Study on the Optimal Travel Route Selection Based on Ant Colony Algorithm Model

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Abstract. Based on the perspective of travel agencies, this paper focuses on the optimization of tourist traffic routes, and divides the optimization of tourist traffic routes into "one day tour", the optimization of tourist traffic routes and the optimization of "multi day tour" tourist traffic routes. The objective function of tourism traffic route optimization is improved by using principal component analysis. Finally, the ant colony algorithm is used to model, which completes the research based on the ant colony algorithm model to select the best tourism route, so that the travel agency get the most benefits and the tourists enjoy the most humane experience.

1. INTRODUCTION
Optimizing tourism routes can reduce costs and improve efficiency for people's travel. Ant colony algorithm is a powerful tool to solve the problem of line optimization. It is a new simulated evolutionary algorithm put forward by Italy scholar DorigoM in the early 1990s [1]. But the ant colony algorithm is easy to fall into the local optimal solution, thus improving the ant colony algorithm has become one of the focuses of current research. Scholars have done a lot of work from the path selection of ant colony algorithm, the updating criterion of pheromone, local search and global search and convergence speed. The German scholar Thomassttzle proposed a improved algorithm of max min ant system, avoid the information content of a path is far greater than the other path; Zheng Song proposed a dynamic selection strategy to strengthen its global search ability; Liu Changan from wolves distribution principle of pheromone update, avoid the ant colony algorithm into a local optimum in the search; according to the basic ant colony algorithm for the problem of slow convergence, references to its improvement, the improved algorithm has faster convergence speed [2-4]. However, there are still few articles about the improvement of ant colony algorithm path selection, because the basic ant colony algorithm selects the next node with the shortest path of neighboring nodes, which makes the total length of global path not always the smallest [5]. In this paper, ant colony algorithm is used to study the optimization of tourist traffic lines, and the optimization of tourist routes is carried out by ant colony algorithm. As far as possible famous and fantastic sights to increase tourism attraction; as far as possible with the least time to finish most of the trip in order to ensure the limited price includes the content as much as possible; where conditions permit, as far as possible some of the attractions in the same place, so as to make tourism it runs in rich content, but also can earn more profit.
2. ANT COLONY ALGORITHM

Although the ant has no vision, it will find a path by releasing an information in the path. There are two kinds of information, one is the food pheromone spilled by ants and the other is the pheromone that finds the nest of the ants in the nest. The environment disappears at a certain rate of pheromone. Each ant can only perceive the environmental information within its range. When ants search for food, when there is no pheromone guidance, ants will move down according to their original motion direction, and there will be a random small disturbance in the direction of the movement. In order to prevent the ants from turning around in situ, it will remember what points they have just passed recently [6]. If they find that the next point they are going to have gone through recently, they will try to avoid it. When they encounter an uncrossed intersection, they randomly select a path and release the pheromone associated with the path length. The longer the ant walks, the less the pheromone is released. When the later ants encounter this intersection again, the probability of choosing a larger path is relatively large.

The rules of ants looking for a nest are just like the rules mentioned above, but it responds to the pheromone of the nest and does not respond to the food pheromone. The combination of the above rules has two characteristics: diversity and positive feedback. We can see diversity as a kind of creativity, which ensures that ants can’t go into the dead end while they are looking for food, instead of going to the endless lane [7]. The positive feedback is a learning enhancement ability, which ensures relatively good information can be saved. The power of positive feedback can also be likened to authoritative opinion [8]. Diversity is the creativity that breaks the authority. It is these two clever ingenious combinations that make intelligent behavior emerge.

The problem of traveling salesman optimization is introduced to explain the ant system model. The essence of the traveling salesman problem is that in the N cities, the traveler has and only once passed every city, making it the shortest route. The number of cities is N; ants have M only, and ants choose the next city to visit by the transfer probability. The taboo table tabu(k) is artificially set in the ant colony algorithm to store the cities that have been visited by ants. The ants choose the next city that is not in the tabu table according to the memory, and the transfer probability expression is:

$$p_{ij}(t) = \frac{\tau_{ij}^t(\alpha)n_{ij}^t}{\sum_{j \neq \text{tabu}(k)} \tau_{ij}^t(\alpha)n_{ij}^t}, \text{ otherwise.}$$

(1)

$\tau_{ij}$ is the pheromone size that ants leave from the city i to the city j on the path ij;
$\alpha$ is an important degree of pheromone;
$\eta_{ij}$ is an inspiring factor on the path ij;
$\delta_{ij}$ indicates the distance between the city i and the city j;
$\beta$ is an indication of the importance of the heuristic factor;
$N_k^t$ is a city that has not been visited;
$p_{ij}^t(t)$ indicates the probability of selecting the city j at the city i at the time t.

The pheromone $\tau_{ij}$ is updated in a certain way, and its expression is:

$$\tau_{ij}(t + 1) = \rho \cdot \tau_{ij}(t) + \sum \Delta \tau_{ij}^t$$

(2)

Where $\rho$ is the pheromone residue factor, $0 < \rho < 1$; at the initial time $\Delta \tau_{ij}^0 = C$ and then $\Delta \tau_{ij}^t$ changes into:

$$\Delta \tau_{ij}^t = \begin{cases} Q / L_k, & j \neq \text{tabu}(k), \\ 0, & \text{otherwise} \end{cases}$$

(3)

In which $L_k$ represents the total path length of the ant k access at the end of a tour, and Q is a constant.

The main flow of the ant colony algorithm in solving the TSP problem can be compared clearly with the following flow chart 1:
The characteristics of the ant colony algorithm are as follows: 1) Ant colony algorithm is a self-organizing algorithm. In theory, there are two basic categories of organization system, self-organization and its organization. The difference between the two is mainly whether the command is acquired from the system, which is just contrary to its organization. This special function of time and space can be obtained if there is no external intervention. In a sense, his system entropy will increase as we say that he is self-organization, and ant colony algorithm confirms this. At the initial time of algorithm, what ants are looking for is just a disorder solution [9]. After a period of algorithm evolution, we find some near optimal solutions between pheromones of artificial ants through spontaneous growth tendency. 2) The ant colony algorithm is fundamentally a parallel algorithm. Any ant is not interfered with each other in the search process, only communicating information through information hormones. Therefore, a multi distributed Agent system can be seen as another form of ant algorithm. 3) Ant colony algorithm is a positive feedback algorithm. Ant's foraging finds the shortest way through the accumulation of information pheromones in the shortest path. It also proves that it is a positive feedback process, and also an important feature of ant algorithm. 4) Ant colony algorithm is a kind of robust algorithm. The robustness of ant colony algorithm is reflected in that the final solution is irrelevant to the initial value and external participation. Meanwhile, the number of parameters used in ant colony algorithm is less and simpler, so it can be used to solve other combinatorial optimization problems well.

![Flow Chart of Ant Colony Algorithm](image)

**Figure 1. Flow Chart of Ant Colony Algorithm.**

### 3. OPTIMIZATION OF TOURIST TRAFFIC LINES

The optimization of tourist traffic lines is actually the route choice of lines. In a certain situation, there will be different combinations, different sightseeing times and tour order combinations. The optimization of tourism traffic route is mainly about how to choose a suitable tourist traffic route among many specific combinations to make scenic spots tour so that tourists' satisfaction with tourist traffic will reach the maximum [10].
First, the optimization of the travel routes between the two attractions is often encountered in the design of the travel agency lines. When designing travel routes, travel agencies need to convert conceptual lines into specific and operable lines after the idea is completed. The optimization of tourist routes between the two scenic spots is an important link, which is the premise and foundation for the optimization of the "one day tour" and the optimization of the "multi day tour" tourist route optimization. In fact, many geographic information systems now have such a shortest circuit module [11]. As long as we enter the destination and destination, we can quickly calculate a shortest route or the least cost route, which is undoubtedly of great practical significance for the route design of travel agencies.

Second, "one day tour" travel route optimization problem. The problem is not only for traveling tourists, but also suitable for circular tourist traffic lines in space topology. In the study of this kind of problem, we need to discuss how to form a closed optimal loop.

Here is a simple example by an example. If the travel agencies in Dalian plan to arrange a tour day tour routes, to visit the main attractions: Dalian Golden Pebble Beach Park, Tiger Beach Park, the Polar Museum, Fujiazhuang beach, Xinghai Square and Xinghai Park Orianne cruise Sun Asia Ocean world. The traffic in Dalian is very convenient, and there are many roads connected between each scenic spot, as shown in figure 2. As visitors are arranged to live in the hotel, the passengers want to go back to the hotel after the tour of the hotel and not go back. The so-called return way is to repeat the same route; a tourist attraction is more than one time, which is all the tourists don't want to see. This kind of problem is often encountered in the optimization of tourist traffic lines. We can solve the problem of traveling salesman (TSP) in graph theory.

Third, "multi day tour" travel route optimization problem. It is mainly discussed that in the case of certain scenic spots, tourists should start from their domiciles every day, visit some of the scenic spots and return to their homes. During the n days of the tour all the scenic spots were visited and the total travel route of the tourists was the best.
feel the campus life of their own, so that their children will have strong interest in learning and establish lofty ideals. The main content of this tourism product is to lead children to visit places of interest and campus in Beijing, including libraries, classrooms and so on, so that children can experience the university life [12]. Suppose that the tourist agency plans to lead the child to visit a scenic spot including the University in advance, and intends to finish all the scenic spots in three days. Every day the children start from the hotel, visit a day, and finally get back to the rest. The children visited the 14 sights for three days. The combination of what kind of travel routes can be asked to visit a world, unique is recorded as \( \tau \).

ij, and each \( \tau \), select the transfer probability biggest attractions; when the random number \( \tau \) place, Wanshou temple, Baita temple, \( \tau \) and so on. The combination of what kind of travel routes can be asked to ensure the shortest route on the road for the three days. The ant algorithm is applied to optimize the path, and the graphical output is shown in figure 3.

Although this kind of problem is very common, it has not been systematically put forward in the past articles on the optimization of tourism traffic lines. Generally speaking, scholars mainly focus on the optimization of tourist routes between two scenic spots, or further study on the optimization of tourist traffic routes for one-day tours. However, there is no special research on the problem of multi day travel. Because the traveling salesman problem is a difficult problem and the problem of multiple travelling is also a difficult problem. For its solution, the heuristic algorithm is used basically, and the optimal solution is gradually forced into the solution. With the increase of the number of scenic spots, we have to calculate and solve it by computer programming.

4. TOURISM TRAFFIC ROUTE OPTIMIZATION BASED ON ANT COLONY ALGORITHM MODEL

First, we design to optimize the tourism line China international travel service "Beijing one day tour" as an example to carry out the travel routes. "Beijing ancient capital one day tour" needs six scenic spots. They are the Imperial Palace, China Millennium Monument, Old Summer Palace, Wanshou temple, Baita temple, Peking University and Tiantan park.

It is assumed that starting from the Beijing Jiaotong University, we need to go back to Beijing Jiaotong University after visiting all the scenic spots. The traveler’s way of traveling is a tourist bus, and the coordinates of the Beijing Jiaotong University are \((0,0)\). Marking the attractions, the the Imperial Palace, China Millennium Monument, Old Summer Palace, Wanshou temple, Baita temple, Peking University and Tiantan park are labeled 2, 3, 4, 5, 6, 7, 8, respectively. The coordinates of each point are shown below:

| Table 1. "One Day Tour" Travel Route Optimization Each Scenic Spot Coordinate |
|------------------|-------|-------|------|-------|-------|------|-------|-------|
| \( x(i) \)       | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     |
| \( y(i) \)       | 0     | -89.8 | -80.1 | 126.5 | -5.3  | -61.7 | 101.5 | -156.2 |

In this paper, the process of "one day tour" travel route optimization is as follows:

**Step 1.** Initialization of the parameters: NC=0; the weight of each side is recorded as \( d_i \) (the linear distance between the two nodes); \( d_i = D(i,j), D \) is a matrix of \( n \times n \); TT is a matrix of \( n \times n \), and each element is equal to 1 (initialization pheromone). \( \tau_i = 1, \tau_r = \tau_r(i,j) \); \( \Delta \tau_n = 0, \Delta \tau_r = \Delta \tau_r(i,j) \); \( \Delta \tau \) is a matrix of \( n \times n \) and each element is 0; put an ant on the 1 node.

**Step 2.** The initial city number 1 of each ant is placed in tabu, which is a matrix of \( n \times n \), and \( n \) is the number of nodes (the k line of the matrix corresponds to the node that the ant \( k \) has passed).

**Step 3.** \( K \) only ants can select the next node that should be reached according to the probability \( p_{ij} \). In this paper, pseudo random number is adopted to select the next node. When the random number is greater than \( p_o \), select the transfer probability biggest attractions; when the random number generated by less than \( p_o \), then take the form of roulette probability; the probability of the selected node is larger, so it can increase the diversity of search and avoid premature in search stagnation. The
selected nodes are inserted into the tabu(k, :) when k=1,2,....,m; J was defined as the set of nodes without access, when the J is empty, all the nodes access (after traversing all the attractions).

**Step 4.** Calculate the total path length L of the K ant; record the shortest path length and node access order in the iteration;

**Step 5.** Update the pheromone concentration on each side;

**Step 6.** \( NC = NC + 1 \);

**Step 7.** If \( NC \leq NC_{\text{max}} \), emptying tabu, that is, tabu is set to a zero matrix of \( m \times n \); return step 2;

**Step 8.** If \( NC > NC_{\text{max}} \), algorithm end.

The flow chart using a specific ant colony algorithm is shown in figure 4:

![Flow Chart](image)

**Figure 4.** "One Day Tour" Travel Route Optimization Flow Chart

In the example, the initial parameters are set: \( Q=100, NC_{\text{max}}=300, m=6 \). Matlab programming is used to calculate the shortest total distance as the target function, and the final lines are 1 1, 6, 2, 8, 3, 5, 7, 4. Starting from Beijing Jiaotong University, the first tourist attractions were Baita temple, followed by the Imperial Palace, Tiantan Park, China Millennium Monument, Wanshou temple and Peking University. Finally, they visited Old Summer Palace and returned to Beijing Jiaotong University. This kind of tour order can not only save traffic cost and time, but also improve the quality of tourist traffic to a certain extent. As shown in the following figure 5, the graph shows the coordinates of every node and the tour order of nodes visually.

![Graph](image)

**Figure 5.** The Best Path of "One Day Tour"
The optimization of "multi day tour" travel route is much more complicated by the optimization of "one day tour". We need to consider not only the grouping of scenic spots, but also the tour order of scenic spots. More importantly, a new constraint is added to the "multi day tour" tourism route optimization, that is, time constraint. From the perspective of travel agencies, tourists start off punctually every day and return to the rest in the afternoon. Except for one hour of lunch, the total time of sightseeing and travel can not exceed 9 hours per day.

Taking the tour order can save the traffic cost and time to the maximum, and better achieve the long travel length. In this way, it can not only increase the income of tourism enterprises, but also improve tourists' satisfaction to tourism to a certain extent. On the basis of introducing the principle of ant colony algorithm, this chapter improves the parameter setting of ant colony algorithm and ant's route selection rule, and applies it to solve the optimization problem of tourist traffic line. Taking the actual problem as an example, the comparison calculation shows that the improved algorithm is effective. Finally, this chapter, taking Beijing "one day tour" as an example, combines programming to illustrate the problem of travel route optimization.

5. CONCLUSION
In this paper, the model and algorithm of tourism traffic line optimization are studied and the preliminary progress has been made. The main embodiment is to introduce the principal component analysis method to the improvement of the objective function of the travel route optimization problem. The objective function of the optimization of tourism traffic route is no longer limited to the shortest path and the minimum cost. It takes into account the factors such as travel time, travel distance, travel cost and road congestion. In this paper, the ant colony algorithm is improved effectively. The pseudo random proportion rule is used to select ant path, and the principle of dynamic setting for heuristic factors, information Volatilization Coefficient and other parameters is adopted, which greatly improves the shortcomings of ant colony algorithm falling into local optimal solution. The paper takes the problem in the standard database as an example to verify the effectiveness of the improved algorithm. The results show that the improved ant colony algorithm can improve the performance of the algorithm greatly. In this paper, the improvement of ant colony algorithm can also be used for reference to the application of ant colony algorithm in other fields. Based on the algorithm design of "multi day tour" tourism route optimization problem, every ant's path is constructed into a feasible path, which greatly simplifies the difficulty of solving "multi day tour" tourism traffic optimization problem. In the use of programming, a clever data structure is adopted, which greatly simplifies the complexity of the program.

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References
[1] Liang, Sun, Lin, et al, Appl. Sof. Com 38(2018)
[2] Wei, Liu, J. Yan, Uni 1(2015)
[3] Tian, Gao, Ge, Eur. J. on WC & N 1(2016)
[4] Yang, Hu, Informatics and Service Sciences (IEEE,2015)
[5] Chen, Bo, Dong, et al, International Conference on Development in Power System Protection(IET,2016)
[6] Chen, Yang, Zhi, et al, J. HUT (2015)
[7] Tian, Zhao, Zhao, Ma, P & T (2016)
[8] Wang, Wang, Int. J. S & I. A 9(2015)
[9] Meng, He, Song, et al, Control Conference(IEEE, 2016)
[10] An, Yang, Mu, et al, IEEE International Conference on Systems, Man, and Cybernetics(IEEE, 2016)
[11] Bo, Wang. Xu. Int. J. OE 12, 10(2016)
[12] Wang, Shi. Sci. Tec. Man. R (2017)