Research on Storage Optimization Problem Based on Improved Genetic Algorithm

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Abstract: The traditional genetic algorithm is easy to fall into the local optimal solution in the multi-objective function model of the distribution center warehouse, which produces many infeasible solutions. To this end, the paper proposes an improved genetic algorithm, using mutation operator selection and other items. By selecting the control parameters reasonably, it is possible to obtain relatively good individuals of each alphabet, and then select the optimal solution of multi-objective functions to reduce the defects of genetic algorithm. Finally, the paper validates the effectiveness of improved genetic algorithm in the storage location optimization of the distribution center warehouse.

1. Introduction

As an important link in modern logistics management, warehousing links all other links in logistics and plays a decisive role in the integration of goods flow. How to rationally distribute the goods in the automated warehouse, to achieve the purpose of improving the efficiency of goods out of storage and reducing the cost of goods storage has become the primary task of enterprise warehouse managers. For the problem of location optimization, domestic and foreign scholars have proposed many algorithms, such as: ant colony algorithm, genetic algorithm, hybrid taboo search algorithm, particle swarm algorithm network.

Scientific and reasonable distribution of goods can balance the time and workload of picking, avoiding the idleness of personnel and improving the quality of picking. The logistics distribution center must be classified and managed according to different cargo properties and packaging conditions, and adopt the district picking operation mode. Therefore, the research on the sorting efficiency under the district picking system still has strong practical value. For the partition picking system, only the picking time of each partition tends to be equalized, the total picking time can be minimized, and the idle rate of the partitioning resources can be reduced. Therefore, in order to achieve the storage optimization of the partition picking system, it is necessary to fully consider the sorting factor. On this basis, the improved genetic algorithm is used to establish multi-objective functions, and the storage optimization problem is also solved [1].

2. Distribution Center Warehouse Storage Optimization Model

2.1 Analysis of the efficiency of the inbound and outbound

According to the specific conditions and development requirements of the logistics enterprise's three-dimensional warehouse, the goal of cargo space optimization is to improve the efficiency of warehouse work and the constraints that must be considered in reality.

2.1.1 Minimum access time

In order to improve the efficiency of the warehousing, it is necessary to shorten the time for the goods to enter and exit the warehouse. The key to shortening the time of entering and leaving the warehouse is to shorten the path of the picking operation, that is, the distance from which the warehousing moves (the total path of the forklift) [2]. Suppose the coordinates of a cargo location are (x,y,z) (row, column, high), and the origin coordinates of the shipping area are (0, 0, 0). Because the forklift carrying the cargo actually moves, it cannot travel along the shortest path in the space. According to the actual situation of the picked goods, the speed of the forklift in the vertical direction is less than the speed in the horizontal direction. Let V_x be the average moving speed of the stacker along the x-axis, V_y is the average moving speed of the stacker along the y-axis, and V_z is the rising speed of the stacker in the axial direction, and $V_x = V_y > V_z$. To achieve the optimization of the cargo space and improve the efficiency of the goods entering and leaving the warehouse is to minimize the total time spent on the goods in the warehouse. Therefore, the objective function that satisfies the highest efficiency of inbound and outbound storage is as follows:

$$\min f_1(x,y,z) = \sum_{x=1}^{a}\sum_{y=1}^{b}\sum_{z=1}^{c}\left(\frac{x}{V_x}+\frac{y}{V_y}+\frac{z}{V_z}\right)L_0 P_i \tag{1}$$

2.1.2 Minimum energy consumption

According to the investigation, it is found that the energy consumption in the warehouse operation is related to the storage position (K), the access frequency (M), the quality of the goods (P), the length of the goods (L), and the height of the goods (h). From the mathematical model of the location optimization, it is possible to know the energy consumed to access the materials in the entire three-dimensional warehouse, and the statistical quality of the entire material (the product of the material quality and its frequency of entry and exit) and the unit mass energy consumption function. Great relationship. The greater the statistical quality of materials, the more energy is consumed by the warehouse; the greater the unit mass energy consumption function, the more energy is consumed by the materials.

$$\min f_2(x,y,z) = \sum_{x=1}^{a}\sum_{y=1}^{b}\sum_{z=1}^{c} K M_{xyz} P_i g^2 z f(x+y) \tag{2}$$

2.2 Shelf stability analysis

2.2.1 Minimum shelf center of gravity

The second factor to consider is the stability of the shelf of the cargo space. For any shelf, its load-bearing capacity is limited, so the cargo is placed on the shelf according to the actual bearing capacity of the shelf. For the bearing capacity problem, in order to maintain the stability of the shelf, when placing the goods, it is necessary to place the heavier goods on the bottom of the shelf and the lighter goods on the upper shelf. In actual situations, the stability of an object is related to its center of gravity, and the lower its center of gravity, the better the stability. Therefore, placing the goods according to the principle of light weight can reduce the center of gravity of the shelf, thereby achieving the purpose of enhancing the stability of the shelf. So, the next step is to calculate the center of gravity of the shelf. Its basic principle is that the center of gravity of the entire shelf is at its lowest.

If the quality of the goods stored on a certain cargo space (x,y,z) is M_{xyz}, in order to satisfy the lowest total center of gravity of the placed goods, the product of the cargo quality M_{xyz} and the number of layers in which the cargo space (x,y,z) is located must be minimized. To meet the stability of the shelf, there are the following objective functions [3]:

$$\min f_3(x,y,z) = \frac{\sum_{x=1}^{a}\sum_{z=1}^{c} zL_0M_{xyz}}{\sum_{x=1}^{a}\sum_{z=1}^{c} M_{xyz}} \tag{3}$$

2.2.2 Single-row shelf weight balance at both ends

Single-row shelves also need to consider the stability of the shelf level, that is, the weight of the two ends of the shelf should be balanced. The center of the horizontal direction is at the position of $b/2$, like the modeling principle in the vertical direction, and has the following objective function:

$$\min f_4(x,y,z) = \frac{\sum_{x=1}^{a}\sum_{z=1}^{c} (y\text{-}b/2)^2 L_0M_{xyz}}{\sum_{x=1}^{a}\sum_{z=1}^{c} M_{xyz}} \tag{4}$$

3. Algorithm model

3.1 Improved genetic algorithm

The first step, the initialization operation: initialize the population $x_1^0\left(i=1,...,N_p\right)$ by using the n-dimensional optimization parameter to define the random number in the space S_0, determine that the mutation rate is F, the hybridization parameter is C_R, the maximum evolution algebra is G_m, and let $G=0$.

In the second step, for the individual $x_i^G\left(i=1,...,N_p\right)$ in the G generation, the third, fourth, and fifth steps are performed to implement the $G+1$ generation individual [4].

The third step is to manipulate the variation. The variant individual x_i^{G+1} is generated according to the formula (5), and the expression is as follows.

$$x_i^{G+1} = x_p^G + F\left(x_j^G - x_k^G\right) \tag{5}$$

Among them, j,k,p are the distinct integer randomly selected from 1 to N_P, and the variance F is a real number, which is used to scale the difference component $x_j^G - x_k^G$. Note: x_p^G is a randomly selected individual in the Gth generation. The role is to generate x_i^{G+1}, and there is no relationship between x_i^{G+1} and x_i^G.

The fourth step is the hybridization operation. By performing a binomial distribution on the $x_i^{G+1} = \left(x_1, x_2, \ \dots, x_n\right)_i^{G+1}$ generated in the third step and the current individual $x_i^G = \left(x_1, x_2, \ \dots, x_n\right)_i^G$, a hybrid individual $\overline{x}_i^{G+1}$ is generated, and the expression is as follows:

$$\overline{x}_i^{G+1} = \begin{cases} x_{k_j}^G, & P_c > C_R \\ x_{k_j}^{G+1}, & otherwise \end{cases} \qquad k_i = 1,2,...,n \tag{6}$$

Where $C_R \in [0,1]$ is the hybridization parameter and P_c is the random number of $\in [0,1]$.

The fifth step is competition operation. The hybrid individual $\overline{x}_i^{G+1}$ generated in the fourth step competes with the individual x_i^G. When the objective function value of $\overline{x}_i^{G+1}$ is better than x_i^G, then when when there is $f\left(\overline{x}_i^{G+1}\right)\le f\left(x_i^G\right)$, there is $\overline{x}_i^{G+1}$ instead of x_i^G, and x_i^G is retained to the next generation.

$$x_i^{G+1}==\begin{cases}\overline{x}_i^{G+1}, & f\left(\overline{x}_i^{G+1}\right)\le f\left(x_i^G\right)\\ x_i^G, & otherwise\end{cases} \tag{7}$$

The sixth step, $G=G+1$.

In the seventh step, repeat steps 2 through 7 until the optimal solution is solved, or $G>G_m$.

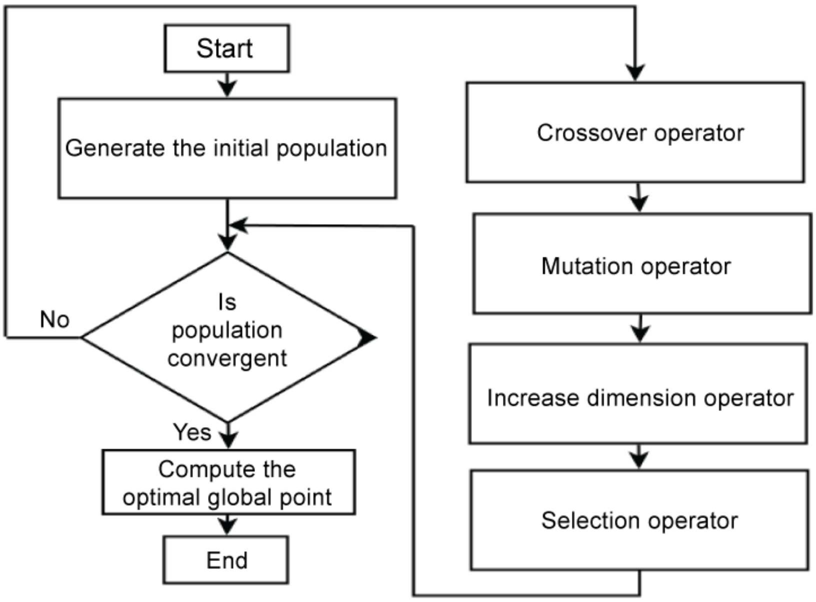

Fig.1 Flow chart of improved genetic algorithm

3.2 Adaptive mutation operator

The adaptive mutation operator can adaptively determine the mutation rate according to the search condition of the algorithm, so that the algorithm can ensure the individual diversity in the initial period and avoid the premature operator. Reduce the mutation rate in the later stage of the algorithm, thus ensuring the optimal information, avoiding the destruction of the optimal solution and increasing the probability of global search to the optimal solution.

There are adaptive mutation operator expressions as follows:

$$\lambda=\mathrm{e}\left[1-\frac{G_m}{G_m+1-G}\right] \tag{8}$$

$$F=F_0*2 \tag{9}$$

Among them, F_0 represents the variation parameter, G_m is the largest evolutionary algebra, and G is the forward algebra. The mutation rate at which the algorithm starts is $F=2F_0$, which has a large mutation rate, and can ensure individual diversity in the initial stage. During the progress of the algorithm, the mutation rate is gradually reduced, and the late mutation rate is close to F_0, thus avoiding the destruction of the optimal solution.

4. Case Analysis

There are many types of goods in a logistics center warehouse, and the frequency of entry and exit of various types of goods is also different. At this time, the number of corresponding partitions is large. Reusing the previous method to solve the optimal distribution of goods for such problems is quite complicated and often cannot be solved. Because genetic algorithm is easy to operate and has strong searching ability in solving combinatorial optimization problems, this paper uses genetic algorithm to study the problem of warehouse cargo space optimization [5].

Tab.1 Example optimization simulation basic parameters

X direction moving speed V_x	1	Number of shelves	6
Y direction moving speed V_y	1	Number of shelves	4
Z direction moving speed V_z	0.5	Algorithm iterations	100
Location unit length L_0	1	Initial population	40
Number of rows of shelves	4		

Tab.2 Initial plan for storage and transportation

product number	Turnover	quality	Location coordinates
1	0.25	5	(1,2,4)
2	0.94	8	(1,4,4)
3	0.24	9	(3,2,1)
4	0.25	15	(3,1,3)
5	0.18	4	(2,2,2)
6	0.01	7	(3,1,4)
7	0.35	15	(1,4,2)
8	0.56	25	(3,4,4)
9	0.70	74	(3,1,2)
10	0.50	52	(1,1,1)
11	0.08	14	(1,2,3)
12	0.17	11	(3,1,1)
13	0.54	25	(1,1,2)
14	0.24	36	(1,2,1)
15	0.59	15	(4,2,1)

The chromosome 122121141111311312231113321131221221211241121 after optimization was obtained after 100 first iterations. The results after finishing the optimization are shown below:

Tab.3 Optimized results

product number	Turnover	quality	Location coordinates
1	0.25	5	(1,2,2)
2	0.94	8	(1,3,4)
3	0.24	9	(3,3,1)
4	0.25	15	(3,1,1)
5	0.18	4	(2,1,2)
6	0.01	7	(3,2,3)
7	0.35	15	(2,4,2)
8	0.56	25	(3,4,1)
9	0.70	74	(3,2,2)
10	0.50	52	(1,2,1)
11	0.08	14	(1,2,2)
12	0.17	11	(3,2,1)
13	0.54	25	(2,2,2)
14	0.24	36	(1,1,1)
15	0.59	15	(3,2,1)

The algorithm through the iterative operation of the initial population multiple cross-variation, the optimal storage allocation scheme effectively improves the partition picking time of each batch, the total picking operation time tends to be stable, and the picking operation equalization partition picking operation time is realized. optimize the target.

5. Conclusion

In this paper, an improved genetic algorithm is proposed for the traditional genetic algorithm to solve the problem that the algorithm existing in the multi-objective programming model of the three-dimensional warehouse is easy to be trapped in the local optimal solution and the cross-variation process produces many infeasible solutions. Compared with the traditional genetic algorithm, the algorithm combines the advantages of parallel selection and single parent genetic algorithm. On the one hand, it avoids the phenomenon that the local optimal solution is trapped due to too many objective functions, and avoids many invalid solutions due to population crossover. Thus, the problem of the algorithm is terminated early. It can be seen from the analysis of the example that the parallel selection of the single parent genetic algorithm can improve the global optimization ability in the solution process, and can provide a theoretical basis for the enterprise warehouse decision.

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