An Improved Ant Colony Algorithm for Optimal Path of Travel Research and Simulation

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Abstract. Tourist travel path’s unseemliness will result in serious of problems, such as expenses, comfort level, travel safety, etc. This paper analyzed the NP hard problem of travel optimal path, proposed an improved ant colony algorithm. Firstly, distance matrix was constructed, the travel spots’ initial order were represented by subscript randomly. Secondly, the path choose model was proposed by travel example, and analyzed the simulation result based on the improved ant colony algorithm; Finally, this paper analyzed the influence of parameters with path result, the simulation result proved the validity of the algorithm, which could plan the travel path reasonably, would assist travel agency to formulate probe travel strategy, and improved the travel cost and traffic for tourist

Introduction

Recently, serious of travel problems take place while people traveling, travel safety problem is the most important, such as the unreasonable travel itinerary arrangement, the travel cost is much more expensive than company’s offer, the travel safety is difficult to guarantee [1]. Nowadays, multi-scenic spots cities are usually large and medium size cities, how to plan the travel path, how to relieve traffic and environment pressure, how to improve the tourist’s enjoyment and safety, which is a hot research region.

Dorigo M etc. used ant colony algorithm for solve the traveling salesman problem successfully [2]. Ant colony algorithm is a robustness arithmetic, is suitable for solving complex combination optimization problem, so more and more researches proved improved ant colony algorithm for solving all kinds of optimization problem [3]. This paper analyzed the travel path arrangement problem of large quantity of travel spots, chose Wuhan city’s travel spots, proposing an improved ant colony algorithm for solving travel path problem. This paper chose 15 travel spots as example, using the improved ant colony algorithm solving how to traverse these spots, and acquired the optimal path, the results showed that the improved algorithm is feasibility for travel path arrangement.

The travel path arrangement model for large quantity of travel spots, which can compute the most optimal path in high-efficiency as improved ant colony algorithm, can provide travel consult for tourist and travel company, relieving the travel transportation, and improving the tourist’s enjoyment and safety, etc.

Building the Model of Large Quantity of Travel Spots

Large quantity of travel spots path is different from common path, which is consider the shortest and path factors, and update dynamically, setting weight value based on congestion condition in different time in city, acquiring the most optimal path dynamically and really.

While most of common path arithmetic usually consider one factor, which is the shortest time or the shortest distance, these arithmetic aren’t apply in real environment. The short path arithmetic is the base of choose travel model, the common shortest arithmetic include Disjkstra arithmetic, Floyd arithmetic, Moore-pape arithmetic, etc. All the above common arithmetic can apply in travel model,
but the Disjkstra arithmetic’s speed is very low, Floyd arithmetic is not suitable for large travel model [4]. Ant colony algorithm is the most optimal algorithm of travel path, which is suitable for travel path choosing.

While we research the travel path model, we should confirm the spot’s coordinate, if we construct coordinate for marking the spots, it will be randomness, and will result in insignificance, so we should refer longitude and latitude, then conform the spot’s coordinate. As Yellow Crane Tower an example, finding the longitude and latitude value, acquiring the longitude and latitude map by Baidu searcher, inquiring Yellow Crane Tower’s location, the result show that the location is north latitude N30°32.41.40, east longitude E114°17.31.43, then transforming the form of coordinate, finally acquiring the Yellow Crane Tower’s coordinate, but in real world, city transportation isn’t conform by two points’ line distance, different spot’s connection should be arrived by transportation and road, the real distance is much larger than line distance of two points, the common method isn’t apply in real traveling at all.

**Constructing the Path Model**

To the model suitable for real life, we set the spots set \( V = \{V_1, V_2, ..., V_n\} \), spot \( V_i \) and \( V_j \)'s distance define as \( d(i, j) \), computing the shortest distance between the two spots by search tool, constructing the distance set of spots [5].

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D_1 = \{d_{11}, d_{12}, ..., d_{1n}\}
\]

represents the distance between spot \( V_1 \) and the other spots, \( D_2 = \{d_{21}, d_{22}, ..., d_{2n}\} \) represents the distance between spot \( V_2 \) and the other spots, according to the number of spot set \( V \), constructing spot distance set \( D = \{D_1, D_2, ..., D_n\} \), supposing the time of spots \( V_1 \) and \( V_j \) is \( t(i, j) \), conforming the shortest time of one spot and the other spots on the basis of search tool, constructing the spot time set \( T_1 = \{t_{11}, t_{12}, ..., t_{1n}\} \), which presents the time of \( V_1 \) and the other spots, constructing spot time set \( T_2 = \{t_{21}, t_{22}, ..., t_{2n}\} \), which presents the time of \( V_2 \) and the other spots, in the accordance with the number of spot set \( V \), building the spot time set \( T = \{T_1, T_2, ..., T_n\} \), then in the light of traffic flow and the congestion condition in city at some time, conforming the weight of every time, according to \( \varepsilon (0 < \varepsilon < 1) \), weighted summation of distance set and time set, acquiring the synthetically matrix \( M = \{M_1, M_2, ..., M_n\} \).

Searching the whole subset of integer \( X = \{1, 2, 3, ..., n\} \), the number of \( X \) is the n spots serial arrangement, \( m(X) = \{V_1, V_2, ..., V_n\} \) take \( \sum_{i=1}^{n-1} m(i, i + 1) + m(1, n) \) get the minimum value.

**Example Analyzing**


**The improved Ant Colony Algorithm of Path Model**

According the establishment of travelling path model, the improved ant colony algorithm should run as follows Figure 1 [6]:

1. Initialization parameter of model
   Initialization parameter of model before computing.
2. Building solution space of model.
   Firstly, setting every ant on different start direction, in accord with the above formula, secondly, computing next spot of every ant \( k \) \((k = 1, 2, ..., m)\), finally, all ants visit all spots in end.
3. Update pheromone
Computing the path length $L_k (k = 1, 2, \ldots, m)$ of every ant, saving the current optimal value, then on the basis of formula, updating the concentration of pheromone on every spot path [7, 8].

4. Judge the ending condition
   If $NC \leq NC_{\text{max}}$, then $NC = NC + 1$, clearing the path table of ant travelled path, then return step 2; else ending computation, output the optimal value.

![Figure 1. The step of path choice model.](image)

Simulation Experiment

In the accordance with the above analysis on ant colony algorithm, then applying the improved model by matlab simulation.

Setting Relative Parameter of the Model

(1) The number of ant: $m=14$. The number of ant is influence on simulation result, the number is usually from 0.6 to 0.9 of spot number $n$, the number of spot is $n=15$, so the number of ant is 14 [9].

(2) The number of spots: $n=15$. It’s in the light of the above analysis.

(3) Inspiring factor of pheromone: $\alpha (\text{alpha})=1$, which is the importance of influence on ant’s pheromone of movement to searching path. The $\alpha$ is usually set from 0 to 5, here is set $\alpha=1$.

(4) Inspiring function $\beta (\text{beta})=2$. While the bigger of $\beta$, the ant will choose the shortest path in local, although the improvement of convergence speed, there will be result in optimal value locally; While the smaller of $\beta$, the smaller of inspiring function’s role. It’s very difficult to find the optimal value, the $\beta$ is usually from 0 to 5, here is set $\beta=2$.

(5) The initialization time, the initializing concentration is 0 in order to ensure every ant’s path probability as the same.

(6) The whole number of pheromone: $Q=100$. The $Q$ is usually set from 10 to 10000, for the small scale problem, the $Q$ is set 100, so here is set $Q=100$ because of the model’s spot number is 15.

(7) Pheromone volatilize parameter $\rho$ is set 0.1

(8) The max iteration $NC_{\text{max}} =50$. 

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Simulation Result

On the basis of above analysis to every parameters, here is set $\alpha=1$, $\beta=2$, $m=14$, $Q=100$, $\rho=0.1$, $NC_{\text{max}}=50$, the simulation result as shown in Figure 2:

![Optimal path graph](image)

Figure 2. The optimal path graph of travelling choice.

The Figure 2 is the optimal path graph in 15 spots, it’s proved that ant colony algorithm can solve the travel path choice problem. Through the matlab simulation result, the shortest path is 104.382 km in traversing in 15 spots, accruing the optimal path is:

$$8 \rightarrow 10 \rightarrow 15 \rightarrow 14 \rightarrow 13 \rightarrow 12 \rightarrow 11 \rightarrow 9 \rightarrow 5 \rightarrow 2 \rightarrow 4 \rightarrow 7 \rightarrow 1 \rightarrow 6 \rightarrow 3 \rightarrow 8$$

The above optimal is not unique, but the shortest path data is all 104.382 km, and every path is different in different time, and the iteration time is also different, which improve the result would be optimal value in locally, not wholly, and the result is relative with parameters, the average distance and the shortest distance of iteration as shown in Figure 3:

![Average distance and shortest distance](image)

Figure 3. The average distance and the shortest distance of every iteration.

As shown in Figure 3, the black line represents the average path length of ever iteration, the blue line represents the shortest path of every iteration. The result shows that the black line’s average path length is much higher than the blue line’s shortest path, because some ant path is better and shorter, some ant path is worse and lengthier, while the iteration time reaches 25, it will be the shortest
distance, it’s proved that ant colony algorithm exist astringe earlier in locally, so the parameter choice is very important.

**Result Analysis**

From the analysis of experiment result: Pheromone volatilize parameter $\rho$ is one of factors influence on astringe performance of ant colony algorithm, while the $\rho$ is smaller, the astringe speed is quicker, while the $\rho$ is bigger, the astringe speed is slower obviously, so it’s an important condition of choice suitable $\rho$ in light of problem scale for experiment result. The numbers of ants are influenced on algorithm’s astringency, while the number of ant is bigger, the problem scale is small, which will result in astringe speed quicker and reaching optimal value locally, so the number of ant is from 0.6 to 0.9 of spot number. The $\alpha$ and $\beta$ of ant colony algorithm are relative with algorithm performance, which are the mainly factor in algorithm performance and astringe speed of ant colony algorithm: if the $\alpha$ is bigger, pheromone’s importance is proved in searching, the ant’s path is relative with pheromone’s guidance completely, while the problem scale is bigger, it will be result in optimal locally. On the other hand, if the $\alpha$ is smaller, the pheromone’s importance isn’t proved in searching, the ants will choose the nearest location, this condition is difficult for attaining optimal value [10].

**Conclusion and prospect**

This paper analyzed the shortest travel path of spots in tourist travelling, proposed the travel path arrangement model of multi spots, and proposed the improved ant colony algorithm for attaining the optimal path. The 15 travelling spots arrangement simulation is completed by matlab in Wuhan City, the simulation result showed that the improved ant colony algorithm could plan the travel path reasonably. In real life, the travelling path problem is dynamic, and the notes of traffic network are complex, so we should choose the key notes for analyzing, this is the next research.

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**References**


