Research on Modern Higher Education 3, 01007 (2017)
DOI: 10.24104/rmhe/2017.03.01007

Research on development characteristics of railway logistics specialty under “the Belt and Road” strategy

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ABSTRACT: With the proposed “the Belt and Road” strategy in China, the railway logistics specialty becomes one of the important links which draws more attention. Based on this, the paper studies transport route of railway logistics and sets up its model of the optimal route combining with ant colony algorithm. It carries out simulation analysis of each parameter of ant colony algorithm and chooses the optimal region of corresponding parameter. By taking railway logistics in Hubei Province as an example, the optimal transport route plan and its schematic drawing are required through calculation, which provides the important guidance on railway logistics transportation under “the Belt and Road” strategy in China

Keywords: ant colony algorithm; optimal route; the Belt and Road; optimization and simulation; railway logistics transportation

1 INTRODUCTION

With the emergence of “the Belt and Road” and rapid growth of China-EU international trade, all kinds of industry planning and resource allocation develop under the trend of globalization[1]. Transportation is an important part of depicting the spatial structure of economy and dominating its evolution. Constructing the transportation system is the prerequisite and important basis of implementing “the Belt and Road” strategy. It is not only a bridge linking facilities, trade and people in countries along the line, but also the prior strategic task which needs to be broken through. In the future, the establishment of dominant position of railways bureau in the market and the full implementation of diversification strategy of railway will dominate the direction of market demand and make fully use of advantages of railways, so as to full develop more operating projects, broadly expand the market of railways and business methods, and increase economic benefits of both railways and operation. As an important project in China, railway logistics is an important link in “the Belt and Road” strategy. How to design the railway logistics route is an important work[3].

The methods commonly used in the route design of railway logistics transportation are intelligent optimization methods, such as BP neural network algorithm, Graph Theory, minimum spanning tree, etc. which are used to make the optimal route scheme from the viewpoint of the shortest distance, which uses the internal mechanism to analyze the path equation, uses the repetitive process analysis or memory training for route selection, and uses training experience to determine the final route scheme[4]. There is a great subjectivity in parameter selection of optimization algorithm, which means the influence of human factors is large, so the true optimal route cannot be calculated accurately and objectively [5]. Based on this, in order to obtain the best scheme of railway logistics transportation route with objectivity, this paper tries to research the object influence of parametric variation in ant colony algorithm on route, and then objectively select parameters to build the optimal route model based on ant colony algorithm, so as to the optimal route scheme.

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2 ANT COLONY ALGORITHM

2.1 *Principle and basic mechanism of ant colony algorithm* [6]

The studies of experts in bionics find: ants will leave volatile secretion (pheromone) in the course of crawling. Under the condition of the same target and different routes, the left pheromone intensity is different, which will affect the selection of ants, and they will tend to crawl along the route with a high density and intensity of pheromone, looking for targets. As more and more ants pass the junction, a positive feedback is formed gradually, which makes ants find the optimal route after recycling. Simultaneously, the ant colony will reselect the route with the changing circumstances and then determine the optimal route again. Based on this, the experts and scholars introduce an organic intelligent algorithm - ant colony algorithm by simulating the foraging behavior of ants. The algorithm is based on the following hypotheses:

(1) The ant colony reacts with circumstances and communicates through pheromones.

(2) The reaction of the ant colony to circumstances depends on the internal model, which is determined by the genic adaptivity.

(3) The individual independently selects only on the basis of circumstances, while the selection of the individual in groups is random, which becomes high orderly through spontaneous organizational behavior.

Upon all these points, this paper draws the basic logical thinking of ant colony algorithm as shown in Figure 1.

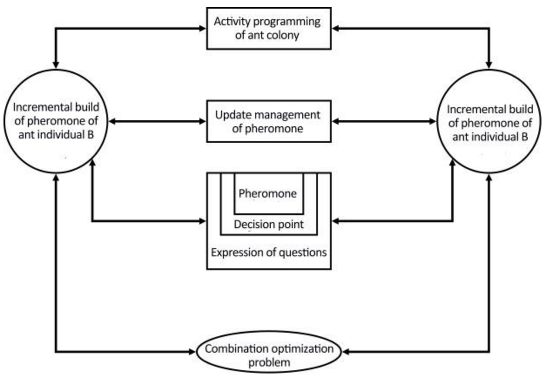

Figure 1. Ant colony algorithm basic logic thinking

2.2 *Basic model of ant colony algorithm*

$$P_{ij}^{k}(t)=\frac{\tau_{ij}^{k}(t)\cdot\eta_{ij}^{\beta}(t)}{\sum_{s\in allowed_k}\tau_{is}^{\alpha}(t)\cdot\eta_{is}^{\beta}(t)} \quad (1)$$

Where: ρ represents volatilization factor of pheromone; α represents heuristic representation factor; β represents heuristic factor; $1 - \rho$ represents information eclipse degree; η_{ij} represents visibility of edge (i, j); $\eta_{ij}=1/d_{ij}$, d_{ij} represents distance between the target i and the target j; $tabu_K$ represents cities visited by ant k; $allowed_K$ represents the next target of ant.

After n moment, ants complete a cycle, and then the amount of information on each route will be constantly adjusted with the amount of information:

$$\iota_{ij}(t+n)=\rho\cdot\iota_{ij}(t)+V\iota_{ij}, V\iota_{ij}=\sum_{k=1}^{m}V\tau_{ij}^{k} \quad (2)$$

Where: Q is a constant; L_K represents the total length of route in current tour by ant k; $V\tau_{ij}$ represents an increment of information of ij on the cyclic route; $V\tau_{ij}^{K}$ represents the amount of information left by ant k on the route ij on the cyclic route

$$V\tau_{ij}^{K}\equiv\begin{cases}Q/L_K, \text{ if ant } k \text{ gets through } ij\\ 0, \text{ or else}\end{cases} \quad (3)$$

2.3 *Parameters of ant colony algorithm*

There are many parameters in the ant colony algorithm, including heuristic factor of pheromone α, volatilization factor of pheromone p, heuristic factor β and pheromone strength q, which are related to the iterations of the ant colony algorithm and the shortest route, so selection of different parameters may lead to different results. However, in most cases, the parameters are given, and have a lot of uncertainty, leading to different results. Next, this paper will explore the impact of the parameters on the ant colony algorithm.

2.3.1 *Optimum range of volatilization factor of pheromone p*

In order to research the optimal range of residual pheromone, there is a need to make other variables constant. According to research in a large number of literatures, when the number of ant is 2.3 times of city amount, the result is optimal. Therefore, other parameters can be set as follows: x = 20, m = 46, α = 1, β = 5, q = 100. To substitute parameters into the program, the following results can be obtained:

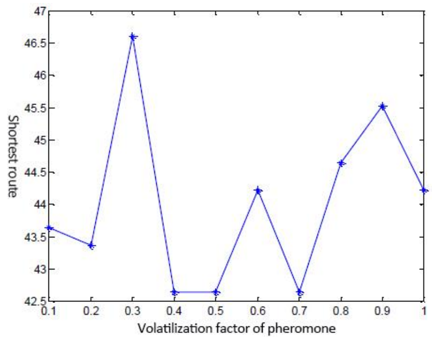

Figure 2. Shortest route information volatile factors change line chart

As can be seen from Figure 2, when the volatilization factor of pheromone is relatively small, the result of shortest route is relatively large; when the volatilization factor of pheromone is relatively large, the result is also relatively large; when the volatilization factor of pheromone is between 0.4~0.5, the result of shortest route is the smallest. Therefore, the optimal range of volatilization factor of pheromone can be determined as 0.4~0.5.

2.3.2 *Optimal range of heuristic factor of pheromone α*

The heuristic factor of pheromone α reflects the degree of relative importance of the amount of information accumulated by ants in the process of movement on guiding ant colony to search. The greater the amount is, the greater the possibility for ants to select the route walked previously is, and randomness of search will be weakened; when the heuristic factor is too small, it will make ants search fall into local optimum too early. In order to explore the optimal range of a single factor, other parameters can be assumed as $x = 20$, $m = 46$, $p = 0.5$, $\beta = 5$, $q = 100$, and the parameters are substituted into the program, obtaining the following experimental results:

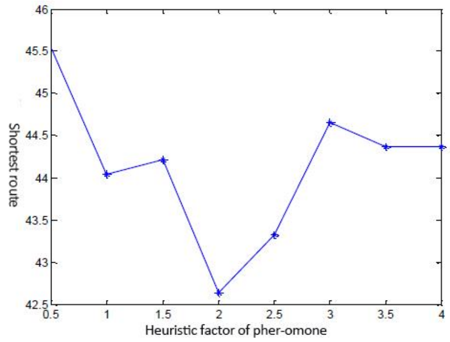

Figure 3. Shortest route inspired by pheromone factor to the change of the α line chart

As can be seen from the above figure, when the heuristic factor of pheromone is relatively small, the result of shortest route is relatively large; when the volatilization factor of pheromone is relatively large, the result is also relatively large; when the volatilization factor of pheromone is between 1.5~2.5, the result of shortest route is the smallest. Therefore, the optimal range of volatilization factor of pheromone can be determined as 1.5~2.5.

2.3.3 *Optimal range of heuristic factor of pheromone β*

The heuristic factor β is related to the amount of information, and also has an impact on the selection of shortest route. Similar to the previous methods, in order to research the range of a single factor, the control variable method is used to obtain the optimal range. The parameters are assumed as $x = 20$, $m = 46$, $p = 0.5$, $\alpha = 2.5$, $q = 100$, and the parameters are substituted into the program, obtaining the experimental results in Figure 3.

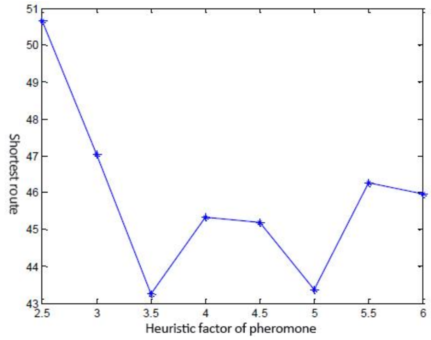

Figure 4. Shortest route inspired by pheromone factor to the change of the β line chart

As can be seen from Figure 3, when the heuristic factor β is relatively small, the result of shortest route is relatively large; when the heuristic factor β is relatively large, the result is also relatively large; when the volatilization factor of pheromone is between 3~4, the result of shortest route is the smallest. Therefore, the optimal range of volatilization factor of pheromone can be determined as 3~4.

2.3.4 *Optimal range of pheromone strength* [9] *q*

Pheromone strength q has a very strong correlation with the amount of information, and its size also has an impact on the shortest distance. In order to research the range of a single factor, the control variable method is used to obtain the optimal range. The parameters are assumed as $x = 20$, $m = 46$, $p = 0.5$, $\alpha = 2.5$, $\beta = 5$, and the parameters are substituted into the program, obtaining the following experimental results:

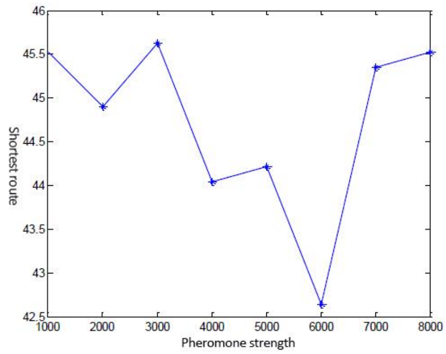

Figure 5. Shortest route change line chart by pheromone strength

As can be seen from Figure 5, when the pheromone strength is 5000~7000, the shortest route first reduces and then increases; when the pheromone strength is

6000, the result is the smallest. The optimal range is 5000~7000.

3 RAILWAY LOGISTICS ROUTE

Based on the proposed "the Belt and Road" strategy in China, this paper selects the railway logistics transportation route in Hubei province as the research object to explore the optimal route of railway logistics in Hubei. According to the principle of shortest route, combine the ant colony algorithm to simplify the routes among cities and construct a Hamilton cycle [10]. Its algorithm idea is as follows:

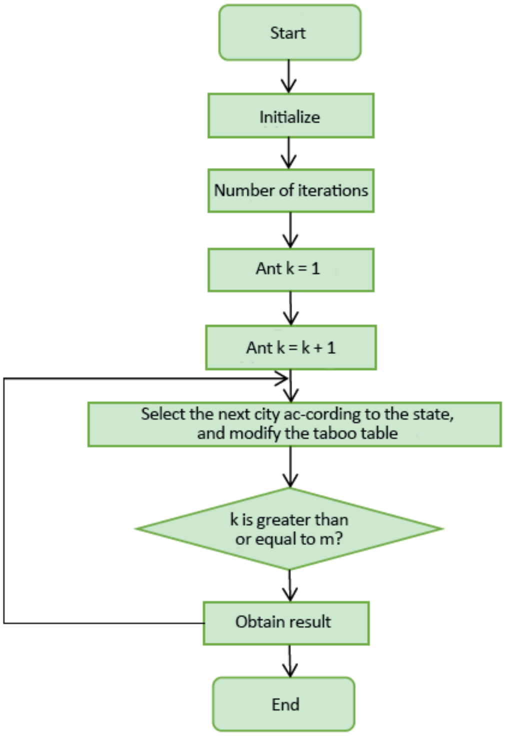

Figure 6. The ant colony algorithm design flow chart

Hubei province is located in central China and in the middle reaches of the Changjiang River, known as the "province of a thousand lakes". Because of abundant water and land resource, a wide variety of living and mineral resources, and the larger population density, the exploitation of the railway logistics route in Hubei can be used as a model of Hubei province's development and responding to "the Belt and Road" strategy in China. Owing to a large number of cities in Hubei, in order to better figure out the optimal route of Hubei railway logistics, 42 cities with developed transportation and large scale of urban development in Hubei province are selected as the research object with corresponding serial numbers (see Table 1).

Table 1. Number table

No.	City	Longitude	Latitude
1	Wuhan	114.31	30.52
2	Huangmei	115.93	30.09
3	Yingshan	115.57	30.75
4	Guangji	115.56	29.85
5	Luochuan	115.37	30.79
6	Qichun	115.3	30.24
7	Xishui	115.22	30.46
8	Yangxin	115.22	29.83
9	Huangshi	115.09	30.2
10	Macheng	115	31.17
11	Huanggang	114.87	30.44
12	Echeng	114.87	30.38
13	Xinzhou	114.8	31.84
14	Hong'an	114.61	31.29
15	Tongshan	114.52	29.6
16	Huangpi	114.36	30.88
17	Wuchang	114.33	30.35
18	Xianning	114.28	29.87
19	Dawu	114.09	31.56
20	Chongyang	114.04	29.54
21	Hanyang	114.02	30.57
22	Xiaogan	113.91	31.92
23	Jiayu	113.91	29.97
24	Puqi	113.85	29.71
25	Ying Mountain	113.81	31.62
26	Tongcheng	113.8	29.23
27	Yunmeng	113.73	31.02
28	Anlu	113.69	31.25
29	Yingcheng	113.6	30.94
30	Hanchuan	113.59	30.63
31	Guangshui	113.48	31.37
32	Suizhou	113.22	31.42
33	Jingshan	113.11	30.03
34	Jianli	112.9	29.83
35	Zhongxiang	112.58	31.17
36	Shishou	112.41	29.73
37	Shashi	112.24	30.32
38	Jingmen	112.19	30.02
39	Jiangling	112.18	30.35
40	Xiangfan	112.14	30.02
41	Yichang	111.3	30.7
42	Shiyan	110.79	32.65

After numbering cities, to abstract Hubei province as a map, establish a rectangular coordinate system, establish a rectangular coordinate system *xoy* according to a certain scale, regard each city selected as a coordinate point, and record its coordinate $c(i, j)$ according to the location of each city as a set of urban coordinate C, optimized reasonable parameters can be obtained according to the previous experimental analysis of each parameter in the ant colony algorithm: $m = 60$, $\alpha = 2.5$, $\beta = 3.5$, $p = 0.5$, $q = 6000$. MATLAB is used for programming calculation, obtaining the following results, as shown in Figure 7.

Each point is substituted into the original set, in order to obtain the serial number of each facility visited in the shortest route: 1, 17, 21, 30, 29, 27, 28, 19, 22, 25, 31, 32, 33, 35, 38, 42, 41, 39, 37, 40, 36, 34, 23, 24, 26, 20, 18, 15, 8, 4, 2, 6, 9, 12, 11, 7, 3, 5, 10, 13, 14, 16, 43.

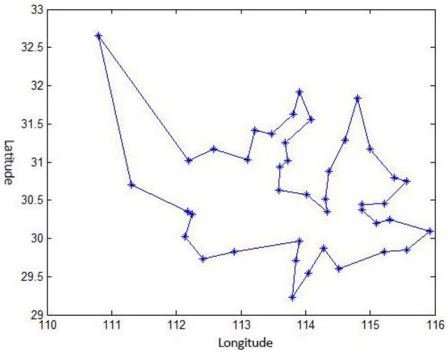

Figure 5. The optimal route map of Hubei

4 CONCLUSION

The paper mainly analyzes the impact of every parameter in ant colony algorithm on the optimal route, obtains the best value range of corresponding parameters and builds the corresponding optimal route model. At last, by taking Hubei province as an example, abstract the 42 cities which make the most influence on railway logistics transportation to particles with coordinates, and figure out the optimal transportation route plan and the schematic drawing of optimal route of this province, which provide an important guidance for railway logistics transportation under "the Belt and Road" strategy in China.

ACKNOWLEDGEMENT

This paper is funded by the General Program of Hubei Education Science Planning 2016 (2016GB207).

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