Nature Inspired Algorithm For Computer Aided Process Planning

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ABSTRACT

Many firms are under significant pressure to produce low cost, high quality products that can compete in the world marketplace. It might be useful if the process plan could be dynamically modified to consider the current state in the manufacturing shop floor. The research mainly observes the relationship between numbers of product being produced, production time, waiting time, number of item waiting and also instantaneous use of machines in the job shop condition. The development of process plan and the determination of standard process time are essential functions for many manufacturing organization. These functions are time consuming and require significant skill or great deal of experiential knowledge. So a better process plan is need to reduce the manufacturing lead time and to improve the overall productivity. Various machining operations that are involved in the manufacture of any component depend on the facilities (machines, tools etc.,) available in the factory. In factory environment each of operations can be carried out on different machines and tools. This combinational problem is tried non-traditional optimization tool genetic algorithms, specially designed operators are used for cross over and mutation. Minimization of process total time is taken as criteria for optimization. This paper deals with the use of genetic algorithm to perform process planning and process time prediction activities.

Keywords: Process planning, Genetic algorithm, processing time.

I .INTRODUCTION

Process planning is an engineering task that determines the detailed manufacturing requirements for transforming a raw material into a completed part, within the available machining resources. The output of process planning generally includes operations, machine tools, cutting tools, fixtures, machining parameters, etc. In this approach, the process planning for a component is modeled in a network by simultaneously considering the selection of operations, machines and operation sequence, as well as the constraints imposed by the precedence relationships between operations and available machining resources. Genetic algorithm is developed to find the optimal plan. Process planning is the activity which is done next to product design or specification, which is defined in terms of the design engineer's terminology (eg.,size, shape, tolerance, finish and material properties/ treatment) and transforming it into a detailed list of manufacturing instructions which are stated in terms that are useful to manufacturing personnel (eg., specifications for materials, processes, sequences and machining parameters).For many products there is no unique manufacturing method and many variations of the process plan could provide an acceptable end product.

II .COMPUTER AIDED PROCESS PLANNING (CAPP):

In General, the manufacturing process is planned in a static manner, whether it is prepared by human or with computer assistance. However, due to the dynamic fluctuation of customer demands in the market, manufacturing enterprises are facing difficulties in rapidly responding to Market changes. Thus, it might be useful if the process plan could be dynamically modified to consider the current state of the manufacturing system so as to study the manufacturing performance in unpredictable situation. For the purpose of increasing the responsiveness of manufacturing systems to handle unstable market changes, the integration of Process planning and production scheduling concept has been introduced[1]. There is much interest by manufacturing firms in automating the task of process planning using computer – aided process planning (CAPP) systems. The shop-trained people who are familiar with the details of machining and other processes are gradually retiring and these people will be unavailable in the future to do process planning an alternative way of accomplishing this function is needed, and CAPP systems are providing this alternative. CAPP is usually considered to be a part of computer aided manufacturing (CAM).

III.GENETIC ALGORITHM:

The GA's have been developed by Holland. A GA is a search algorithm that is on the biological principles of selection, reproduction and mutation. It uses the principles to explore and exploit the solution space associated with a problem. The reason behind the using of GA in present study is given below.

- It is the global search algorithm resulting in better / improved solutions to complex problems of various manufacturing as well as related fields, where analytic methods or other algorithms are either difficult to formulate or solve.

- It is capable of providing multiple solutions simultaneously by nature of its working.

3.1 GENETIC OPERATORS:

The mechanics of simple genetic algorithms are surprisingly simple, involving nothing more complex than coping string, swapping partial strings and bit conversion. A simple genetic algorithm that yields good results in many practical problems is composed of three operators.

- Reproduction
- Crossover
- Mutation

3.1.1 Reproduction:

Reproduction is a process in which individual strings are copied according to their function values. Coping strings according according to their fitness values means that strings with a higher fitness value have a higher probability of contributing one or more offspring in the next generation. This operator, of course, is an artificial version of natural selection. It is important to note that no new string formed in the reproduction phase.

3.1.2. Crossover:

Crossover combines a pair of "parent" solutions to produce a pair of "children" by breaking both parent vectors at the same point and reassembling the first part of one parent solution with the second part of the other, and vice versa.

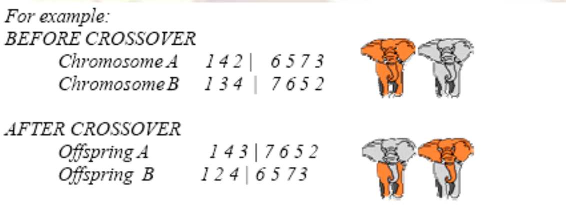

Fig 1

3.1.3. Mutation:

Mutation operation randomly changes the offspring resulted from crossover. Mutation is intended to prevent falling of all solutions in the population into a local optimum of the solved problem.

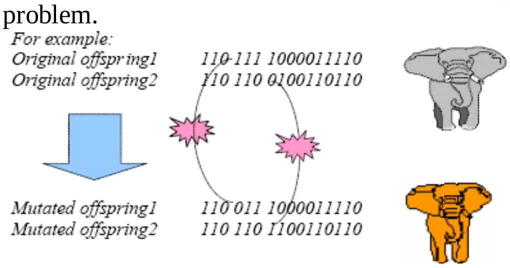

Fig 2

3.1.4. Fitness function:

For the minimization problems, it is an equivalent maximization problem chosen such that the optimum point remains unchanged. A number of such transformations are possible. The fitness function often used is F(x) = 1 / (f(x)).This transformation does not alter the location of the minimum, but converts a minimization problem into an equivalent maximization problem.

3.1.5. Working of Genetic Algorithm:

With the initial population for the next generation is to be generated which are the offspring of the current generation. The reproduction operator selects the fit individuals from the current population and places them in a matting pool. Highly fit individuals get more copies in the matting pool where as the less fit ones get fewer copies.

3.1.6. GA applied in process planning:

Optimization is collective process of determining a set of conditions required to achieve the best results from a given situation. The basic concept of Genetic Algorithm (GA) is to encode a potential solution to a problem of series parameters. A single set of parameter value is treated as the genome of an individual solution. An initial population of individuals is generated at random or statistically. Genetic algorithm was successfully applied in a robust and general way to the process plan optimization problem. This lead to a highly generalized extension into parallel plan optimization as a new way of tackling the job- shop scheduling problem[2]. The application of the technique to process plan optimization is then described in detail further.

3.1.7. PSEUDO-CODE FOR GENETIC ALGORITHM

Procedure for genetic algorithm:

```
begin
    set time t := 0
    select an initial population P(t) = {x1t, x2t, …, xnt}
    while the termination condition is not met, do:
   begin
      evaluate fitness of each member of P(t);
      select the fittest members from P(t);
      generate off springs of the fittest pairs using
      genetic operators;
      crossover with specific P_c and site;
      mutation with specific P_m and site;
      replace the weakest members of P(t) by these
     offsprings;
      set time t := t+1
     end
end.
```

3.1.8. Process planning for a sample component – A case study.

The following component is considered for optimizing the process planning. The objective function taken here is process time (it should be minimized). The process time includes all machining operations involved in manufacturing the component.

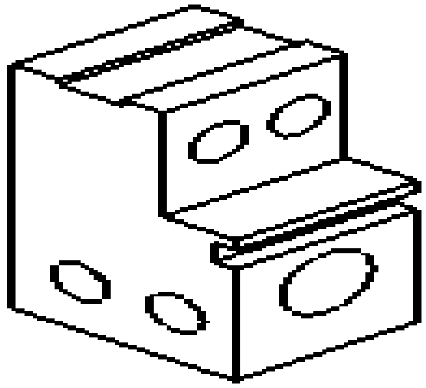

Fig 3 : Sample component

3.1.9. Desired objective function:

$$T = \text{Minimize} \sum_{i=1}^{n} [S.T + M.T + TT]$$

Where

T – Total time (in min)
S.T – Setting time (in min)
M.T – Machining Time (in min)
T.T – Travel time (in min)
n – No of iterations.

Table 1: Assumptions made

OPERATION NUMBER	OPERATIONS
1	FACING
2	DRILLING 1
3	DRILLING 2
4	DRILLING 3
5	TAPER
6	SLOT 1
7	SLOT 2

Table 2: Machine Number

MACHINE NUMBER	MACHINE
8	LATHE
9	SHAPER
10	MILLING MACHINE
11	DRILLING MACHINE

3.1.10. Steps involved in solving the problem:

The steps involved to obtain optimal time for the manufacturing component using GA as follows.

STEP 1: Generate initial population randomly.
STEP 2: Evaluate the fitness function value for the initial population.
STEP 3: Select the parent sequence based on the fitness value using rank based roulette wheel selection strategy.
STEP 4: Perform crossover operation to generate offspring's using single point cross over technique.
STEP 5: Perform mutation operation using swapping operator.
STEP 6: Evaluate the fitness value for the new chromosomes and store the best solution.
STEP 7: If the termination condition is reached go to 6 else go to step 3.
STEP 8: Print the best solution.

3.1.11. GA PARAMETERS:

The following parameters are fixed before initializing the population.
Number of solution / Chromosome / population size: 10
Number of iterations / Generations: 100
Crossover probability: 0.9
Mutation probability : 0.3.

Table 3: Initial population (operation sequence):

1	3	3	5	4	6	5
1	5	2	6	5	7	3
1	2	5	5	3	3	6
1	3	5	2	6	5	7
1	2	3	6	5	7	5
1	3	4	6	6	5	2
1	2	4	5	3	6	6
1	6	3	6	4	6	4
1	7	4	5	5	3	3
1	2	4	4	5	4	5

Table 4: MACHINE SEQUENCE:

8	10	8	10	9	8	11
10	10	9	8	8	11	10
8	9	11	9	10	8	11
10	9	8	11	11	9	8
9	8	8	9	8	10	11
9	11	9	9	9	10	10
8	10	10	8	11	9	8
10	9	11	11	10	11	9
9	8	10	8	9	8	8
8	9	9	8	8	9	11

3.2.0. Evaluation of objective function values:

The total time taken as an objective function and that should be minimum. From objective function the sequence of operation is determined.

3.2.1. Illustration:

152 154 143 163 164 176 178 185 190 203

IV. Results and discussion:

The most optimal solution for the problem is obtained by using genetic algorithm with crossover probability 0.9, mutation probability 0.3. They are as follows

4.1. Operation sequence:

1 2 4 6 5 7 3

4.2. Corresponding operations:

Facing,DrillingØ10mm,DrillingØ 16mm,Slot 5x5mm,taper 5x45˚,Slot 7 x 8mm,Drilling Ø8 mm.

4.3. Machine sequence:

10 11 10 11 10 10 10

V. Conclusion

The manual process plan preparation for a component takes lot of time. Even then the real optimum may not be found since the process planner may have made some cut short assumptions. Again it is highly impossible to check each and every possibility of the process plan. But using this developed System, the user can get various machining sequences and finally the optimized process plan in much less time. This paper deals the process planning optimization using GA by minimizing the process time. The proposed methodology is tested using program developed in C language. The GA has been successfully applied to search in the process planning model. The work is being extended to multi objective optimization and also influence of crossover and mutation probability of GA performance.

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