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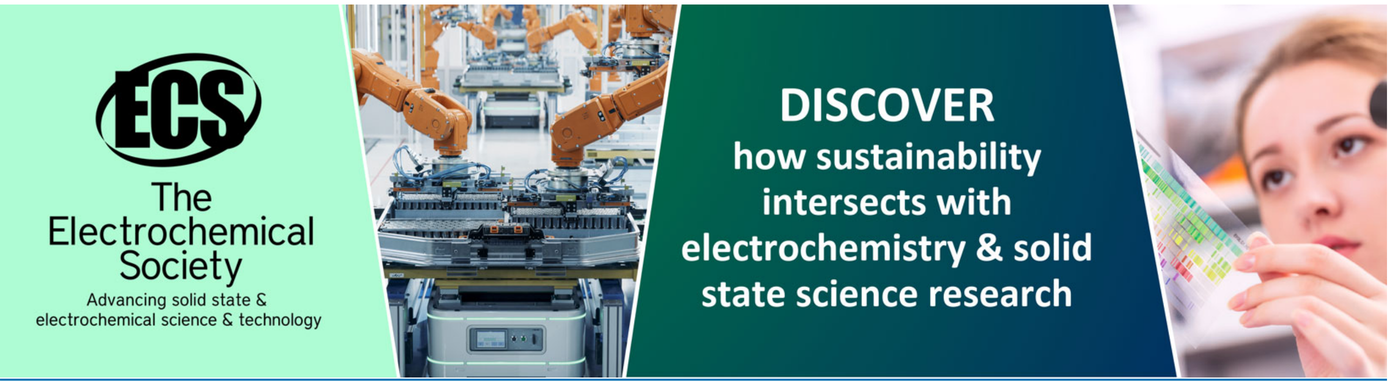

Research on Storage Location Optimization Based on Genetic Algorithms

Wei Xu[1,2,*] Hongwei Jia[1]

[1]East China University of Technology, Economic Development Zone Guanglan Avenue 418, Nanchang330013, China

[2]Jiangxi Engineering Technology Research Center of Nuclear Geoscience Data Science and System, Economic Development Zone Guanglan Avenue 418, Nanchang330013, China

E-mai: jhw_1979@163.com E-mail: 22661246@qq.com

Abstract: Based on the assumptions given by the model, a mathematical model of multi-objective optimization problem is established on the basis of considering the requirements of gravity center, frequency and the time required for a single operation mode to complete the operation of warehouse entry and exit. A genetic algorithm is proposed to solve the problem of warehouse location optimization. The simulation results show that the genetic algorithm can effectively solve the problem of warehouse location optimization.

1. Introduction

With the rapid development of information technology and e-commerce, third party logistics, as one of the outstanding achievements of logistics industry, plays a more prominent role in social economy. Improving logistics efficiency has become the main goal of modern economy. At present, the status of warehouse location optimization in China has seriously affected warehousing efficiency, and warehousing is an important part of logistics, which will inevitably affect the improvement of logistics efficiency. In order to meet the requirement of high efficiency of modern logistics, it is necessary to solve the problem of goods location optimization and improve the level of warehousing management[1].

2. Current Situation of Warehousing Management

Warehousing, as an important part of logistics, mainly includes unloading inspection, warehousing management, warehousing management and inventory management. Among them, unloading inspection, inventory management and warehousing management have reached a relatively advanced level. However, the operation of warehousing management is still chaotic, staying in a more traditional state: only store goods in the warehouse space that can accommodate goods, without considering the overall optimization of warehousing management, without considering different customer inventory models and other factors. As a result, the management process is slow, inefficient and space utilization is insufficient to meet the requirements of market economy[2-4].

3. The Solution to the Problem of Location Optimization

The main index to measure the performance of warehouse is the efficiency of accessing and storing goods, and the efficiency of accessing and storing goods depends on the optimal management of goods location. Scientific optimization of goods location can improve the efficiency of warehouse, facilitate the delivery and picking operation of warehouse, improve the space utilization ratio of warehouse, and help to strengthen the stability of shelves. At present, most of the allocation strategies only consider the shortest moving distance of the stacker in and out of the warehouse. Based on this, this paper proposes a multi-objective optimization solution of the warehouse location problem based on genetic algorithm. Considering factors such as the frequencies of goods in and out of the warehouse and the weight of the goods, the corresponding mathematical model is established and solved[5-7]. Through the simulation analysis of the data after the solution, it is possible to solve the problem. It can be seen that the new solution can improve the storage efficiency more effectively.

4. Genetic Algorithms to Solve the Location Optimization Problem

Genetic algorithm is a kind of randomized search algorithm that draws lessons from natural selection and natural genetic mechanism of biology[8-10]. It is a computational model that simulates the evolution process of Darwin's genetic selection and natural elimination. It is a new computational method formed by the combination of natural genetics and computer science.

4.1. Solution steps of genetic algorithm

The steps of genetic algorithm to solve the problem are as follows[11]:

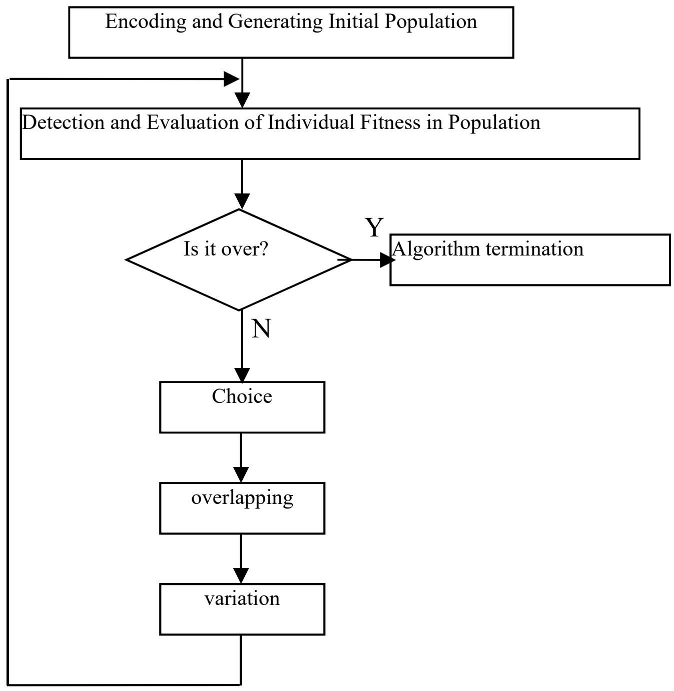

Fig 1 genetic algorithm's flow chart

4.2. Establishment of Cargo Location Optimization Model

There are two principles to be followed in the process of goods location optimization: high efficiency of goods access and good shelf stability. In order to improve the efficiency of goods access, we should try to make the sum of inventory turnover of all goods multiplied by the running time of the stacker as small as possible. In order to pursue the stability of the shelf, we need to keep the goods with higher quality at the bottom of the shelf, that is, the center of gravity of the shelf should be as low as possible[12].

This paper assumes a general warehouse with n rows of shelves and a row of shelves with Q rows i n layer P. The nearest row to the roadway entrance is marked as the first row, the lowest row as the first row, and the row j i n layer I is marked as (i, j) (i = 1,....,P;j=1,..,q), The length, width and height of each shelf are a, B and c, and the width of the pillars on the shelf is not counted . f_{ij} is defined as the inventory turnover rate of goods on the first floor of the shelf, m_{ij} is defined as the weight of goods on the shelf (i, j), E is defined as the storage efficiency of goods on the shelf , Z_y is defined as the location of the center of gravity off the ground on the Y axis (vertical direction) of a row of shelves. The model of such a multi-objective optimization problem can be expressed as:

$$\begin{cases} \min E = \min\left(\sum_{i=1}^{p}\sum_{j=1}^{q}\left(f_{ij} \bullet t_{ij}\right)\right) \\ \min Z_y = \min\left(\dfrac{\sum_{i=1}^{p}\sum_{j=1}^{q}\left(m_{ij}\left(i-\frac{1}{2}\right)\bullet c\right)}{\sum_{i=1}^{p}\sum_{j=1}^{q} m_{ij}}\right) \end{cases} \quad (1)$$

$$s.t. \begin{cases} i = 1,2,\cdots,p \\ j = 1,2,\cdots,q \end{cases} \quad (2)$$

4.3. Model solving process

As it is difficult to give a clear preference for the requirements of center of gravity, frequency and time, it becomes very difficult to evolve into a single objective. Traditional operations research methods, such as dynamic programming, branch and bound, can only solve small-scale problems. When the scale is large, combinatorial explosion will occur. Therefore, it is not suitable for the situation of more cargo locations. The multi-objective optimization method based on artificial intelligence can solve the combinatorial optimization problem better. Based on the hypothesis given by the optimization model of cargo location, a mathematical model of multi-objective optimization problem is established on the basis of considering the requirements of gravity center, frequency and time. By comparing the solving methods of many multi-objective problems and combining with the actual situation of large scale of solving the optimization problem of cargo location, the genetic algorithm is finally determined to solve the optimization problem of cargo location. The steps are as follows:

1.Encoding. Using one-to-one coding, each cargo location is regarded as an allele on the chromosome, and all cargo occupies the cargo location to form the whole chromosome. Chromosome Fig. 2:

$$\begin{bmatrix} 1 & 10 & 0 & 11 \\ 2 & 5 & 6 & 12 \\ 3 & 9 & 7 & 13 \\ 4 & 8 & 0 & 14 \end{bmatrix}\begin{bmatrix} 13 & 14 & 15 & 16 \\ 12 & 1 & 2 & 3 \\ 10 & 6 & 5 & 4 \\ 11 & 7 & 8 & 9 \end{bmatrix}\begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \\ 13 & 14 & 0 & 0 \end{bmatrix}\begin{bmatrix} 1 & 16 & 8 & 12 \\ 2 & 5 & 9 & 13 \\ 3 & 7 & 10 & 14 \\ 4 & 6 & 11 & 15 \end{bmatrix}$$

Fig 2 individuals

2.Initialize the population. Genetic algorithm is an evolutionary operation of population, so the population must be initialized before solving, and these population data are also the initial search points. Initialization of the population should be done step by step: calculating the number of goods, calculating the size of individuals, and setting the size of the population.

3. Fitness. The individual coding genotype is decoded to get the individual's phenotype, and the corresponding objective function value is obtained. The individual's fitness is calculated by the objective function according to certain transformation rules.

4.Choice. If the population size is M and the fitness of individual I is Fi, then the probability that individual I is selected is Pi:

$$P_{\mathrm{i}} = \frac{F_i}{\sum_{i=1}^{M} F_i} \qquad (i = 1,2,3,\cdots,M-1,M) \quad (3)$$

In order to ensure the unity of the two optimization objectives, when an individual is selected to the next generation of population, a label "S" or "E" is attached to it, and "S" is used to identify that the individual is selected according to the stability objective, and "E" is used to identify that the individual is selected according to the access efficiency objective. The label in the initial population is used to ensure the normal crossover operation and avoid the crossover operation in a generation. Individuals are labeled with a label that sets them at half of each generation.

5.Crossover. A partial mapping crossover operator is used to randomly select the values of four elements in the matrix to cross their positions. First, the crossover probability is determined, and then the paired chromosomes between two individuals are exchanged with the probability to generate new individuals.

$$\overset{S}{\begin{bmatrix} 13 & 14 & 15 & 16 \\ 12 & \boxed{1} & \boxed{2} & 3 \\ 10 & \boxed{6} & \boxed{5} & 4 \\ 11 & 7 & 8 & 9 \end{bmatrix}} \times \overset{E}{\begin{bmatrix} 1 & 16 & 8 & 12 \\ 2 & \boxed{5} & \boxed{9} & 13 \\ 3 & \boxed{7} & \boxed{10} & 14 \\ 4 & 6 & 11 & 15 \end{bmatrix}}$$

$$\Downarrow$$

$$\overset{S}{\begin{bmatrix} 13 & 14 & 15 & 16 \\ 12 & \boxed{5} & \boxed{9} & 3 \\ 10 & \boxed{7} & \boxed{10} & 4 \\ 11 & 7 & 8 & 9 \end{bmatrix}} \quad \overset{E}{\begin{bmatrix} 1 & 16 & 8 & 12 \\ 2 & \boxed{1} & \boxed{2} & 13 \\ 3 & \boxed{6} & \boxed{5} & 14 \\ 4 & 6 & 11 & 15 \end{bmatrix}}$$

Fig 3 crossover operation

6.variation. Select a part of individuals according to probability to implement mutation, and the selected individuals will mutate in the following way: randomly select two cargo locations with probability P_m, and exchange the cargo on the two cargo locations, and keep the identity of the individual unchanged before and after the change, which corresponds to small-scale variation. Generally, the value of P_m is 0.01-0.2. For small-scale variation, the value of P_m is 0.03.

$$\overset{E}{\begin{bmatrix} 1 & 2 & 3 & 4 \\ \boxed{5} & 6 & 7 & 8 \\ 9 & 10 & \boxed{11} & 12 \\ 13 & 14 & 15 & 16 \end{bmatrix}} \Rightarrow \overset{E}{\begin{bmatrix} 1 & 2 & 3 & 4 \\ \boxed{11} & 6 & 7 & 8 \\ 9 & 10 & \boxed{5} & 12 \\ 13 & 14 & 15 & 16 \end{bmatrix}}$$

Fig 4 mutation operation

Considering that a certain number of empty containers will be reserved on the shelf as a buffer, and the number of goods on some of them may be 0. According to the requirements of shelf stability and access efficiency, these empty containers should be arranged at the top or farthest from the roadway entrance. The crossover and mutation operators may transfer these empty containers to other containers, so they will be paired after each crossover and mutation. The child body performs an adjustment operation.

$$\overset{S}{\begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 0 & 12 \\ 0 & 14 & 15 & 16 \end{bmatrix}} \Rightarrow \overset{S}{\begin{bmatrix} 1 & 2 & 0 & 0 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 3 & 12 \\ 4 & 14 & 15 & 16 \end{bmatrix}}$$

Fig 5 modified individual

5. Experimental simulation

Taking the warehousing data of Haiyan Publishing House of Guangzhou Province as an example, the validity of the warehousing location optimization model established in this paper is tested. According to the actual situation of Storage Department of Haiyan Publishing House, the parameters needed for the model are substituted into the mathematical model. The length, width and height of the shelf are 1.4 m, 1 m and 0.6 m, and the shelf is 7 storeys and 16 rows. The initial population size of manual input is 100, the number of iterations is 30, the crossover probability is 0.98, and the mutation rate is 0.03. By comparing the results of optimization with the results of manual experience, it is found that the obtained location is 0.19 meters lower in the center of gravity and 38.9% higher in efficiency than that of manual placement.

Table 1 Weight of Books and Inventory Turnover Rate of Haiyan Publishing House

Book designation	Title	Number of books	Per weight	Total package number	Inventory Turnover Rate
RMJ000521	150 Patriotic Chorus Songs	10	500.000	29	1.33
RMC000908	2007 Cultural China	24	208.333	30	1.27
RMK002212	Yu Jing, Lingnan Cultural Knowledge Books	100	50.000	10	3.22
RMI002010	Interpretation of Chen Yinluo's Poems in Lingnan Culture Bookstore (Volume 2 and Volume 2) (Hard Edition)	10	500.000	40	1.21
RMD001713	Oral Records of the Pioneers of Reform and Opening-up in Guangdong	40	125.000	33	1.72
MD001291	Mao Zedong-Stalin and the Korean War	24	208.333	24	2.66
MI002003	Kapok Kai-Ren Zhongyi in Guangdong	100	50.000	26	0.32
MI0000006	The South China Sea! The South China Sea!	30	166.667	28	1.03
MB000740	Missing ancestors and loving hometown: the complex of overseas Cantonese	52	96.154	32	1.76
MI001980	Pretty baby	40	125.000	46	2.68

6. Conclusion

Based on the analysis of the characteristics of the existing inventory optimization model, a suitable inventory optimization model for warehousing industry was established, and the genetic algorithm was used to solve the model. Taking the stability requirement of high-rise shelves in warehouse as one of the purposes and the minimum product of the total time spent by the stacker in a single mode of operation and the inventory turnover rate as the second purpose, the mathematical model considering multiple conditions is established, the validity of the mathematical model is carried out, and the multi-objective optimization problem is better solved; the genetic algorithm is modified in the coding process. In order to ensure the unity of the two optimization objectives, individuals are selected to the next generation of population and labeled with different targets respectively. In cross operation, only individuals with different labels can pair; and the termination conditions of the algorithm are set simultaneously. Two conditions, as long as one of them holds, terminate the execution of the algorithm.

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Authors

< **Wei XU** >, <4 -13-1983 >,<Jiang Xi >
Current position, grades: Senior Lecturer, master graduate
University studies:School of Software, East China University of Technology
Scientific interest:information management technology and algorithm analysis
Experience: Present Senior Lecturer, East China University of Technology;
2007-2010 East China Institute of Technology ; a master's degree; Advisor: Prof.Yueshun He
1999-2003 East China Institute of Technology ; a bachelor's degree

< **Hongwei JIA** >, <10 -24-1979 >,<Jiang Xi >
Current position, grades: Senior Lecturer, master graduate
University studies: Institute of electrical and mechanical, East China University of Technology
Scientific interest: information management technology and algorithm analysis, Artificial intelligence
Experience: Present Senior Lecturer, East China University of Technology
2005-2008 East China Institute of Technology ; a master's degree; Advisor: Prof.Xiang LI
1997-2001 North China institute of technology ; a bachelor's degree

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