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Research on Workshop Scheduling Problem Based on Genetic Algorithm

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Abstract: ***Studying workshop scheduling problems can improve the efficiency of workshop operations. Based on the analysis of the basic characteristics and requirements of workshop scheduling, this paper constructs a mathematical model of the workshop scheduling system. The genetic algorithm is used to optimize the solution of the workshop scheduling problem, and the MATLAB software is used for simulation calculation. The results show that the genetic algorithm optimization can obtain better workshop scheduling results and improve work efficiency.***

Keywords: shop scheduling; genetic algorithm; optimization

1. Introduction

The workshop scheduling problem is a problem that enterprises must deal with in the production work. The traditional manual scheduling method [1] [2] not only requires the scheduling person to have a lot of experience, but also the efficiency of handling the problem is not high. Especially in the face of complex workshop scheduling problems, the optimal solution cannot be obtained [3] [4]. The significance of studying the workshop scheduling problem is to reduce the working time and cost by changing the processing sequence of each item in the workshop to ensure the improvement of work efficiency and profit.

Based on the analysis of the basic requirements and rules of the shop scheduling problem, this paper constructs a mathematical model of the shop scheduling problem and introduces its objective function and constraint conditions. With the help of genetic algorithm, the workshop scheduling problem is optimized and solved, and the optimization steps and implementation process are given. MATLAB software is used for simulation calculation to verify the correctness of the model.

2. Workshop scheduling model

2.1 Brief description of the problem

In the workshop scheduling problem, three aspects are mainly optimized: the processing time of each item, the allocation of processing resources and the order of processing items. From the point of mathematical planning, the problem of workshop scheduling can be described as optimizing the required objective function under the constraints of multiple inequalities or equations, so as to make the enterprise workshop efficient The purpose of stable operation [5] [6]. Evaluating the efficiency of workshop scheduling can be evaluated in terms of project cost, product quality, production speed, and raw material utilization.

In the actual production process, the workshop first needs to meet the production speed of the product, and the product must be processed within the time specified by the company. On this basis, we need to optimize the workshop scheduling plan to improve work efficiency and reduce costs, so that enterprises can operate more efficiently.

2.2 Mathematical model

In the workshop scheduling process, the constraints that must be met include,

1) Product processing speed: We must complete the processing of this product within the time specified by the company.
2) Workshop resources: We must rationally use the resources in the workshop, and cannot schedule the workshop beyond the total resources of the workshop.
3) Product cost: In order for the company's workshop to be profitable, we must control the cost of the product, and we cannot ignore the cost of processing just for the quality of the product.

To mathematically model the workshop scheduling problem, the following definitions need to be made [7] [8].

Definition 1: Set P as a set of n work pieces, then P can be expressed as $P=\{P_1, P_2, \cdots, P_n\}$.

Definition 2 Set M as a set of m machines, then M can be expressed as $M=\{M_1, M_2, \cdots, M_m\}$.

Definition 3 Set the number of processes of the work piece P_i to k_i. JP_i represents the process set of P_i, then JP_i can be expressed as $JP_i=\{J_i(1), J_i(2), \cdots, J_i(k_i)\}$.

Definition 4 Set the processing sequence of each process in the process J_i in P_i on the machine M as $M_{i(1)}, M_{i(2)}, \cdots, M_{i(m)}$, and record them as $i(1), i(2), \cdots, i(k)$, in this formula, k is the maximum value of k(1), k(2), k(n), $0 \leqslant i \leqslant n$, $0 \leqslant j \leqslant k$, $0 \leqslant val(i(j)) \leqslant m$, then the processing sequence of the machine can be expressed as,

$$Q=\begin{bmatrix} 1(1) & 1(2) & \ldots & 1(k) \\ 2(1) & 2(2) & \ldots & 2(k) \\ \ldots & \ldots & \ldots & \ldots \\ n(1) & n(2) & \ldots & n(k) \end{bmatrix} \tag{1}$$

Definition 5 Set the process sequence of machine M_i during processing to JM_i, and the value range of i is (0, m), then JM_i can be expressed as $JM_i = j(1), j(2), \cdots, j(l_i) \}$, l_i represents the total number of processing steps, and j_i represents the processing number of the part.

Definition 6 Suppose w is the maximum value of $l_1, l_2, \cdots l_m$, then the matrix JM represents the process sequence of the machine,

$$JM = \begin{bmatrix} 1(1) & 1(2) & \dots & 1(w) \\ 2(1) & 2(2) & \dots & 2(w) \\ \dots & \dots & \dots & \dots \\ m(1) & m(2) & \dots & m(w) \end{bmatrix} \quad (2)$$

$$JM = \begin{pmatrix} JM_1 \\ JM_2 \\ \dots \\ JM_m \end{pmatrix} \quad (3)$$

Definition 7 The processing time T is defined as,

$$JM = \begin{bmatrix} t1(1) & t1(2) & \dots & t1(w) \\ t2(1) & t2(2) & \dots & t2(w) \\ \dots & \dots & \dots & \dots \\ tm(1) & tm(2) & \dots & tm(w) \end{bmatrix} \quad (4)$$

Definition 8 If JM_0 minimizes the value of the objective function F(JM), that is, $T(JM_0) = \min T(JM)$, and satisfies Q, then we call JM_0 the optimal solution of the workshop scheduling system.

3. Genetic optimization algorithm

3.1 Principles of bionics

The basic idea of genetic algorithm originated from Mendel's law of inheritance. The organism itself will cross and copy its own genes, so that the inheritance of its own traits can be controlled. At the same time, in the process of biological development, through genetic mutation, chromosome recombination in number and structure and gene recombination can produce various mutation phenomena. Biological heredity can ensure the overall stability of organisms in the process of reproduction, and biological variation can make organisms more easily adapt to environmental variations during growth, resulting in new traits, and sometimes new ones. Species, so that biological populations can develop better.

Genetic algorithm is an optimization algorithm that uses the law of population genetics and the theory of natural selection. It uses the laws of evolution in biology, uses the survival of the fittest to search, and obtains an approximate optimal solution in the search process. The main idea is to set some main parameters, calculate the fitness of each individual, and then select the individual according to the fitness, crossover and mutation, and finally select the better individual.

3.2 Main parameters

(1) Group size

The size of the population is one of the main factors affecting the optimization results and operating efficiency of the genetic algorithm. If the group size is too small, the diversity of the group will be reduced, it is difficult to provide enough samples, resulting in poor optimization effect of genetic algorithm, and it is difficult to get the optimal solution. If the group size is too large, the amount of calculation will increase significantly, and the optimization efficiency is too low. Therefore, after research by scholars, it is found that when the group size is between 10 and 200, a better optimization effect will be achieved.

(2) Mutation probability

The level of mutation probability plays a vital role in maintaining the diversity of the population. The probability of mutation is too low, which will cause the loss of some important genes in the population, and may not produce new individuals. If the mutation probability is too high, the genetic algorithm will become a random search. Normally, the mutation probability is 0.001~0.1.

(3) Maximum evolutionary algebra

The maximum evolution algebra can be used as the termination condition of this genetic algorithm. When the number of evolution reaches the maximum evolution algebra, the algorithm stops. The optimal solution at this time is the optimal solution of the research problem. Generally the value is 100~1000.

(4) Crossover probability

The crossover probability indicates how often we perform crossover operations. A larger crossover probability can expand the search range, but if individuals change too fast, individuals with stronger adaptability will also be destroyed. The smaller the probability of crossover is because the crossover operation is rarely performed, which makes the search stalled.

4. Genetic algorithm optimization solution

4.1 Implementation process

The genetic algorithm is used to optimize the solution of the shop scheduling model. The flowchart is shown in Figure 1. The solution steps are summarized as follows.

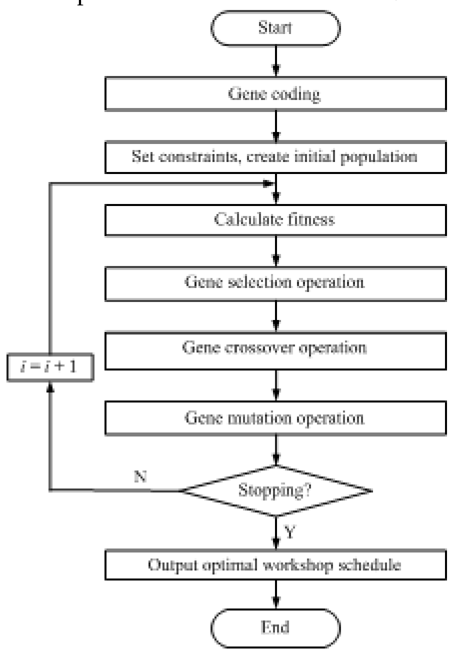

Figure 1 Flow chart of genetic algorithm to solve shop scheduling problem

(1) Genetic algorithm coding: reasonable coding of feasible solutions to the workshop scheduling problem is the key to completing the workshop scheduling. The coding method used in this article is based on the process expression of parts. Using the expression method, the scheduling can be encoded into the sequence of the process. Each gene represents a process, and each gene chain represents the possibility of completing a task. For our common workshop scheduling problem of n workpieces and m machines, each chromosome has m•n genes, and each workpiece appears m times on the chromosome, but each gene is not a specific workpiece process, but represents all the machining process of the workpiece.

(2) Set the constraints of the workshop scheduling, such as the delivery time of the product, the time to complete the product, and the cost of producing the product.

(3) Set initial parameters, such as the algebra to terminate evolution, crossover probability, mutation probability, and population size.

(4) Calculate the fitness of all individuals.

(5) Perform selection operations, crossover operations and mutation operations on all individuals to generate new individuals.

(6) Judgment of termination conditions: Judge whether the maximum evolution algebra has been reached, and if the maximum evolution algebra has been reached, the iteration will be terminated, and the optimal individual will be output as the optimal solution for workshop scheduling, otherwise, return to step (4) and continue iteration.

4.2 Analysis of results

Suppose our research question is: a certain part needs to be processed through 31 procedures, each process only needs to be processed once, and finally the part is returned to the initial position, requiring the shortest distance.

The coordinates of each process are: [1304 2312; 3639 1315; 4177 2244; 3712 1399; 3488 1535; 3326 1556; 3238 1229; 4196 1004; 4312 790; 4386 570; 3007 1970; 2562 1756; 2788 1491; 2381 1676 ;1332 695;3715 1678;3918 2179;4061 2370;3780 2212;3676 2578;4029 2838;4263 2931;3429 1908;3507 2367;3394 2643;3439 3201;2935 3240;3140 3550;2545 2357;2778 2826;2370 2975].

MATLAB software is used for simulation calculation, and the parameters are set as: the population size is 200, the dimension of chromosomal genes is 31, and the number of generations to terminate evolution is 1000. The optimization result is shown in Figure 2. The shortest distance after optimization is 17863m.

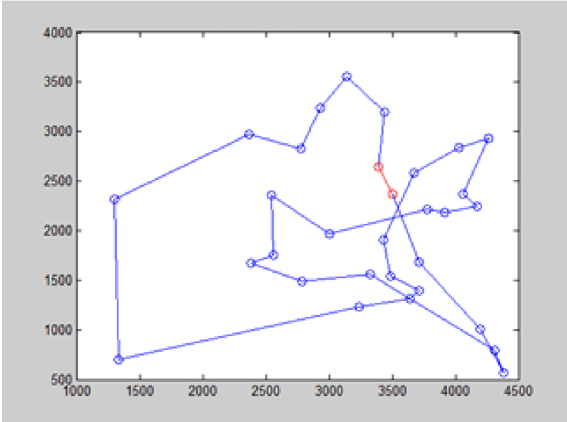

Figure 2 Coordinate diagram of machined parts

5. Conclusion

Based on the analysis of the constraint conditions of shop scheduling, this paper constructs a mathematical model of shop scheduling. With the help of genetic algorithm, the workshop scheduling problem is optimized and solved, and the simulation flowchart and implementation steps are given. MATLAB software is used for simulation calculation, and the optimal solution for workshop scheduling is given.

6. Acknowledgements

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Author Profile

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