	1	2	3	4	5	6	7	8	9	10
results	487	474	472	465	467	486	513	517	498	515

It can be seen from the data in the table that the results obtained by running ten times are all better than those obtained by the economization method. And the fourth time we got the optimal solution 465. It can be seen that the optimal solution or approximate optimal solution of optimized logistics distribution path can be obtained quickly and effectively by using Genetic Algorithm.

5. Conclusion

The experiment shows that the precise algorithm and heuristic algorithm cannot find the optimal solution of path optimization, so according to the possible problems of distribution, we introduce the feasibility of Genetic Algorithm and the basic solution idea. It is a heuristic search method with good performance to establish the mathematical model of optimizing logistics distribution path and then use Genetic Algorithm to optimize the solution. It can quickly and effectively obtain the optimal solution to optimize the logistics distribution path, greatly improve the distribution efficiency and reduce the cost. The coding method, adaptive value method and selection, crossover and mutation operators used in this paper are valuable for solving similar combinatorial optimization problems.

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