Research on Optimization of in-warehouse picking Model based on genetic algorithm

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Abstract: This paper mainly aims at the large amount of picking work and activity cost in the e-commerce distribution center, so optimizing the picking path and reducing the picking time is of great significance to improve the operation efficiency and reduce the cost of the distribution center. In this paper, according to the example route and way in which the picker enters the shelf, the picker is regarded as a particle and the classification path optimization strategy is adopted. it is composed of three kinds of distances, that is, between the goods grid, between the goods grid and the check table, and between the check table and the check table. Then the genetic algorithm based on Jenetics algorithm library is introduced to solve the problem, and the global optimal grid access and the walking path of the returned check station are iterated, and the shortest completion time of the solution is obtained. Then, aiming at the path planning problem of multi-starting point, multi-check station, multi-task single or even multi-picker, it is a multi-objective complex problem, which is properly reduced and optimized layer by layer. And reconsider the time impact of the order of tasks, each layer to find the optimal solution, then the final result must be optimal.

1. Introduction

With the rapid development of e-commerce, logistics warehousing plays a more and more important role in supporting the development of e-commerce[1]. Warehousing is the basic activity of e-commerce production and operation and the creation of competitive advantage. Sorting operations occupy the main operating time and cost of warehousing operations, so it is very important to optimize e-commerce warehousing and sorting operations. By analyzing the characteristics of current e-commerce warehousing, optimizing the picking strategy, the warehousing operators analyze and classify the orders, and formulate the corresponding picking strategy, which can effectively avoid repetitive work, improve the overall efficiency and make the operation orderly. Picking strategy is the key to affect the efficiency of picking operation, which mainly includes zoning, order segmentation, order batching and classification[2]. The interaction of these four factors can produce multiple picking strategies.

2. Model analysis

Under the condition that all the check stations are working normally, the picker P traverses all the goods points on the task order T0001 and finally goes back to the nearest review station to make the optimal planning problem, to obtain the best grid access order and the returned check desk[3], and to calculate the time it takes to complete the depot (from the picker's picking start to all tasks to check the time spent on the completion of packing). Because the walking speed of the picker is fixed, and the time spent in the process of removing the goods from the shelves is exactly known according to the different quantity of goods, in the problem of busy waiting time without a review desk, the shortest time problem can be transformed into the shortest path problem[4].

Then the optimal solution of the picker's path planning problem can be described as follows:

$$minT_{task} \tag{1}$$

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Among them, the total distance of the outgoing completion path can be expressed as the sum of the total distance between the walking boxes and the distance between the total boxes and the nearest check station, that is:

$$L_{task} = L_{BB} + L_{BT} \tag{2}$$

The total outgoing completion time can be expressed as the sum of the total picking time, the total loading time, the total waiting time of the picker caused by the busy review desk[5], and the review and packing time after the last task order is delivered to the review desk:

$$T_{task} = T_{path} + T_{ul} + T_{wait} + T_{lt} \tag{3}$$

3. Model building

When picking goods in the warehouse shown in figure 1, the picker needs to walk between the boxes, between the boxes and the check desk, and between the check desk and the check desk[6]. Since these walks usually have to bypass obstacles, the Euclidean distance can not be calculated directly by coordinates, but the shortest walking distance of the picker between the two coordinates can be calculated. Therefore, a graph-based classification routing model is established, which is composed of three sub-models of distance calculation to study the distance between any two points. As a result, a method for calculating the distance between 3000 boxes and 13 check stations with a total of 3013 elements is obtained, and a 3013 × 3013 distance matrix is finally obtained.

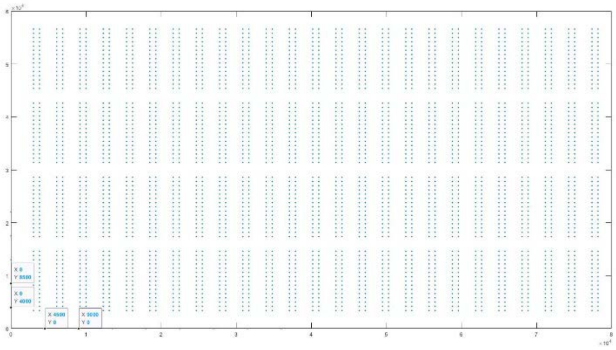

Fig.1 Schematic diagram of scatter points in midpoint coordinates of warehouse elements

It is assumed that all the review desks are working properly, so the total waiting time of the picker caused by the busy review desk is T_wait=0.

Objective function:

$$minT_{task} \tag{4}$$

It can be transformed from the shortest time function to the shortest distance function, that is,

$$minL_{task} \tag{5}$$

$$minL_{task} = min(L_{BB} + L_{BT}) \tag{6}$$

4. Model solving

4.1 Genetic algorithm

Itinerant traveling Salesman problem (TSP), 1948. TSP has become a typical problem in the field of combinatorial optimization in modern times, driven by the official words of Guoland. It should be said that TSP is a combinatorial optimization problem with extensive application background and important theoretical value, and it has been proved to be a NP problem. Using graph language to describe TSP:, we give a graph G = (VMague E), each side e ∈ E has a nonnegative weight ω (e).. Find the Hamilton cycle C of G such that the total weight W (C) = of C is minimized.

TSP search space increases with the increase of the number of city pairs, and the combination number of all travel routes is (n-1)! / 2. To find the optimal solution in the huge search space, for conventional methods and existing computing tools, there are many computational difficulties, so it is a natural idea to solve the TSP problem with the help of the search ability of genetic algorithm.

The method of genetic algorithm to search the optimal solution is to imitate the process of biological evolution and to simulate the phenomena of replication crossover and mutation in natural selection and heredity. It starts with a population that represents a set of potential solutions to the problem, while a population is made up of a certain number of individuals encoded by genes. The selection, crossover and mutation of the population are carried out repeatedly, and the fitness of each individual is estimated. According to the evolution rule of "survival of the fittest and survival of the fittest", a group of individuals who are more adaptable to the environment are produced, which makes the population evolve to the direction of the optimal solution more and more. Finally, the optimal individual in the last generation population is decoded to obtain the optimal solution that meets the requirements.

However, unlike the TSP problem, the walking path of the second picker does not form a closed loop, and the fitness function should add the distance from the last goods point to the nearest check station, that is, the chromosome target fitness function:

$$f_{fit}(x) = minL_{task}\# \tag{7}$$

4.2 Chromosome coding

The item point coding in the task order is realized by the internal function Permutation of Jenetics algorithm library, such as S08502 S13509 S14908 S12608 S10115 S07515. The gene length is equal to the number of orders for the task order, which is 23 in this model.

According to the genetic algorithm based on Jenetics algorithm library and the task table given in Annex 1, the optimal path planning model of one picker and one task order is solved. The parameters of genetic algorithm are set as follows: the initial population size, that is, the number of individuals is 50, the probability of crossover cp=0.96, mutation is m p = 0.2, and there is no upper limit for the maximum evolution algebra. By solving the problem, the walking path scheme table of a picker's task order T0001 is obtained, and the space is limited to listing only several sets of iterative solutions near the optimal solution.

```
276672  50      634950  392400
S00107,S01713,S01308,S07515,S08502,S06213,S07212,S10115,S11106,S11205,S13509,S15911,S14401,S14908,S12608,S14510,S13812,S13809,S13004,S12103,S10508,S10501,S07305,FH7
277006  50      583410  387400
S00107,S01713,S01308,S07515,S08502,S06213,S07212,S10115,S11106,S11205,S13509,S12608,S14401,S15911,S14908,S14510,S13812,S13809,S13004,S12103,S10508,S10501,S07305,FH7
277297  50      592416  392400
S00107,S01713,S01308,S07515,S08502,S06213,S07212,S10115,S11106,S11205,S13509,S15911,S14401,S14908,S12608,S14510,S13812,S13809,S13004,S12103,S10508,S10501,S07305,FH7
277606  50      612048  392400
S00107,S01713,S01308,S07515,S08502,S06213,S07212,S10115,S11106,S11205,S13509,S15911,S14401,S14908,S12608,S14510,S13812,S13809,S13004,S12103,S10508,S10501,S07305,FH7
278198  50      484790  387400
S00107,S01713,S01308,S07515,S08502,S06213,S07212,S10115,S11106,S11205,S13509,S12608,S14401,S15911,S14908,S14510,S13812,S13809,S13004,S12103,S10508,S10501,S07305,FH7
278503  50      607152  381000
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Fig.2 Optimal solution path

If the function value of the fitness function of different iterative algebra changes as shown in the figure, the optimal solution is obtained when the function value converges to the minimum.

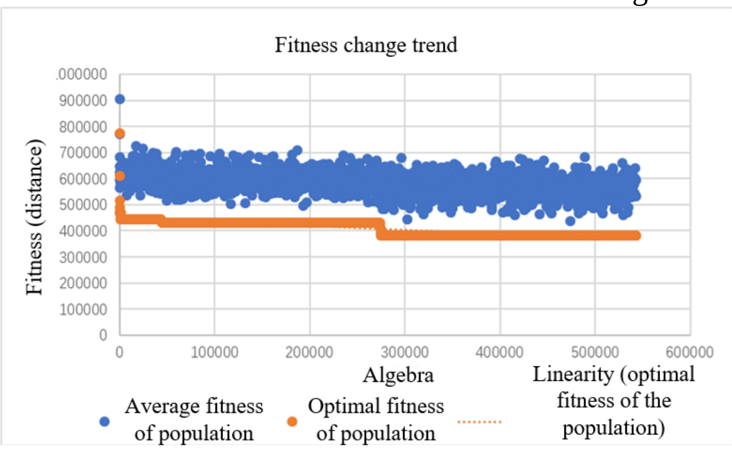

Fig.3 Fitness change trend

4.3 Result analysis

According to the above results, it can be seen that the optimal walking path of the picker is S00107 "S01713" S01308 "S08502" S07515 "S06213" S07212 "S10115" S11106 "S11205" S12608 "S13509" S15911 "S14401" S14908 "S14510" S13812 "S13809" S13004 "S12103" S10501 "S10508" The walking track is shown in the figure:

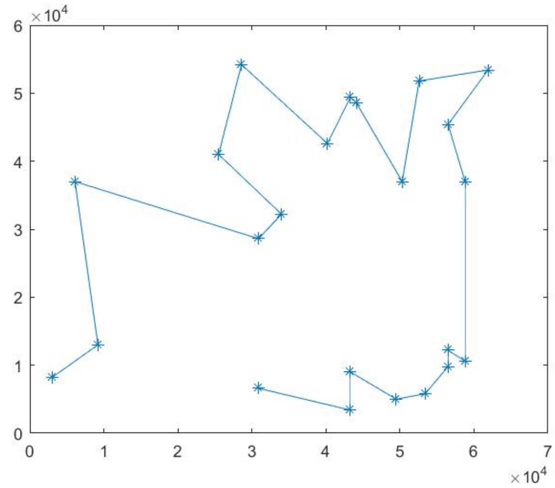

Fig.4 Optimal behavior path

Solution to the optimal path is obtained by programming. Because the length of the optimal solution in this question is too large, only the time spent by each worker and the waiting time at the review table under the optimal scheme are given, then the total time to complete the exit of the warehouse should be based on the time spent by the picker who takes the longest time, and the total time T_task=5337.3s should be calculated. For the task order assignment plan and path planning assigned to workers, see "Qes4" in the table "calculation results".

For multiple tasks in the same task order, we should group as many orders as possible on the shelves on the other side of the same roadway, and distribute the orders equally to the whole warehouse as far as possible, instead of stacking them all on one side of the warehouse. Since the review time is always fixed, the main factor affecting the waiting time is the walking time required for each completion of the optimal review desk corresponding to the final task of a task order. if all on one side, the review desk with the best distance after the completion of the task will be in the working state, and the arrival time is much less than the static time due to the working state, so that the queue length is too long to make multiple pickers unable to work again. If most of the task orders are far away from the review station, it will lead to the completion of the review task, and the walking time of the dispatcher in completing the picking task is much longer than the review time of the review station, which makes more review stations idle time and greatly reduces the utilization rate of the review station.

5. Conclusions

This paper classifies the path optimization strategy, fully considers the path path and path route under different conditions, and skillfully projects the whole discount trajectory to the X and Y coordinate directions, and the solution process is clear and concise, which lays a theoretical foundation for the realization of the shortest distance. In order to solve the problem of single-person picking, the genetic algorithm based on Jenetics algorithm library is adopted. Compared with the traditional genetic algorithm, the function of the library greatly saves the complexity of genetic algorithm in coding and other aspects, and the calculation time is shorter and the efficiency is higher. Modern intelligent algorithm is fully applied to the solution of mathematical modeling problems. In the multi-person warehouse picking model, using the layer-by-layer optimization method, the train of thought is clear and complicated to simplify, and the complex NP problem is transformed into the actual solvable optimization problem through the best benefit step by step. Based on the choice of the highest benefit of the current situation, the greedy algorithm can quickly get the optimal result, which not only shortens the solving time, but also ensures the scientificalness and practicality of the model.

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