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Route Optimization of Stacker in Automatic Warehouse Based on Genetic Algorithm

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Abstract

Today, automatic warehouse system gradually replaced manual labor, and played an important role in the production work, especially in the cargo handling work. It was important to research the time-consuming and efficiency of stacker in the automated warehouse system. This paper researched the path of stacker in automated warehouse and calculated the operation time of stacker working path according to actual working condition, and then put forward a route optimization method of stacker based on genetic algorithm, finally simulated this algorithm by using MATLAB. The simulation results showed that this algorithm could shorten the way of stacker, and increase the working efficiency of the warehouse.

Keywords: *automatic warehouse, stacker, genetic algorithm, MATLAB*

1. Introduction

The emergence of automatic warehouse promotes the development of logistics industry and delivers and accesses the goods through stacker. It only needs a few operators and stackers which can be comparable to the workload of dozens of workers. The utilization of automated warehouse effectively reduces the employee's work intensity, the number of employees and the cost, and increases the work efficiency [1]. At the same time, it can greatly avoid the situation of misplacing goods in the process of cargo handling. Stacker is a kind of machinery vehicle which can transport and access goods, and its working process is relatively complex. Stacker finds goods allocation according to the computer set, removes parts or packing cases automatically, and sends parts or packing cases to the appointed warehouse shelves according to certain routes.

In automatic warehouse, stacker takes much time in the process of transporting goods. Under the condition of maintaining the original investment basically unchanged and the condition that stacker can not increase the speed of horizontal and vertical, it becomes a powerful method that shorten the way of stacker,and reduce the time of delivering and accessing goods in the view of the analysis of stacker path. It's imperative to analyze the route optimization of stacker in automatic warehouse and conclude a better solution. Genetic algorithm firstly proposed by professor J. Holland in the university of Michigan in 1975. It is a kind of calculation model simulated natural selection and genetic mechanism of biological evolution process in Darwinism, and it is the method to select optimal solution through simulating natural evolution [2]. Calculate the stacker way according to the working principle, and draw the corresponding calculation formula of time-consuming, after combining genetic algorithm and stacker operation route, optimize the stacker path, to greatly improve the effect of automatic warehouse operation efficiency.

2. Introduction of Genetic Algorithm

Genetic algorithm gets inspiration from biological evolution, and is a random searching algorithm which takes example by natural inheritance and evolution [3]. Genetic algorithm uses coding technology to get alphanumeric strings, and gets new alphanumeric strings through

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simulating the evolution of the alphanumeric string. This process is similar to that of survival of the fittest in biological world, and finally gets the optimal solution. At present, genetic algorithm has been widely used in the fields of industrial transportation, computer algorithm and mathematical calculation, etc.

The specific algorithm is as follows:

(1) Generation of coding and initial population: the initial population of genetic algorithm is distributed widely, otherwise the characteristics of initial population will worse, and it may have negative effects on the final results.
(2) Fitness evaluation of individual in initial population: fitness function is the standard of individual characteristics. Select the individual that is suitable to be the parent according to the results of fitness function.
(3) Selection algorithm: select the excellent individual according to the varied weights and make the fitness of offspring much better.
(4) Crossover algorithm: local cross between parents and children and make the new individual possess the characteristics of parents.
(5) Mutation algorithm: change an individual with a certain probability and certain way and it is also a method to provide new individuals.
(6) Terminate the judgment condition: if t≤T, then t=t+1, go to step 2; if t>T, then output the individual with biggest fitness, and the calculation ends [4]. The flow chart is shown in Figure 1.

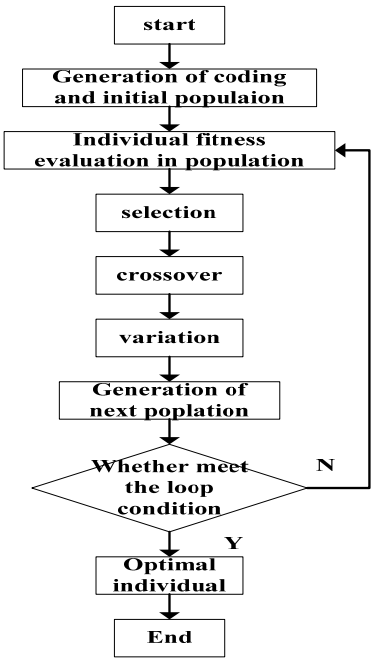

Figure 1. Genetic Algorithm Flow Chart

3. Introduction of Automatic Warehouse

3.1. The Structure of Automatic Warehouse

At present, the unit load AS is the main structure of warehouse and three-dimensional storage unit goods format warehouse as the main architecture, and warehouse shelves along the width direction parallel to a number of rows. There is a railroad laneway between adjacent two rows of shelves, and only one stacker can operate on it [5]. There are several shelves parallelly laid in warehouse and there are several layers of every shelf. There are several columns in shelf along the lengthwise direction which form a large number of compartments, to store parts and containers. Stacker operates between two parallel shelves to finish the tasks.

3.2 Analysis of Stacker Operation

Stacker can send the goods in the railroad tunnel, and finish the operation such as inbound or outbound with the computer control. Staff sending commands to computer control center to make the stacker can accurately complete the operation of storage or removement for certain goods shelves. Workers, according to order requirements, send the location of goods of the order to the computer in advance, the computer precesses and judges to the position, and then when the stacker completes a picking task, it will automatically run to the next chosen location for storage or remove operation according to the processing of computer, and so on, until it completes the las task. According to the actual operation of stacker in warehouse, the stacker operating parameters are set as follows:

(1) In order to conveniently analyze the data, assuming that when stacker delivers or accesses goods, maintain the speed in horizontal and vertical and ignore the process of slowing and accelerating;
(2) Assume that when the stacker stores or removes goods, time-consuming will not vary with the weight of the load;
(3) Ignore time-consuming of stacker caused by breakdown.

4. The Calculation Process of Genetic Algorithm in the route Optimization of Stacker

4.1. Generation of Coding and Initial Population

Genetic algorithm coding is the genetic representation of solution, and is the first step to find the solution. Usually use the binary code which is composed of binary notation set {0, 1}. Binary code is extremely convenient in encoding and decoding ,and is the premise of the selection, crossover and mutation operations. For example, X = 100100010001 represents an individual, the individual chromosome length is n=12. When coding, we can set the scope of a parameter is [U1, U2]. If the length of binary code is k, then it can produce 2^k parameters. Corresponding relationships between coding and parameters are established [6]. Specific process is as follows:

$$\begin{aligned}
&00000 \cdots 000 = && 0 \to U_1 \\
&00000 \cdots 001 = && 1 \to U_1 + \delta \\
&00000 \cdots 010 = && 2 \to U_1 + 2\delta \\
&\quad\vdots \qquad\quad \vdots && \quad\vdots \\
&11111 \cdots 111 = && 2^k - 1 \to U_2
\end{aligned}$$

Where $\delta = \frac{U_2 - U_1}{2^k - 1}$. When decoding, we can set a code $b_k b_{k-1} \ldots b_2 b_1$ for an individual, then the decoding formula is as follows:

$$X = U_1 + (\sum_{i=1}^{k} b_i * 2^{k-1}) * \frac{U_2 - U_1}{2^k - 1}$$

4.2. Fitness Evaluation of Individual

In the genetic algorithm, select new individuals and transmit to future generation according to adaptive degree [7]. The probability that high fitness individuals are transmitted to the next generation is also relatively great. Practice shows that fitness function has a great impact on the performance of genetic algorithm. The bad design of fitness function can bring deceptive problem to genetic algorithm and affects the performance of the final solution. Fitness function should satisfy the conditions:

(1) Fitness function should satisfy the performance of monodrome, succession, and nonnegative [8];
(2) Fitness function should be reasonable and consistent, which can evaluate the fitness of individual objectively;
(3) Fitness function has less calculation which is convenient to subsequent calculations. The calculation process of fitness function;

(4) In view of the problem that objective function is maximization in this paper, and the running time of the objective function is positive, then:

$$F(f(x)) = f(x)$$

(5) This method has such problems as the difficult evaluation and inaccuracy of threshold value, so change as follows to make fitness function bounded:

$$F(f(x)) = \frac{1}{1+f(x)}$$

(6) In genetic algorithm, enlarge or reduce the fitness function in order to ensure the diversity of population. Specific calculation i s as follows:

$$F' = aF + b$$

Where a and b are fitness functions, and affects the change of fitness function [9]. Formulas a and b are as follows:

$$\begin{cases} a = \dfrac{F_{avg}}{F_{avg} - F_{\min}} \\ b = \dfrac{-F_{\min} \bullet F_{avg}}{F_{avg-}F_{\min}} \end{cases}$$

Where, F_{avg} is the average value of fitness function [10].

4.3. Selection Operation

Just like the principle of natural selection, selection operation can select the excellent individuals from the whole population as the parent to breed the next generation. Fitness is the standard of evaluating whether the individual has the qualification to be the parent. Roulette wheels selection is adopted in this paper. The number of selected and individual choice probability is Proportional. The formula is as follows:

$$P_i = f / \sum_{k=1}^{M} f_k$$

4.4 Crossover Selection

Crossover operation is used to exchange the partial data of the new individual with the parent individual [10]. Therefore, it can generate new individuals on the basis of inheriting parent characteristics. In this article, the stacker goes through the goods allocation once when it stores or removes. in the crossover operation, we must ensure that a cargo does not repeat coding. This article adopts the method of mapping to ensure that a cargo will not be repeated coding. The process is as follows:

(1) Select some of the goods allocation as cross object, select 2 and 3 from the parent individual 1, select 4 and 1 from the parent individual 2, which is shown below:

Parent individual 1 1-|2-3|-4-5-6
Parent individual 2 3-|4-1|-5-6-2

(2) Cross the overlapping object selected which is shown as follow:

Parent individual 1 1-|4-1|-4-5-6
Parent individual 2 3-|2-3|-5-6-2

(3) Take 2/4 as a pair of mapping and 1/3 as a pair of mapping. Map in the two parent individuals and obtain the result which is as follow:

Parent individual 1 3-|4-1|-2-5-6
Parent individual 2 1-|2-3|-5-6-4

4.5. Mutation Selection

Mutation operation randomly selects the coding string of an individual or several individuals from the group at a certain probability for the selected individual [11]. Exchange the data of an individual at a certain probability or a certain way, which realizes the exchange of the data and information and then generate new individuals.

This article uses greedy transposition, randomly selects a position number, removes the adjacent pallet number, selects the nearest position left or right, and switches the two number. If select the number 1 in the original individual, and according to the principle of shift to the left, we can get the results as follows:

Original individual 3-4-1-2-5-6
New individual 1-4-3-2-5-6

5. Simulation and Results

In order to detect the effect of genetic algorithm proposed in this paper on the route optimization of stacker in the automatic warehouse, MATLAB is used to simulate under Windows XP operating system.

Assuming the plane sections of a row of shelves is replaced by a coordinate axis. Randomly assign the operation order of stacker, and set the horizontal speed of stacker is Vx=2l/m, longitudinal velocity is Vy=2h/m; point coordinates of goods are (X, Y), the unit of abscissa is l, the unit of vertical is h. Set there are nine goods waiting for storage handling, and coordinates sets of nine goods:

{(12,8),(8,10),(1,8),(12,4),(5,1)(2,3),(8,2),(8,6),(3,11)}

The operation time can be shown as follows:

$$t(i,j)=\max[\frac{|X_i-X_j|\bullet l}{V_x},\frac{|Y_i-Y_j|\bullet h}{V_y}]$$

We can get that the time of completing the task is t = 25.5 min which is obtained by the above mentioned formula of the total time that stacker takes. Simulate in MATLAB. The random route of stacker is shown in Figure 2, and the route optimization of stacker is shown in Figure 3. The label in the graph shows the route that stacker arrives the location of goods. The time of finishing the task is t= 16.5 min, less 9 min than the initial route.

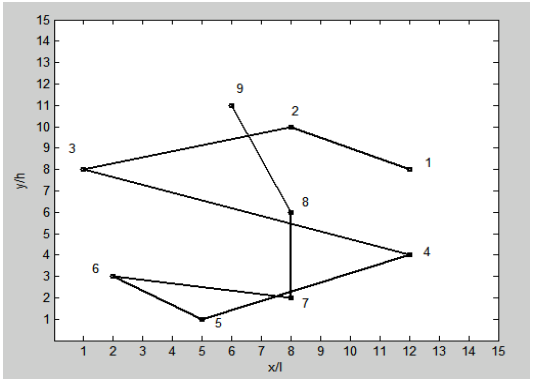

Figure 2. The Random Route of Stacker

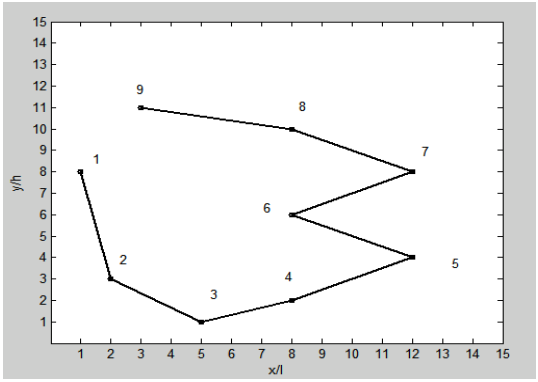

Figure 3. The Route Optimization of Stacker

In order to obviously test the effect of this algorithm and increase the sample size and the number of goods, the time-consuming of finishing the task is as shown in Table 1. Results show that after a certain times, the time-consuming by using the genetic algorithm is obviously

less than that of randomly assignment, and the more the goods is, the more obvious the effect is.

Table 1. The Time-consuming of Finishing the Task

The number of goods	5	10	15	20	25	30	35
Time-consuming of randomly assignment(min)	13	28	49.5	59	73.5	81	102.5
Time-consuming after optimization(min)	10	19.5	33.5	40.5	52	56.5	71

6. Conclusion

For the current structure system of the automatic warehouse, and the actual operation situation of stacker, this paper puts forwards the route optimization of stacker in warehouse to reduce the elapsed time of storage or removement of goods, and improve the work efficiency. This paper also expounds the ways of stacker operating, and simulates the route according to the actual situation. Then calculate the time-consuming according to the operation route, finally puts forward a route optimization scheme of stacker in automatic warehouse based on the genetic algorithm.

We can learn that, from this article, genetic algorithm is mainly divided into coding and the generation of initialization population, individual fitness evaluation, selection, crossover operation and mutation operation, and each step takes the example of a stacker and proceeds the corresponding operation [12]. Simulate the algorithm by using MATLAB. From the simulation results, we can understand that the operation time calculated by the genetic algorithm is significantly less than the normal time which proves that the route optimization of stacker in automatic warehouse based on genetic algorithm is helpful to reduce the operation time of stacker in warehouse, improves the efficiency of the automatic warehouse, and promotes the development of logistics industry.

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