Research on Intelligent Transportation Logistics Technology Based on Energy Saving and Emission Reduction

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Abstract. Through the analysis of the relationship between logistics and economy, energy and environment, a mathematical model for the path optimization of multiple logistics distribution centres for energy conservation and emission reduction in logistics is established. According to the characteristics of the problem, a genetic algorithm is constructed to solve the problem, and the path optimization problem of multiple logistics distribution centres is integrated and solved by a mathematical model. This thesis establishes a mathematical model of the path optimization problem of multiple logistics distribution centres. This article proposes the concept of invalid genes, which is not limited to making every gene in an individual must be expressed, thus enhancing the flexibility of coding. Simulation experiments prove the effectiveness and operability of the method.

Key words: Logistics engineering; energy saving and emission reduction; genetic algorithm; logistics distribution.

1. Introduction

In recent years, driven by a series of national policies and market demand, my country's logistics industry has continued to develop rapidly, and the environmental and energy problems brought by it have become increasingly prominent. In the face of the worldwide demand for environmental protection, the Chinese government has clearly put forward energy-saving and emission-reduction targets during the planning period in the Copenhagen Conference, the National "Twelfth Five-Year Plan" and the "Twelfth Five-Year Plan" of the Ministry of Transport. In view of the interaction between my country's logistics and economy, energy, and environment, many domestic scholars have analysed it and put forward policy recommendations for energy conservation and emission reduction in my country's logistics industry, but most of them are qualitative studies or only study logistics and economics. The quantitative relationship between, energy and environment.

Logistics distribution is an extremely important link in logistics management. It refers to the activities of distributing and distributing goods in the distribution centre according to the user's order requirements, and delivering the matched goods to the consignee in time. Logistics distribution mainly studies vehicle scheduling and routing issues [1]. In recent years, scholars at home and abroad have conducted a lot of research on logistics distribution problems, and these studies mainly focus on the vehicle scheduling
and route arrangement of single logistics distribution centres. Since the distribution route optimization problem is an NP problem, most researchers use heuristic algorithms and intelligent algorithms or add optimization strategies in the intelligent algorithm optimization process to construct hybrid intelligent algorithms to solve the logistics distribution problem. However, at present, there are few research results on the logistics distribution problems of multiple logistics distribution centres at home and abroad, and most of the existing research results are to study the problems of multiple distribution centres into a single logistics distribution centre problem through task assignment. The method divides the demand points into each distribution centre in advance, and then makes appropriate adjustments during the solution process. This method is actually just a simple combination of single logistics distribution centre optimization, and usually only an approximate optimal distribution plan can be obtained.

Because genetic algorithm has good global optimization performance, and does not require continuous search space, this is in line with the characteristics and requirements of the problem. Therefore, this paper also uses genetic algorithm to solve. Based on the overall path optimization, multiple logistics distribution centres serve multiple demand points at the same time to establish a general multi-logistics distribution centre distribution model, and give a solution algorithm. The route optimization problem of a single logistics distribution centre can determine in advance the number of vehicles that need to be dispatched, but in the route optimization problem of multiple logistics distribution centres, how many vehicles need to be dispatched by each distribution centre is uncertain. Therefore, conventional methods cannot be used to determine the length of chromosomes. In order to solve the problem of gene coding, this paper proposes the concept of invalid gene [2]. The so-called invalid gene is a gene that is not expressed during a gene expression process. However, in the crossover process, the invalid gene can be selected as the crossover point, and the invalid gene may be transformed into an effective gene after the crossover. Therefore, some genes are invalid genes when they are effective genes, and invalid genes act as a buffer when it is not clear whether some genes are well expressed.

2. Model establishment
The problem of multi-logistics distribution path optimization can be described as: deliver goods from multiple distribution centres to multiple demand points with multiple delivery vehicles. Each demand point has a certain location and demand. It requires a reasonable distribution route to maximize the objective function. Excellent or close to optimal. In order to facilitate the research and have practical significance, the following assumptions are made: (1) The sum of the demand at each demand point on each distribution route does not exceed the carrying capacity of the delivery vehicle; (2) Each demand point must be met and only can be delivered by a delivery vehicle.

The various symbols and their meanings in this article are explained as follows: M represents the number of distribution centres; i represents the subscript of the distribution centre; j represents the subscript of the delivery vehicle; k represents the subscript of the demand point; N represents the number of demand points; \( i_{L} \) represents the number of delivery vehicles in the i distribution centre; \( i_{j}Q \) represents the load capacity of the j vehicle in the i distribution centre; \( k_{q} \) represents the demand at the k demand point; \( d_{k}^{(1)}d_{k}^{(2)} \) represents the demand point k(1) The haul distance to k(2); \( d_{k}^{n} \) represents the haul distance from the distribution centre to the demand point k; F represents the number of demand points delivered by the j vehicle in the i distribution centre; \( n_{j}=0 \) represents the j vehicle is not used; \( R_{j} \) the delivery path of the j vehicle in the i distribution centre; \( r_{jk} \) represents the k demand point of the j vehicle in the i distribution centre, and \( r_{jk}=0 \) represents the distribution centre.
\[ Q = \min Q_j, i = 1, 2, \ldots, M; j = 1, 2, \ldots, L_j \]

\[ n = \left\lceil \frac{\sum_{k=1}^{N} q_k}{Q} \right\rceil + 1 \]  

(1)

Among them, \( \lceil \cdot \rceil \) represents the largest integer not greater than the number in parentheses. If the shortest distribution path is taken as the objective function, the following optimization model of the distribution path can be established:

\[ \min Z = \sum_{i=1}^{M} \sum_{j=1}^{L_i} \left( \sum_{k=1}^{n_{ij}} d_{(i-1)k} + d_{q_jq_{n_{ij}}} f(n_{ij}) \right) \]

(2)

\[ \sum_{k=1}^{n_{ij}} q_{kij} \leq Q_j \]

(3)

\[ 0 \leq n_{ij} \leq N \]

(4)

\[ \sum_{i=1}^{M} \sum_{j=1}^{L_i} n_{ij} = N \]

(5)

\[ R_j \in \{ r_{qk} | \ r_{qk} \in [1, 2, \ldots, N], k = 1, 2, \ldots, n_j \} \]

(6)

\[ f(n_{ij}) = \begin{cases} 1 & n_{ij} \geq 1 \\ 0 & \text{otherwise} \end{cases} \]

(7)

3. Genetic Algorithm Design

3.1. Determination of coding method and generation of initial population

According to the characteristics of the path optimization problem of multiple logistics distribution centres, the author proposes a coding method that directly arranges distribution centres and demand points. This representation method is to directly produce N non-repeating natural numbers between 1-N to encode the N demand points, and then to produce M non-repeating negative integers between M-1 to encode the M distribution centres. Combine each of the M non-repeating negative integers between M-1 and each of the N non-repeating natural numbers between 1-N to form a sequence of length n*M+N. One position is randomly arranged with a negative integer, and the remaining positions are arranged randomly, that is, a chromosome is formed [3]. Randomly generate m such individuals to form an initial population with a population size of m. Figure 1 shows the basic flow of genetic algorithm.
Figure 1. The basic process of genetic algorithm

Such a chromosome structure can be explained as: starting from the distribution centre corresponding to the negative number, delivering to the demand points corresponding to several positive numbers immediately following the negative number, and then returning to the distribution centre to form a sub-path [4]. A negative number that is not immediately followed by a positive number is an invalid gene and does not mean anything, but crossover operations can be performed at this gene. If the negative number is followed by a positive number after the crossover, the negative number changes from an invalid gene to an effective gene, and its meaning is the same as described in (1).

3.2. Determination of fitness assessment method
The fitness function is related to the objective function and requires non-negative. The fitness function is obtained by transforming the objective function: \[ f_i = \frac{b z'}{z_k} \]. Among them, \( b \) is a constant, \( z' \) is the best chromosome delivery distance in the initial population, and \( z_k \) is the delivery distance corresponding to the current chromosome.

3.3. Select operation.
This paper adopts the following selection strategy that combines the best individual retention and the selection of the gambling wheel: arrange the \( m \) individuals in each generation group from large to small in terms of fitness, and the first individual with the best performance, copy it [5]. Enter the next generation directly and rank first; the other \( m-1 \) individuals of the next generation group need to be based on the fitness of \( m \) individuals of the previous generation group.

3.4. Cross operation
For the new population generated by the selection operation, in addition to the best one in the first place, the other \( m-1 \) individuals should be paired and cross-recombined according to the crossover probability \( P_c \). In this paper, the OX-like method is used to implement the crossover operation. The operation process is: If the two genes at the chromosome crossover point are both negative, then the order-based
crossover is used directly; if the genes at the chromosome crossover point are not all negative, then Move the intersection to the left (shift right) until the genes at the left and right intersections are negative, and then perform operations. For example:

Father 1: 1, 4, 1, 2, 3, 4, 5, 5.

Father 2: 5, 1, 3, 1, 5, 2, 4, 4, 2, 1, 3, 3, 5, 5.

| | is the matching segment, which is formed after the maximum retention crossover operation.

Offspring 1: 1, 1, 4, 4, 2, 1, 2, 3, 3, 5, 5.

Offspring 2: 5, 1, 3, 5, 2, 4, 1, 2, 1, 4, 3.

3.5. Mutation operation

Because the method of retaining the best individuals is adopted in the selection mechanism, in order to maintain the diversity of individuals in the group, this paper uses the mutation technique of multiple consecutive swaps to make the individual arrangement order have greater changes [6].

3.6. Termination criteria

Use the best individual to retain the termination pass of the specified number of generations, that is, if an individual is the best individual for several consecutive generations, indicating that the individual is a good individual, stop the operation.

4. Simulation experiment

This paper uses MATLAB to compile a genetic algorithm calculation program for the path optimization problem of multiple logistics distribution centres. Calculation example: There are two distribution centres each with two distribution vehicles delivering to 9 demand points, and the carrying capacity of the distribution vehicles is 10 tons [7]. The distance $d_{ki}^{(1)} d_{ki}^{(2)}$ between the distribution centre (numbered 1 and 2) and the demand point and between the demand points, and the demand of 9 customers are shown in Figure 2. It is required to arrange a reasonable distribution route so that the total distribution route is the shortest.

| $d_{ki}^{(1)}$ (km) | $d_{ki}^{(2)}$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|------------------|----------------|---|---|---|---|---|---|---|---|---|
| 1                | 0              | 10| 6 | 12| 4 | 10| 4 | 6 | 10| 13| 3 |
| 2                | 0              | 12| 8 | 12| 4 | 6 | 8 | 4 | 9 | 9 | 9 |
| 1                | 0              | 13| 5 | 11| 8 | 9 | 13| 10| 6 |
| 2                | 0              | 15| 10| 10| 8 | 10| 5 | 11|
| 3                | 0              | 10| 6.5|10| 11| 14| 6 |
| 4                | 0              | 3 | 7 | 3 | 10| 8 |  |
| 5                | 0              | 5 | 7 | 12| 7 |  |
| 6                | 0              | 8 | 8 | 4 |  |
| 7                | 0              | 12| 10|  |
| 8                | 0              | 10|   |  |
| 9                | 0              |   |   |  |

$g_k \ (1)$

Figure 2. Known conditions of the calculation example

According to the characteristics of the calculation example, the following parameters are used when solving it with the genetic algorithm: the population size is 25, the evolution algebra is 100, the crossover probability is 0.9, the mutation probability is 0.01, and the penalty weight for the infeasible path is 100km. Solve the calculation example 10 times, and the calculated results are shown in Table 1.

| Calculation order | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Average |
|-------------------|---|---|---|---|---|---|---|---|---|----|---------|
| Total delivery distance (km) | 67| 64| 68| 70| 64| 68| 64| 67| 68| 64 |         |
| The algebra of the first search to the final solution | 43| 38| 36| 42| 53| 57| 49| 51| 48| 52 |         |
It can be seen from Table 1 that out of the 10 times of solving the calculation example with the genetic algorithm, the optimal solution of the problem 64km was obtained 4 times (the corresponding distribution route plan is: route 1:1,1,3,1; Path 2: 1, 5, 6, 9, 1; Path 3: 2, 4, 7, 2; Path 4: 2, 2, 8, 2). The approximate optimal solution of the problem is obtained 6 times. This method solving the path optimization problem of multiple logistics distribution centres is obviously better than solving the problem of multiple distribution centres into a single logistics distribution centre problem through task assignment.

5. Conclusion
This paper establishes a model of multiple logistics distribution centres, and designs a solution algorithm based on the characteristics of multiple logistics distribution centres. Since the number of trains that each distribution centre needs to dispatch is uncertain, the article uses invalid genes to solve the problem of inability to encode individuals due to the uncertainty of how many trains each distribution centre needs to dispatch. In this way, a mathematical model can be used to solve the distribution optimization problem of multiple logistics distribution centres. This method is better than the method of dividing the demand points into each distribution centre in advance to transform into a single logistics distribution centre solution. In the short-term analysis of energy conservation and emission reduction in the logistics industry, in addition to strengthening the national environmental pollution control, it can also reduce energy consumption and CO2 emissions by adjusting fuel surcharges and levying carbon taxes on CO2 emissions. Based on the analysis of industry taxation situation and business status, the logistics industry is still in its infancy and rapid transformation stage, and the implementation strategy of fiscal and taxation policies needs further study. From the mid-term analysis, in addition to adjusting the proportion of transportation methods, it is necessary to reduce the energy consumption of each transportation method.

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