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# The Application of GA in the location of Third-party logistics center

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**Abstract:** With the development of modern logistics systems, distribution centers play an increasingly important role. Facing the planning stage, third-party distribution center location problem is the primary challenge, and it is the most complex problem. On the distribution center location problem, genetic algorithm has received increasing attention in recent years. Innovation of this article is based on specific location issues and redesigns the algorithm encoding. By setting different parameters, the results are compared with different analysis and then we achieve the optimal solution.

**Key word:** Third-party distribution Center; Location problem; genetic algorithm

Distribution center as a node of the whole logistics distribution network, its geographical location is very important. Therefore, a reasonable logistics distribution center location becomes necessary. Under the influence of the distribution of commodity resources, demand conditions, as well as transportation and other natural conditions, different layout options may make the different cost of the entire logistics system, so under the objective conditions, the correct selection of the specific location of distribution centers can effectively save the cost of whole logistics system and guarantee the balanced development of the logistics system. [1] In recent years, genetic algorithm in distribution center site selection has accepted more attention. Li Junqi [2] combined the physical model, proposed hybrid parallel codes coding idea and achieved faster processing speeds. Liu Hailong [3] designed a fuzzy random simulation genetic algorithm and had been dealing with uncertainty problems. Trevor S. Hale [4] summarized advantages of genetic algorithm in application of location. In addition, there are other literatures that analyzed the effectiveness of genetic algorithm. [5-7]

This paper redesigns the encoding according to the specific sitting issue and through different setting of parameters, compares the result and obtains the optimal solution with analysis of specific example.

## 1. Model design

Now the distribution center services range is wide, generally not only for a single demand point, but also distribution center project cost spends more and generally for the varieties goods. For the convenience of solving practical problems, this paper considers only the transportation cost and the construction cost from distribution center to users, and makes goods for single variety.

Specific assumptions are as follows:

(1) only consider the new distribution center in certain range of optional; (2) transportation cost is proportional to the amount;(3) a distribution center can service multiple demand points, a demand point just only served by a distribution center; (4)

distribution center capacity can satisfy the demand; (5) all demand is certain known; (6) the requirements of goods once completes transportation; (7) system total cost does not consider distribution center storage costs, only consider fixed construction cost and transportation cost.

Objective function:

$$\min E = \sum_{i=1}^{m}\sum_{j=1}^{n} h_{ij} X_{ij} + \sum_{i=1}^{m} F_i Z_i \qquad (1.1)$$

Constraint conditions:

$$\sum_{j=1}^{n} X_i \leq M_i \ , \quad i = 1,2,\ldots,m \quad (1.2) \qquad\qquad X_{ij} \geq D_j \ , \quad i = 1,2,\ldots,m; j = 1,2,\ldots,n \quad (1.3)$$

$$Z_i = \begin{cases} 1, & if\ i\ to\ be\ selected \\ 0, & if\ i\ not\ to\ be\ selected \end{cases}, \quad i = 1,2 \quad (1.4) \qquad\qquad X_{ij} \geq 0 \ , \quad i = 1,2,\ldots,m; j = 1,2,\ldots,n \quad (1.5)$$

All above formula's symbol table is as follows:

Table 5.1 Symbol Notes

| Symbol | Symbol Notes |
|---|---|
| M | The number of alternative distribution center points |
| N | The number of demand points |
| $X_{ij}$ | The traffic from the distribution center i to demand point j |
| $Z_i$ | Integer variable |
| $M_i$ | Capacity of optional distribution center i |
| $h_{ij}$ | the unit transport cost from i to j |
| $F_i$ | construction cost of distribution centers |
| $D_j$ | Demand quantity of demand point j |

Type of 1.2 said the amount transportation quantity of selected distribution center i cannot exceed its capacity; Type of 1.3 said the traffic distribution center to demand point i should meet its demand quantity.

**2. Algorithm described**

The basic idea in this paper is according to the certain information of demand points, considers distribution and construction cost of optional distribution center by genetic algorithm, which shall choose the most saving solution according to distribution costs and construction costs.

Algorithm is respectively designed through the following steps:

Step1: encoding

On site selection encoding, due to the feature of logic decision variable individual $Z_i$, most researchers use traditional binary coding scheme, the individual 0110100 expresses 2,3,5 to be selected in seven alternative sites. But in addition, numeric type decision variable $X_{ij}$ not to be encoded, namely which user selects distribution center that served and the corresponding transportation quantities are not displayed. Therefore, except for binary code used to standing for the selected distribution center, the traffic variable also needs to be encoded, today mostly using floating-point coding so that it can combine both ways to achieve complete solutions. Thus, chromosome length will be increased and effects operation efficiency.

For this model, this paper considers another kind of coding method which with optional point numbers coding, demand point number n said chromosome length, the gene i in chromosome j said distribution center i provides services to demand point j, so a chromosome is chosen to represent for a optional solution, not only can say selected distribution center, and also say that it provides services for which demand points. At the same time as a demand point only served by a distribution center, the transportation quantity will draw. For example, individual 24254525 means the1,3,7 user in the first eight users are served by distribution center 2, the 2,5 served by distribution center 4, the 4,6,8 served by distribution center 5, thus selects point is 2,4,5.

Step2: fitness function design

For optimization problems, generally has two kinds, one kind is for the maximum objective function, the other is for the minimum objective function. Generally speaking, for these two types of questions, we can convert objective function to the fitness function. In this minimum value model, we should convert as follows:

$$F(X)=\begin{cases} C_{\max}-E & if\ C_{\max}-E\geq 0 \\ 0 & if\ C_{\max}-E<0 \end{cases} \quad (2.1)$$

$C_{\max}$ is as an appropriate relatively large number.

Existing constraints:

$$\sum_{j=1}^{n} X_i \leq M_i (i=1,2,....,m), \quad X_{ij}\geq D_j (i=1,2,...,m; j=1,2,...,n),$$

Due to the assumptions, a user only served by a distribution center, according to the front of the coding method, the traffic of chromosomes is definite, namely user demand quantity. So the last constraint condition may not be considered, while only consider a constraint conditions. Here specifically by introducing the penalty function method to realize the result. Make an assumption that $S_i = M_i - \sum_{j=1}^{n} X_i$ .The penalty function is P= -e*min $\{s_i\}$, e is as a penalty factor. After introducing the penalty function, the fitness functions as follows:

$$F(X)=\begin{cases}C_{\max}-(E+P) & if\ C_{\max}-(E+P)\geq 0\\ 0 & if\ C_{\max}-(E+P)<0\end{cases} \quad (2.2)$$

If the traffic capacity beyond, then $s_i \leq 0$, $\min\{s_i\} \geq 0$, $p \geq 0$, $F(X)$ will reduce; while traffic capacity not beyond, then $\min\{s_i\} \geq 0$, $p \leq 0$, $F(X)$ will increase or unchanged.

Step3: Choose operation

For selection strategy, this paper first determines the generation gap G, namely the proportion of father generation group by selected, and then chooses the roulette method, and the specific steps are as follows:

1. Calculate the sum of fitness value about all group chromosomes F: $F = \sum_{k=1}^{n} f_k$ .

2. Compute select probability for each chromosome $p_k : p_k = f_k / F, k = 1,2,\ldots,m.$

3. Compute accumulated probability for each chromosome $q_k : q_k = \sum_{j=1}^{k} p_j, k = 1,2,\ldots,m.$

4. Compute a random number r between 0 and 1, if $r \leq q_k$ , then choose the first chromosome, Otherwise, select the first k chromosome $v_k\ (k = 2,\ldots,n)$, make that $q_{k-1} < r < q_{k-1}$.Repeat 4 step, until the needed body is selected.

Step4: Crossover for each chromosome

Here cross the single point, chromosome string randomly generates a crossroads, then change the part of two interchangeable chromosomes. Specific implementation process is that randomly matches pairs for each individual, and set up a loci after crossing, then according to the crossover probability produces interchangeable parts in the intersection set, then achieves a new individual chromosome.

Step5: Mutation

The possibility of species variation is small, so in the genetic algorithm, mutation operation can only play a supporting role, specifically improve the performance of its local search capabilities. Based on the characteristics of the previous chromosome, here takes a more specific variation of methods, that we set a range for each chromosome, so that the natural number of individuals mutate through a specific method to obtain a new individual.

Step6: Control parameters and termination conditions

In the operation process of the genetic algorithm, a group of parameters have impact on the performance. Main parameters include chromosome group size N, gap G, crossover probability Pc and mutation probability Pm, etc. The general scope is respectively: N for 20 to 100, G for 0.1 ~ 1, Pc 0.4 ~ 0.99, Pm 0.0001~0.1. Termination conditions can be used to set the maximum iteration method, namely when iteration is smaller than the maximum iterations, then repeat genetic operation until get the maximum number of iterations, then output. Most of the iteration value range is generally 100 ~ 1000. For the parameters set of genetic algorithm, the better method is not fixed, so this paper analyzes the results of different control parameters by experiments, and combines the result of excellent parameter to achieve the optimal parameters.

## 3. Analysis of Example

### 3.1 Solving of the example

One distribution center needs to be build in somewhere to serve 30 users, each user's demand is certain and known.18 alternative points have been identified and construction costs and capacity are known as well, the unit transportation cost from users to the alternative points is known. The optimal location of distribution centers program needs to be chosen to make the total cost of transportation and construction expenses minimum. The known conditions are as follows (all data are generated randomly):

Table5.2 Optional construction costs (Yuan) and capacity (Tons)

| user | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| demand | 5 | 12 | 14 | 12 | 17 | 6 | 11 | 17 | 7 | 8 |
| user | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| demand | 18 | 7 | 24 | 30 | 21 | 10 | 17 | 3 | 26 | 24 |
| user | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| demand | 7 | 17 | 10 | 12 | 9 | 15 | 15 | 5 | 12 | 8 |

Table5.3 User demand (ten thousand tons)

| optimal Points | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| expense | 80 | 60 | 120 | 60 | 90 | 130 | 90 | 100 | 160 |
| capacity | 60 | 39 | 52 | 41 | 65 | 62 | 29 | 43 | 37 |
| optimal Points | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| expense | 70 | 90 | 150 | 70 | 80 | 110 | 90 | 100 | 70 |
| capacity | 98 | 16 | 28 | 37 | 19 | 48 | 33 | 95 | 92 |

Table5.4 Unit transportation expenses (ten thousand Yuan/ ten thousand tons)

| Optimal points / user | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6 | 5 | 7 | 7 | 7 | 1 | 1 | 3 | 6 | 4 | 5 | 9 | 8 | 10 | 3 | 4 | 2 | 5 |
| 2 | 8 | 5 | 1 | 3 | 2 | 3 | 5 | 4 | 5 | 7 | 5 | 9 | 7 | 1 | 5 | 7 | 3 | 7 |
| 3 | 7 | 1 | 3 | 3 | 7 | 9 | 4 | 6 | 7 | 9 | 6 | 10 | 10 | 10 | 3 | 5 | 5 | 7 |
| 4 | 4 | 8 | 5 | 1 | 2 | 8 | 5 | 8 | 4 | 1 | 7 | 4 | 3 | 2 | 7 | 8 | 2 | 8 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 1 | 6 | 7 | 6 | 5 | 7 | 7 | 2 | 7 | 7 | 2 | 8 | 3 | 2 | 10 | 5 | 5 | 3 |
| 6 | 8 | 2 | 7 | 5 | 9 | 9 | 3 | 7 | 6 | 10 | 3 | 8 | 4 | 8 | 7 | 7 | 5 | 7 |
| 7 | 6 | 3 | 6 | 8 | 6 | 10 | 3 | 7 | 2 | 6 | 9 | 3 | 4 | 2 | 6 | 8 | 10 | 7 |
| 8 | 2 | 8 | 7 | 1 | 6 | 6 | 9 | 2 | 4 | 1 | 5 | 5 | 4 | 2 | 9 | 5 | 9 | 8 |
| 9 | 3 | 6 | 7 | 4 | 8 | 4 | 7 | 5 | 5 | 7 | 8 | 6 | 3 | 2 | 9 | 5 | 9 | 6 |
| 10 | 8 | 9 | 9 | 8 | 4 | 3 | 8 | 8 | 4 | 1 | 4 | 5 | 8 | 10 | 6 | 10 | 6 | 4 |
| 11 | 5 | 9 | 2 | 5 | 8 | 9 | 8 | 4 | 6 | 4 | 2 | 2 | 7 | 5 | 2 | 2 | 5 | 2 |
| 12 | 6 | 2 | 10 | 5 | 6 | 9 | 9 | 10 | 1 | 1 | 7 | 1 | 6 | 5 | 9 | 3 | 1 | 5 |
| 13 | 9 | 6 | 8 | 7 | 3 | 7 | 1 | 7 | 7 | 9 | 9 | 10 | 8 | 6 | 10 | 6 | 1 | 4 |
| 14 | 6 | 9 | 9 | 6 | 6 | 7 | 1 | 7 | 4 | 8 | 5 | 2 | 2 | 3 | 2 | 2 | 1 | 5 |
| 15 | 9 | 5 | 7 | 3 | 6 | 5 | 2 | 5 | 9 | 1 | 1 | 3 | 3 | 6 | 7 | 5 | 3 | 10 |
| 16 | 3 | 6 | 2 | 5 | 6 | 1 | 10 | 8 | 8 | 9 | 9 | 1 | 10 | 9 | 8 | 6 | 2 | 7 |
| 17 | 2 | 2 | 10 | 7 | 3 | 4 | 5 | 7 | 1 | 1 | 6 | 9 | 4 | 5 | 1 | 2 | 7 | 6 |
| 18 | 2 | 1 | 10 | 4 | 8 | 10 | 3 | 5 | 5 | 6 | 9 | 2 | 2 | 4 | 1 | 6 | 8 | 1 |
| 19 | 8 | 2 | 4 | 8 | 3 | 7 | 2 | 6 | 9 | 3 | 8 | 2 | 4 | 6 | 8 | 2 | 7 | 6 |
| 20 | 5 | 6 | 6 | 5 | 7 | 2 | 7 | 3 | 10 | 5 | 6 | 6 | 5 | 7 | 2 | 8 | 6 | 3 |
| 21 | 1 | 8 | 1 | 7 | 8 | 8 | 1 | 1 | 8 | 9 | 7 | 7 | 5 | 1 | 4 | 10 | 2 | 9 |
| 22 | 1 | 7 | 8 | 4 | 3 | 2 | 1 | 9 | 5 | 5 | 3 | 7 | 10 | 7 | 6 | 9 | 9 | 6 |
| 23 | 8 | 6 | 10 | 4 | 3 | 3 | 1 | 8 | 10 | 4 | 4 | 5 | 7 | 3 | 3 | 9 | 7 | 8 |
| 24 | 10 | 4 | 7 | 7 | 6 | 8 | 5 | 6 | 5 | 6 | 5 | 8 | 5 | 7 | 8 | 3 | 5 | 10 |
| 25 | 6 | 1 | 2 | 6 | 1 | 5 | 7 | 2 | 7 | 8 | 10 | 2 | 2 | 8 | 2 | 2 | 2 | 10 |
| 26 | 3 | 8 | 7 | 1 | 8 | 1 | 7 | 8 | 8 | 1 | 5 | 5 | 6 | 7 | 2 | 3 | 9 | 5 |
| 27 | 1 | 6 | 8 | 4 | 10 | 5 | 1 | 2 | 7 | 7 | 3 | 7 | 10 | 7 | 6 | 9 | 9 | 6 |
| 28 | 7 | 9 | 8 | 3 | 7 | 1 | 2 | 10 | 6 | 10 | 4 | 5 | 7 | 3 | 3 | 9 | 7 | 8 |
| 29 | 8 | 1 | 10 | 2 | 7 | 7 | 4 | 4 | 4 | 8 | 5 | 5 | 1 | 8 | 6 | 2 | 3 | 8 |
| 30 | 3 | 1 | 1 | 2 | 10 | 2 | 3 | 7 | 5 | 8 | 4 | 7 | 5 | 8 | 5 | 7 | 8 | 3 |

For this problem, the paper uses the design of genetic algorithm to achieve results on MATLAB R2007 platform. The initial operating parameters make the following settings: the maximum generation MAXGEN=100; population size N=40; gap G=0.9; crossover probability Pc=0.4; mutation probability Pm=0.1.The optimal solution is obtained after running the programs.

The distribution center is build in the alternative points 1,4,11,13,14,17,18.Among these, the distribution center 1 serves the users 9,10,12,21,22; the distribution center 4 serves the users 17,26; the distribution center 11 serves the users 11,28; the distribution center 13 serves the users 6,18,19,24; the distribution center 14 serves the users 3,5,27,30; the distribution center 17 serves the users 1,2,4,8,13,14,16,25,29; the distribution center 18 serves the users 7,15,20,23.The total expense is 15.56 million Yuan.

### 3.2. Analysis of Performance

This paper tests results by changing the different parameters at the same time, conducting comparative analysis in order to obtain excellent solution in the set of parameters of a more reasonable data size. Through the comprehensive comparison of the above results, we can see that the results are better than the original one when generation, population size and crossover probability increase; when gap and mutation probability reduce, the results are worse than the original one.

Table5.5 The scheme of different Parameters

| | The optimal solution | | | | | | | | | | | | | | | Total expenses |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum generation 500 | 7 | 18 | 10 | 18 | 14 | 14 | 7 | 14 | 14 | 7 | 18 | 14 | 18 | 10 | 7 | 12.57 million |
| | 10 | 18 | 18 | 18 | 8 | 10 | 18 | 7 | 18 | 1 | 18 | 1 | 14 | 7 | 14 | |
| Group size 100 | 7 | 7 | 10 | 10 | 1 | 14 | 10 | 14 | 10 | 14 | 18 | 18 | 7 | 10 | 7 | 13.42 million |
| | 1 | 4 | 7 | 18 | 18 | 10 | 18 | 4 | 18 | 7 | 1 | 18 | 18 | 18 | 10 | |
| Generation gap 0.4 | 10 | 3 | 4 | 18 | 17 | 10 | 13 | 17 | 10 | 4 | 18 | 10 | 7 | 7 | 18 | 16.46 million |
| | 10 | 2 | 17 | 1 | 18 | 10 | 10 | 18 | 7 | 2 | 1 | 13 | 4 | 17 | 2 | |
| Crossover probability 0.9 | 7 | 7 | 10 | 17 | 17 | 13 | 10 | 4 | 10 | 7 | 18 | 17 | 7 | 7 | 18 | 14.15 million |
| | 17 | 13 | 13 | 18 | 13 | 10 | 18 | 7 | 1 | 7 | 13 | 1 | 1 | 7 | 7 | |
| Mutation probability 0.01 | 6 | 4 | 14 | 17 | 1 | 9 | 10 | 14 | 10 | 17 | 10 | 14 | 17 | 17 | 6 | 16.77 million |
| | 6 | 18 | 9 | 18 | 18 | 1 | 18 | 4 | 6 | 4 | 17 | 11 | 11 | 6 | 14 | |

The parameters are made the following settings based on the above conclusions: the maximum generation MAXGEN=500; population size N=100; gap G=0.9; crossover probability Pc=0.9; mutation probability Pm=0.1.The total cost of the optimal solution is 11.10 million Yuan. We can see that the improved parameters make the solution further optimized.

## 4. Conclusion

In this paper, the designed genetic algorithm is used to solve the problem of the location of distribution center by building a mathematical model. The coding manner is put forward which is adapted to the solving of this model aiming at the specific conditions and validate it through the concrete example. Since the results are influenced by the algorithm parameters greatly, so in this paper every parameter has been changed and the result is done by a comparative analysis to seek the excellent solution. Finally, we get the more reasonable setting of the parameters in the data size of the example and draw the more excellent solution.

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