Adaptive Path Optimization of Logistics and Distribution Based on Genetic Algorithm

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Abstract. Designing a logistics network adjustment plan will better ensure the normal operation of the logistics network. Based on the analysis of logistics freight data, when a certain station (DC-5 station is selected in this paper) is shut down, the cargo volume of the relevant line of the site is allocated to other lines and constructed, the impact on the logistics network is dynamically analyzed, and the path optimization problem of automatic acquisition and adaptive adjustment of search direction is carried out based on genetic algorithm without given conditions, and the optimal path allocation scheme is found. Keep as few lines as possible that change in volume before and after this site goes down, and keep the workload of each line as balanced as possible.

Keywords: Path Optimization, Genetic Algorithm, Logistics.

1. Introduction

Logistics operation consumes a huge amount of capital, if not carried out scientific prediction and analysis in advance, not only will cause a waste of funds, planning will also lack rationality and scientificity, logistics network consists of different logistics sites and transportation lines[1-3].

If some sites are temporarily or permanently deactivated, based on the historical freight data and the processing capacity of each logistics site and the load capacity of different routes, design a logistics network adjustment scheme[4], so that the goods at the shutdown site can be distributed to other lines for normal circulation, and the load of each line is fully considered to make the workload of the entire logistics network structure as balanced as possible, and the normal operation of the logistics network can be better guaranteed[5-9]. Therefore, the content explored in this article is not only practical in terms of life, but also has a certain cutting-edge.hypothesis**:** The historical maximum freight volume per route is the maximum load of the route[10].

2. The establishment and solution process of genetic algorithm

2.1. Introduction of genetic algorithms

Darwin famously said, "Natural selection, survival of the fittest." "It means that the more individuals in the population adapt to the environment, the more they can continue to reproduce and pass on excellent genes." Genetic algorithm is a data calculation model that simulates the biological evolution and the changing process of gene pool of natural selection and genetic mechanisms (such as variation and crossover) of Darwin's theory of biological evolution, and is a method for searching for optimal solutions by simulating the succession of natural selection and species evolution.

The main feature of genetic algorithm is that it directly processes the structural objects in the population, and there is no mathematical derivative calculation and whether the function is continuous; Therefore, it has inherent implicit parallelism and a better way to explore the optimal solution in the overall environment; It is very in line with the needs of path optimization in our logistics and transportation problems. We use the given probabilistic method of finding the optimal solution, which automatically obtains and guides the optimized search space without constraints, and automatically adjusts the prediction direction.

The genetic algorithm takes all individuals in a population as the object, and after using the given probability, the randomization technique under the condition of a fixed probability guides the efficient calculation exploration of a coded algorithm model and space. Among them, selection, crossover, and variation constitute the genetic behavior of changing genetic diversity in genetic algorithms and are also our operations; The five elements of parameter setting, initial population restriction, exploration and determination of fitness function, operation and setting of genetic behavior, and operation of control parameters in the algorithm model constitute the core content of the genetic algorithm. And its mode of operation is shown in Figure 1

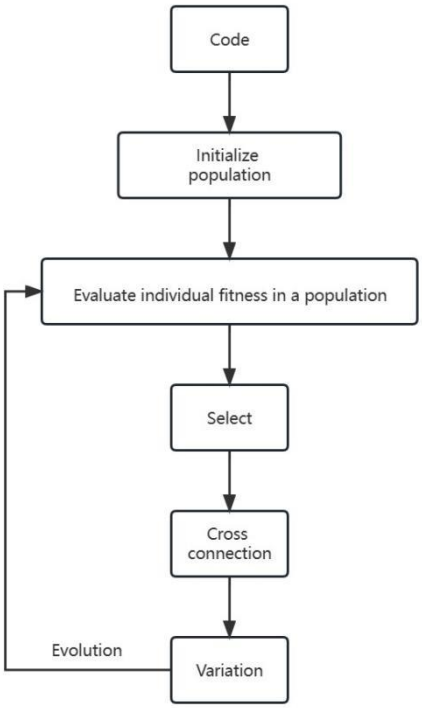

Figure 1. The Basic Process of Genetic Algorithm

2.2. Introduction of relevant concepts and parameters

Simple genetic algorithm(abbreviated SGA)is a large-scale individual operation setting behavior, the operation to a large number of individuals as the unit of operation, the use of simple genetic operator: selection operator, crossover operator and mutation operator, its genetic evolution and gene pool change and optimization of the operation process is simple, in line with Darwin's theory of biological evolution, easy to understand, is the source of some other genetic algorithms, we based on the characteristics of the simple genetic algorithm can obviously find that it is very suitable for solving our logistics and transportation process, SGA not only provides a basic framework for various genetic algorithms, but also selects, crossovers and variation are the three main operators of genetic algorithms, which constitute genetic operations and behavioral operations of gene pool changes, and we can use these three operations to algorithmically convert the problems we need to solve and write an operable code based on MATLAB for path optimization modeling work.

It is represented as follows:

$$SGA = (C,\ E\ ,p_0\ ,M\ ,\phi\ ,\Gamma,\ \psi\ ,\ T) \tag{1}$$

In the above formula:

C means an individual's coding scheme; E means the individual fitness evaluation function; p_0 means the initial population; M means indicates population size; ϕ means selection operator; Γ means crossover operator; ψ means mutation operator; T means a genetic algorithm termination condition.

2.3. Processing of data

This topic requires us to update and upgrade the distribution route, is a typical problem of finding the optimal distribution route, we can take the amount of goods carried as the length of the transportation route, the larger the amount of goods carried on the line, it can be considered that the longer the distance of this route transportation, the longer the transportation time that needs our distribution, that is, the load situation of the route is more serious, we need to comprehensively consider the load of each route and consider different logistics sites to find the shortest path problem, This makes it possible to reduce the load on the individual routes, optimize distribution concepts and have a small impact on the overall logistics network (fewer lines that change the transport situation).

We take each site in the problem as a starting point in turn, and construct the adjacency matrix B of the place according to the logistics and distribution relationship. Direct volumes between locations are represented in the adjacency matrix, where; Firstly, take the weighted adjacency matrix B as the initial value of the quantity matrix M, that is, M(0)=B ;Add a new transfer station to the initial routing route, and if the resulting new route is shorter than the original route, replace the original route with the new route. This is produced sequentially $M^{(k)} = (d_{ij}^{(k)})_{m\times n}$, i.e., the kth matrix $d_{ij}^{(k)} = min\left\{d_{ij}^{(k-1)}, d_{ik}^{(k-1)}+d_{lj}^{(k-1)}\right\}$;

During the operation, k starts from 1, and the coefficients i and j traverse from 1 to n, respectively, until it stops when k = n. The established adjacency matrix is repeatedly overlapped and optimized, and the optimal solution is retained, and when the last iteration is over, the minimum path value between any two logistics stations can be calculated, which is the distribution scheme with the lowest load. The Floyd algorithm is solved by MATLAB to obtain the shortest path matrix B of any two towns.

$$\begin{pmatrix}
0 & 72 & 98 & 133 & 54 & 105 & 55 & 83 & 79 & 140 & 26 & 50 & 121 & 115 \\
72 & 0 & 56 & 97 & 18 & 69 & 52 & 74 & 66 & 111 & 98 & 90 & 108 & 102 \\
98 & 56 & 0 & 123 & 44 & 95 & 78 & 100 & 92 & 137 & 124 & 116 & 134 & 128 \\
133 & 97 & 123 & 0 & 79 & 28 & 113 & 111 & 55 & 70 & 108 & 84 & 97 & 91 \\
54 & 18 & 44 & 79 & 0 & 51 & 34 & 56 & 48 & 93 & 80 & 72 & 90 & 84 \\
105 & 69 & 95 & 28 & 51 & 0 & 85 & 83 & 27 & 42 & 80 & 56 & 69 & 63 \\
55 & 52 & 78 & 113 & 34 & 85 & 0 & 36 & 65 & 126 & 62 & 38 & 107 & 101 \\
83 & 74 & 100 & 84 & 56 & 56 & 36 & 0 & 29 & 90 & 57 & 33 & 71 & 65 \\
79 & 66 & 92 & 55 & 48 & 27 & 67 & 56 & 0 & 61 & 53 & 29 & 42 & 36 \\
140 & 111 & 137 & 70 & 93 & 42 & 127 & 117 & 61 & 0 & 114 & 90 & 72 & 25 \\
26 & 98 & 124 & 108 & 80 & 80 & 62 & 57 & 53 & 114 & 0 & 24 & 95 & 89 \\
50 & 90 & 116 & 84 & 72 & 56 & 38 & 33 & 29 & 90 & 24 & 0 & 71 & 65 \\
121 & 108 & 134 & 97 & 90 & 69 & 109 & 98 & 42 & 72 & 95 & 71 & 0 & 47 \\
115 & 102 & 128 & 91 & 84 & 63 & 103 & 92 & 36 & 25 & 89 & 65 & 47 & 0
\end{pmatrix}$$

2.4. Establishment of genetic algorithm model

In the assignment operation for the individual attributes of logistics goods, we choose the most easy-to-understand random method construction, and leave the optimization of the results to the search process of the genetic algorithm. When establishing the initial individuals of the population, we need to pay attention to ensure the difference of the population, that is, the similarity between each individual cannot be too high, otherwise the mutation rate of the offspring individuals will be insufficient.

First of all, in our thinking on this problem, we think that in the process of establishing the initial individuals of our "population", the diversity of genes needs to be considered, which is also our preconceived guessing work for the mutation of the gene pool and the change of gene frequency, and the gene sequence between each individual cannot be too similar, otherwise the variation and optimization of the gene pool cannot be guaranteed.

Secondly, we have pre-processed the data, and the required delivery time for each logistics route is our purpose function, and the logistics vehicle passes through all logistics transshipment locations as our requirement. The objective function is established as:

$$min\ f\ (\pi_1, \pi_2, \ldots, \pi_{14}) = \sum_{i=1}^{13} d_{\pi_i \pi_{i+1}} \tag{2}$$

We encode the route of each logistics vehicle as a gene, use VS's strand(time[(NULL)]) function to generate a set of random number sequences so that each random number in this series has a mapping relationship with each genome in our population, for the assignment operation of the individual attributes of logistics goods, we choose the most easy for us to understand the random method construction, and the optimization of the results is handed over to the search process of the genetic algorithm.

After solving the construction of the initial population (initial solution set), the next step is the core design of the genetic algorithm, which operates on the above three operators in the algorithm.

In Genetic Crossover, we design the first two operators, and we also need to evaluate and screen the individual fitness of the population. For the selection of the parent node, you can randomly select two different ones, or you can select the roulette wheel according to the degree of excellence, this article chooses the second method to select the parent node for roulette. The use of sequential crossover for gene recombination allows us to obtain better mutant individuals in many cases, which is conducive to improving the genetic diversity of the gene pool. The mutation process uses the probability of a given mutation, cross-mutation, randomly selects individuals with genetic mutations for gene exchange, and avoids duplication in the logistics site. Through a large number of iterations, the optimal path scheme is obtained. The following formula can be used to calculate the fitness of individual sequences to the environment.

$$fitness(i) = \frac{1}{f} \tag{3}$$

For the output results to continuously optimize the best optimization route and distribution scheme in the logistics process, we correspond to the probability of being selected by the adaptability of each individual discussed above to the environment, and the individuals with high environmental fitness (with excellent genetic characteristics) are screened and those with low environmental suitability are eliminated. The probability of an individual being selected is calculated by a formula.

$$p(i) = \frac{fitness(i)}{\sum_i fitness(i)} \tag{4}$$

After the above selection process, we selected outstanding individuals, and many favorable genetic traits were retained by us. Compared with our problem, that is, our path optimization operation, the optimized path transportation scheme was retained by us.

3. Result

3.1. Data from

Data from http://www.mathorcup.org/.

3.2. Training and solving of genetic algorithm models

Table 1: Genetic algorithm parameter settings

numbering	parameter	numeric value
1	Number of gene pool individuals	100
2	Maximum number of evolutions	100
3	Crossover chances	0.9
4	Chance of mutation	0.05
5	Logistics transport vehicles	1

We set the parameters of the genetic algorithm, and the parameter values are shown in Table 1, we take the previous discussion as the benchmark, and the performance of the solution space is th e ordinate, and the training curve of the genetic algorithm is shown in Figure 2:

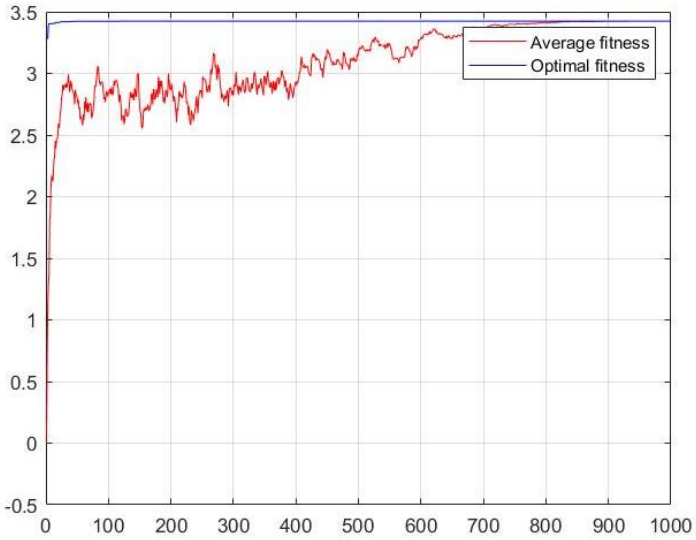

Figure 2. For the training results of the algorithm

We continue to change the number of iterations of the algorithm, and the relationship between the number of iterations and the running time is shown in the figure below, and we can see that when the number of iterations of the genetic algorithm reaches 800, the optimal solution has been solved. That completes our quest.

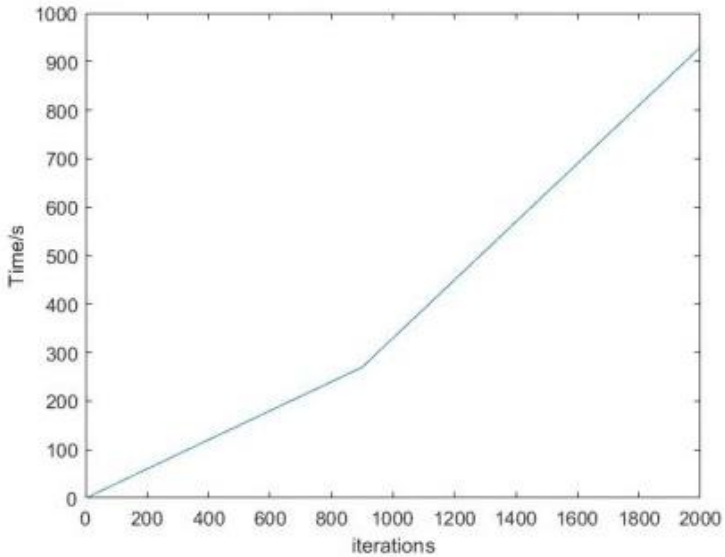

Figure 3. Genetic algorithm runtime

We change the number of iterations of genetics, and the relationship between iteration and running time is shown in Figure 3, which can be seen.that the running time of the algorithm model is approximately proportional to the number of iterations at the beginning, and the running time will increase more rapidly when the number of iterations increases.

3.3. Conclusion

We set the upper limit of the number of iterations to 2000, and it is easy to conclude from the running chart that when the number of iterations reaches 800, the optimal fitness has been reached, and the optimized distribution scheme is found.After 1000 iterative calculations with the genetic algorithm, the optimal scheme sequence is obtained: 9-13-14-10-6-4-6-5-3-2-5-7-1-11-12-8-9.

The genetic algorithm model we established can be applied to the current hot logistics industry, which is convenient for managers to arrange transportation, sorting and other plans, when some sites are temporarily or permanently disabled, based on the calculation results of the algorithm model and the processing capacity of each logistics site and the transportation capacity of the line, the design of logistics network adjustment scheme will better ensure the normal operation of the logistics network, thereby reducing operating costs and improving operational efficiency.

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