Academic Journal of Computing & Information Science
ISSN 2616-5775 Vol. 2, Issue 1: 155-161, DOI: 10.25236/AJCIS.010030

Application of Genetic Algorithm in Logistics Path Optimization

JI XueJing, YONG Xu

1Northeastern University, information and computing science, 1501,Shenyang, Liaoning, 110004 China

ABSTRACT: *This paper considers genetic algorithm to process logistics path optimization. Genetic algorithms are significant in location issues, distribution issues, scheduling issues, transportation issues, and layout issues. A genetic algorithm for solving this problem is constructed base on the mathematical model of logistics distribution path optimization problem. The calculation results show that using genetic algorithm to optimize the logistics distribution path can easily and effectively obtain the optimal solution or approximate optimal solution.*

KEYWORDS: *Genetic algorithm; Data mining; Logistics path optimization; Binary code*

1. Introduction

During 2018 Double Eleven online Shopping Event, opening only 2 minutes and 5 seconds, the total transaction amount exceeded CNY 10 billion. According to the statistics of the National Bureau of Statistics, during the peak period of the 2018 Double Eleven Business, the national postal and express delivery enterprises handled a total of 1.882 billion postal (fast) pieces, a year-on-year increase of 25.8%.

In recent years, the development of Chinese express delivery industry has increased rapidly, and the number of express delivery has continued to grow. With such a large amount of logistics demand, even a small amount of cost reduction in the logistics phase will bring significant benefits. Therefore, the logistics path optimization is put on the agenda, and the logistics path problem should be solved from the Vehicle Routing Problem (VRP).

The VPP problem is a combinatorial optimization problem that was suggested by George Dantzig and John Ramser in 1959 [1]. The classic VRP problem is that a service center uses M vehicles to deliver goods to N users who are discretely distributed in one area in the case of determining that the total transportation cost of each vehicle travel route is the smallest and only one vehicle is accessed once at

ISSN 2616-5775 Vol. 2, Issue 1: 155-161, DOI: 10.25236/AJCIS.010030

each service demand point [2]. In this case, we need to achieve the shortest distance, the least cost, and the least time spent [3]. VRP has important applications in transportation, resource allocation and logistics supply.

The VRP problem can be translated into the Traveling Salesman Problem (TSP) when the vehicle's capacity constraints are not considered and it is stipulated that only one vehicle is utilized to serve all users. Gaery has proved that the TSP problem is NP-hard. Therefore, VRP is also NP-hard [4].

Since VRP is an NP problem, it is difficult to solve with accurate calculation. The main current solution algorithm is heuristic algorithm. Among them, heuristic algorithms include conservation method, simulated annealing method, deterministic annealing method, tabu search method, genetic algorithm, ant colonization algorithm, etc [5].

Among them, the genetic algorithm was first proposed by J.H.Holland, who solved the VRPTW problem by genetic algorithm coding. This algorithm is a method to simulate Darwin's theory of evolution and Mendel's genetic theory to search for optimal solutions by simulating natural evolutionary processes. It has good characteristics for solving combinatorial optimization problems [6].

The main applications of data mining include decision trees, neighbor algorithms, genetic algorithms, rule induction, and neural networks [7].

2. Mathematical Model

In order to build the model and process the discussion, we use the following assumptions:

The location and demand of each user is known;

Distribution outlets and delivery distances are known;

The items delivered are the same;

Meet users' arrival time requirements;

Distribution outlets have sufficient distribution capacity;

There is a limit to the load of each delivery vehicle.;

The total running time (or total running distance) of the sending vehicle has a predetermined upper limit.

To achieve the goal and carry out logistics path optimization, the problem can be presented as: multiple vehicles are delivered to multiple users from the distribution center. Each user's location and demand are fixed. Every user's needs must be satisfied and can only be delivered by one vehicle. The load of each vehicle is fixed. It is required to arrange the vehicle route reasonably so that the total distance is the shortest.

ISSN 2616-5775 Vol. 2, Issue 1: 155-161, DOI: 10.25236/AJCIS.010030

Built on the above conditions, we can build logistics path optimization model as following.

There are M vehicles in the distribution center. The load of each vehicle is L_m (m = 1, 2, ..., M). The maximum driving distance for one delivery is D_k. It is necessary to deliver goods to N users. The demand of user i is q_i. Set x_m as the number of users for the m-th vehicle (x_m =0 means that the m-th vehicle is not used), and set R_m to represent the m-th path, where r_{mi} indicates that the order of the user r_{mi} in the path m is i (without the distribution center). Let r_{mi} =0 represent the distribution center. The distance from the distribution center to the user i is d_{oi}, and the distance between the users i and j is d_{ij}, (i, j =1, 2, ..., N). Then we can establish a mathematical model to optimize the logistics distribution path:

$$\min P = \sum_{m=1}^{M}\left[\sum_{i=1}^{x_i} d_{r_{m(i-1)}r_{mi}} + d_{r_{mx_m}r_{m0}sign(x_m)}\right]$$

$$s.t. \quad \sum_{m=1}^{x_m} q_{r_{mi}} \le L_m$$

$$\sum_{m=1}^{M} d_{r_{m(i-1)}r_{mi}} + d_{r_{mx_m}r_{m0}sign(x_m)} \le D_m$$

$$0 \le x_m \le N$$

$$\sum_{m=1}^{M} x_m = N$$

$$R_m = \left\{ r_{mi} \mid r_{mi} \in \{1, 2, ..., N\}, 1, 2, ..., x_m \right\}$$

$$R_{m_i} \cap R_{m_j} = \varnothing \left(\forall m_i \ne m_j \right)$$

$$sign(x_m) = \begin{cases} 1\left(x_m \ge 1\right) \\ 0\left(\text{other}\right) \end{cases}$$

3. Genetic Algorithm

3.1 Basic Concept

The basic operation process of the genetic algorithm is reproduced below. It contains six essential elements:

a) Initialization: Set the evolution algebra counter t=0, set the maximum evolution algebra T, and randomly generate M individuals as the initial population P(0).

b) Individual evaluation: Calculate the fitness of each individual in the population P(t).

c) Select the operation: Apply the selection operator to the group. The purpose of the selection is to directly infer the optimized individual to the next generation or to create a new individual through pairing to regenerate to the next generation. The selection operation is based on the fitness assessment of the individual in the group.

d) Crossover operation: The crossover operator is applied to the population. The core function of genetic algorithms is the crossover operator.

e) Variation operation: The mutation operator is applied to the population. That is, changes in the gene value at certain loci of individual strings in a population. The population P(t) is subjected to selection, crossover, and mutation operations to obtain the next generation population P(t+1).

f) Termination condition judgment: If t=T, the individual with the greatest fitness obtained in the evolution process is output as the optimal solution, and the calculation is terminated.

3.2 Logistics Path Optimization Based on Genetic Algorithm

a) Initialization

In this section, we use binary code, and use 0 for the distribution center and 1 for a user. There are M vehicles in the distribution center. Therefore, that means there are M distribution routes at most. And each of them starts at the distribution center and finally reaches the distribution center. Thus, N “1” or M -1 “0” are randomly arranged into a chromosome of N + M -1, which is commensurate with a distribution path scheme.

b) Individual evaluation

Randomly generate a sequence of N “1” and M -1 “0” to form a chromosome. Set the population size to W, which means there are W different chromosomes constitute the initial population.

c) Select the operation

ISSN 2616-5775 Vol. 2, Issue 1: 155-161, DOI: 10.25236/AJCIS.010030

To judge the distribution path scheme corresponding to a certain chromosome, it is necessary in order to see whether it can satisfy the constraints of the distribution and calculate the objective function value [8].

The coding method should guarantee that each user has to deliver the service and each user has only one vehicle delivery constraint, but cannot meet the sum of theuser demand on each route does not exceed the vehicle load and each. The length of the delivery route is not greater than the constraint of the maximum distance traveled by the vehicle at one time. Therefore, for each distribution path scheme corresponding to each chromosome, each path should be judged one by one to see if it can satisfy the constraint condition: if it is not satisfied, the path is an infeasible path and its objective function value is calculated.

For a certain chromosome, the number of infeasible paths of the corresponding distribution path scheme is W_i(W_i=0 means that the individual corresponds to a feasible solution). The objective function value is P, then the fitness of the individual can be expressed as follows:

$$N_j = 1/(W_j G + P_j)$$

G is the weighting factor.

d) Crossover operation

N chromosomes in each generation are classified in order of fitness from large to small. The most adaptive chromosome, copy directly into the next generation. Then, according to the fitness of the N chromosomes of the population, the roulette method is used to generate another N-1 chromosomes of the next generation population [9]. This method is to calculate the sum of all chromosome fitness in the population ($\sum N_j$); then calculate the proportion of fitness of each chromosome ($N_j/\sum N_j$) as its chosen probability P_{si}.

e) Variation operation

The new population is produced by the selection operation. In addition to the original chromosome, the other N-1 chromosomes are cross-paired according to the crossover probability Pc. The two-point intersection method is employed in the paper.

f) Termination condition judgment

Moderate variation can not only maintain the diversity of individuals within the population, but also improve the efficiency of genetic algorithms. The following variation methods are used in the text. According to the probability of mutation, once a gene fragment of a chromosome needs to be mutated, another fragment on the chromosome also has to mutate at the same time.

4. Experiment

In this section, we calculated the following example:

ISSN 2616-5775 Vol. 2, Issue 1: 155-161, DOI: 10.25236/AJCIS.010030

A distribution center delivers goods to 8 users with 2 vehicles. Set the load of the vehicle to 8 × 103kg. The maximum driving distance for each delivery is 40km. The distance between the distribution center and the user, the user and the user, and the demand of each user are given in Table 1.

Table1. The distance between the distribution center and the user /km and the needs of each user

i	j								
	0	1	2	3	4	5	6	7	8
0	0.0	4.0	6.0	7.5	9.0	20.0	10.0	16.0	8.0
1	4.0	0.0	6.5	4.0	10.0	5.0	7.5	11.0	10.0
2	6.0	6.5	0.0	7.5	10.0	10.0	7.5	7.5	7.5
3	7.5	4.0	7.5	0.0	10.0	5.0	9.0	9.0	15.0
4	9.0	10.0	10.0	10.0	0.0	10.0	7.5	7.5	10.0
5	20.0	5.0	10.0	5.0	10.0	0.0	7.0	9.0	7.5
6	10.0	7.5	7.5	9.0	7.5	7.0	0.0	7.0	10.0
7	16.0	11.0	7.5	9.0	7.5	9.0	7.0	0.0	10.0
8	8.0	10.0	7.5	15.0	10.0	7.5	10.0	10.0	0.0
$q_j(t)$	----	1	2	1	2	1	4	2	2

The following parameter values were employed in the experiment: population size W was 50, crossover probability Pc was 0.65, mutation probability was 0.005, and termination algebra T was 100. The weight factor is 100km. We used C language to execute 10 times, and got the calculation results as following Table 2.

Table2. Calculation results

Calculation order	1	2	3	4	5	6	7	8	9	10
Total delivery distance P/km	72.0	72.0	76.5	70.0	67.5	70.0	73.5	75.0	71.5	69.0

From Table2, the 5th operation obtained the optimal solution of 67.5km, and its corresponding delivery path scheme is: 1 -1 -1-0 -1 -1 -1 -1 -1 -0 (the specific delivery path is 4 -7 -6 -0 -2 -8 -5 -3 -1).

ISSN 2616-5775 Vol. 2, Issue 1: 155-161, DOI: 10.25236/AJCIS.010030

5. Conclusion

This paper takes care of Application of genetic algorithm in logistics path optimization. Experiments show that the mathematical model of optimizing the logistics distribution path is first established, and then the genetic algorithm is utilized to optimize the solution, which can quickly and effectively find the optimal solution for optimizing the logistics distribution path. This method can be applicable to data mining and create logistics transportation system.

References

[1] Dantzig, George Bernard; Ramser, John Hubert (October 1959). The Truck Dispatching Problem. Management Science. 6 (1): 80－91.

[2] Li Xiangyang.Genetic Algorithms for VRP Problem[J].Computer Engineering and Design, 2004,25(2): 271-276. [3] Paolo Toth，Daniele Vigo. THE VEHICLE ROUTING PROBLEM[M]. Society for Industrial and Applied Mathematics philadephia.2002.

[4] Zhu Chongjun, Liu Min, Wu Cheng. Research Progress and Prospect of Vehicle Routing Problem in Supply Chain [J]. Computer Integrated Manufacturing System－CMS.2001,7(11):1-6.

[5] MBA think tank encyclopedia. Vehicle routing problem [EB/OL]. https://wiki.mbalib.com/wiki/vehicle routing problem,2016-11-09.

[6] J.H.Holland. Adaptation in Natural and Artificial Systems[M]. University of Michigan Press, Ann Arbor, 1976.

[7] Li Zhengyan. Research on Logistics Transportation System Based on Data Mining [D]. Chongqing University,2010.

[8] Tian Shaoliang, Zuo Ming and Wu Shaowei. An improved load balancing algorithm based on dynamic feedback [J]. Computer engineering and design. 2007. 28(3): 572-573.

[9] Peiming. Research on Some Key Problems of Massive Data Processing in Grid Environment [D]. Beijing: Institute of High Energy Physics, Chinese Academy of Sciences,2007: 72-75.