Study a sequence of processing craftwork decision-making base on constraint matrix and genetic algorithm

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Abstract

In order to solve the problem of the order of processing technology in CAPP, which proposes a method of intelligent decision-making process base on constraint matrix and genetic algorithm, establishes the mathematical model of the order of processing technology based on genetic algorithm, uses constraint matrix to describe processing technology prior relation between the processing units. Studies of the order of decision-making processing technology base on genetic algorithm. In the final, this system use in C# as development language, it has been developed successfully the process decision-making system module and it is verified the feasibility of this method by sample.

Key words: Constraint matrix; Genetic algorithm; The order of processing craftwork decision-making **Introduction**

Computer Aided Process Planning (Computer Aided Process Planning, CAPP) is the manufacturing method using computer technology-assisted processes to design parts from rough to finished product and the technology that enterprise product design data converted to product manufacturing data. Process decision is usually divided into the decision-making method and craft processing sequence decision-making, which in the case of clear the characteristics of parts surface processing method of processing route optimization decisions, so that in meet certain processing constraints to order processing arrangements reasonable and try to improve the processing efficiency[1]. The traditional crafts processing order of decision-making based on the general laws of the process, using of linear programming methods for the processing order of the decision-making, this may lead to some of the original optional process route program is discarded prematurely in the early of process planning or the route process scheme is not optimal finally due to excessive of process constraint problems in late. Therefore, the processed sequential decision is one of the key issues needs to solve in process planning system.

1. mechanism of the process decision-making

1.1 Introduction to Genetic Algorithms

The genetic algorithm is an optimization algorithm based on the "survival of the fittest", through "chromosome" group evolving eventually from generation to generation and converge to the individual of "the best adapted to the environment" and to find the optimal solution of the problem[2]. Processed order decision-making flow chart based on genetic algorithm shown in Figure 1.

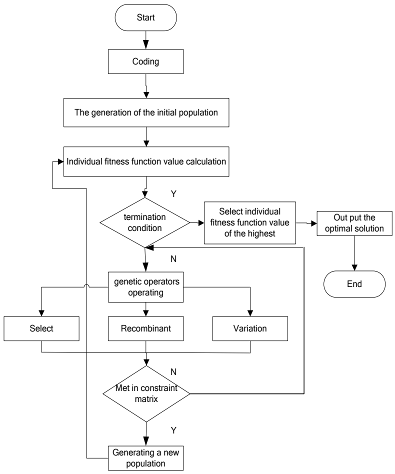

Fig. 1 The flow diagram based on GA's order decision-making process

1.2 generation of constraint matrix

If it has N processing in g a processing parts, then define the adjacency matrix of order N to represents a precedence constraint relationship between the content of these processing, that is constraint matrix. Assume the constraint relationship between processing [3]:

$$R=\begin{bmatrix} R_{11} & R_{12} & \cdots & R_{1N} \\ R_{21} & R_{22} & \cdots & R_{2N} \\ \vdots & \vdots & \vdots & \vdots \\ R_{N1} & R_{N2} & \cdots & R_{NN} \end{bmatrix} \quad (1)$$

Where i, j = 1, 2, ..., N. R_{ij} represents the constraint relationship between the i processing content and the j processing, conversion rules for:

(1) When the i machining content first in the j processing content, R_{ij} =1 , R_{ji} =0;

(2) Other case $R_{ij} = R_{ji}$ =0.

1.3 mathematical model of processing sequential decision

Provided that a process route as X={ $O_1^{'}, O_2^{'}, \ldots, O_n^{'}$ }, wherein{ $O_1^{'}, O_2^{'}, \ldots, O_n^{'}$ }={ $O_1, O_2, \ldots, O_n$ }, that is the elements of the processing elements in the two sets is the same. The constraint condition denoted as: R={ $R_1, R_2, \ldots, R_n$ }. The problem using mathematical programming model is described as follows [4]:

$$\begin{cases} \max F = f(X) \\ s.t. X \in R^n \\ R^n \in \Omega \end{cases} \quad (2)$$

Therefore, the mathematical model of sequential decision processing technology can be described as: for a machining parts, find a processing sequence feasible solution X and meet the process precedence relationships set of constraints R^n in a given process sequence Ω, so that the objective function to achieve optimal, that $\max F$.

2. processing sequential decision-making process based on genetic algorithms

2.1 gene coding [5]

Using natural number coding is the most effective for the processed sequential decision. A processing parts consists of n processing element (processing method), then on each chromosome contains n genes, that $G = \{G_1, G_2, \ldots, G_i, \ldots, G_n\}$. Each gene is by six parts, that G_i = (processing element number, characteristic element code, processing method code, machine code, the tool code, the fixture code).

2.2 Initial population generation

The most critical of generation of the initial population is to set the size of the population size, that the number of chromosomes. The number of chromosomes is randomly generated and it based on experiment and experience, the general value of tens to hundreds [6].

2.3 The fitness function design

The fitness function design is the sole basis of genetic manipulation in Genetic algorithm. Between conversion cost / time in each processing element is mainly decision by the machine conversions frequency M_c 、 tool conversions frequency T_c and fixture conversions frequency S_c. Therefore, this paper makes the smallest weighted value as optimization objective to achieve processing sequential decision.

(1) Machine normalized conversion formula

Assumed the number of processing element is n for the processing parts, and the collection of all machine is M, scilicet

$$M = \{M_1, M_2, \cdots, M_m\} \tag{3}$$

Obviously, the number of conversions of the machine M_c has a maximum value Max (M_c) = n and the minimum value Min (M_c) = m. Normalization the number of machine conversions M_c:

$$f(M_c) = \frac{Max(M_c) - M_c}{Max(M_c) - Min(M_c)} = \frac{n - M_c}{n - m} \tag{4}$$

(2) Tool normalized conversion formula

Assumed the number of processing element is n for the processing parts, and the collection of all tool is T, scilicet

$$T = \{T_1, T_2, \cdots, T_t\} \tag{5}$$

Obviously, the number of conversions of the tool T_c has a maximum value Max (T_c) = n and the minimum value Min (T_c) = t. Normalization the number of tool conversions T_c:

$$f(T_c) = \frac{Max(T_c) - T_c}{Max(T_c) - Min(T_c)} = \frac{n - T_c}{n - t} \tag{6}$$

(3)Fixture normalized conversion formula

Assumed the number of processing element is n for the processing parts, and the collection of all fixture is S, scilicet

$$S = \{S_1, S_2, \cdots, S_s\} \tag{7}$$

Obviously, the number of conversions of the fixture S_c has a maximum value Max (S_c) = n and the minimum value Min (S_c) = s. Normalization the number of fixture conversions S_c:

$$f(S_c) = \frac{Max(S_c) - S_c}{Max(S_c) - Min(S_c)} = \frac{n - S_c}{n - s} \tag{8}$$

In order to better express the relationship between these three with processed sequential decision, this paper design the fitness function as follows:

$$F = f(x) = w_1 \times f(M_c) + w_2 \times f(T_c) + w_3 \times f(S_c) \tag{9}$$

Where w_1 , w_2 , w_3 represent respectively the weight coefficient of the number of machine conversions M_c , the number of tool changer T_c, the number of fixture conversions S_c . Solving the weight coefficient can obtain AHP, and its value is: w_1 =0.67 , w_2 =0.09 , w_3 =0.24. Therefore, the fitness function of the formula (9) can be written as [7]:

$$F = f(x) = 0.67 \times f(M_c) + 0.09 \times f(T_c) + 0.24 \times f(S_c) \tag{10}$$

2.4 Select

This paper uses fitness proportional method to select operation, concrete steps are as follows [8]:

(1) Assuming the individual x_i fitness function values is f_i, to thereby calculate

the probability of selection of each individual $p_i = \frac{f_i}{\sum_{i=1}^{n} f_i}$;

(2) In accordance the value of individual choice probability p_i to arrangement individual from largest to smallest, the first individual select two and individual choice once ranked in the middle and at the back of the individual does not choose according to a certain proportion.

2.5 Recombinant

Genetic recombination is also called the crossover operation, the paper makes in the following manner to recombinant gene [9] [10], as shown in Figure 2.

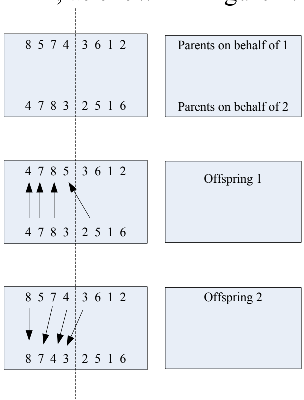

Fig. 2 The schemes of gene recombinant

2.6 Variability

The variation is to change the value of the operation of certain gene locus in the chromosome according to a certain mutation probability Pm, the process shown in Figure 3.

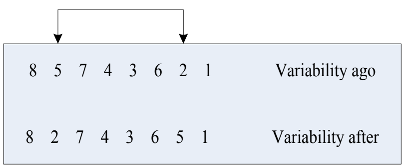

Fig. 3 The schemes of gene mutation

3. System running instance

A stepped shaft as example to details of the running of the system, and the parts are shown in Figure 4.

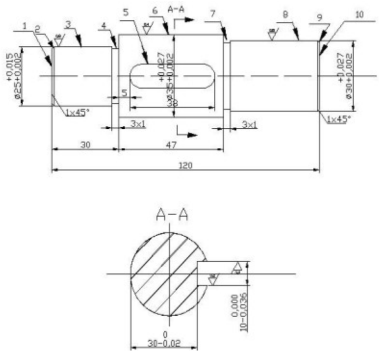

Fig.4 Ladder axis part figure

The figure shows that the part composed by 10 feature element, its gene encoding shown in Schedule 1.

Gene encoding completed into the process constraint relations interface, as shown in Figure 5.

Fig. 5 The interface of process constraint relation

Enter the appropriate operating parameters in the processed sequential decision-making interface according to the actual situation, and then click on the "run" button and it will output processed order line on the optimal, as shown in Figure 6.

Fig. 6 Craft processing order decisions

Seen from Figure 6, the machine converted 4 times, the number of conversion tool is 8 times, fixture converted 4 times, the fitness function value F is 0.959, it reduces production cost and production cycle.

4. Conclusions

This paper processed sequential decision method based on genetic algorithm, established a mathematical model of the process decision, studied its operations, and the use of the constraint matrix to describe the precedence constraint relationships between each processing element, and finally using of specific examples to verify the validity and rationality of this method with the lowest production costs as the objective function. However, the characteristic element of the division needs a good recognition of the part feature, generating each processing chain of feature element requires a lot of process knowledge for knowledge representation, and these two issues will be the mainly direction of our future research.

5. References

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Schedule 1 Genetic encoding

The processing element No.	characteristic element	processing method	machine code	tool code	fixture code
1	1 End face A_1	Rough	1Lathe	6Facing tool	4Lathefixture
2		Semi-intensive car	1Lathe	6Facing tool	4Lathefixture
3		Coarse grinding	4Grinder	7Grinding wheel	5Grinder fixture
4		Semi-fine grinding	4Grinder	7Grinding wheel	5Grinderfixture
5		Fine grinding	4Grinder	7Grinding wheel	5Grinderfixture
6	2 Chamfer A_2	Rough	1Lathe	8External Turning Tool	4Lathefixture
7	3 Cylindrical surface A_3	Rough	1Lathe	8External Turning Tool	4Lathefixture
8		Semi-intensive car	1Lathe	8External Turning Tool	4Lathefixture
9		Coarse grinding	4Grinder	7Grinding wheel	5Grinderfixture
10		Semi-fine grinding	4Grinder	7Grinding wheel	5Grinderfixture
11		Fine grinding	4Grinder	7Grinding wheel	5Grinderfixture
12	4 Undercut A_4	Vehicle undercut	5Milling Machine	9 Grooving knife	6Milling fixture
13	5 Keyway A_5	Roughing	5Milling Machine	4 Cutter	6Milling fixture
14		Precision milling	5Milling Machine	4 Cutter	6Milling fixture
15	6 Cylindrical surface A_6	Rough	1Lathe	8External Turning Tool	4Lathefixture
16		Semi-intensive car	1Lathe	8External Turning Tool	4Lathefixture
17		Coarse grinding	4Grinder	7Grinding wheel	5Grinderfixture
18		Semi-fine grinding	4Grinder	7Grinding wheel	5Grinderfixture
19		Fine grinding	4Grinder	7Grinding wheel	5Grinderfixture
20		Precision grinding	4Grinder	7Grinding wheel	5Grinderfixture
21	7 Undercut A_7	Vehicle undercut	5Milling Machine	9 Grooving knife	6Milling fixture
22	8 Cylindrical surface A_8	Rough	1Lathe	8External Turning Tool	4Lathefixture
23		Semi-intensive car	1Lathe	8External Turning Tool	4Lathefixture
24	8 Cylindrical surface A_8	Coarse grinding	4Grinder	7Grinding wheel	5Grinderfixture
25		Semi-fine grinding	4Grinder	7Grinding wheel	5Grinderfixture
26		Fine grinding	4Grinder	7Grinding wheel	5Grinderfixture
27	9 Chamfer A_9	Rough	1Lathe	8External Turning Tool	4Lathefixture
28	10 End face A_{10}	Rough	1Lathe	6Facing tool	4Lathefixture
29		Semi-intensive car	1Lathe	6Facing tool	4Lathefixture
30		Coarse grinding	4Grinder	7Grinding wheel	5Grinderfixture
31		Semi-fine grinding	4Grinder	7Grinding wheel	5Grinderfixture
32		Fine grinding	4Grinder	7Grinding wheel	5Grinderfixture