Research on RGV Optimal Dynamic Scheduling Scheme Based on Heuristic Algorith

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Abstract: With the development of industrial production, the work efficiency of improving the operation process has beco-me the focus of people's attention. In terms of the current probl-em, this paper focuses on the optimal dynamic scheduling scheme of RGV (Rail-Guided Vehicle) to achieve maximize production b-enefits and save hum-an resources. In this paper, the number of processes is classified and discussed. In one process, the ant colo-ny algorithm is used to find the optimal path for each step, and t-he material situation of CNC machined by RGV is simulated. T-he relation-ship between RGV processing and optimal scheduling of loading and unloading was studied. In the two processes, this paper uses the heuristic algorithm-genetic algorithm in biogene-tics to construct a new model, and then combines the roulette al-gorithm to select different allocation strategies to get the best sc-heduling scheme. Finally, we use eM-Plant 13.0 software to carry out simulation test to verify the practicability and effectiveness of the model, and to determine the optimal dynamic scheduling pro-blem of RGV to improve the production efficiency of the factory.

1. Introduction

The RGV is a driverless, intelligent vehicle that can run f-reely on fixed tracks. RGV dynamic scheduling is an intelige-nt vehicle scheduling mode under the environment of intelige-nt processing system. It can automatically control the moving direction and distance according to the instructions, and comp-lete tasks such as loading and unloading and cleaning materia-ls. The use of RGV greatly improves the work efficiency of t-he task, saves human resources, and has a broad application p-rospects and utilization value.

At present, the application of RGV mostly focuses on dy-namic scheduling to get the best decision. Yan Penghu et al. p-roposed a hybrid algorithm based on genetic and tabu search t-o study the time scheduling problem of minimum completion. Wu Changqing et al. proposed a dynamic model of RGVS sys-tem based on two-layer coloring timed petri net(1). Chen Hua et al. used a mixed integer linear programming model based o-n region-based 2-RGV scheduling problem to achieve schedu-ling optimization(2).

In this paper, the idea of artificial intelligence algorithm is oriented, from the aspects of different process quantities, com-bined with genetic algorithm, ant colony algorithm and roule-tte algorithm to determine the best dynamic scheduling scheme.

2. The Research Methods

2.1 Model assumptions

- Since the actual cleaning time of clinker in the cleaning tank is very short, much less than the time that the robot puts the material onto the unloading conveyor, the cleaning time is ignored in the optimized scheduling scheme;

- It is assumed that the RGV car will not have other faults during the operation, and there is no interference under special circumstances (special circumstances such as sudden power failure);
- It is assumed that once the RGV car starts a shipment, it cannot be stopped midway until the delivery is completed. One RGV trolley can only perform one of processing, loading, unloading, cleaning, moving, and stopping waiting tasks at a time.
- Assuming that the work table is flat and the raw material supply is sufficient, there will be no shortage.

2.2 Analysis of a process

Through the analysis of the problem, the realization goal of the model is to dynamically optimize the material processing operation of one process. Under the premise that the same tool is installed in each CNC and the material can be processed on any CNC, the RGV is adopted. Move to plan to produce the most products produced within the specified time. Therefore, ant colony algorithm is adopted to solve the problem of path selection. The ant colony algorithm simulates the process of ants searching for food, that is, starting from the starting point, finally returning to the starting point after several intermediate points, and the overall cost is the least. We take the time spent at all processing points as an excellent indicator of the distribution strategy.

2.3 Model establishment and solution------a process

2.3.1 Processing time range

In this model, we mainly discuss the range of values of the time when the CNC processes the material. It is assumed that the given time for processing the material by the CNC is much longer than the loading and unloading time of the item, which is divided into the following cases:

- Processing speed is less than loading and unloading speed: 15
- Processing speed is equal to loading and unloading speed: 35
- Processing speed is slightly larger than the loading and unloading speed: 150
- Processing speed is much higher than loading and unloading speed: 400

2.3.2 Concrete implementation

Firstly, two key record marks are defined and the status an-d time schedule of the CNC are recorded separately. At the sa-me time, according to the time between the processing time of the material and the time of loading and unloading parameters of the CNC, the specific values of the parameters are set, and t-he parameters include different distances of RGV movement. Time spent, RGV cleaning time, CNC machining time, CNC l-oading and unloading time. The key to the model is the control of the overall processing time, that is, using a loop, the loop en-d condition is set to 8*3600(s), which is the assumed 8-hour w-orking time.

When the model's working time does not reach the termina-tion condition, the initialization of the record flag and the cons-truction of the CNC ready state are performed separately. The CNC state is then traversed to find the location for the next mo-ve. If it is judged that no CNC is ready, the counter performs an auto-increment operation, and then directly jumps to the next r-ound of the model algorithm to determine whether the working time has reached the termination condition. The model algorit-hm calculates the movement path time, representing the move-ment of the RGV. After that, first judge the time. If it exceeds the specified time, return directly to the starting point. If the sp-ecified time is not reached, the output of the loading and unloa-ding time and the optimal scheduling are performed, and the ti-me stamp is updated simultaneously at the time of loading, and then the blanking time is calculated.

2.4 Analysis of two processes

The situation we analyzed in this paper is the material pro-cessing operation of the two processes. Since the tool cannot be replaced during the process, the first and second processes of each material are processed by two different CNCs in sequ-ence. Because the processing of the two processes involves t-wo different CNCs, that is, the cross-selection of two sets of d-ata is needed. To solve this problem, we adopt a heuristic alg-orithm, which is a genetic algorithm to solve this problem. Th-e genetic algorithm model is a computational model that simu-lates the natural evolution of Darwin's biological evolution th-eory and the biological evolution process of genetic mechanis-m. It is a method to search for optimal solutions by simulating natural evolutionary processes. We use the CNC coding of the combination of the two processes of the CNC car, and then ge-nerate the population size, calculate the objective function and the fitness function value according to the set function, and us-e the proportional individual selection probability calculation method from the parent population. Choosing good individua-ls produces offspring individuals.

Then calculate the ratio of the time spent by each selection strategy to the total time, find the probability that each scheme is selected, use the roulette algorithm to randomly select, and determine the scheme with the most selection times as the opt-imal scheme. Optimize the formulation of the scheduling plan.

2.5 Genetic model establishment

2.5.1 Encoding

For coding, the commonly used coding methods are bina-ry coding, Gray coding, real coding, and double structure codi-ng. After consulting the literature, the binary code method has a large representation character length, so the search efficiency is also low, and the stability of the population size in the genet-ic algorithm cannot be guaranteed. The coding methods such as Gray coding and real coding overcome the binary coding. The shortcomings, but for the problem, we hope to solve the combi-nation relationship between the coded individuals and how to process the loading and unloading. Therefore, we have adopted the two-dimensional coding method. There are many kinds of schemes for two-dimensional coding. We randomly generate a coding scheme for solving problems, and subsequent algorith-ms such as selection, crossover and mutation assist in further solving the problem.

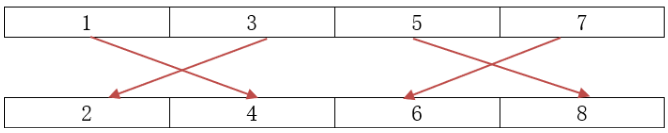


Figure 1. Coding scheme

Note: The straight line represents the match, and each number represents the CNC number. Randomly select the generated coded representation:

1	3	5	7
4	2	8	6

Figure 2. Code representation

2.5.2 Calculation of individual objective function value and fitne-ss value

The so-called individual objective function refers to the time T used to deliver a set of Q inbound and outbound tasks, namely:

$$T = t_1 + t_2 + t_3 + t_4 \tag{1}$$

t1 : RGV spends time on the journey (s)
t2 : RGV takes time to load and unload (s)
t3 : RGV spends time processing materials (s)
t4 : Time spent on RGV cleaning (s)

The fitness is very important for solving the optimal value and solving the problem of the subsequent problem. The size of the fitness value can distinguish the superiority and inferior-ity of the individual in the offspring. Above average moderati-on, there is an opportunity to carry out the next generation of reproduction, and for less than moderate, it is necessary to im-prove the operations such as crossover and mutation.

There are several commonly used calculation methods for solving individual fitness:

- direct objective function method, this method is to use the maximum value of the objective function as the value of individual fitness, although this algorithm is simple and p-opular, easy to use, but when the maximum and minimum of the objective function are too different The algorithm converges too fast, affec ting the performance of the algo-rithm, and the optimal solution cannot be obtained.
- The objective function transformation method with parameters. In this solution algorithm, the situation is analyzed, and the objective function and the maximum value are calculated as follows:

when $f(\mathrm{x}) - w_{\min}$ >0, $g(\mathrm{x}) = f(\mathrm{x}) - w_{\min}$;

other cases are 0;

when $w_{\max} - f(\mathrm{x})$ >0, $g(\mathrm{x}) = w_{\max} - f(\mathrm{x})$;

other cases are 0;

New parameters ($w_{\min}$ 、 $w_{\max}$) have been introduced in the current algorithm, but we cannot estimate the accuracy of the parameters. So we gave up this solution.

We have adopted a new calculation method to calculate, which is a sorting-based fitness allocation method. In this method, we first need to preprocess the value of the objective function, sort the values of the objective function. Then determine the value of the fitness function, the value is calculated as follows:

$$g(\mathrm{x}) = 2 - p + \frac{2(\mathrm{p}-1)(\mathrm{n}-1)}{N-1} \tag{2}$$

Among them, N represents the total number of individuals in the population size, n represents the sequence position of individuals in the population in the whole population, p represents the selection pressure, and the value of p is generally between 1 and 2. From 1 to 2, the value of fitness gradually increases, and the rate of population convergence gradually decreases. In order to balance the advantages and disadvan-tages, we integrated the average of both, and set the value of p as 1.5.

2.5.3 Choice

The genetic algorithm uses the value calculated by the fitness to provide the basis for the subsequent crossover operation. In the calculation of fitness, we have already explained that we should choose individuals with high fitness to carry out cross work and ensure the goodness of breeding offspring. After reading the literature research, among the many selected methods, we choose the calculation method of probability. Calculated as follows:

$$f(\mathrm{i}) = \frac{g(\mathrm{i})}{\sum_{i=1}^{N} g(\mathrm{i})} \tag{3}$$

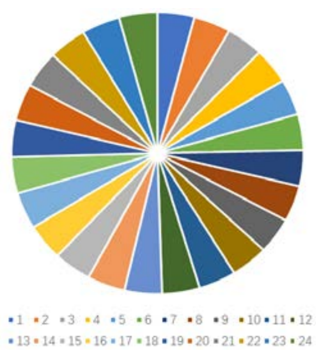


Figure 3. Two process scheduling

This method is simple and convenient, and is easy to calculate. After we have calculated the probability of selection for each individual, we use the roulette algorithm to calculate the cumulative probability of each individual.

The cumulative probabilities calculated in Table 1 through Table 3 are as follows:

Table1. Cumulative probabilities

individual	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Selection probability	**0.0408**	**0.0410**	**0.0412**	**0.0412**	**0.0412**	**0.0413**	**0.0412**	**0.0414**
Cumulative probability	**0.0408**	**0.0818**	**0.123**	**0.1642**	**0.2054**	**0.2467**	**0.2879**	**0.3293**

Table2. Cumulative probabilities

individual	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Selection probability	**0.0415**	**0.0413**	**0.0413**	**0.0417**	**0.0415**	**0.0419**	**0.0419**	**0.0417**
Cumulative probability	**0.3708**	**0.4121**	**0.4534**	**0.4951**	**0.5366**	**0.5785**	**0.6204**	**0.6621**

Table3. Cumulative probabilities

individual	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Selection probability	**0.0421**	**0.0417**	**0.0425**	**0.0423**	**0.0424**	**0.0420**	**0.0426**	**0.0424**
Cumulative probability	**0.7042**	**0.7459**	**0.7884**	**0.8307**	**0.8731**	**0.9151**	**0.9577**	**1.0000**

For the roulette algorithm, first, we set a disc with zero points. From these zero points, we will fill the calculated cumulative probability on the disc in turn. If the turntable turns to the probability value, it is selected. The probability value; if going to the middle of the two probabilities, the larger probability is selected as the selected probability value. However, it should be noted that the frequency with which the probability is selected is not necessarily high.

2.5.4 Cross and variation

In the genetic algorithm, the cross plays a very import-ant role. Through the crossover algorithm, we can get a var-iety of situations to ensure the superiority of the offspring genes and increasing the diversity of the population. When we cross-operate, we also need to choose one P_c , that is, t-he cross-probability. The size of the cross-probability also has a significant effect on the performance and results of t-he population. If the value is too large, the convergence wi-ll be too fast, the global optimal solution cannot be obtaine-d; if the value is too small, it will cause the convergence to be too slow or tend to be unable to converge. According to experience and knowledge, the range is generally between 0.7 and 1.0. In order to get better experimental results, we have chosen a value of 0.9. There are many other methods for crossover, including binary-coded single-point crossov-er, two-point crossover, multi-point crossover etc(3) , but for t-his problem, our coding method is not binary coding, so in the course of this question, We have chosen a partial match-ing crossover method. This algorithm can solve the situati-on of repetition after the intersection. After many crosses, t-here will be many results.

For the mutation algorithm, the purpose of using the mutation in this problem solving process is to obtain a new gene, to achieve local optimization and to promote the effe-ct of global optimization. For the variation, there is a certa-in probability of occurrence, we set The probability of mut-ation is , through a large number of experiments in history, the range of its values is generally between 0.001 and 0.1, and the value we obtained in this experiment is 0.05.

2.5.5 End condition

In this question, the main factor limiting us is the overall processing time. In general, for the consideration of the end condition, function value, fitness value and other factors, the flag time we set in the end condition, we set the time limit of 8 hours.

3. Model solution and validation

3.1 Model establishment and solution

The key part of the model is the control of the overall processing time by using a cycle and setting the cycle end condition to 8*3600(s), which is our initial condition. The processing table contains 8 CNC machines. The processing diagram is as follows:

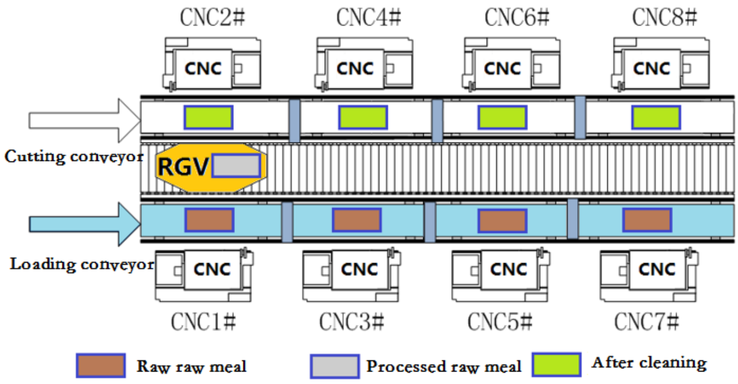


Figure 4. Working condition

When the operation time of the model does not reach the termination condition, the initialization of the recording flag a-nd the construction of CNC ready state are carried out respect-ively. Then the CNC state is traversed to find the next moving position. If it is found that the CNC is not ready, the counter will carry out self-increasing operation, and then jump directly into the next cycle of the model algorithm to judge whether th-e operation time has reached the termination condition . In the process of solving this model, we mainly classified and discu-ssed the processing time and feeding time, and roughly divided them into four cases:

- when the processing time is less than and equal to the blanking time:

In this case, due to the short processing time, we on-ly need to move on the control board of CNC no. 1 and no. 2 to avoid moving to other positions, resulting in wa-ste of time. The current situation is relatively simple, so the optimal scheduling scheme is respectively CNC1-> CNC2 ->CNC1

- when processing time is much longer than feed and feed time:

We use one of the cases as an example to verify that the time for RGV to travel is 20, the time for two-way jo-urney is 33, the time for three-way journey is 46, and the time for RGV trolley to the left CNC is 28 , the right CN-C loading and unloading time is 31.The following experi-mental results can be obtained by solving the model, as s-hown in the table:

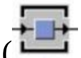
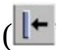
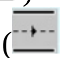
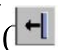
According to the table, our optimal scheduling scheme is: 1—>2—>3—>4—>5—>6—>7—>8.

As the ratio of processing time to feed time increases, the optimal scheduling scheme becomes: 1—>2—>3—>4—>5—>6—>7—>8.

Through the connection and analysis with the actual situ-ation, in the real production process, the processing time is us-ually much larger than the loading and unloading time, which can improve the machine utilization rate and play the applicat-ion value of the algorithm in this paper. To verify our algorit-hm, we conducted a simulation demonstration of the specific situation:

Table 4. Experimental result

FEED NUMBER	FEEDING TIME (S)	CUTTING TIME(S)	OPTIMAL SCHEDULING
1	0	606	1->2
2	28	662	2->3
3	79	738	3->4
4	110	794	4->5
5	161	870	5->6
6	192	936	6->7
7	243	1002	7->8
8	274	1058	8->1
⋮ ⋮	⋮ ⋮	⋮ ⋮	⋮ ⋮
234	18529	19135	1->2
235	18605	19211	2->3
236	18661	19267	3->4
237	18737	19343	4->5
238	18793	19399	5->6
239	18869	19475	6->7
240	18925	19747	7->8
241	19110	19716	8->1
⋮ ⋮ :	⋮ :	⋮ ⋮	⋮ ⋮

- Incoming station: represented by single station works-tation SingleProc object ()Shipment station
- Shipment station: expressed by Drain object ()
- Track: represented by a single lane route object ()
- RGV: expressed by the Transporter object ()
- Incoming task generator: represented by Source object ()
- Shipment task generator: Represented by Source object ()
- Timing clock: represented by EventController object ()
- Connection component: represented by the Connector object ()

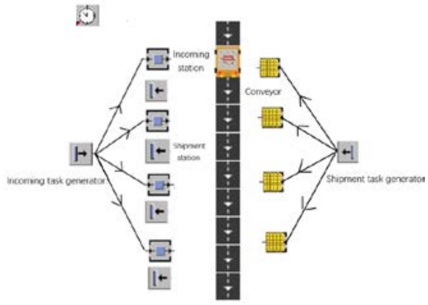


Figure 5. Simulation diagram

3.2 Comparative efficiency analysis

In order to better prove the effectiveness of our algorithm and the practicability of the model, we calculate the original s-cheduling and optimization scheduling separately. It can be se-en from the calculation data that under the premise that the pr-ocessing time is 8 hours and other unexpected conditions are not considered, the number of products produced by the origi-nal scheduling method is less than 50 pieces. With the dynam-ic optimization scheduling model established in this paper, it is possible to produce more than 350 products in 8 hours, and the production efficiency is improved by at least six times. It can greatly improve the production efficiency.

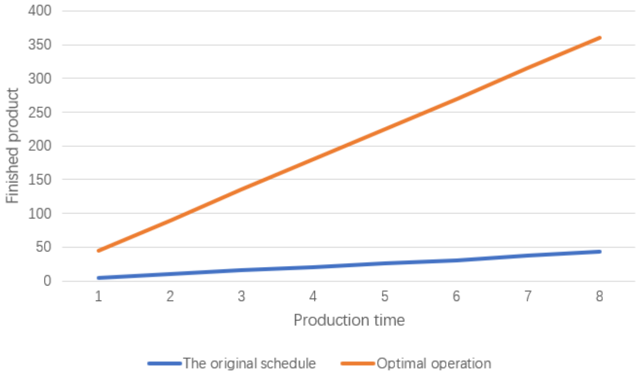


Figure 6. Efficiency comparison chart

4. Conclusion and analysis

In this paper, the heuristic scheduling algorithm we have used has a certain improvement compared with the original algorithm. The production efficiency has been improved compared with the previous one, but the real scheduling problem is very complicated and may appear with a certain probability. In some cases, in the future, we will study the scheduling of each different factors, propose a more reasonable scheduling scheme for different situations, and apply it to the planning of actual production scheduling operations.

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