Application of improved ant colony algorithm in food delivery system

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Abstract

With the rapid development of China's economy and the improvement of the pace of life, takeaway has become a part of young people's life. How to effectively deliver takeaway delivery personnel in a limited time is an urgent problem to be solved in the current delivery system. At present, there are some problems in the system, such as path redundancy and large sample size, which affect the efficiency and speed of the food distribution system. In this paper, the original ant colony algorithm is improved by using pheromones released by ants and path-finding methods. In order to reduce the redundancy of path selection, improve the computational efficiency and find the optimal balanced path, ant colony optimization algorithm is considered to select the distribution path. Experimental results show that this algorithm can find the global optimal path more accurately than the traditional ant colony algorithm.

Keywords

Ant colony algorithm; Optimal path; Global optimization.

1. Introduction

With the quickening pace of people's life, their demand for a more convenient way is becoming stronger and stronger. Takeaway emerged at the historic moment, greatly meeting people's demand for the development of the ordering system. A more important problem is the delivery speed of takeout [1]. With the acceleration of urbanization, there are many factors affecting the delivery efficiency of food delivery, such as the number of motor vehicles and the increasing traffic congestion and accidents. Considering the problem of optimal path selection in the current system and the connection relation of road network, we consider to obtain information from the existing database to plan the path. In order to effectively and accurately plan the optimal path, so as to help the deliveryman choose the optimal path according to the policy.

The traveling salesman problem was solved by simulating the process by which ants explore food -- that is, by communicating and collaborating with each other to find the shortest path from the nest to the food source. In recent years, many researchers have proposed many algorithms based on ant colony algorithm, the most typical one is ANTNET [2]. Compared with Dijisktra, ant colony algorithm has certain advantages in network optimization algorithm. A series of good experimental results have been obtained by using ant colony algorithm to solve travel salesman problem, assignment problem, scheduling problem, shortest path search problem, etc. Nowadays, ant colony algorithm has become a focus of attention, but it still has some problems, such as unbalanced network appearance, low utilization rate of network resources, serious network congestion, low efficiency in path optimization, and weak real-time information. This paper attempts to use improved ant colony algorithm to solve the optimal path planning problem in the current food delivery system.

The rest of this paper is organized as follows: the section 2 proposes a new improved algorithm based on ant colony algorithm. The main function of this algorithm is to realize the path planning between the known starting point and the end point, which can provide the food deliverers with accurate, timely and optimized road conditions, and provide active and reasonable guidance to meet the needs of users. The section 3 analyzes the efficiency of the improved algorithm and makes simulation experiments. The section 4 gives conclusions and future research work.

2. Improved Ant Colony Algorithm (IACO)

Ant colony optimization (ACO) is an extension of ant foraging in reality. It uses pheromone traces released by ants to make indirect communication and interaction between ants, so as to achieve positive feedback effect that accelerates the integration of the system. When the ant comes to a fork in the road, it has to make a choice. But since there were few clues to choose from at first, it chose the path with the same probability. The result was that half of the ants took route A, and the other half took route B. When the ants found the food source, they followed the same route, leaving the pheromones again [3]. Given that all the ants have the same speed, the pheromone left by route B is stronger than that by route A, since route B is shorter and the ants that choose this route return to the original fork. When the next batch of ants reach the fork in the road, the probability of ants choosing route B is higher because of the strong pheromone of route B, which attracts more ants, leaves more pheromones, and forms a positive feedback, so that all ants finally choose route B.

The ACO algorithm uses an ant-like control package to explore routing between two nodes and improve availability routing information. These ants act as a query packet that attempts to set up all possible routing nodes from the source to the target. The algorithm takes into account that the vehicle contains a destination and uses two different types of forward ants from the origin to the destination, discovering the route and collecting information [4]. In addition to the backward ant moves backward to the origin and destination to get the data updated as each sensor moves.

In order to overcome the shortcomings of traditional ant colony algorithm, such as early convergence and slow operation, and improve the performance of the algorithm in path planning, an improved algorithm is proposed. The main goal of ant colony optimization algorithm is to provide an optimal path to the delivery staff and reduce the delivery time. In view of the slow convergence speed of ant colony algorithm, when global update is considered to improve the optimal solution, the pheromones left before will gradually evaporate with the passage of time, and at the same time, there will be propane left on the path of ant colony, so the pheromones on the path should be updated [5]. The global update rule is adopted here, that is, at the end of an iteration, after all ants have constructed a solution, they will release new pheromones according to the following rules:

$$\tau_{ij}(t+1) = (1-\rho)\tau_{ij}(t) + \Delta\tau_{ij}{}^{best}(t,t+1) - \Delta\tau_{ij}{}^{worst}(t,t+1). \ \rho\epsilon(0,1) \quad (1)$$

and between them, $\Delta\tau_{ij}{}^{best}$ and $\Delta\tau_{ij}{}^{worst}$ respectively:

$$\Delta\tau_{ij}^{best} = \begin{cases} \dfrac{1}{C^{best}} & i,j \in C^{best} \\ 0, others \end{cases} \quad (2)$$

$$\Delta\tau_{ij}^{worst} = \begin{cases} \dfrac{W \times C^{ws}}{C^{best} + C^{worst}} & i,j \in C^{worst} \\ 0, others \end{cases} \quad (3)$$

and C^{best} means the best path the ant took, and C^{worst} means the worst path the ant took.

In order to induce ants to approach the path that satisfies the constraint, the function F(s) of road s is introduced. After the end of an iteration, the equation (1) is updated is:

$$\tau_{ij}(t+1) = (1-\rho)\tau_{ij}(t) + \Delta\tau_{ij}^{best}(t,t+1) - \Delta\tau_{ij}^{worst}(t,t+1) + F(s), \rho \in (0,1) \quad (4)$$

$$F(s) = -uF_1(s) - vF_2(s) + wF_3(s) \quad (5)$$

For the parameters u, v and w in the public formula, they represent the relative importance of cost requirements, time requirements and safety requirements, F_1 represents the cost on the path, F_2 represents the time estimation, and F_3 represents the safety limit.

$$F_1(s) = \sum\sum X_{ij}^t f_{ij} \tag{6}$$

$$F_2(s) = \sum\sum X_{ij}^t t_{ij} \tag{7}$$

$$F_3(\mathrm{s}) = \begin{cases} G_s - \prod(1 - X_{ij}^t g_{ij}), G_s > \prod(1 - X_{ij}^t g_{ij}), \\ 0, \text{ others} \end{cases} \tag{8}$$

If the chosen path has the lowest overall starting and ending time cost and meets safety constraints, then the pheromones on the path should be increased correspondingly, which will inspire more ants to converge to the edge of these paths [6].

3. Efficiency analysis of food delivery staff with improved ant colony algorithm

3.1 Experimental data and algorithms

The data used in this paper is the data of a takeaway delivery shop, which includes the delivery data of April 20, 2018 solstice and April 20, 2019. The data are provided and extracted by the store management staff, and the route planning for the food delivery staff is initiated. The following reduces the delivery man to ant. Set the number of ants m and the maximum number of cycles, set the disturbance coefficient N, increase the pheromone and reduce the parameter V, read the data to get the coordinates of the city, obtain the connection matrix D_{ij} between buildings, and initialize the pheromone matrix. M ants were placed in the same position to start the first search, and the initial point was set as the current solution set for each ant. In order to prevent the algorithm from easily falling into the local optimal solution, a new parameter R was introduced, so that ants could choose the next city according to the accessibility. After joining parameter R, every once in a while will make the algorithm must shake, the ants in the choice is going to visit the location of the next, undertake choosing according to accessibility, thus limits the positive feedback of ant colony algorithm leads to biggish error solution and the effect of enhancement algorithm of random search performance, shorten the delivery time [7,8]. Using the method of roulette wheel selection, select the next arrival site and put it into the current solution set. After completing the search, calculate the path length of the ant. The search process is repeated until all ants reach the end point, and the optimal and worst solutions of the cycle are calculated and compared.

3.2 Experimental Results

We'll use the improve the algorithm in the current room system, the selection of starting point of a same path, this paper has chosen the store with the lotus pool area of the township government as experiment from a path), and compared with before improvement algorithm, considering the city's traffic jams, the distribution of the building, room engineer familiar degree of city and cost factors, such as comprehensive analysis can be seen that the improved ant colony algorithm, both in the path length, cost and time consuming, etc., are better than the improved algorithm[9].

We performed the improved ant colony algorithm and the basic ant colony algorithm for 100 times respectively, and the results were compared as shown in table 1, where the failure indicated that the result was not the optimal result.

Table 1 Comparison results of improved ant colony algorithm and basic ant colony algorithm

Algorithm	Failure	The success rate
ACO	24	79%
I-ACO	10	91%

The fitness function changes are shown in the figure 1, where the horizontal coordinate is the iteration number and the vertical coordinate is the distance. We can see from the figure that the improved ant colony algorithm is obviously superior to the unimproved ant colony algorithm in seeking the shortest distance.

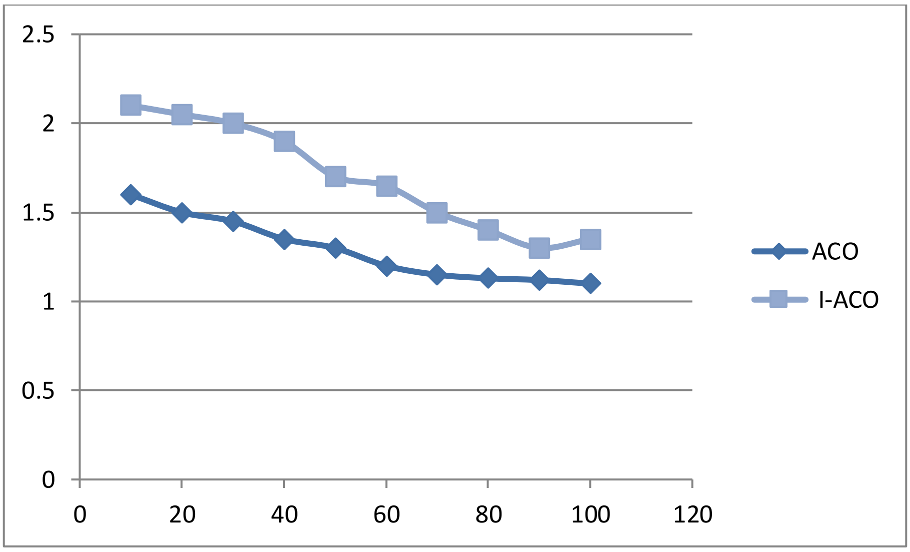

Fig.1 The distance between the improved ant colony algorithm and the unimproved ant colony algorithm with the number of iterations

It can be seen from the table 2, the disturbance velocity and pheromone update, under the action of the improved ant colony algorithm can find time to find a balance between time and cost of the optimal path and the improved algorithm also speed up the search speed of ants, expand the search scope, compared with traditional before improvement algorithm, traversed more paths, which contributed a lot to find the optimal solution, has the strong practical value.

Table 2 The comparison between improved ant colony algorithm and unimproved ant colony algorithm

Algorithm	Time	Cost/yuan	Delivery Time/min	Optimal Path
ACO	164.5	60	20	A-B-D-E-F-H-C
I-ACO	130.2	51	15	A-F-G-C

4. Conclusion

With the development of technology and times, people's demand for high quality and high efficiency takeout is also increasing day by day. The improved ant colony algorithm can provide more convenience for food delivery personnel and customer groups, thus saving more time. In this paper, an improved ant colony algorithm is proposed for food delivery system [10]. The improved ant colony algorithm is used to plan the route of food delivery and find the optimal solution, so as to provide convenience for merchants and bring greater benefits.

References

[1] Muhammad Babar,Fahim Arif,Mian Ahmad Jan,Zhiyuan Tan,Fazlullah Khan.Urban data management system: Towards Big Data analytics for Internet of Things based smart urban environment using customized Hadoop[J]. Future Generation Computer Systems,2019.

[2] CROSSAN J D. A survey of anonymity in wireless communication systems.[J]. Security & Communication Networks, 2010, 2(5):427-444.

[3] Zhou Zheng, Xiao xuan. Path Planning MethodBased on Improved Ant Colony Algorithm[J]. Journal of Hubei University of Technology,2018,33(5):50-52.

[4] S.W. Lu, Z.Q. Wang, J. Shen, Neuro-fuzzy synergism to the intelligent system for edge detection and enhancement, Pattern Recognition 36 (2008) 2395–2409.

[5] Udomchaiporn, A., Coenen, F., Garca-Fienana, M., Sluming, V, D MRI brain scan feature classification using an oct-tree representation. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol. 8346, p.(2013) 229-240.

[6] S.B. Park, J.W. Lee, S.K. Kim, Content-based image classification using a neural network, Pattern Recognition Lett,Y.D. Qu, C.S. Cui, S.B. Chen, J.Q. Li, A fast subpixel edge detection method using Sobel–Zernik.25 (2010) 287–300.

[7] D.C. Tseng, C.C. Lai, A genetic algorithm for MRF-based segmentation of multi-spectral textured images, Pattern Recognition Lett. (2014) 1499–1510.

[8] Zhu, J, Zhang, T.. An evolutionary algorithm based on Reed-Muller partition tree model. Int. J. Wirel. Mob. Comput. 8 (2015), 301-308.

[9] Zhang C, Ling YZ, Chen MY. Path planning of mobile robot based on an improved ant colony algorithm. 30(2016):1758–1764.

[10] Oshaba AS, Ali ES, Abd-Elazim SM. Speed control of SRM supplied by photovoltaic system via ant colony optimization algorithm. Neural Comput Appl 28(2) (2017):365–374.